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<th>Title</th>
<th>Categorial Grammar and Type Ambiguity of Japanese Particles</th>
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<td>Nishiguchi, Sumiyo</td>
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Categorial Grammar and
Type Ambiguity of Japanese Particles

Sumiyo Nishiguchi

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) \textit{d-rule}

change type \(<a, a>\) to \(<a, <a, b>>\)

![Fig. Type-raising of \textit{kakari} particles](image)

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 \textit{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  
\[ \begin{array}{c}
\text{NP/NP} \\
\text{NP} \\
\text{NP/S} \\
\text{S}
\end{array} \]

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 \(<\text{et}, \text{t}>\) in type theory.

(3) Poor  John  sleeps  
\[ \begin{array}{c}
\text{NP/NP} \\
\text{NP} \\
\text{NP/S} \\
\text{S/(NP\$S)} \\
\text{S/(NP\$S)} \\
\text{S/(NP\$S)} \\
\text{S}
\end{array} \]

(4) Montague Rule

change type a to \(<a, b>, b>\)

Montague rule allows type \(<\text{e}>\) to be raised to \(<\text{et}, \text{t}>\), but type \(<\text{e}, \text{e}>\) is not allowed to shift to \(<\text{et}, <\text{et}, \text{t}>\), 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 Nick are happy.
$S/(NP/S)$ $((S/(NP/S))/(S/(NP/S)))/(S/(NP/S))$
$NP/S$ $((NP/S)/(NP/S))$ $NP/S$

(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 and/or Hanako danced.’

(10) Taroo—to/ka
$S/(NP/S)$ $((S/(NP/S))/(S/(NP/S)))/(S/(NP/S))$
$NP/S$ $((NP/S)/(NP/S))$ $NP/S$

(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
NP  NP\NP  NP\S  S\(S/S)  NP  NP\NP
odotta.
NP\S

However, "Geaching" by no means derives $<e, et, t>$ 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

$z(f) = \lambda g[\lambda x[f(g(x))(x)]]$ (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) $z (love')$

$love' \rightarrow z love'; \lambda f[\lambda x[love'(f(x))(x)]]$

Nevertheless, z-rule does not enable any of the types $<e, e>$,
\(<et, et>, <et, et>, <et, et>, <e, <et, et>>\) 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):

\[
(16) \text{Forward composition} (\triangleright B)
X/Y \quad Y/Z \Rightarrow_B X/Z \quad \text{(Steedman 2000:40)}
\]

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. \[
   \text{Taroo} \quad \underline{-mo} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{NP\S}
   \]

   \[
   \text{c. Taroo-} \quad \underline{-wa} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{NP\S}
   \]

   \[
   \text{d. Taroo-} \quad \underline{-dake-ga} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{NP\S}
   \]

   \[
   \text{e. Taroo-} \quad \underline{-sae} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{NP\S}
   \]

   \[
   \text{f. Taroo-} \quad \underline{-dake} \quad \underline{-ga} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{S/(NP\S)} \quad \text{S/(NP\S)} \quad \text{NP\S}
   \]

   \[
   \text{g. Taroo-} \quad \underline{-sae} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{NP\S}
   \]

   \[
   \text{h. Taroo-} \quad \underline{-sae} \quad \text{hasitta.}
   \text{NP} \quad \text{NP\/(S/(NP\S))} \quad \text{NP\S}
   \]
(18) Particles Attached to CN
a. Inu-\textit{wa} hasitta.
dog-TOP ran
'The dog ran.'
b. Inu-\textit{wa} hasitta.
\[
\begin{array}{c}
\text{NP}\backslash S \\
\text{(NP}\backslash S)\backslash(S/(NP\backslash S))
\end{array}
\begin{array}{c}
\text{NP}\backslash S
\end{array}
\]
c. Inu-\textit{mo} hasitta.
dog-also ran
'The/a dog ran, too.'
d. Inu-\textit{mo} hasitta.
\[
\begin{array}{c}
\text{NP}\backslash S \\
\text{(NP}\backslash S)\backslash(S/(NP\backslash S))
\end{array}
\begin{array}{c}
\text{NP}\backslash S
\end{array}
\]
e. Inu-\textit{dake-ga} hasitta.
dog-only-NOM ran
'Only the dog ran.'
f. Inu-\textit{dake-ga} hasitta.
\[
\begin{array}{c}
\text{NP}\backslash S \\
\text{(NP}\backslash S)\backslash(S/(NP\backslash S))
\end{array}
\begin{array}{c}
\text{(S/(NP\backslash S))}\backslash(S/(NP\backslash S))
\end{array}
\begin{array}{c}
\text{NP}\backslash S
\end{array}
\]
g. Inu-\textit{sae} hasitta.
dog-even ran
'Even the/a dog ran.'
h. Inu-\textit{sae} hasitta.
\[
\begin{array}{c}
\text{NP}\backslash S \\
\text{(NP}\backslash S)\backslash(S/(NP\backslash S))
\end{array}
\begin{array}{c}
\text{NP}\backslash S
\end{array}
\]

