

Centering in Japanese Discourse

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Abstract

In this paper we propose a computational treatment of the resolution of zero pronouns in Japanese discourse, using an adaptation of the centering algorithm. We are able to factor language-specific dependencies into one parameter of the centering algorithm. Previous analyses have stipulated that a zero pronoun and its cospecifier must share a grammatical function property such as SUBJECT or NONSUBJECT. We show that this property-sharing stipulation is unnecessary. In addition we propose the notion of TOPIC AMBIGUITY within the centering framework, which predicts some ambiguities that occur in Japanese discourse. This analysis has implications for the design of language-independent discourse modules for Natural Language systems. The centering algorithm has been implemented in an HPSG Natural Language system with both English and Japanese grammars.

1 Introduction

Japanese is a language well-known for grammaticization of discourse function. It is rich with ways for speakers to indicate the information status of the discourse entities they are talking about. Japanese allows a speaker to clearly indicate topic-hood, along with the grammatical functions such as subject, object and object2, by using the morphological case markers *wa*, *ga*, *o*, *ni*. In addition, it provides morphological means to indicate speaker's perspective through the use of verbal compounding, i.e. the addition of suffixes such as *kureta*, *kita* (See section 3). Unexpressed arguments of the verb are common; these are known as zero pronouns.

Because there are zero pronouns and because Japanese is a head-final language with otherwise relatively free word order, there could, in principle, be a great deal of ambiguity. However this is not the case. Speakers are assumed to be cooperative, to be col-

laborating with the hearer in conversation, and to be ensuring that each utterance is relevant and coherent in the context of what was said before [Gri75, SSJ74]. We believe that speakers do not choose to express their thoughts through arbitrary syntactic constructions, but that there is some correspondence between choice of syntactic construction, what the speaker wants to convey, and aspects of the current discourse situation [Pri85].

Within a theory of discourse, CENTERING is a computational model of the process by which a speaker and hearer make obvious to one another their assumptions about the salience of discourse entities. Using pronominal referring expressions is one way for discourse participants to do this. We propose that the resolution of zero pronouns is constrained by centering, and ambiguity is thereby reduced.

Centering has its computational foundations in the work of Grosz and Sidner [Gro77, Sid79, GS85] and was further developed by Grosz, Joshi and Weinstein [GJW83, GJW86, JW81]. It is formalized as a system of constraints and rules, which can, as part of a computational discourse model, act to control inferencing [JW81]. Brennan, Friedman and Pollard use these rules and constraints to develop an algorithm for resolving the co-specifiers of pronouns [BFP87, Wal89]. Our analysis uses an adaptation of this algorithm. By making full use of the centering formalism, we avoid the postulation of additional mechanisms, e.g. property sharing [Kam88].

In addition, we propose a notion of TOPIC AMBIGUITY, which characterizes some ambiguities in Japanese discourse that are allowed by the centering process. Topic ambiguity has been ignored in previous accounts of Japanese zero pronoun resolution, but it explains the availability of interpretations that previous accounts would predict as ungrammatical. Centering gives us a computational way of determining when a zero pronoun may be assigned TOPIC.

This analysis informs the design of language independent discourse processing modules for Natural Language systems. We propose that the centering component of a discourse processing module can be constructed in a language independent fashion, up to the declaration of a language-specific value for one variable in the algorithm, i.e., Cf list ranking (see section 2). The centering algorithm has been implemented in an HPSG Natural Language system with both English and Japanese grammars.

2 The Centering Formalism

The modeling of attentional state in discourse by centering depends on analyzing each pair of utterances in a discourse according to a set of transitions. These transitions are a measure of the coherence of the segment of discourse in which the utterance occurs. Each utterance in a discourse has associated with it a set of discourse entities called FORWARD-LOOKING CENTERS, Cf, and a special member of this set called the BACKWARD-LOOKING CENTER, Cb. The FORWARD-LOOKING CENTERS are ranked according to discourse salience; the highest ranked member of the set is the PREFERRED CENTER, Cp. With these definitions we can give the constraints:

- **CONSTRAINTS**

For each U_i in a discourse segment U_1, \dots, U_m :

1. There is precisely one Cb.
2. Every element of $Cf(U_i)$ must be realized¹ in U_i .
3. The center, $Cb(U_i)$, is the highest-ranked element of $Cf(U_{i-1})$ that is realized in U_i .

