

Resolving Zero Anaphora in Japanese

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Abstract

The paper presents a computational theory for resolving Japanese zero anaphora, based on the notion of *discourse segment*. We see that the discourse segment reduces the domain of antecedents for zero anaphora and thus leads to their efficient resolution.

Also we make crucial use of functional notions such as *empathy hierarchy* and *minimal semantics thesis* to resolve reference for zero anaphora [Kuno, 1987]. Our approach differs from the *Centering* analysis [Walker *et al.*, 1990] in that the resolution works by matching one empathy hierarchy against another, which makes it possible to deal with discourses with no explicit topic and those with cataphora [Halliday and Hassan, 1990].

The theory is formalized through the definite clause grammar (DCG) formalism [Pereira and Warren, 1980], [Gazdar and Mellish, 1989; Longacre, 1979].

Finally, we show that graphology i.e., quotation mark, spacing, has an important effect on the interpretation of zero anaphora in Japanese discourse.

1 Introduction

Over the past years, schemes like *Focusing* and *Centering* have dominated computational approaches to resolving anaphora [Sidner, 1983; Walker *et al.*, 1990]. Their success derives from the utility they have in identifying salient discourse entities such as *topic* and thereby locating the antecedent for an anaphor. But they all suffer from the problem of

directionality; they process the text (the list of sentences) from left to right, picking out focus along the way and see if an anaphor corefers with a focus already encountered. With the one-way processing, forward-looking pronouns (cataphora) are not possible to resolve. Since Japanese has great tolerance with forward reference, a proper theory of zero pronouns should meet the problem of directionality.

In what follows, we discuss some points about discourse segment and zero pronoun in Japanese. We begin by introducing the idea of *discourse segment*. Consider the pair:

- (1) Taro-ga sara_{<i>}-wo dasi, Hanako
nom plate acc prepare-and
-ga 02_{<i>} ryori -wo morituketa.
nom food acc arranged

Taro prepared the plates, Hanako arranged food on them.

- (2) Taro -ga sara_{<k>} -wo dasi, Hanako_{<i>} -wa
top
01_{<i>} 02_{<k>} ryori-wo morituketa.

Taro prepared the plates, Hanako arranged food.

Here, 02 represents a suppressed expression. It acts as an indirect object of the verb *moritsuketa*.¹ 1 and 2 are morphologically identical except that 1 has *ga* (nominative marker) where 2 has *wa* (topic marker). But they differ widely in meaning: 1 implies that Hanako arranged food on the plates that Taro prepared, the reading 2 does not imply; in 2,

¹Here and throughout, we intend the term 01 to represent a zero pronoun for the subject, 02 for the indirect object, and 03 for the direct object.

Hanako could have arranged food on plates somebody other than Taro prepared. Now locating the difference will involve the notion of *discourse segment*. A discourse segment is defined as a set of sentences which appear in some region of text and which is delimited by a topic-particle *wa*. Thus 2 breaks up into two segments, a clause with *Taro-ga* and one with *Hanako-wa*;1, containing no *wa*-marked element, forms a segment by itself. Section 2.1 provides syntactic definitions for the discourse segment.

Another important feature of discourse segment is that of complying with the *Minimal Semantics Thesis* (MST) [Nomoto, 1992], a functional property that makes a segment cohere. The MST says, 'Assume as identical any pair of zero pronouns if it is part of some segment and does not occur as arguments for the segment's predicate.' Thus any pair of zero pronouns that fall into the domain of discourse segment are taken to be coreferential, unless they occur for the same predicate.² Significantly, the MST is amenable to syntactic treatment.

In addition, we make use of the *empathy hierarchy* to choose between coreference relationships admitted by the MST. We specify a predicate for the empathy hierarchy and resolve zero anaphora by unifying one predicate's empathy hierarchy with another which occurs in the same segment. Since unification is a non-directional operation, we are able to treat forward as well as backward reference.

2 Theory

2.1 General

A discourse segment (DS) is a two-part structure consisting of head and body; a head is a nominal with a *wa* marking; a body is a set of sentences, which end with a period. Note that an adjunctive clause is not a sentence here, since it ends with connectives like *-node because*, *-kara because/after*, *-to and-then*, etc. Formally, we assume sentence has the following analyses, which are given in the DCG formalism.

- (3) S → C+, N(pp:wa).
 S → C*, N(pp:wa), C+.
 S → C+.

C+ denotes one or more occurrences of clause, C* zero or more occurrences of clause, and N(PP:wa) denotes a *wa*-marked nominal; pp:wa specifies that the attribute pp (for postposition) has wa for the value.³ Let us define discourse segment by:

²[Hobbs, to appear] talks about the *cognitive economy* in understanding discourse: it says in effect that coherence is the result of minimizing the number of entities in discourse.