(19) Particles Attached to Infinitive Verb
a. Taroo-\textit{wa} taberu-\textit{dake-da}.
Taroo-TOP eat-only-be
'Taroo only eats.'
b. Taroo **-wa** taberu **-dake**
   \[\frac{NP}{(NP\langle S/(NP\langle S\rangle)\rangle)} \frac{NP\langle S\rangle}{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}\]
   **-da**.
   \[\frac{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}\]

(20) Particles Attached to VP

a. Taroo-*wa* tumazuita-*dake*-*da*.
   "Taroo-*TOP* stumbled-only-*be*"
   "Taroo only stumbled."

b. Taroo **-wa** tumazuita **-dake**
   \[\frac{NP}{(NP\langle S/(NP\langle S\rangle)\rangle)} \frac{NP\langle S\rangle}{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}\]
   **-da**
   \[\frac{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}\]

(21) Particles Attached to PP

a. Taroo-*ga* Makudonarudo-*de-*wa* taberu-(koto)
   "Taroo-*NOM* McDonald's-LOC-*TOP* eat-(fact)"
   "Taroo eats only at McDonald's."

b. Taroo **-ga** Makudonarudo **-de**
   \[\frac{NP}{(NP\langle NP\rangle/\langle NP\rangle)} \frac{NP\langle NP\rangle}{(NP\langle NP\rangle/\langle NP\langle NP\rangle\rangle)}\]
   **-wa**
   \[\frac{(NP\langle NP\rangle/\langle NP\rangle)/(NP\langle NP\rangle/\langle NP\rangle)}{(NP\langle NP\rangle/\langle NP\rangle)/(NP\langle NP\rangle/\langle NP\rangle)}\]
   taberu-(koto)
   \[\frac{NP\langle S\rangle}{(NP\langle S\rangle/\langle NP\langle S\rangle\rangle)}\]

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 **-de**
   \[\frac{NP}{(NP\langle NP\rangle/\langle NP\rangle)} \frac{NP\langle NP\rangle}{(NP\langle NP\rangle/\langle NP\rangle)} \frac{NP\langle NP\rangle}{(NP\langle NP\rangle/\langle NP\rangle)}\]
   **-sae**
   \[\frac{(NP\langle S\rangle/\langle NP\rangle)/(NP\langle S\rangle/\langle NP\rangle)}{(NP\langle S\rangle/\langle NP\rangle)/(NP\langle S\rangle/\langle NP\rangle)}\]
   taberu.
As shown in above examples, Japanese *kakari* particles go through type-shifts between \(<e, e\>\), \(<e, \langle et, t\rangle\>\), \(<et, et\>\), and \(<\langle et, et\>, \langle et, et\>\>\). Geaching raises type \(<e, e\>\) to \(<et, et\>\) and to \(<\langle et, et\>, \langle et, et\>\>\):

\[
\begin{align*}
\text{(22) } \quad & <e, e> \\
\quad & \overline{\text{Geaching}} \\
\quad & <et, et> \\
\quad & \overline{\text{Geaching}}
\end{align*}
\]
If we assume the associative law, we can deduce \(<e, <e, t>, t>\) from \(<<e, e>, t>, t>\):

\[\text{(23) } \langle e, e \rangle \]

\[\text{Montague rule} \]

\[\langle e, e, t>, t> \]

\[\text{Associative rule} \]

\[\langle e, et>, t> \]

\[\text{Associative rule} \]

\[\langle e, et, t> \]

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 \((NP \backslash S) \backslash (S/ (NP \backslash S))\), 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):

\[\text{(24) a. } \text{So-ko}_i\text{-no bengosi-ga Toyota}_i\text{-nomi-o uttaeta.} \]

\[\text{that-place-GEN lawyer-NOM Toyota-only-ACC sued} \]

\[\text{That place's lawyer sued only Toyota.}\]
b. *So-ko1-no bengosi-ga Toyota1-mo uttaeta.
   that-place-GEN lawer-NOM Toyota-also sued
   'That place's lawyer also sued Toyota.'

c. *So-ko1-no bengosi-ga Toyota1-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-ko1-no bengosi-ga Toyota1-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-itu1-no titioya-ga1 gakusei1-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 de-
erved 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 \textit{d-rule}. This enables cross-categorial Japanese particles to raise between not only \textit{<e, e>}, \textit{<et, et>}, \textit{<et, et>}, \textit{<et, et>}, and \textit{<et, et, t>}, but also \textit{<et, et, t>} type. The fact that \textit{kakari} particles, such as \textit{wa}, \textit{mo}, \textit{dake}, and \textit{sika} raise to determiner type was attested to by the syntactic evidence of Weak Crossover effects.

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References


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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.