

Japanese Discourse and the Process of Centering

Marilyn Walker*
University of Pennsylvania

Masayo Iida†
Stanford University

Sharon Cote‡
University of Pennsylvania

This paper has three aims: (1) to generalize a computational account of the discourse process called CENTERING, (2) to apply this account to discourse processing in Japanese so that it can be used in computational systems for machine translation or language understanding, and (3) to provide some insights on the effect of syntactic factors in Japanese on discourse interpretation. We argue that while discourse interpretation is an inferential process, syntactic cues constrain this process; we demonstrate this argument with respect to the interpretation of ZEROS, unexpressed arguments of the verb, in Japanese. The syntactic cues in Japanese discourse that we investigate are the morphological markers for grammatical TOPIC, the postposition wa, as well as those for grammatical functions such as SUBJECT, ga, OBJECT, o and OBJECT2, ni. In addition, we investigate the role of speaker's EMPATHY, which is the viewpoint from which an event is described. This is syntactically indicated through the use of verbal compounding, i.e. the auxiliary use of verbs such as kureta, kita. Our results are based on a survey of native speakers of their interpretation of short discourses, consisting of minimal pairs, varied by one of the above factors. We demonstrate that these syntactic cues do indeed affect the interpretation of ZEROS, but that having previously been the TOPIC and being realized as a ZERO also contributes to the salience of a discourse entity. We propose a discourse rule of ZERO TOPIC ASSIGNMENT, and show that CENTERING provides constraints on when a ZERO can be interpreted as the ZERO TOPIC.

1. Introduction

1.1 Centering in Japanese Discourse

Recently there has been an increasing amount of work in computational linguistics involving the interpretation of anaphoric elements in Japanese (Yoshimoto 1988; Kuno 1989; Walker, Iida, and Cote 1990; Nakagawa 1992). These accounts are intended as components of computational systems for machine translation between Japanese and English or for natural language processing in Japanese alone. This paper has three aims: (1) to generalize a computational account of the discourse process called CENTERING (Sidner 1979; Joshi and Weinstein 1981; Grosz, Joshi, and Weinstein 1983; Grosz, Joshi, and Weinstein unpublished), (2) to apply this account to discourse processing

* University of Pennsylvania, Computer Science Department, Philadelphia PA 19104. E-mail: lyn@linc.cis.upenn.edu.

† CSLI, Stanford University, Stanford CA 94305. E-mail: iida@csli.stanford.edu.

‡ University of Pennsylvania, Linguistics Department, Philadelphia PA 19104. E-mail: cote@linc.cis.upenn.edu.

in Japanese so that it can be used in computational systems, and (3) to provide some insights on the effect of syntactic factors in Japanese on discourse interpretation.

In the computational literature, there are two foci for research on the interpretation of anaphoric elements such as pronouns. The first viewpoint focuses on an inferential process driven by the underlying semantics and relations in the domain (Hobbs 1985a; Hobbs et al. 1987; Hobbs and Martin 1987). A polar focus is to concentrate on the role of syntactic information such as what was previously the topic or subject (Hobbs 1976b; Kameyama 1985; Yoshimoto 1988). We will argue for an intermediate position with respect to the interpretation of ZEROS, unexpressed arguments of the verb, in Japanese. Our position is that the interpretation of zeros is an inferential process, but that syntactic information provides constraints on this inferential process (Joshi and Kuhn 1979; Joshi and Weinstein 1981). We will argue that syntactic cues and semantic interpretation are mutually constraining (Prince 1981b, 1985; Hudson-D'Zmura 1988).

The syntactic cues in Japanese discourse that we investigate are the morphological markers for grammatical TOPIC, the postposition *wa*, as well as those for grammatical functions such as SUBJECT, *ga*, OBJECT, *o*, and OBJECT2, *ni*. In addition, we investigate the role of speaker's EMPATHY, which is the viewpoint from which an event is described. This can be syntactically indicated through the use of verbal compounding, i.e. the auxiliary use of verbs such as *kureta*, *kita*.

In addition to the argument that a purely inference-based account does not consider limits on processing time, another argument against a purely inference-based account is provided by the minimal pair below. Here, the only difference is whether Ziroo is the subject or the object in the second utterance. Note that the interpretation of zeros is indicated in parentheses:

Example 1

- a. Taroo *ga* kooen *o* sanpositeimasita.
Taroo SUBJ park in walking-was
Taroo was taking a walk in the park.
- b. Ziroo *ga* 0 hunsui no mae de mitukemasita.
Ziroo SUBJ OBJ fountain of front in found
Ziroo found (Taroo) in front of the fountain.
- c. 0 0 kinoo no siai no kekka *o* kikimasita.
SUBJ OBJ yesterday of game of scores OBJ asked
(Ziroo) asked (Taroo) the score of yesterday's game.

Example 2

- a. Taroo *ga* kooen *o* sanpositeimasita.
Taroo SUBJ park in walking-was
Taroo was taking a walk in the park.
- b. 0 Ziroo *o* hunsui no mae de mitukemasita.
SUBJ Ziroo OBJ fountain of front in found
(Taroo) found Ziroo in front of the fountain.
- c. 0 0 kinoo no siai no kekka *o* kikimasita.
SUBJ OBJ yesterday of game of scores obj asked
(Taroo) asked (Ziroo) the score of yesterday's game.

In 1b and 2b, the syntactic position in which Ziroo is realized has the effect that 1c

means *Ziroo asked Taroo the score of yesterday's game*, while 2c means *Taroo asked Ziroo the score of yesterday's game*. On the other hand, some purely syntactic accounts require that antecedents for zeros be realized as the grammatical TOPIC, and thus cannot explain the above example because Taroo is never explicitly marked as the topic (Yoshimoto 1988).

In the literature, ZEROS are known as zero pronouns. We adopt the assumption of earlier work that the interpretation of zeros in Japanese is analogous to the interpretation of overt pronouns in other languages (Kuroda 1965; Martin 1976; Kameyama 1985). Japanese also has overt pronouns, but the use of the overt pronoun is rare in normal speech, and is limited even in written text. This is mainly because overt pronouns like *kare* ('he') and *kanozoyo* ('she') were introduced into Japanese in order to translate gender-insistent pronouns in foreign languages (Martin 1976). In this paper, we only consider zeros in subcategorized-for argument positions. Since Japanese doesn't have subject or object verb agreement, there is no syntactic indication that a zero is present in an utterance other than information from subcategorization.¹

First, in Section 1.2 we describe the methodology that we applied in this investigation. In Section 2, we present the theory of centering and some illustrative examples. Then, in Section 3, we discuss particular aspects of Japanese discourse context, namely grammatical TOPIC and speaker's EMPATHY. We will show how these can easily be incorporated into a centering account of Japanese discourse processing, and give a number of examples to illustrate the predictions of the theory. We also discuss the way in which a discourse center is instantiated in Section 4.