The typology of transitions from one utterance, U_i , to the next is based on two factors: whether the backward-looking center, Cb, is the same from U_{i-1} to U_i , and whether this discourse entity is the same as the preferred center, Cp of U_i . Backward-looking centers are often pronominalized and discourses that continue centering the same entity are more coherent than those that shift from one center to another. This means that some transitions are preferred over others. These two facts give us the rules:

- **RULES**

For each U_i in a discourse segment U_1, \dots, U_m :

1. If some element of $Cf(U_{i-1})$ is realized as a pronoun in U_i , then so is $Cb(U_i)$.
2. Transition states are ordered. CONTINUING is preferred to RETAINING is preferred to SHIFTING-1 is preferred to SHIFTING².

The transition states that are used in the rules are defined in Figure 1, (BACKWARD-LOOKING CENTER = Cb, PREFERRED CENTER = Cp).

$$Cb(U_i) = Cb(U_{i-1}) \quad Cb(U_i) \neq Cb(U_{i-1})$$

$Cb(U_i) = Cp(U_i)$	CONTINUING	SHIFTING-1
$Cb(U_i) \neq Cp(U_i)$	RETAINING	SHIFTING

Figure 1: Transition States

The centering algorithm incorporates these rules and constraints in addition to linguistic constraints on coreference[BFP87]. The behavior of the centering algorithm for the resolution of pronouns is largely determined by the ranking of the items on the forward center list, Cf, because, as per Constraint 3, this ranking determines from among the elements that are realized in the next utterance, which of them will be the Cb for that utterance. Although all of the factors that contribute to the Cf ranking have not been determined, syntax and lexical semantics have an effect[Pri81, Pri85, HD88, Bre89, GJW86, JW81, BF83]. We postulate that this ordering will vary from language to language depending on the means the language provides for expressing discourse functions. Our adaptation of the algorithm for Japanese consists of substituting a different ranking of the forward centers list Cf. In every other way, the algorithm functions exactly as it is for English.

3 Centering in Japanese

In order to apply the centering algorithm to the resolution of zero pronouns in Japanese, we must determine how to order the forward centers list, Cf. The function TOPIC is indicated by the morphological marker *wa*, along with SUBJECT (*ga*), OBJECT (*o*), and OBJECT2 (*ni*). The optional use of *wa* picks out the most salient entity in the discourse. In addition, Kuno proposed the notion of EMPATHY,

²[BFP87] introduces the distinction between SHIFTING-1 and SHIFTING.

¹An utterance U (of some phrase, not necessarily a full clause), *realizes* c if c is an element of the situation described by U , or c is the semantic interpretation of some subpart of U .

which is the perspective from which a speaker describes an event[Kun73]. The realization of speaker’s empathy is especially important when describing an event involving some transfer. For example, there is no way to describe a *giving* and *receiving* situation objectively[KK77]. In (1), the use of the past tense *kureta* of the verb *kureru*, indicates the speaker’s empathy with the discourse entity realized in object position³.

- (1)
 Hanako wa Taroo ni hon o kureta.
 top-subj obj2 book obj give-past
 “Hanako gave Taroo a book.”
 EMPATHY=OBJ2=TAROO

In (2), the speaker’s empathy with the subject entity’s perspective is indicated using *yatta*, the past tense of the verb *yaru*.

- (2)
 Hanako wa Taroo ni hon o yatta.
 top-subj obj2 book obj give-past
 “Hanako gave Taroo a book.”
 EMPATHY=SUBJ=HANAKO

The use of deictic verbs such as *kuru* (‘come’), and *iku* (‘go’) also indicate speaker’s perspective.

Kuno calls a verb that is sensitive to the speaker’s perspective an EMPATHY-LOADED verb, and defines EMPATHY LOCUS as the argument position whose referent the speaker is identifying with⁴. Any Japanese verb can be made into an empathy-loaded verb by using an empathy-loaded verb as an auxiliary, which is suffixed onto the main verb stem. The complex predicate made by this operation inherits the empathy-locus of the suffixed verb. The *kureru* form of (‘give’) can be used as a suffix, to mark OBJ or OBJ2 as the empathy-locus, as can the deictic verb *kuru* (‘come’) The use of the suffix *kureta* is shown in (3).