³We take a *wa*-marked nominal to be a sentence adverbial. Thus our approach differs from the traditional gap analysis of topic construction [Kuroda, 1965; Inoue, 1978; Kitagawa, 1982; Gunji, 1987], which assumes that a *wa*-

- (4) D → S+.

and text by

- (5) T → D+.

As discussed in section 1, we choose to restrict D to containing at most one N(pp:wa). We implement the restriction by way of some additions to the rule set 3.

- (6) a S(head:X) → C+, N(morph:X,pp:wa).
 b S(head:X) → C*, N(morph:X,pp:wa), C+.

Here, the 6 rule takes care of inverted sentence and the 6 rule non-inverted sentence. The rule set 6 enforces unification between the head value and the morph value. morph represents the morphology of the nominal; thus morph:taro specifies that the associated nominal has the morphology "taro".

Notice that unification fails on a multiply headed segment. A head attribute, once instantiated to some value, will never unify with another. Unification, therefore, acts to limit each segment in the discourse to a single head. Note also that a non-headed discourse, that is, discourse with no headed segments, has a legitimate DS analysis, for unification is possible between empty heads. The following lists the rules for DS Grammar.

- (7) T → D+(head:).
 D(head:X) → S+(head:X).

- S(head:X) → C+, N(morph:X,pp:wa).
 S(head:X) → C*, N(morph:X,pp:wa), C+.
 S(head:.) → C+.

2.2 Headed vs. Non-Headed Discourse

The discourse can be perfectly intelligible without an explicit topic or *wa*-nominal, which implies that a discourse segment may not be headed at all. It appears, however, that a discourse segment always comes out headed except when there is no head available in the text. In fact, a segment associates with a head nominal regardless of where it occurs in that segment.

- (8) Taro<i> -wa 01<i> 02<j> seki -wo uzutte
 top seat acc give
 -ageta node, 01<i> 02<j> orei -wo
 help because thank
 iwar eta. 01<i> chotto terekusa katta.
 say pass slightly embarrassed cop

nominal is dislocated from the sentence and leaves a gap behind. In fact the analysis meets some difficulty in accounting for the *wa*-nominal having semantic control over a set of period-marked sentences. cf. [Mikami, 1960]. Ours, however, is free from the problem, as we see below.

Because Taro gave him/her a favor of giving a seat, he/she thanked Taro, who was slightly embarrassed.

- (9) 01_{<i>} 02_{<j>} seki -wo uzutte -ageta -node,
Taro_{<i>} -wa 01_{<i>} 02_{<j>} orei-wo iwareta.
01_{<i>} chotto terekusak -atta.

Because Taro gave him/her a favor of giving a seat, he/she thanked Taro, who was slightly embarrassed.

- (10) 01_{<i>} 02_{<j>} seki -wo uzut -te -ageta -node,
01_{<i>} 02_{<j>} orei-wo iwareta. Taro_{<i>} -wa
01_{<i>} chotto terekusak -atta.

Because Taro gave him/her a favor of giving a seat, he/she thanked Taro, who was slightly embarrassed.

8, 9 and 10 each constitute a discourse segment headed with *Taro*.⁴ A discourse can be acceptable without any head at all:

- (11) 01_{<i>} 02_{<j>} seki wo uzutte ageta node,
 seat acc give favor because
01_{<i>} 02_{<j>} orei -wo iwar eta. 01_{<i>}
 thanks acc say pass
chotto terekusa katta
slightly embarassed cop

Because he/she gave him/her a favor of giving a seat, he/she thanked him/her, who was slightly embarrassed.

The speaker of 11, or *watashi I* would be the most likely antecedent for the elided subjects here; whoever gave the favor was thanked for the kindness. Let us say that a discourse is *headed* if each of its segments is headed, and *non-headed*, otherwise. Our assumption is that a discourse is either headed or non-headed, and not both (e.g. figure 1, figure 2).⁵

Formally, this will be expressed through the value for the *head* attribute.

- (12) T → D(head:empty).

An empty-headed discourse expands into one segment; its head value will be inherited by each of the S-trees down below. Note that unification fails on

⁴The *Centering* algorithm is not equipped to deal with cases like 9 and 10, where the backward-looking center *Taro* refers back to an item in the previous discourse.

⁵It is interesting to note that a multiple-head discourse may reduce to a single-head discourse. This happens when discourse segments (DS) for a discourse, share an identical head, say, *Taro* and head-unifies with each other. In fact, such a reduction is linguistically possible and attested everywhere. Our guess is that a repeated use of the same *wa*-phrase may help the reader to keep track of a coreferent for zero anaphora.