In Section 5 we propose a discourse rule of ZERO TOPIC ASSIGNMENT, and use the centering model to formalize constraints on when a zero may be interpreted as a ZERO TOPIC. Our account makes a distinction between two notions of TOPIC—grammatical topic and zero topic. The grammatical topic is the *wa*-marked entity, which is by default predicted to be the most salient discourse entity in the following discourse. However, there are cases in which it may not be, depending on whether ZERO TOPIC ASSIGNMENT applies. This analysis provides support for Shibatani's claim that the interpretation of the topic marker, *wa*, depends on the discourse context (Shibatani 1990). ZERO TOPIC ASSIGNMENT actually predicts ambiguities in Japanese discourse interpretation and provides a mechanism for deriving interpretations that previous accounts claim would be unavailable.

We delay the review of related research to Section 6 when we can contrast it with our account. The two major previous accounts are those of Kuno (Kuno 1972, 1976b, 1987, 1989) and Kameyama (Kameyama 1985, 1986, 1988). Finally, in Section 7, we summarize our results and suggest topics for future research.

1.2 Methodology

Most of the examples in this paper are constructed as four utterance discourses that fit one of a number of structural paradigms. In all of the paradigms, a discourse entity is

¹ When zero pronouns should be stipulated is still a research issue. For example, Hasegawa (1984) described a zero pronoun as a phonetically null element in an argument position. However, as shown in the following example, Terazu, Yamanasi, and Inada (1980) assumed that zero pronouns are not limited in their distribution and stipulated them in adjunct positions as well (Iida 1993).

Taroo wa Hanako no kaban o mitukemasita.

Taroo TOP/SUBJ Hanako GEN bag OBJ found

Taroo found Hanako's bag.

O O tanzyoobi no purezento o iremasita.

birthday GEN present OBJ put

(Taroo) put a birthday present (in her bag).

introduced in the first utterance, and established by the second utterance as the CENTER, what the discourse is about. The manipulations of context occur with the third and the fourth utterances. In each case the zero in the third utterance cospecifies the entity already established as the center in the second utterance. The fourth utterance consists of a potentially ambiguous sentence containing two zeros. The variations in context are as shown below:

Third Utterance		Fourth Utterance		EXAMPLES
SUBJECT	OBJECT(2)	SUBJECT	OBJECT(2)	
zero	NP(o or ni)	zero	zero	5
zero	NP(o or ni)	zero	zero, empathy	36
NP(ga)	zero	zero	zero	32, 34
NP(wa)	zero	zero	zero	4, 33
NP(ga)	zero	zero	zero, empathy	35

Thus we are manipulating factors such as whether a discourse entity is realized in subject or object position in the third utterance, whether a discourse entity realized in subject position is *ga*-marked or *wa*-marked in the third utterance, and whether a discourse entity realized in the fourth utterance in object position is marked as the locus of speaker's EMPATHY.

We collected a group of about 35 native speakers by solicitation on the InterNet to provide judgments for most of the examples given in this paper. These native speakers were readers of the newsgroups *sci.lang.japanese* and *comp.research.japan*. They were thus typically well-educated, bilingual engineers. Whenever an example was tested in this way, we provide the number of informants who chose each possible interpretation to the right of the example. Some examples that are included for expository reasons were not tested.

Participation in our survey was completely voluntary, and the data were collected over three surveys. Thus the numbers of subjects varied from one survey to another, and this is reflected in the numbers accompanying our examples. This data collection was carried out on written examples using electronic mail in a situation in which the informants could take as long as they wanted to decide which interpretation they preferred. The instructions sent with the surveys are given in Appendix A.

This paradigm clearly cannot provide information on which interpretation a subject might arrive at first and then perhaps change based on other pragmatic factors, and thus it contrasts with reaction time studies. However, the judgments given should be stable and should reflect the fact that our informants were able to use all the information in the discourse. It is a useful paradigm given that we are exploring the correlation of syntactic cues and discourse interpretation. It has been claimed that syntactic cues are only used in automatic processing and can be overridden by deeper processing. However, Hudson's results suggest that subjects may judge a discourse sequence to be nonsensical when it is incoherent according to centering (Hudson-D'Zmura 1988). Di Eugenio claims that discourse sequences in Italian that are not discourse-coherent according to centering theory produce a garden-path effect (Di Eugenio 1990). The methods we used allow us to explore the results of these interactions, and yet it

would be beneficial for these results to be expanded upon by careful psychological experimentation.

For most of the examples reported here, we asked subjects to choose one preferred interpretation instead of allowing them to rank interpretations. The motivation for doing this was to force differences to come out for slight preferences, with the theory being that other variations would come out across subjects. In a few cases we allowed subjects to indicate no preference; these examples will be clearly indicated.

In addition, we used the same gender for multiple discourse entities to prevent any tendency for judgments to be influenced by gender stereotypes. We also avoided using verbs with causal biases toward one of their arguments, and we used few cue words such as *but*, *because*, and *then*, which could result in a bias toward, say, a cause-effect or temporal sequence of events interpretation. We also omitted honorific markers, which are normally a part of Japanese ambiguity resolution.² This was done to isolate the effects of the variables that we were exploring in this study, namely topic marking, grammatical function, empathy, and realization with a zero or with a full noun phrase.

2. Centering Theory

Within a theory of discourse, CENTERING is a computational model of the process by which conversants coordinate attention in discourse (Grosz, Joshi, and Weinstein unpublished). Centering has its computational foundations in the work of Grosz and Sidner (Grosz 1977; Sidner 1979; Grosz and Sidner 1986) and was further developed by Grosz, Joshi, and Weinstein (1983, unpublished) and Joshi and Weinstein (1981). Centering is intended to reflect aspects of ATTENTIONAL STATE in a tripartite view of discourse structure that also includes INTENTIONAL STRUCTURE and LINGUISTIC STRUCTURE (Grosz and Sidner 1986). In Grosz and Sidner's theory of discourse structure, discourses can be segmented based on intentional structure, and a discourse segment exhibits both local and global coherence. Global coherence depends on how each segment relates to the overall purpose of the discourse; local coherence depends on aspects such as the syntactic structure of the utterances in that segment, the choice of referring expressions, and the use of ellipses. CENTERING models local coherence and is formalized as a system of constraints and rules. Our analysis uses an adaptation of the Centering algorithm that was developed by Brennan, Friedman, and Pollard, based on these constraints and rules (Brennan, Friedman, and Pollard 1987; Walker 1989).

The purpose of centering as part of a computational model of discourse interpretation is to model ATTENTIONAL STATE in discourse in order to control inference (Joshi and Kuhn 1979; Joshi and Weinstein 1981).³ Our approach to modeling attentional state is to explore aspects of the correlation between syntax and discourse function. This assumes that there are language conventions about discourse salience and that conversants attempt to maintain a sense of shared context.

2 While native speakers understandably found some of these examples "stilted" or "awkward," they were still able to give their judgments based on the information that was provided in the discourses.

3 Recent work in situation theory proposes to control computation with a similar notion of background information in terms of constants of the situation that thus are not explicitly realized in an utterance (Nakashima 1990). The situation-theoretic work does not as yet distinguish shared knowledge that determines discourse salience and derives from the discourse context and the way utterances are expressed (Clark and Haviland 1977; Clark and Marshall 1981; Prince 1981b) from shared knowledge that is part of general background knowledge such as cultural assumptions (Prince 1978a; Joshi 1982) or shared knowledge that might derive from the task context (Grosz 1977).

Section 2.1 presents the centering rules and constraints. Sections 2.2 and 2.3 illustrate the theory and the definitions with a number of examples. Section 2.4 discusses the centering algorithm for the resolution of zeros in Japanese.

