Categorial Grammar and Type Ambiguity of Japanese Particles

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Abstract

The purpose of this article is to present a new type-shifting rule from <a, a> to <a, <a, b≫, which I call *d-rule*. This unknown raising is called for in view of the polymorphism of Japanese particles, *kakari zyosi*, such as *wa*, *mo*, *sae*, *dake* and *sika*, which undergo an extraordinary type-shift between <e, e>, <et, et>, <t, t>, ≪et, et>, <et, et≫, <e, <et, t≫, as well as the determiner type <et, <et, t≫. None of the present type-shifting rules in the framework of Combinatory Categorial Grammar, or 'Geach Rule,' 'Montague Rule,' 'argument lowering' in Partee and Rooth (1983), or 'z-rule' (Jacobson 1999) in Flexible Categorial Grammar is applicable to these natural language phenomena. The fact that *kakari* particles undergo type-shift to determiner-type, as attested to by Weak Crossover effects, requires such a novel type-raising rule.

1 Introduction

Japanese *kakari zyosi*, such as *wa* (topic marker), *mo* ('also'), *sae* ('even') and *dake* ('only'), are polymorphic in that they can attach to CN, PN, VP, PP or S (Nishiguchi 2003). This indicates that they go through unusual type-shift between <e, e>, <et, et>, <t, t>, ≪et, et>, <et, et≫, <e, <et, t≫, as well as the determiner type <et, <et, t≫, which is detected by the syntactic Weak Crossover (WCO) effects. In this paper, I suggest a new type-raising rule, because of the insufficiency of the combinatory

rules in Combinatory Categorial Grammar (CCG), and type-shift rules such as Geach Rule (Geach 1972) in the framework of Flexible Categorial Grammar. Although most of the type-shifts of these particles are explainable in the present analyses, another type-raising mechanism, which I call d-rule, should be constructed between <e, e> type and <et,<et, t≫ type:

(1) *d-rule*
change type *<a, a>* to *<a, <a, b≫*

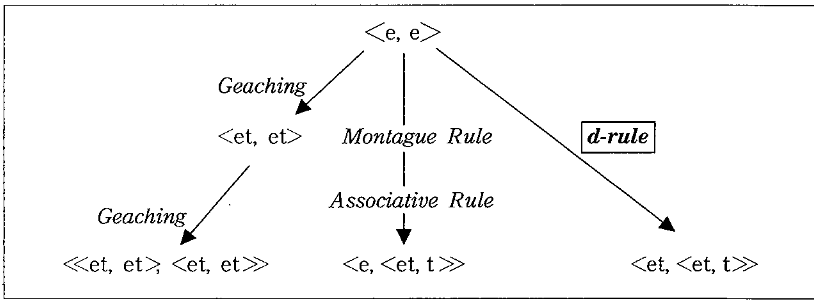


Fig. Type-raising of *kakari* particles

First, I will briefly overview the frameworks of Categorial Grammar (CG), starting from the Ajdukiewicz-Bar-Hillel calculus, Flexible Categorial Grammar and Combinatory Categorial Grammar. Then, the unique types of Japanese particles will be discussed.

2 Categorial Grammar

The original Categorial Grammar proposed by Ajdukiewicz (1935) and Bar-Hillel (1953) was based on fixed categories. Categories could be combined by a rule of functional application.

In the framework of Bar-Hillel (1953), e. g., the English sentence *Poor John sleeps* belongs to category s (for *sentence*), *John* to the category n, *poor* to $\frac{n}{[n]}$, and *sleeps* to $\frac{s}{(n)}$, where n is approximately interpreted as the category of name-like strings. $\frac{n}{[n]}$ is the category of those strings with an n to their right forms a string belonging to the category n. $\frac{s}{(n)}$ is the category with n to the left which forms s.

In the current theory of CG, the corresponding notation is as follows:

(2)
```
Poor      John        sleeps
NP/NP     NP          NP\S
------------
    NP
    ------------------------
              S
```

2. 1 Flexible Categorial Grammar

2. 1. 1 Montague Rule

Many attempts have been made to add various operations on the functions and arguments to the basic context-free apparatus. More flexible versions incorporating type-change have been proposed since then. For example, Montague Rule (Montague 1973) raises *John* (NP) to S/(NP\S), which corresponds to <et, t> in type theory.

(3)
```
Poor                        John          sleeps
NP/NP                       NP            NP\S
--------------------------  ------------
(S/(NP\S))/(S/(NP\S))       S/(NP\S)
----------------------------------------
         S/(NP\S)
         ---------------------------------------
                          S
```

(4) *Montague Rule*
change type *a* to ≪*a*, *b*>, *b*>

Montague rule allows type <e> to be raised to <et, t>, but type <e, e> is not allowed to shift to <et, <et, t≫, which Japanese *kakari* particles undergo, to be discussed in section 3.