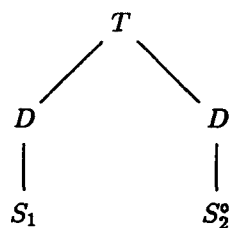


Figure 1: Unacceptable DS-tree. “S^o” denotes a sentence with a *wa*-marked nominal.

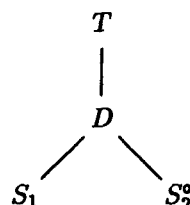


Figure 2: Acceptable DS-tree

the head value if any of the S’s should be headed and thus specified for the *head* attribute.

The following rule takes care of headed constructions.

- (13) T → D+(head:.).

The rule says that each of the segments has a non-null specification for the *head* attribute.

2.3 Minimal Semantics Thesis

Minimal Semantics Thesis (MST) concerns the way zero pronouns are interpreted in the discourse segment; it involves an empirical claim that the segment’s zeros are coreferential unless considerations on the empathy hierarchy (section 2.4) dictate to the contrary.

- (14) Kono ryori_{<i>} wa saishoni 01_{<i>} mizu
 this food acc first water
wo irete kudasai. Tugini 01_{<i>} sio
 acc pour in imperative next salt
wo hurimasu. 5 hun sitekara, 01_{<i>}
 acc put-in min. after passing
niku wo iremasu.
 meat acc add

As for this food, first pour in some water. Then put in salt. Add meat after 5 min.

We see that 14 constitutes a single discourse segment. According to the minimal semantics thesis, all of the zeros in the segment are interpreted as coreferential, which is consistent with the reading we have for the example. Here is a more complex discourse.

- (15) Taro-wa 01<i> machi -niitte, 01<i> huku
 top town to go cloth
 -wo katta. Masako<j> -wa 01<k> sono
 acc bought top that
 huku -wo tanjyobi -ni moratte, 01<k>
 cloth acc birthday on got
 totemo yoroko -n'da.
 much rejoice past

Taro went downtown to buy a clothing. Masako got it for her birthday present and she was very happy.

The first two zeros refer to *Taro* and the last two refer to *Masako*. But this is exactly what the MST predicts; 15 breaks up into two discourse segments, one that starts with *Taro-wa* and the other that starts with *Masako-wa*, so zeros for each segment become coreferential.

2.4 Empathy Hierarchy

It appears to be a fact about Japanese that the speaker of an utterance empathizes or identifies more with the subject than with the indirect object; and more with the indirect object than with the direct object [Kuno, 1987; Kuno and Kaburaki, 1977]. In fact, there are predicates in Japanese which are lexically specified to take an empathy-loaded argument; *yaru give* and *kureru receive* are two such. For *yaru*, the speaker empathizes with the subject, but with the indirect object, in the case of *kureru*.

The relevance of the speaker's empathy to the resolution problem is that an empathized entity becomes more salient than other elements in the discourse and thus more likely to act as the antecedent for an anaphor.

- (16) Taro -ga Masako<j> -ni hon -wo katte
 nom to book acc buy
 -kureta. Imademo 01<j> sono hon -wo
 helped still that book acc
 dajjini siteiru.
 care keep

Taro gave Masako a favor in buying her a book. She still keeps it with care.

In 16, 01, subject of the second sentence, corefers with the indirect object *Masako* in the first sentence, which is assigned empathy by virtue of the verb *kureta*.

Formally, we define the empathy hierarchy as a function with three arguments.⁶

$\text{empathy}(Z1, Z2, Z3)$

⁶The definition is based on the observation that Japanese predicates take no more than three argument roles.

With the definition at hand, we are able to formulate the lexical specification for *kureru*:

$V(\text{empathy}(\text{Arg2}, \text{Arg1}, \text{Arg3}),$
 subject:Arg1, object2:Arg2,
 object:Arg3) \rightarrow [kureru].

yaru has the formulation like the following:

$V(\text{empathy}(\text{Arg1}, \text{Arg2}, \text{Arg3}),$
 subject:Arg1, object2:Arg2,
 object:Arg3) \rightarrow [yaruu].

Further, let us assume that variables in the empathy hierarchy represent zero pronouns. If a variable in the hierarchy is instantiated to some non-zero item, we will remove the variable from the hierarchy and move the items following by one position to the left; we might call it *empathy shifting*.⁷ Now consider the discourse:

- (17) 01<i> 02<j> hon -wo yatta -node,
 book acc favored because
 01<k> 02<g> orei -wo iwareta.
 gratitude acc say cop

'Because he/she gave a book to him/her, he/she was thanked for it.'