2.1 Rules and Constraints

The centering model is very simple. Each utterance in a discourse segment has two structures associated with it. First, each utterance in a discourse has associated with it a set of discourse entities called FORWARD-LOOKING CENTERS, Cf. Centers are semantic entities that are part of the discourse model. Second, there is a special member of this set called the BACKWARD-LOOKING CENTER, Cb. The Cb is the discourse entity that the utterance most centrally concerns, what has been elsewhere called the 'theme' (Reinhart 1981; Horn 1986). The Cb entity links the current utterance to the previous discourse.

The set of FORWARD-LOOKING CENTERS, Cf, is ranked according to discourse salience. We will discuss factors that determine the ranking below. The highest-ranked member of the set of forward-looking centers is referred to as the PREFERRED CENTER, Cp.⁴ The PREFERRED CENTER represents a prediction about the Cb of the following utterance. Sometimes the Cp will be what the previous segment of discourse was about, the Cb, but this is not necessarily the case. This distinction between looking back to the previous discourse with the Cb and projecting preferences for interpretation in subsequent discourse with the Cp is a key aspect of centering theory.

In addition to the structures for centers, Cb and Cf, the theory of centering specifies a set of rules and constraints. Constraints are meant to hold strictly whereas rules may sometimes be violated.

• CONSTRAINTS

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

1. There is precisely one backward-looking center Cb.
2. Every element of the forward centers list, Cf(U_i), must be realized 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 .⁵

Constraint (1) says that there is one central discourse entity that the utterance is about, and that is the Cb. The second constraint depends on the definition of *realizes*. An utterance U *realizes* a center c if c is an element of the situation described by U , or c is the semantic interpretation of some subpart of U (Grosz, Joshi, and Weinstein unpublished). Thus the relation REALIZE describes zeros, explicitly realized discourse entities, and those implicitly realized centers that are entities inferable from the discourse situation (Prince 1978a, 1981b).

A specialization of the relation REALIZE is the relation DIRECTLY REALIZE. A center is directly realized if it corresponds to a phrase in an utterance. We restrict our focus to entities realized by noun phrases; however, it is clear that propositions can be centers, so we assume that the account given here can be extended to propositional entities as well (Webber 1978; Sidner 1979; Prince 1986, 1978b; Ward 1985).

⁴ The notion of PREFERRED CENTER corresponds to Sidner's notion of EXPECTED FOCUS (Sidner 1983).

⁵ This could possibly be rephrased as: Assume the Cp(U_{i-1}) is the Cb(U_i) unless there is evidence to the contrary (Carter 1987).

As we discuss further in Section 3, zeros refer to entities that are already in the discourse context. The fact that the current utterance REALIZES one or more zeros follows from information specified in the subcategorization frame of the verb. These arguments must be interpreted and thus acquire a degree of discourse salience that nonsubcategorized-for discourse entities lack.

Constraint (3) stipulates that the ranking of the forward centers, Cf, determines from among the elements that are realized in the next utterance, which of them will be the Cb for that utterance. If the PREFERRED CENTER, Cp(U_i), is realized in U_{i+1}, it is predicted to be the Cb(U_{i+1}). We will use the following forward center ranking for Japanese:⁶

(GRAMMATICAL OR ZERO) TOPIC > EMPATHY > SUBJECT > OBJECT2 > OBJECT > OTHERS

Backward-looking centers, Cbs, are often deleted or pronominalized and some transitions between discourse segments are more coherent than others. According to the theory of centering, coherence is measured by the hearer's inference load when interpreting a discourse sequence (Joshi and Weinstein 1981; Grosz, Joshi, and Weinstein unpublished). For instance, discourse segments that continue centering the same entity are more coherent than those that repeatedly shift from one center to another. These observations are encapsulated in two rules:

- **RULES**

For each U_i in a discourse segment U₁, . . . , 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. CONTINUE is preferred to RETAIN is preferred to SMOOTH-SHIFT is preferred to ROUGH-SHIFT.⁷

Rule (1) captures the intuition that pronominalization is one way to indicate discourse salience. It follows from Rule (1) that if there are multiple pronouns in an utterance, one of these must be the Cb. In addition, if there is only one pronoun, then that pronoun must be the Cb. For Japanese, we extend this rule directly to zeros, assuming that zeros in Japanese correspond to distressed pronouns in English.

Rule (2) states that modeling attentional state depends on analyzing adjacent utterances according to a set of transitions that measure the coherence of the discourse segment in which the utterance occurs. Measuring coherence is based on an estimate of the hearer's inference load, but this measure must always be relative since there is no grammar of discourse. Thus methods for exploring these issues must use comparative measures of how some discourses are easier to process than others. Centering theory models this by stipulating that some transitions are preferred over others.

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.⁸

⁶ This ranking is consistent with Kuno's Empathy Hierarchies and with Kameyama's Expected Center Order (Kuno 1987; Kameyama 1985, 1988). This will be discussed in Section 6. We do not include discourse entities for verb phrases or other propositional entities in this ranking since we have not studied their contribution (but see Sidner 1979, 1981 and Carter 1987).

⁷ Smooth-shift was called shifting-1 by Brennan, Friedman, and Pollard (1987).

⁸ It is possible that restricting the relation between the Cb(U_i) and the Cb(U_{i-1}) to be coreference (equality) may be too strong. Future work should examine the role of shifts to functionally dependent entities or entities related by partially ordered set (POSET) relations to the previous Cb.

	$Cb(U_i) = Cb(U_{i-1})$ OR $Cb(U_{i-1}) = [?]$	$Cb(U_i) \neq Cb(U_{i-1})$
$Cb(U_i) = Cp(U_i)$	CONTINUE	SMOOTH-SHIFT
$Cb(U_i) \neq Cp(U_i)$	RETAIN	ROUGH-SHIFT

Figure 1
Centering transition states, rule 2.

KEY

BACKWARD-LOOKING CENTER = Cb
 PREFERRED CENTER = Cp
 Uninstantiated $Cb = [?]$

1. $Cb(U_i) = Cb(U_{i-1})$, or there is no $Cb(U_{i-1})$
2. $Cb(U_i) = Cp(U_i)$

If both (1) and (2) hold then we are in a CONTINUE transition. The CONTINUE transition corresponds to cases where the speaker has been talking about a particular entity and indicates an intention to continue talking about that entity.⁹ If (1) holds but (2) doesn't hold then we are in a RETAIN transition. RETAIN corresponds to a situation where the speaker is intending to SHIFT onto a new entity in the next utterance and is signalling this by realizing the current center in a lower ranked position on the Cf (examples follow below).

If (1) doesn't hold then we are in one of the SHIFT states depending on whether or not (2) holds. This definition of transition states is summarized in Figure 1 (Brennan, Friedman, and Pollard 1987). We will use the notation of $Cb(U_{i-1}) = [?]$ for cases where there is no $Cb(U_{i-1})$. Section 4 will discuss center instantiation.