- (3)
 Hanako wa Taroo ni hon o yonde-kureta.
 book read-gave
 “Hanako gave Taroo a favor of reading a book.”
 EMPATHY=OBJ2=TAROO

The suffixation of verbs such as *iku* (‘go’) and the *yaru* form of (‘give’), mark SUBJECT as the empathy-locus, e.g. *itta* in (4).

- (4)
 Hanako wa Taroo o tazunete-itta.
 visit-went
 “Hanako went to visit Taroo.”
 EMPATHY=SUBJ=HANAKO

The relevance of speaker’s empathy to centering is

³We use identifiers of all capital letters to denote the discourse entity realized by the corresponding string. Centers are semantic entities, not syntactic ones.

⁴The speaker does not necessarily take his/her own perspective to describe an event in which s/he is involved.

that a discourse entity realized as the empathy-locus is more salient, so that the empathy-locus position is ranked higher on the Cf. Therefore, we use a ranking for the Cf in Japanese that incorporates EMPATHY as follows:

Cf Ranking for Japanese

TOPIC > EMPATHY > SUBJ > OBJ2 > OBJ

This ranking is a slight variation of that proposed by Kameyama[Kam88]. The centering algorithm works by taking the arguments of the verb and ordering them according to the Cf ranking for Japanese given above. In the cases where there are zero pronouns, there will be multiple possibilities for their interpretation and this will result in there being a priori several possible Cf lists⁵. These Cf lists are filtered according to the centering rules and constraints in section 2. If there are still multiple possibilities, then the ordering on transitions applies, and CONTINUING interpretations are preferred.

Many cases of the preference for one interpretation over another follow directly from the distinction between CONTINUING and RETAINING.

- (5)
 U_n:
 Taroo wa paatii ni syootai-sareta.
 party to invited-was
 “Taroo was invited to the party.”
- | | |
|------------|---------|
| Cb: | TAROO |
| Cf: | [TAROO] |
- U_{n+1}:
 0 Hanako o totemo kiniitta.
 very-much was-fond-of
 “He liked Hanako very much.”

Cb:	TAROO
Cf:	[TAROO, HANAKO]
	subj obj

- U_{n+2}:
 Kinoo 0 0 eiga ni sasotta rasii.
 yesterday movie to invite seems
 “Seemingly he invited her to a movie.”

Cb:	TAROO
Cf1:	[TAROO, HANAKO] CONTINUING
	subj obj
Cf2:	[HANAKO, TAROO] RETAINING
	subj obj

When the centering algorithm applies in (5) to U_{n+2}, constraint 3 says the Cb must be the highest ranked element of Cf(U_{n+1}) realized in U_{n+2}. Because there are 2 zeros in U_{n+2}, TAROO must be realized and therefore must be the Cb. The only CONTINUING interpretation available, *Taroo invited Hanako ...*, corresponds to the forward centers list

⁵A discourse entity can simultaneously fulfill multiple roles. The entity is ranked according to the highest ranked role.

Cf1. The fact that the preferred interpretation is the one in which the SUBJECT zero pronoun takes a SUBJECT antecedent is eiphenomenal.

Example (6) demonstrates the effect of speaker’s empathy on the salience of discourse entities.

(6)
 U_n :
 Hanako wa tosyokan de benkyoositeita.
 library in studying-was
 “Hanako was studying in the library.”

Cb: HANAKO
Cf: [HANAKO]

U_{n+1} :
 Taroo ga Hanako o tetudatte-kureta.
 help-gave
 “Taroo gave Hanako a favor in helping her.”

Cb: [HANAKO]
Cf: [HANAKO, TAROO]
empathy subj

U_{n+2} :
 Tugi no hi 0 0 eiga ni sasotta.
 next of day SUBJ OBJ movie to invited
 “Next day she invited him to a movie.”

Cb: HANAKO
Cf: [HANAKO, TAROO] CONTINUING
subj obj

In (6), HANAKO is the most highly ranked entity from U_{n+1} realized in U_{n+2} , and therefore must be the Cb. The preferred interpretation will therefore be the *she invited him...* one that results from the more highly ranked CONTINUING transition, in which HANAKO is the preferred center (Cp).