- (18) a $\text{empathy}(01<i>, 02<j>, -)$
 b $\text{empathy}(01<k>, 02<g>, -)$

18(1) corresponds to the empathy hierarchy for the first clause in 17; 18(b) corresponds to the hierarchy for the second clause. Unifying the two structures gives us the correct result: namely, $01<i> = 01<k>$, and $02<j> = 02<g>$. Notice that zero items in the segment are all unified through the empathy hierarchy, which in effect realizes the Minimal Semantics Thesis. As it turns out, the MST reduces the number of semantically distinct zero pronouns for a discourse segment to at most three (figure 3). We conclude the section with a listing of the relevant DCG rules.

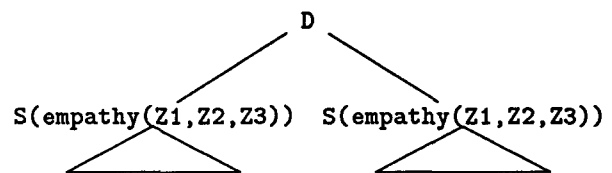


Figure 3:

$D(\text{head}:X) \rightarrow S+(\text{head}:X, \text{empathy}(Z1, Z2, Z3)).$
 $S(\text{head}:X, \text{empathy}(Z1, Z2, Z3)) \rightarrow$
 $C+(\text{empathy}(Z1, Z2, Z3)),$
 $N(\text{morph}:X, \text{pp}:wa).$
 $S(\text{head}:X, \text{empathy}(Z1, Z2, Z3)) \rightarrow$
 $C*(\text{empathy}(Z1, Z2, Z3)),$

⁷The empathy hierarchy here deals only with pronoun variables; we do not want two constant terms unifying via the hierarchy – which is doomed to failure.

N(morph: X, pp: wa),
C+(empathy(Z1, Z2, Z3)).

3 T-structure in Discourse

3.1 Embedding and Interleaving

In this section, we will illustrate some of the ways in which T-structure figures in Japanese discourse.⁸

What we have below is a father talking about the health of his children.

Chichioya<i> -wa 01<i> warat -te,
father top laugh and

"Taro<k> -wa yoku kaze -wo hiku -n'desuyo.
Taro top often cold acc catch aux-polite
Kinou -mo 01<k> kaze -wo hi'ite, 01<k>
yesterday also cold acc catch

gakko -wo yasu -n'da -n'desuyo.
school acc take leave past aux-polite

Masako<j> -wa 01<j> gen'kide, 01<j> kaze
top healthy cold

-wo hi'ita koto -ga arimas en.
acc caught experience nom occur aux-neg

01<j> itsumo sotode ason'de -imasuyo."
often outdoors play aux-polite

-to 01<i> itta.
comp said

"Taro often catches a cold. He got one yesterday again and didn't go to school. Masako stays in a good health and has never been sick with flu. I often see her playing outdoors." Father said with a smile on his face.

Here are the facts: (a) zero anaphora occurring within the quotation (internal anaphora) are coreferential either with *Taro* or with *Masako*; (b) those occurring outside (external anaphora), however, all refer to *chichioya*; (c) *chichioya* has an anaphoric link which crosses over the entire quotation; (d) syntactically, the quoted portion functions as a complement for the verb *-to itta*. It appears, moreover, that an internal anaphor associates itself with *Taro* in case it occurs in the segment headed with *Taro*, and with *Masako* in case it occurs in the segment headed with *Masako*. Then, since the quoted discourse consists of a set of discourse segments, it will be assigned to a T-structure. But the structure does not extend over the part *01 itta*, which completes the discourse, for the 01 corefers with *chichioya*, and neither with *Taro* or *Masako*. This would give us an analysis like one in figure 4.

⁸ Here and below we call a tree rooted at *T* a 'T-structure' and one rooted at *D* a 'D-structure'.

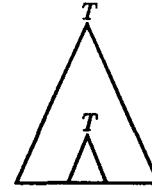


Figure 4: embedding

The following discourse shows that the T-structure can be discontinuous:

[a] "Masako<i> -ga kinou sigoto -wo
nom yesterday work acc

yasun'da -n'desuyo." [b] Hahaoya<k> -wa
took leave aux-polite mother nom

01<k> isu -ni suwaru -to 01<k> hanashi
chair on sit when tell

hazimeta [c] "Kaze -demo 01<i> hi'ita -noka."
began. cold acc caught question

[d] -to Chichioya -ga 03<k> tazuneta.
comp father nom asked

"Masako took a leave from the work yesterday.", Mother began to tell, as she sat on the chair. "Did she catch a cold?", asked Father.