The combination of the constraints, rules, and transition states makes a set of testable predictions about which interpretations hearers will prefer because they require less processing. For example, maximally coherent segments are those that require less processing time. A sequence of a CONTINUE followed by another CONTINUE should only require the hearer to keep track of one main discourse entity, which is currently both the Cb and the Cp . A single pronoun in an utterance is the current Cb (by Rule 1) and can be interpreted to cospecify the discourse entity realized by $Cp(U_{i-1})$ in one step (Constraint 3).

The ordering of the Cf is the main determinant of which transition state holds between adjacent utterances. This means that the predictions of the theory are largely determined by the ranking of the items on the Cf. But there are many factors that can contribute to the salience of a discourse entity; among them are factors that we will not examine here such as lexical semantics, intonation, word-order, and tense.¹⁰ In this

9 A prediction made by the preference for CONTINUE is that intersentential antecedents for pronouns will be preferred over intrasentential candidates. This preference is one that distinguishes Centering for pronoun interpretation from the proposal made by Hobbs (1976a, 1976b). However, this preference needs to be constrained further by the fact that sortal filters may rule out the Cp of the previous utterance as the current Cb . In this case the data suggest that perhaps intrasentential candidates should be preferred (Walker 1989). Carter explored this in his extension of Sidner's theory of local focusing (Carter 1987).

10 See Hudson-D'Zmura (1988) for an examination of the role of lexical semantics in centering.

paper we explore the influence of various syntactic factors, which we discuss in detail in Section 3. We will also examine the relative contribution of pronominalization and postposition marking in Section 5. We postulate that the Cf ordering will vary from language to language depending on the means the language provides for expressing discourse function. However much of this variation can be captured in the ranking of the Cf due to the modularity of the theory.

In Sections 2.2 and 2.3 we will present some simple examples to motivate these definitions. In Section 2.4 we will present a slightly modified version of the centering algorithm (Brennan, Friedman, and Pollard 1987). In the following discussion we assume that the centering rules and constraints and the notion of centering transition states have some cognitive reality (Brennan submitted; Hudson-D'Zmura 1988; Gordon, Grosz, and Gilliom 1993; Hudson-D'Zmura and Tanenhaus, 1995). However, we make no claims about the cognitive reality of the centering algorithm that we discuss in Section 2.4.

2.2 The Distinction between Continue and Retain

This theory predicts preferences in the interpretation of utterances whose meaning depends on parameters from the discourse context. Thus if there are still multiple possibilities for interpretation after the application of all constraints and rules, the ordering on transitions applies, and CONTINUE interpretations are preferred (Rule 2). Indeed, many cases of the preference for one interpretation over another follow directly from the distinction between the transition states of CONTINUE and RETAIN. Let us look at a simple example. In the discourse segment in 3, the zero in the second sentence is understood as referring to *Taroo*, and not to *Hanako*. Remember that the interpretation of zeros is indicated with parentheses.

Example 3

- a. Taroo wa Hanako o eiga ni sasoimasita.
 Taroo TOP/SUBJ Hanako OBJ movie to invited
Taroo invited Hanako to the movie.

Cb: TAROO
Cf: [TAROO, HANAKO]

- b. 0 itiniti-zyuu nani mo te ni tukimasendesita.
 SUBJ all-day anything even hand to attached-not
(Taroo) could not do anything all day.

Cb: TAROO
Cf: [TAROO]

In example 3, the Cf from 3a contains the discourse entity for Taroo as the first element and for Hanako as the second element. When the unexpressed argument is interpreted in 3b, the information from this Cf is used. Because the zero subject may REALIZE either Taroo or Hanako, both Constraint 3 and Rule 1 would be obeyed with either interpretation.¹¹ However by interpreting the zero as Taroo, Taroo is the Cb, and it is possible to get a preferred CONTINUE interpretation *Taroo could not do anything all day*. In this interpretation, Taroo is both the Cb(3b) and the Cp(3b).

¹¹ The hypothesis that *wa* in 3a instantiates Taroo as the Cb will be discussed in Section 4.

2.3 The Distinction between Smooth-Shift and Rough-Shift

In example 4, we illustrate the difference between the transition states of ROUGH-SHIFT and SMOOTH-SHIFT. Remember that ROUGH-SHIFT is claimed to be less coherent than SMOOTH-SHIFT (Brennan, Friedman, and Pollard 1987). In both cases the speaker has shifted the center to a different discourse entity. However, in the SMOOTH-SHIFT transition state, the speaker has indicated an intention to continue talking about the recently shifted-to entity by realizing that entity in a highly ranked Cf position such as subject, whereas no such indication is available with the ROUGH-SHIFT transition. The numbers shown to the right of an interpretation correspond to how many native speakers preferred that interpretation.

Example 4

- a. Taroo ga kooen de hon o yondeimasita.
 Taroo SUBJ park at book OBJ reading-was
Taroo was reading a book in the park.

Cb:	[?]
Cf1:	[TAROO, BOOK] SUBJ OBJ

- b. 0 koora o kai ni baiten ni hairimasita.
 SUBJ cola OBJ buy to shop into entered
(Taroo) entered a shop to buy a cola.

Cb:	TAROO
Cf1:	[TAROO, COLA] CONTINUE SUBJ OBJ

- c. Ziroom wa 0 sokode guuzen dekuwasimasita.
 Ziroom TOP/SUBJ OBJ there by chance met
Ziroom met (Taroo) there by chance.

Cb:	TAROO
Cf:	[ZIROOM, TAROO] RETAIN TOP OBJ

- d. 0 0 eiga ni sasoimasita.
 SUBJ OBJ movie to invited.
(Ziroom) invited (Taroo) to a movie.

Cb:	ZIROOM
Cf1:	[ZIROOM, TAROO] SMOOTH-SHIFT 32 subj obj
Cf2:	[TAROO, ZIROOM] ROUGH-SHIFT 2 SUBJ OBJ

In example 4, the use of TOPIC marking in the phrase *Ziroom wa* of utterance (c) means that (c) is interpreted as a RETAIN.¹² Ziroom becomes the most highly ranked discourse entity for c, although Taroo is the Cb since Taroo was most highly ranked for utterance (b) (by Constraint 3). Then when we apply the Centering algorithm in (d), there are two candidates for the Cb(d) from the Cf(c), both Ziroom and Taroo. However, this time when constraint 3 applies, stipulating that the Cb must be the highest-ranked

¹² It has also been claimed that symmetric verbs such as *meet by chance* mark EMPATHY on the subject (Kuno 1976a).

element of Cf(c) realized in 4d, Ziroom must be the highest-ranked entity realized, and therefore must be the Cb. At this point it is clear that some kind of SHIFT is forced by the application of constraint 3. The two candidates are a SMOOTH-SHIFT and a ROUGH-SHIFT. The SMOOTH-SHIFT interpretation corresponds to the reading *Ziroom invited Taroo to a movie* whereas the ROUGH-SHIFT interpretation corresponds to the *Taroo invited Ziroom* reading. The SMOOTH-SHIFT interpretation is more highly ranked, thus considered more coherent and so is the preferred interpretation ($Z = 10.93$, $p < .001$).

2.4 The Centering Algorithm

The CENTERING ALGORITHM that was proposed by Brennan, Friedman, and Pollard incorporates the centering rules and constraints in addition to contra-indexing constraints on coreference (Reinhart 1976; Brennan, Friedman, and Pollard 1987; Iida 1993). These contra-indexing constraints specify that in a sentence such as *He likes him*, that *he* and *him* cannot co-specify the same discourse entity. The algorithm applies centering theory to the problem of resolving anaphoric reference. Application of the algorithm requires three basic steps.