The centering algorithm can also be applied successfully to intrasentential anaphora, by treating the subordinate clause as though it were a separate utterance for the purposes of pronoun interpretation. Consider:

(7)
 Taroo wa Kim ni [0 0 bengosuru] koto o hanasita.
 defend comp told
 “Taroo told Kim that he would defend her”

Cb: TAROO
Cf1: [TAROO, KIM] CONTINUING
subj/top obj2
Cf2: [HANAKO, KIM] RETAINING
subj/top obj2

The CONTINUING interpretation, *Taroo told Kim that he would defend her*, is preferred to the RETAINING interpretation, *Taroo told Kim that she would defend him*.

4 Topic ambiguity

The centering process reduces but does not necessarily eliminate semantic ambiguity in Japanese discourse. Within a loosely defined context, a native speaker’s intuitions sometimes still allow for more than one equally preferred interpretation of an utterance.

4.1 Center Establishment

In the “Introduce” example shown in (8) below, ambiguity arises from the combined facts that the Cb of U_1 is neutral (undefined), and there are more entities on the Cf list of U_1 than there are zero pronouns in U_2 .

(8)
 U_1 :
 Lyn-ga Masayo-ni Sharon-o shookaisita
 SUBJ OBJ2 OBJ introduced
 “Lyn introduced Sharon to Masayo.”

Cb: [?]
Cf: [LYN, MASAYO, SHARON]
subj obj2 obj

U_2 :
 0 0 kiniitteiru
 “Lyn likes Masayo” (Cf1a)
 “Lyn likes Sharon” (Cf1b)
 “Masayo likes Sharon” (Cf2)

Cb1: LYN
Cb2: MASAYO
Cf1a: [LYN, MASAYO]
subj obj
Cf1b: [LYN, SHARON]
subj obj
Cf2: [MASAYO, SHARON]
subj obj

All three of these readings of U_2 are equally preferred CONTINUATIONS. To explain this fact, we posit that the Cb of an initial utterance U_n may be treated as a variable, indicated by [?], which can be equated with whatever Cb is assigned to the subsequent utterance U_{n+1} ⁶. For example, because there are 2 zeros in U_2 of (8) and there are 3 entities available to fill these positions, constraint 3 implies that SHARON (the lowest ranked entity) can never be the Cb, since it will never be the most highly ranked element of Cf(U_1) realized in U_2 . Therefore, whenever LYN is realized, the CONTINUATION interpretation will place LYN in subject position, thus explaining the first two readings of U_2 . The third reading is available because no Cb has yet been established for U_1 , so that a CONTINUATION does not require the realization of LYN in U_2 . Notice that any reading that

⁶Future work will discuss center establishment in more detail, as well as other interactions, e.g., the effect of *wa* marking.

assigns SHARON to the subject position or LYN to a non-subject position would produce a RETENTION.

4.2 Zero Topics

Another class of ambiguities can result from the optional assignment of TOPIC to a zero pronoun. We propose a topic assignment rule:

Zero Topic Assignment

When no CONTINUATION transition is available, and a zero pronoun in U_m represents an entity that was the $Cb(U_{m-1})$ and if no other entity in U_m is overtly marked as the TOPIC, that zero may be interpreted as the TOPIC of U_m .

This fact, which has been overlooked in previous treatments of zero pronouns in Japanese, explains the interesting contrast between the two discourse segments in examples (9) and (10) below. Assume in (9) and (10) that TAROO and HANAKO have already been under discussion:⁷

(9)
 U_n :
 Taroo wa kooen o sanpo-siteita
 SUBJ park walk-around
 “Taroo was walking around the park”

Cb: TAROO
Cf: [TAROO, PARK]
subj obj

U_{n+1} :
 Hanako ga 0 yatto mituketa
 SUBJ finally found
 “Hanako finally found (him).”

Cb: TAROO
Cf1: [TAROO, HANAKO] (C)
topic/obj subj
Cf2: [HANAKO, TAROO] (R)
subj obj

U_{n+2} :
 0 0 yotei o setumeisita
 SUBJ OBJ schedule explained
 He explained the schedule to her. (Cf1)
 She explained the schedule to him. (Cf2)

Cb1: TAROO
Cb2: HANAKO
Cf1: [TAROO, HANAKO] (C)
subj obj
Cf2: [HANAKO, TAROO] (S-1)
subj obj

In (9), there are actually two possible Cf lists in U_{n+1} ; Cf2, which is the only list possible without topic ambiguity, represents a RETENTION (R) rather

⁷Due to lack of space, we can not discuss the interaction of center establishment with zero topic assignment here.