2. 1. 2 Geach Rule

Another prominent rule adopted by flexible categorial grammar is the 'Geach Rule' (Geach 1972):

(5) *Geach Rule*
change type *<a, b>* to *≪c, a>, <c, a≫*

This rule can be used, e. g., to lift cross-categorial connectives *and* or *or*, which can be conjoined with virtually every major category (Montague 1973; Partee and Rooth 1983):

(6)

Bill	and	
S/(NP\S)	((S\(NP\S))\(S/(NP\S)))/(S/(NP\S))	
Nick	are	happy.
S/(NP\S)	(NP/S)/(NP/S)	NP/S

(7)

Polly	dances	and	sings.
NP	NP\S	((NP\S)\(NP\S))/(NP\S)	NP\S

(8)

Sue	swims	and	Terri	eats.
NP	NP\S	(S\S)/S	NP	NP\S

By listing ordinary *and* in lexicon as (S\S)/S, all other categories can be derived by "Geaching."

In the Japanese language, connective particles *to* ('and') and *ka* ('or') are also polymorphic, and Geach Rule, likewise, is eligible for generating all categories.

(9) Taroo-to/ka Hanako-ga odotta.
Taroo-CON Hanako-NOM dance-PAST
'Taroo and/or Hanako danced.'

(10)

Taroo	-to/ka	
S/(NP\S)	(S/(NP\S))\((S/(NP\S))/(S/(NP\S)))	
Hanako	-ga	odotta
S/(NP\S)	(S/(NP\S))\(S/(NP\S))	NP\S

(11) Taroo-ga odotta-ka Hanako-ga odotta.

Taroo-NOM danced-CON Hanako-NOM danced
'Taroo danced or Hanako danced.'

(12)

Taroo	-ga	odotta	-ka	Hanako	-ga	odotta.
NP	NP\NP	NP\S	S\(S/S)	NP	NP\NP	NP\S

However, "Geaching" by no means derives <et, <et, t≫ out of <e, e>, which is necessary for Japanese particles.

2. 1. 3 Partee and Rooth (1983)

Partee and Rooth (1983) suggests 'argument lowering':

(13) *Argument Lowering*
change type ≪*a*, *b*>, *b*>, *c*> to <*a*, *c*>

This changes, e. g., complex intransitive verbs of type ≪e, t>, t>, t> to simple predicates of type <e, t> (van Benthem 1989: 231). But this rule is irrelevant to the type-shift of *kakari* particles.

2. 1. 4 z-Rule (Jacobson 1996, 1999)

Jacobson's z-rule enables variable-free semantics.

(14) *z-rule*
Let f be a function of type <*a*, <*b*, *c*≫. Then **z**(*f*) is a function of type ≪*b*, *a*>, <*b*, *c*≫ such that $\mathbf{z}(f)=\lambda g[\lambda x[f(g(x))(x)]]$ (for g of type <*b*, *a*> and x of type *b*). (Jacobson 1996 : 109)

For instance, **z** can raise transitive verb *love* of type <e, et> to <et, et> type:

(15) **z** (love′)
love′ → z love′; $\lambda f[\lambda x[\text{love}'(f(x))(x)]$

Nevertheless, z-rule does not enable any of the types <e, e>,

<et, et>, ≪et, et>, <et, et≫, <e, <et, t≫ to be raised to the determiner type <et, <et, t≫.

2. 2 Combinatory Categorial Grammar

Combinatory Categorial Grammar (CCG) has been developed by Mark Steedman (Steedman 1987, 1988, 2000). CCG aims to generalize pure Categorial Grammar by Ajdukiewicz and Bar-Hillel. In order to allow coordination of contiguous strings, CCG includes certain further operations on functions related to Curry's combinators such as **B** (Curry and Feys 1958):

(16) *Forward composition*(>**B**)

$X/Y \quad Y/Z \Rightarrow_{B} X/Z$ (Steedman 2000 : 40)

Although there are a lot of composition rules having been developed (*cf.* Steedman 2000:169), none of them enables type-raising of *kakari* particles from <e, e> to <et, <et, t≫. A new rule is called for in order to account for the linguistic evidence relevant to *kakari zyosi.*

3 Polymorphic Aspects of *Kakari* Particles

In the Japanese language, not only coordination, but also *kakari* particles are polymorphic. In section 3. 1., I will introduce the cross-categorial status of Japanese particles, part of which is explainable by present type-raising rules. Section 3. 2 discusses syntactic evidence of quantification of noun phrases attached by *kakari* particles, which attests to the fact that these particles are of determiner type <et, <et, t≫. No existing theory can account for this extraordinary type-shift between <e, e> and <et, <et, t≫. I suggest, in section 4, a new type-raising rule, which is necessary to accommodate these natural language phenomena.