1. GENERATE possible Cb–Cf combinations
2. FILTER by constraints, e.g. contra-indexing, sortal predicates, centering rules and constraints
3. RANK by transition orderings

In order to apply this algorithm to Japanese, possible Cb–Cf combinations (GENERATE step 1) must be constructed from the surface string and information from the subcategorization frame of the verb. First the verb subcategorization is examined, and if there are more entities than appear in the surface string, zeros are postulated as forward centers. These zeros are then treated just like pronouns in English by the rest of the algorithm. We use a different ranking for the Cf for Japanese than for English, but this has no effect on the actual algorithm itself since the Cf ranking is a declarative parameter.

The steps of the algorithm given above can be interleaved to improve computational efficiency. A simple implementation is to:

- Never propose a Cf that violates linguistic constraints on contra-indexing. (In other words, apply the contra-indexing filter as early as possible to avoid Cb–Cf combinations that will be eliminated by that filter.)
- If there are pronouns in an utterance, only propose pronouns as possible Cbs. (Collect the pronouns from the proposed Cfs as Cbs, from Rule 1.)

In addition, it is simple to add additional filters to step (2) of the algorithm. For instance, any constraint that is lexically specified such as [\pm animacy] can be easily applied as a filter. It is also possible to pursue a ‘best first’ strategy by interleaving steps (1), (2), and (3) so that a CONTINUE will be found without extra processing if one exists.

In example 5, we illustrate in more detail how the steps of the algorithm work and the difference between CONTINUE and RETAIN. Each utterance shows what the Cb and Cf would be for that utterance. We will mostly be concerned with the process of resolving the two zeros in utterance 5c.

Example 5

- a. Taroo wa saisin no konpyuutaa o kaimasita.
 TOP/SUBJ newest of computer OBJ bought
Taroo bought a new computer.

Cb:	TAROO
Cf:	[TAROO, COMPUTER]

- b. 0 John ni sassoku sore o misemasita.
 SUBJ John OBJ2 at once that OBJ showed
(Taroo) showed it at once to John.

Cb:	TAROO
Cf:	[TAROO, JOHN, COMPUTER] CONTINUE

- c. 0 0 atarasiku sonawatta kinoo o setumeisimasita.
 SUBJ OBJ2 newly equipped function OBJ explained
(Taroo) explained the newly equipped functions to (John).

Cb:	TAROO		
Cf1:	[TAROO, JOHN]	CONTINUE	27
	SUBJ OBJ		
Cf2:	[JOHN, TAROO]	RETAIN	1
	SUBJ OBJ		
Cf3:	[JOHN, JOHN]	CONTRA-INDEX FILTER	
	SUBJ OBJ		
Cf4:	[TAROO, TAROO]	CONTRA-INDEX FILTER	
	SUBJ OBJ		

Example 5c has *explained* as the main verb, which requires an animate subject and object2. Since there are two animate zeros in 5c, which are also contra-indexed by syntactic constraints, both Zi-roo and Taroo must be realized in 5c. Constraint (3) restricts the Cb to Taroo as the highest-ranked element from the Cf(5b). The interpretive process must also generate the possible candidates for the Cf. If no constraints applied, then all four candidates shown above as Cf1, Cf2, Cf3, and Cf4 would be possible. However, the conraindexing filter will rule out Cf3 and Cf4. As mentioned above, there is no reason that these filters cannot be applied at the GENERATE phase rather than later on.

The only CONTINUE interpretation available, *Taroo explained the newly equipped functions to John*, corresponds to the forward centers Cf1. It is a CONTINUE interpretation because $Cb(5c) = Cb(5b)$ and also $Cb(5c) = Cp(5c)$. The RETAIN interpretation is less preferred and is defined by the fact that $Cb(5c) = Cb(5b)$, but $Cb(5c) \neq Cp(5c)$. This example supports the claim that a CONTINUE is preferred over a RETAIN ($Z = 13.24$, $p < .001$).

In order to find this preferred continue interpretation in a 'best first' fashion, Taroo as the $Cp(U_{i-1})$ would be tried first as the $Cb(U_i)$, and as the interpretation for the subject. Conraindexing rules out Taroo as the object, so John would be tried next as the object.

In the next section, we examine further the application of centering to the interpretation of zeros in Japanese. We will examine the ranking of forward centers that we have adopted for Japanese and explain how this is partially determined by the way the Japanese language allows a speaker to express discourse functions. We will

also give some examples of the interpretation of zeros in cases involving Japanese discourse markers for TOPIC and EMPATHY.

3. Centering in Japanese

The theory of centering is a formal specification that is intended to model attentional state and is defined by the rules and constraints given in Section 2.1. Attentional state in turn constrains the discourse participant's interpretation process; one aspect of attentional state is the notion of discourse salience. In the centering model, the ordering of the forward centers is an approximation of discourse salience. This in turn is the main determinant of discourse interpretation processes such as the resolution of zeros in Japanese. A crucial question then is what discourse factors must be considered to determine the ordering of the forward centers, Cf, in Japanese discourse.

Being a subject has been shown to be an important factor for English; this is reflected in a Cf ordering by grammatical function (Prince 1981b; Brennan, Friedman, and Pollard 1987; Hudson-D'Zmura 1988; Brennan submitted). Aspects of surface order may also affect the interpretation (Di Eugenio 1990; Hajicova and Vrbova 1982). An interpretation algorithm can also use pronominalization as an indicator of what the speaker believes is salient (Grosz, Joshi, and Weinstein unpublished). Furthermore, zeros in Japanese are not realized syntactically so that there must be a way to distinguish zeros from other entities inferred to be part of a discourse situation. Consider:

Example 6

Taroo ga 0 aimasita.
 Taroo SUBJ OBJ2 met
Taroo met (0).

This sentence is not felicitous unless the addressee has already been given some information about the person that Taroo met, either in the current discourse or in previous discourses. In contrast, nonsubcategorized-for arguments such as adjuncts are not necessarily given a specific interpretation, but rather are given a nonspecific one.

Example 7

Taroo ga Hanako ni aimasita.
 Taroo SUBJ Hanako OBJ2 met
Taroo met Hanako.

The sentence means that Taroo met Hanako at some time in some place: the temporal location of the *meeting* situation need not be specified. The speaker can utter this sentence even if the addressee does not know where and when Taroo met Hanako. Thus, in this work, we only represent obligatorily subcategorized arguments of the verb on the Cf, assuming that the salience of discourse entities is partially determined by virtue of filling a verb's argument role, and the information from the subcategorization frame is used to determine that a zero is present in an utterance.

Zeros are then interpreted with reference to the current context. Prince has proposed that the current context should be categorized by ASSUMED FAMILIARITY (Prince 1981b; Horn 1986), with a concomitant goal of determining the correlation between the use of certain linguistic forms and the types of assumed familiarity. The first division of assumed familiarity is into the subtypes of NEW, INFERRABLE, and EVOKED.