than a CONTINUATION (C), thus triggering zero topic assignment. The utterance U_{n+1} , actually has the same meaning for both Cf lists. The ambiguity in U_{n+2} is caused by the fact that the hearer simultaneously entertains both of the Cf(U_{n+1}). The availability of zero topic assignment means that TAROO can be the Cp even when TAROO is realized as the topic/object. The SHIFT-1 interpretation results from the algorithm’s application to Cf2 of U_{n+1} . We can test to see if topic ambiguity is actually the discourse phenomenon at work here by contrasting (9) with its minimal pair (10), in which overt topic marking in U_{n+1} rules out topic ambiguity.

(10)
 U_n :
 Taroo wa kooen o sanpo-siteita
 SUBJ park walk-around
 “Taroo was walking around the park”

Cb: TAROO
Cf: [TAROO, PARK]
subj obj

U_{n+1} :
 Hanako-wa 0 yatto mituketa
 TOP/SUBJ finally found
 “Hanako finally found (him).”

Cb: TAROO
Cf: [HANAKO, TAROO] (R)
top/subj obj

U_{n+2} :
 0 0 yotei-o setumeisita
 schedule explained
 “She explained the schedule to him”

Cb: HANAKO
Cf: [HANAKO, TAROO] (SHIFT1)
subj obj

In (10) the only Cf possible for U_{n+1} is the RETENTION in the parallel utterance in (9). Given that there are 2 zero pronouns in U_{n+2} , constraint 3 forces a shift. The *Hanako explained ...* interpretation is preferred because it is the more highly ranked SHIFT-1 transition. If HANAKO could represent a TOPIC-OBJ there would be another equally ranked SHIFT-1 interpretation. However, HANAKO can not be a zero topic because it was not the Cb of the previous utterance.

5 Discussion

We have demonstrated a computational treatment of the resolution of zero pronouns in Japanese. Kameyama proposed an analysis of Japanese zero pronouns that used centering, but did not distinguish between CONTINUING and RETAINING, and thus required an extra mechanism, i.e. property-sharing[Kam85]. Our examples (5), (6) and (7) show

that property-sharing is an unnecessary stipulation. In addition, there are a number of cases in which property-sharing just doesn't work. Our "introduce" example (8) illustrates that it is not essential for a zero pronoun to share a grammatical function property with its antecedent. In fact property-sharing would falsely predict that the *Masayo likes Sharon* interpretation of (8) U_2 is not possible, as well as falsely predicting the ungrammaticality of examples like (11) below.

(11)

U_n :

Hanako wa repooto o kaita.
report wrote
"Hanako wrote a report"

U_{n+1} :

0_i Taroo ni aini-itta.
to see-went
"She went to see Taroo"
 $0_i = \text{Hanako}$ [SUB EMPATHY]

U_{n+2} :

Taroo wa 0_i kibisiku hihansita.
severely criticized
"Taroo severely criticized her."
 $0_i = \text{Hanako}$ [nonSUB nonEMPATHY]

Property-sharing requires that in U_{n+2} , $i \neq \text{HANAKO}$, since the zero carries the properties (SUBJ, EMPATHY) in U_{n+1} , but has the properties (NONSUBJ, NONEMPATHY) in U_{n+2} ⁸. But in fact U_{n+2} is perfectly acceptable under the intended reading of *Taroo severely criticized Hanako*. Nothing special needs to be said about these to get the correct interpretation using the centering algorithm.

We have also proposed a notion of topic ambiguity, which arises from the fact that the grammatical function of unexpressed zero arguments is indeterminate. The application of zero topic assignment also depends on the centering theory distinction between CONTINUING and RETAINING. In addition, the centering construct of backward-looking center, Cb, gives us a computational way of determining when a zero pronoun may be assigned TOPIC. Topic ambiguity has been ignored in previous analyses, but it explains the availability of interpretations that previous accounts would predict as ungrammatical.

This analysis has implications for the design of language-independent discourse processing modules. We claim that the syntactic factors that affect the ranking of the items on the forward center list, Cf, will vary from language to language. The ordering for Japanese incorporates TOPIC and EMPATHY into the Cf ranking, which is a single parameter of the centering algorithm. In every other respect, the rules and constraints of the centering framework that the

centering algorithm implements remain invariant.

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⁸Kameyama called the Empathy property IDENT.

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