3. 1 Type Ambiguity of *Kakari* Particles

Japanese particles such as *wa* (topic marker), *mo* ('also'), *sae* ('even'), *dake* ('only') and *nomi* ('only') are polymorphic, as I argued in Nishiguchi (2002):

(17) Particles Attached to PN

a. Taroo-*mo* hasitta.
Taroo-also ran
'Taroo ran, too.'

b.

Taroo	*-mo*	hasitta.
NP	NP\(S/(NP\S))	NP\S

c. Taroo-*wa* hasitta.
Taroo-TOP ran.
'Taroo also ran.'

d.

Taroo	*-wa*	hasitta.
NP	NP\(S/(NP\S))	NP\S

e. Taroo-*dake*-ga hasitta.
Taroo-only-NOM ran
'Only Taroo ran.'

f.

Taroo	*-dake*	-ga	hasitta.
NP	NP\(S/(NP\S))	(S/(NP\S))\(S/(NP\S))	NP\S

g. Taroo-*sae* hasitta.
Taroo-even ran
'Even Taroo ran.'

h.

Taroo	*-sae*	hasitta.
NP	NP\(S/(NP\S))	NP\S

(18) Particles Attached to CN

a. Inu-*wa* hasitta.
dog-TOP ran
'The dog ran.'

b.

Inu	*-wa*	hasitta.
NP\S	(NP\S)\(S/(NP\S))	NP\S

c. Inu-mo hasitta.
dog-also ran
'The/a dog ran, too.'

d.

Inu	*-mo*	hasitta.
NP\S	(NP\S)\(S/(NP\S))	NP\S

e. Inu-*dake*-ga hasitta.
dog-only-NOM ran
'Only the dog ran.'

f.

Inu	*-dake*	-ga	hasitta.
NP\S	(NP\S)\(S/(NP\S))	(S/(NP\S))\(S/(NP\S))	NP\S

g. Inu-*sae* hasitta.
dog-even ran
'Even the/a dog ran.'

h.

Inu	*-sae*	hasitta.
NP\S	(NP\S)\(S/(NP\S))	NP\S

(19) Particles Attached to Infinitive Verb

a. Taroo-wa taberu-*dake*-da.
Taroo-TOP eat-only-be
'Taroo only eats.'

b. Taroo -wa taberu *-dake*

NP NP\(S/(NP\S)) NP\S (NP\S)\(NP\S)

-da.

(NP\S)\(NP\S)

(20) Particles Attached to VP

a. Taroo-wa tumazuita-*dake*-da.

Taroo-TOP stumbled-only-be

'Taroo only stumbled.'

b. Taroo -wa tumazuita *-dake*

NP NP\(S/(NP\S)) NP\S (NP\S)\(NP\S)

-da

(NP\S)\(NP\S)

(21) Particles Attached to PP

a. Taroo-ga Makudonarudo-de-*wa* taberu-(koto)

Taroo-NOM McDonald's-LOC-TOP eat-(fact)[1]

'Taroo eats only at Mc Donald's.'

b. Taroo -ga Makudonarudo -de

NP NP\NP NP NP\((NP\S)/(NP\S))

-wa taberu-(koto)

((NP\S)/(NP\S))/((NP\S)/(NP\S)) NP\S

c. Taroo-ga Makudonarudo-de-*sae* taberu-(koto)

Taroo-NOM McDonald's-LOC-even eat-(fact)

'Taroo eats even at McDonald's.'

d. Taroo -ga Makudonarudo

NP NP\NP NP

-de

NP\((NP\S)/(NP\S))

-sae taberu.

((NP\S)/(NP\S))\((NP\S)/(NP\S)) NP\S

e. Taroo-ga Makudonarudo-de-*sika* tabe-nai-(koto)
Taroo-NOM McDonald's-LOC-only eat-NEG-(fact)
'Taroo eats only at McDonald's.'

f. Taroo / -ga / Makudonarudo
NP / NP\NP / NP
-de
NP\((NP\S)/(NP\S))
-sika
((NP\S)/(NP\S))\((NP\S)/(NP\S))
tabe / -nai
NP\S / (NP\S)\(NP\S)

g. Taroo-ga Makudonarudo-de *-dake* taberu-(koto)
Taroo-NOM McDonald's-LOC-only eat-(fact)
'Taroo eats only at McDonald's.

h. Taroo / -ga / Makudonarudo
NP / NP\NP / NP
-de
NP\((NP\S)/(NP\S))
-dake
((NP\S)/(NP\S))\((NP\S)/(NP\S))
taberu
NP\S