NEW can be divided into BRAND-NEW, discourse entities that are both new to the discourse and new to the hearer, and UNUSED, discourse entities old to the hearer but new to the discourse. The information status of EVOKED can be further divided into TEXTUALLY EVOKED, old in the discourse and therefore old to the hearer as well, and SITUATIONALLY EVOKED, entities in the current situation. INFERABLES are technically both hearer-new and discourse-new but depend on information that is old to the hearer and the discourse, and are often treated by speakers as though they were both hearer-old and discourse-old. There is a hierarchy of assumed familiarity in terms of discourse salience:

Assumed Familiarity Hierarchy (Prince 1981b):

TEXTUALLY EVOKED > SITUATIONALLY EVOKED > INFERABLE > UNUSED > BRAND-NEW

Zeros typically refer to EVOKED entities,¹³ but there is a scale of relative salience among the EVOKED entities. In our theory this is modeled with Cf ranking. We repeat the proposed ranking of the Cf here and justify it in the following sections:¹⁴

Cf Ranking for Japanese

(GRAMMATICAL OR ZERO) TOPIC > EMPATHY > SUBJECT > OBJECT2 > OBJECT > OTHERS

The relevance of the notions of TOPIC and speaker’s EMPATHY to centering is that a discourse entity realized as the TOPIC or the EMPATHY LOCUS is more salient and should be ranked higher on the Cf. Whenever a discourse entity simultaneously fulfills multiple roles, the entity is usually ranked according to the highest ranked role.

In the following sections we will discuss the motivation for this ranking. Section 3.1 discusses the role of the grammatical topic marker *wa* in Japanese. Section 3.2 explains the role of EMPATHY in Japanese discourse salience and shows that (GRAMMATICAL OR ZERO) TOPIC > EMPATHY and that EMPATHY > SUBJ. Section 3.2.1 shows how the centering algorithm handles utterances with empathy loci. Zero topics will not be discussed until Section 5.

3.1 Topic

Discourse entities that are EVOKED, INFERABLE, or UNUSED can be marked as the TOPIC. The speaker cannot mark an entity as the grammatical TOPIC unless the hearer is aware of the object that s/he is going to talk about (Prince 1978a; Kuno 1976b). For example:

Example 8

Hutari wa paatii ni kimasita.
two-person TOP/SUBJ party to came
Speaking of two persons, they came to the party.

13 Under certain circumstances that we cannot explore here, it appears that zeros can at times be used to refer to inferable or unused entities, just as pronouns in English sometimes can be.
14 This ranking resembles Kuno’s Empathy Hierarchy and Kameyama’s Expected Center Order, but we distinguish two kinds of TOPIC and we posit that OBJECT2 is more salient than OBJECT. We continue Kuno’s use of the term EMPATHY to represent the EMPATHY LOCUS, whereas Kameyama used the property IDENT for EMPATHY (Kameyama 1988).

Example 8 is felicitous only when *hutari* ('two persons') is understood as meaning *the two people under discussion*. The sentence never means that the people who came to the party numbered two.

The fact that the *wa*-marked entity should be discourse-old is also shown by the fact that a *wh*-question cannot be answered with a *wa*-marked NP.

Example 9

- a. Dono hito ga Ziroo o bengosimasita ka.
 which person SUBJ Ziroo OBJ defended Q
Which person defended Ziroo?
- b-1. Taroo ga Ziroo o bengosimasita.
 Taroo SUBJ Ziroo OBJ defended
Taroo defended Ziroo.
- b-2. *Taroo wa Ziroo o bengosimasita.
 Taroo TOP/SUBJ Ziroo OBJ defended
Taroo defended Ziroo.

What the question context shows is that even in a simple declarative sentence, the use of the topic marker *wa* contrasts with the subject marker *ga* in what is understood as already in the discourse context. For instance, in a discourse initial utterance, 10a, assumes no shared information or that *someone defended Ziroo* and asserts that the someone is Taroo. In 10b, the discourse-old proposition is that *Taroo did something* and what is asserted is that what he did was defend Ziroo.

Example 10

- a. Taroo ga Ziroo o bengosimasita.
 Taroo SUBJ Ziroo OBJ defended
Taroo defended Ziroo.
- b. Taroo wa Ziroo o bengosimasita.
 Taroo TOP/SUBJ Ziroo OBJ defended
Taroo defended Ziroo.

While topics are often subjects, subject and grammatical topic need not coincide. Any argument can be realized as a topic, as shown in examples 11 and 12.

Example 11

- Taroo wa Hanako ga bengosita.
 Taroo TOP Hanako SUBJ defended
As for Taroo, Hanako defended (him).

Example 12

- Tokyoo e wa Hanako ga itta.
 Tokyo to TOP Hanako SUBJ went
To Tokyo, Hanako went.

The assumption that the TOPIC is more salient than the SUBJECT, when the two are different, is supported by the fact that an indefinite NP in subject position such as *who*, *which*, or *somebody* cannot be regarded as the TOPIC: an indefinite NP is never marked by the topic marker *wa*, but by the subject marker *ga*. For example:

Example 13

Dono hito ga Ziroo o bengosimasita ka.
 which person SUBJ Ziroo OBJ defended Q
Which person defended Ziroo?

Example 14

*Dono hito wa Ziroo o bengosimasita ka.
 who person TOP/SUBJ Ziroo OBJ defended Q
Which person defended Ziroo?

It is clear from these examples that the grammatical topic, *wa*-marked entity, in Japanese, represents assumable shared information in an ongoing conversation. It has been taken to be the ‘theme’ or ‘what the sentence is about’ (Kuno 1973; Shibatani 1990). In our framework, this is the role of the Cb. We will provide evidence supporting this position in Section 4. However, we claim that this is just a default and that other factors can contribute to establishing or continuing an entity as the Cb. Kuno also claims that a zero subject is equivalent to a *wa*-marked entity, and we provide support for this claim in Section 5, showing that the property of having previously been the Cb, in combination with being realized by a zero, contributes to an entity being the Cp.

3.2 Empathy

Kuno (1976b) proposed a notion of EMPATHY in order to present the speaker’s position or identification in describing a situation. In a *hugging* situation involving a man named *Taroo* and his son *Saburoo*, Kuno notes that this situation can be described in various ways, some of which are shown in example 15.

Example 15

- a. Taroo hugged Saburoo.
- b. Taroo hugged his son.
- c. Saburoo’s father hugged him.

These sentences differ from each other with respect to *camera angle*, the position that the speaker takes to observe and describe this situation. In 15a, the speaker is assumed to be describing the event objectively: the camera is placed at the same distance from both *Taroo* and *Saburoo*. On the other hand, the camera may be placed closer to *Taroo* in 15b and closer to *Saburoo* in 15c. This is shown by the use of relational terms such as *son* and *father*, respectively. The term EMPATHY is used for this *camera angle*, which indicates the speaker’s position among the participants in the event described.¹⁵

15 The speaker’s position is not determined by his physical proximity, but rather is measured by the emotional or social relationship. In this sense, the term *speaker’s identification* (Kuno 1976b) may be more suitable than the term *speaker’s position*. Furthermore, the notion of EMPATHY is different from that of perspective (Iida 1993). Empathy is the speaker’s identification with a discourse entity, but the speaker does not have to take the perspective of the person who he empathizes with. For example, consider the following utterance:

(i) Taroo wa Hanako ni migigawa no hon o totte-kureta.
 Taroo TOP/SUBJ Hanako OBJ right GEN book OBJ take-gave
Taroo did Hanako a favor in taking a book on his/her right.