01<i> corefers with *Masako*, so [c] forms a T-structure with [a]. But the two are separated by a narrative [b]. Similarly, the coreference between 03<k> and *Hahaoya* gives rise to a T-structure that spans [d] and [b], but there is an interruption by narrative [c] (figure 5).

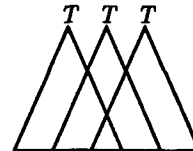


Figure 5: interleaving

3.2 Problem

There is a curious interaction between a paragraph-break and a T/D-structure. [Fujisawa *et al.*, 1993], for instance, observes a strong tendency that Japanese zero anaphora are paragraph-bounded. The following is from *Nihon Keizai Shinbun*, a Japanese economics newspaper.

Kawamata Hideo<i>. 01<i> Sagami tetsudo
Mr. H. Kawamata Sagami Railways

kaichou. [San-gatsu] mik-ka gozen juichi-ji
chairman March 3rd day a.m. 11-hour

nijusan-pun, kokyuhuzen no-tame
23-minute respiratory insufficiency due-to

Tokyo Machida de 01<i> sikyo, 01<i> nanajugo
Tokyo Machida in dies 75
-sai.
yrs. old

Tanaka Yutaka<k>. 01<k> Moto- Matsushita
Mr. Y. Tanaka former Matsushita
tsuushin kogyo senmu. [San-gatsu]
telecom industries executive director March
mik-ka gozen yo-ji san-pun, sin-huzen
3rd day a.m. 4-hour 3-minute cardiac failure
no-tame Yokohama Midoriku de 01<k> sikyo,
due-to Yokohama Midoriku in dies
01<k> rokujuhas -sai.
68 yrs. old

Mr. H. Kawamata, 75, chairman of
Sagami-Railways, died of respiratory insuff-
iciency at 11:29 a.m., in Machida, Tokyo,
March 3.

Mr. Y. Tanaka, 68, former executive direc-
tor of Matsushita telecom industries, died
of cardiac failure at 4:03 a.m., in Midoriku,
Yokohama, March 3.

[Zero-anaphora are made explicit here for expository purposes; they are not part of the newspaper. The rest appears as it does in the paper.] From the way same-index anaphora are distributed over the discourse, it seems rather obvious that a paragraph break has an effect of marking a segment for the discourse.⁹ The present theory, however, fails to deal with the situation like this; it simply assigns a single DS structure to the discourse in question, giving a wrong interpretation that zero anaphora present are all coreferential. As it stands, nothing in the theory provides for treating graphological marks such as a paragraph break. Yet, it is unclear to us whether a paragraph break is a signal for a T- or D-structure.

4 Conclusion

We have developed a computational theory for resolving zero anaphora in Japanese, drawing on the results from previous works on Japanese discourse [Kuno, 1987; Kuno and Kaburaki, 1977], etc). A major departure from the traditional analyses of zero anaphora lies in the reduction of the space of antecedents for zero anaphora. This has been made possible by adopting ideas like *Discourse Segment*, *Minimal Semantics Thesis* and *Empathy Hierarchy*. In particular, we have shown that the Minimal Semantics Thesis leads to reducing the number of antecedents for a segment to at most three. Also shown in the paper is that the resolution of zero anaphora is part of parsing text, so no additional mechanism is

⁹We may note that a recursive embedding of discourse of the sort we have discussed above is effected through the explicit use of quotation marks; their absence would lead to the outright ungrammaticality.

needed. Furthermore, the present theory compares favorably with the previous schemes like *Focusing* and *Centering* in that it is able to deal with forward- and backward-looking anaphora by virtue of the way unification operates on the empathy hierarchy.

Part of our discussion has touched on the effect of graphology on the semantics of discourse. To date, no significant research has been done on that area of academic interests. The literature suggest that in the written language, texts, i.e., cohesive discourses, are marked through a variety of linguistic and non-linguistic means: non-alphanumeric characters (quotation marks, brackets, parentheses), graphic devices (indentation, tabulation, itemization), and so on [Nunberg, 1990; Halliday and Hassan, 1990]. Thus a discourse segment might qualify for the texthood since it has the property that zero pronouns are resolved internally. Its indicator is, of course, the topic particle *wa*. But for the T-structure, it is far from clear whether it is anyway cohesive, and if it is, what its indicators are. (Quotation mark and paragraph break are possible candidates.)

Some of the technical as well as linguistic details are yet to be worked out; we have not talked about how the topic comes to be associated with one or more zero pronouns in the segment. Considerations on empathy may well influence the choice of pronouns to be matched with.

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