As shown in above examples, Japanese *kakari* particles go through type-shifts between <e, e>, <e, <et, t≫, <et, et>, and ≪et, et>, <et, et≫. Geaching raises type <e, e> to <et, et> and to ≪et, et>, <et, et≫:

(22) <e, e>
———————— *Geaching*
<et, et>
———————— *Geaching*

≪et, et>,<et, et≫

If we assume the associative law, we can deduce <e, ≪e, t>, t≫ from ⋘e, e>, t>, t>:

(23) <e, e>

———————— *Montague rule*

⋘e, e>, t>, t>

———————— *Associative rule*

≪e, et>, t>

———————— *Associative rule*

<e,<et, t≫

The above type-shifts can be captured by Geach Rule, Montague Rule, plus Association Rule. However, *kakari* particles demonstrate another category which is problematic for present type-raising theories, which will be discussed in the next section.

3. 2 Quasi-Generalized Quantifiers: Unaccountable Type

There exists syntactic evidence that common noun phrases attached by *kakari* particles demonstrate Weak Crossover effects, proving quantification. This entails that the category of particles are (NP\S)\(S/(NP\S), whose semantic type is of determiner-type, <et, <et, t≫.

It was Kuroda (1970) that first pointed out the quantifier-like behavior of Japanese *kakari* particles. Since Hoji (1985), Weak Crossover effects have been used to detect quantification by Japanese quantifiers.[2] For example, phrases that contain *mo /nomi/sae* particles cannot be co-indexed with *so-ko* in (24):

(24) a. *So-ko$_i$-no bengosi-ga Toyota$_i$-*nomi*-o uttaeta.
that-place-GEN lawyer-NOM Toyota-only-ACC sued
'That place's lawyer sued only Toyota.'

b. *So-ko$_i$-no bengosi-ga Toyota$_i$-*mo* uttaeta.
that-place-GEN lawer-NOM Toyota-also sued
'That place's lawyer also sued Toyota.'

c. *So-ko$_i$-no bengosi-ga Toyota$_i$-*sae*-o uttaeta.
that-place-GEN lawer-NOM Toyota-even-ACC sued
'That place's lawyer sued even Toyota.'

Removing *mo/nomi/sae* improves grammaticality drastically:

(25) So-ko$_i$-no bengosi-ga Toyota$_i$-o uttaeta.
that-place-GEN lawer-NOM Toyota-ACC sued
'That place's lawyer sued only Toyota.'

It is also the case with *dake*:

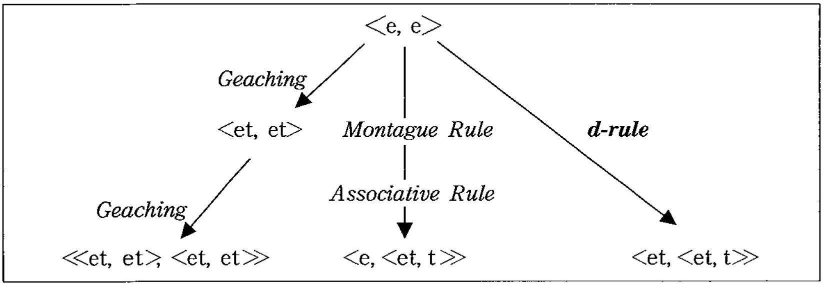
(26) *So-itu$_j$-no titioya-ga$_i$ gakusei$_j$-*dake*-o kawaigatta
that-guy-GEN father-NOM student-only-ACC loved
'His father loved only students'

So-itu (that-guy) cannot be co-indexed with *gakusei* (student), as bound variables. Thus, WCO effects detect quantification with particles.

4 New Type Shift Rule

As I have argued so far, the type <et, <et, t>> cannot be derived by present type-raising rules. However, the existence of such cross-categorial words testifies unknown links between their types. Certain rule should permit the shift between <e, e> or <et, et> and <et,<et, t>>, which I call the *d-rule:*

(27) *d-rule*
change type <*a*, *a*> to <*a*,<*a*, *b*>>



5. Conclusion

I have pointed out unknown phenomena in natural language which call for a new type-raising rule, the *d-rule*. This enables cross-categorial Japanese particles to raise between not only <e, e>, <et, et>, ≪et, et>, <et, et≫, and <e, <et, t≫, but also <et, <et, t≫ type. The fact that *kakari* particles, such as *wa, mo, dake,* and *sika* raise to determiner type was attested to by the syntactic evidence of Weak Crossover effects.

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Notes

1 I add *koto* 'the fact that' at the end of these sentences in order to avoid the unnaturalness resulting from the lack of a topic.

2 See Ueyama (1998), Hoji et al. (2000) and others.