In this example, the speaker empathizes with Hanako as indicated by the empathy verb *kureru*, yet he still can describe the given situation from Taroo’s perspective, which is indicated by ambiguity in the interpretation of the deictic expression *migigawa no* (‘right of’).

In Japanese the realization of speaker's empathy is especially important when describing an event involving *giving* or *receiving*. There is no way to describe a *giving* and *receiving* situation objectively (Kuno and Kaburaki 1977). In 16, the use of the verb *kureru* indicates the speaker's empathy with Ziroo, the discourse entity realized in object position, while in 17, the speaker's empathy with the subject Taroo is indicated by the use of the past tense form *yatta* of the verb *youtu*.

Example 16

Taroo ga Ziroo ni hon o kureta.
 Taroo SUBJ Ziroo OBJ2 book OBJ gave
Taroo gave Ziroo a book. EMPATHY=OBJ2=ZIROO

Example 17

Taroo ga Ziroo ni hon o yatta.
 Taroo SUBJ Ziroo OBJ2 book OBJ gave
Taroo gave Ziroo a book. EMPATHY=SUB=TAROO

A verb that is sensitive to the speaker's empathy is an EMPATHY-LOADED verb. The EMPATHY LOCUS is the argument position whose referent the speaker automatically identifies with. In other words, the verb *kureru* has the EMPATHY LOCUS on the object, while verbs like *youtu* place the EMPATHY LOCUS on the subject.

The use of deictic verbs such as *kuru* ('come'), *iku* ('go'), *okuru* ('send to'), and *yokosu* ('send in') also encode the speaker's empathy. For example, the speaker indicates empathy with Taroo by using the past tense form *kita* of the verb *kuru* in the following example.

Example 18

Hanako wa Taroo no tokoro ni kita.
 Hanako TOP/SUBJ Taroo of place to came
Hanako came to Taroo's place.

Many Japanese verbs can be made into empathy-loaded verbs because of a productive verb-compounding operation by which these empathy-loaded verbs are used as the auxiliary verb, attaching to the main verb.¹⁶ For example, *kureru* can be used as a suffix, to mark OBJ or OBJ2 as the EMPATHY LOCUS. The attachment of *youtu* marks SUBJECT as the EMPATHY LOCUS. The complex predicate made by this operation inherits the EMPATHY LOCUS of the suffixed verb. For example:

Example 19

Hanako ga Taroo ni hon o yonde-kureta.
 Hanako SUBJ Taroo OBJ2 book OBJ read-gave
Hanako did Taroo a favor in reading a book. EMPATHY = OBJ2 = TAROO

In this case Taroo is interpreted as the EMPATHY LOCUS because of the auxiliary *kureta* attached to the main verb. Similarly in example 20, the speaker indicates empathy with Hanako by using the past tense form *yatta* of the verb *youtu* as an auxiliary verb to the main verb *tazuneru*.

¹⁶ Certain intransitive verbs cannot be made into empathy-loaded verbs since the empathy-loaded versions make no sense, e.g. *moreru* (leak).

Example 20

Hanako ga Taroo o tazunete-yatta.

Hanako SUBJ Taroo OBJ visit-gave

(lit.)*Hanako received a favor in visiting Taroo.* EMPATHY = SUBJ = HANAKO

As demonstrated in the following examples, a discourse entity that is realized as the EMPATHY LOCUS must be EVOKED.

Example 21

Taroo ga Ziroo ni okane o kasite-kureta.

Taroo SUBJ Ziroo OBJ2 money OBJ lend-gave

Taroo did Ziroo a favor in lending him some money.

Example 22

*Taroo ga dareka ni okane o kasite-kureta.

Taroo SUBJ somebody OBJ2 money OBJ lend-gave

Taroo did somebody a favor in lending him some money.

Example 23

*Taroo ga misiranu hito ni okane o kasite-kureta.

Taroo SUBJ unknown person OBJ2 money OBJ lend-gave

Taroo did a stranger a favor in lending him some money.

The contrast between 21, 22, and 23 demonstrates that the use of a BRAND-NEW entity in the EMPATHY LOCUS position of the verb *give* is not acceptable. Therefore an entity in the EMPATHY LOCUS position is ranked in a higher position on the Cf than the subject.

3.2.1 Empathy and the Centering Algorithm. Using the Centering Algorithm, we model EMPATHY as a language-specific discourse factor by adding the EMPATHY-marked discourse entity to the Cf ranking. Then preferences for CONTINUE over RETAIN when EMPATHY is involved can be demonstrated, as in example 24 below:¹⁷

Example 24

a. Hanako wa kuruma ga kowarete komatteimasita.

Hanako TOP/SUBJ car SUBJ broken at a loss-was

Her car broken, Hanako was at a loss.

Cb:	HANAKO
Cf:	[HANAKO, CAR]

b. Taroo ga 0 sinsetu-ni te o kasite-kuremasita.

Taroo SUBJ OBJ2/EMP kindly hand OBJ lend-gave.

Taroo kindly did (Hanako) a favor in helping her.

Cb:	[HANAKO]
Cf:	[HANAKO, TAROO]
	EMPATHY SUBJ

17 The verb form *kuremasita* in 24b is the polite form of *kureta*, the past tense form of the verb *kureru*.

- c. Tugi no hi 0 0 eiga ni sasoimasita.
 next of day SUBJ OBJ movie to invited
Next day (Hanako) invited (Taroo) to a movie.

Cb:	HANAKO			
Cf1:	[HANAKO, TAROO]	CONTINUE	16	
	SUBJ OBJ			
Cf2:	[TAROO, HANAKO]	RETAIN	2	
	SUBJ OBJ			

In 24c, the verb *invited* requires an animate subject and object, and these must be realized by different discourse entities because of the conindexing constraint. Hanako is the most highly ranked entity from 24b that is realized in 24c, and therefore must be the Cb. The preferred interpretation is therefore *she invited him to a movie* ($Z = 5.25, p < .001$). This corresponds to Cf1, the more highly ranked CONTINUE transition, in which Hanako is the preferred center, Cp. This interpretation can be found with minimal processing by trying the Cp(24b), Hanako, as the Cb(24c), by interpreting the subject zero as Hanako. This gives a CONTINUE transition. Then conindexing constraints mean that Hanako cannot fill both argument positions, so the object position is interpreted as Taroo. This interpretation is found with minimal processing by interleaving the steps of the Centering algorithm proposed in Brennan et al. (1987).

Note that nothing special needs to be said about the fact that EMPATHY is the discourse factor that made Hanako the Cp in 24b and thus predicted that Hanako would be the Cb at 24c (*pace* Brennan, Friedman, and Pollard 1987). The preference in the interpretation follows from the distinction between CONTINUE and RETAIN and the ranking of Cf. Thus, the centering framework is easily adapted to handle this language-specific feature.

3.3 Topic and Empathy

In general the assignment of the EMPATHY relationship is pragmatic. It is determined by the speaker's relation to the discourse participants in the discourse. In 24, for example, the EMPATHY relationship between the speaker and *Hanako* and between the speaker and *Taroo* is clear: the use of the empathy verb in the second sentence indicates that the speaker is closer to *Hanako* than to *Taroo*.

However, besides cases where the speaker clearly expresses who s/he empathizes with, it is also possible for the context to provide some information about the speaker's proximity relationship with discourse participants in the given discourse, so that the hearer can determine the EMPATHY relation that the speaker has in mind. In this paper, we only consider cases where EMPATHY is syntactically marked by the use of empathy-loaded verbs.

Kuno's notion of EMPATHY is more general. For instance, Kuno's EMPATHY HIERARCHY consists of different scales for EMPATHY that include notions such as TOPIC and SPEAKER (Kuno 1987). Kuno's Topic Empathy Hierarchy suggests that the discourse entity realized as the TOPIC will often coincide with the EMPATHY LOCUS:

Topic Empathy Hierarchy: Discourse-Topic > Discourse-Nontopic

Given an event or state that involves A and B such that A is coreferential with the topic of the present discourse and B is not, it is easier for the speaker to empathize with A than with B.

In support of Kuno's claim, we have found that when no empathy relation is clearly indicated and no topic has been clearly established that it is difficult for a

hearer to determine the empathy relation that the speaker intends. Previous Cbs and current Cps can be high on the empathy scale, and yet the discourse entity realized as the grammatical TOPIC does not necessarily coincide with the discourse entity realized as the EMPATHY LOCUS. A simple sentence to show this point is given in example 25 below:

Example 25

Taroo wa Ziroo ni hon o yonde-kuremasita.
 Taroo TOP/SUBJ Ziroo OBJ2 book OBJ read-gave
Taroo gave Ziroo a favor of reading a book. EMPATHY = OBJ2 = ZIROO

In example 25, Taroo is the TOPIC while Ziroo is the EMPATHY LOCUS. Similarly, a zero does not have to be realized as the EMPATHY LOCUS. In 26b the zero in the subject position realizes the Cb and refers to Taroo.

Example 26

- a. Taroo wa syukudai o zenbu yari-oemasita.
 Taroo TOP/SUBJ homework OBJ all do-finished
Taroo finished his homework.
- b. 0 Ziroo ni hon o yonde-kuremasita.
 SUBJ Ziroo OBJ2 book OBJ read-gave
(Taroo) gave Ziroo a favor of reading a book. EMPATHY = OBJ2 = ZIROO

TOPIC is higher than EMPATHY in the Cf ranking. The higher degree of salience of TOPIC over EMPATHY is shown by the different interpretation of (b) sentences in examples 27 and 28. The only difference in these examples is that Mitiko is *wa*-marked in 27a but is *ga*-marked in 28a:

Example 27

- a. Mitiko wa kanai o gityoo ni osite-kuremasita.
 Mitiko TOP/SUBJ wife OBJ/EMP chairman OBJ2 recommend-gave
Mitiko did my wife a favor in recommending her as chairperson.
- b. 0 asu no kaihyoo-kekka o tanosimi-ni siteim asu.
 SUBJ tomorrow of results OBJ look-forward doing-is
(Mitiko) is looking forward to tomorrow's results.

Example 28

- a. Mitiko ga kanai o gityoo ni osite-kuremasita.
 Mitiko SUBJ wife OBJ/EMP chairman OBJ2 recommend-gave
Mitiko did my wife a favor in recommending her as chairperson.
- b. 0 asu no kaihyoo-kekka o tanosimi-ni siteimasu.
 SUBJ tomorrow of results OBJ look-forward doing-is
(Mitiko) is looking forward to tomorrow's results.
(My wife) is looking forward to tomorrow's results.

The TOPIC *Mitiko* is preferred as the unexpressed subject of the (b) sentence in example 27.¹⁸ On the other hand, the subject *Mitiko* is not strongly preferred, as shown in example 28: the zero in the second sentence in 28 is understood as referring to either *Mitiko* or *my wife*. That is, the possible interpretation in these examples shows that the NP *my wife*, which is realized as the EMPATHY LOCUS, is not as salient as the TOPIC.¹⁹

So why is it easier to empathize with a discourse entity that has been the topic as Kuno demonstrates? It seems important to keep the notions of TOPIC and EMPATHY separate, but in Section 5.1 we will demonstrate an effect where the topic entity is interpreted as the empathy locus. We claim that the ranking of the Cf and the potential for a CONTINUE interpretation determines whether this effect will hold. In other words, the tendency for the topic entity to be interpreted as the empathy locus follows from more general discourse processing factors, such as a hearer preferring CONTINUE transitions within a given local stretch of discourse.

3.4 Summary

To summarize, we have outlined the roles of discourse markers such as those for TOPIC and EMPATHY by which Japanese grammaticizes some aspects of discourse function, and we have argued that TOPIC and EMPATHY markers can only be used on entities that are already in the discourse context.

One factor that hasn't been discussed is the role of pronominalization, but many researchers have argued that discourse entities realized by pronouns are more salient than other discourse entities (Clark and Haviland 1977; Grosz, Joshi, and Weinstein unpublished; Kuno 1976b, 1987). We take zeros in Japanese to be analogous to pronouns in English in this respect. Since pronominalization can apply at any position in the ranking of the Cf, the role of its contribution is particularly interesting when it is in conflict with some other factor such as grammatical function or topic marking. This will be discussed further in Section 5.

4. Initial Center Instantiation

INITIAL CENTER INSTANTIATION is a process by which a discourse entity introduced in a segment-initial utterance becomes the Cb. In our framework, this happens as a side effect of the Centering Algorithm. Typically, when an interpretation is found for the second utterance in a discourse segment, the Cb becomes instantiated.²⁰ The Cb of an initial utterance U_i is treated as a variable that is then unified with whatever Cb is assigned to the subsequent utterance U_{i+1} .

Typically, a discourse entity is introduced as a *ga*-marked subject, and then is referred to by a zero in a subsequent utterance (Clancy and Downing 1987). Consider example 29.

18 The zero may be interpreted as indirectly referring to the speaker. This interpretation is always possible when the verb *kureru* is used: the use of *kureru* implies that the speaker is closer to the beneficiary argument (i.e. the *o*-marked NP in these examples), and the favor given to this person is understood as a benefit to the speaker as well.

19 Although it seems as though empathy isn't higher than subject, the conflating factor is that topic marking establishes a Cb, whereas in 28 no Cb has been established. This is explained in detail in Section 4.

20 In Walker, Iida, and Cote (1990) we called this Center Establishment. Henceforth we will refer to this process as Center Instantiation in order to avoid confusion with Kameyama's term center establishment, which is a different mechanism in her theory (Kameyama 1985).

Example 29

- a. Taroo ga deeta o konpyuutaa ni utikondeimasita.
 Taroo SUBJ data OBJ computer in was-storing
Taroo was storing the data in a computer.

Cb: [?]
Cf: [TAROO, DATA]

- b. 0 yatto hanbun yari-owarimasita.
 SUBJ finally half do-finished
Finally (Taroo) was half finished.

Cb: TAROO
Cf: [TAROO] CONTINUE

Using Taroo as the subject in example 29a is not enough to establish this discourse segment as being about Taroo. It is the use of the zero in example 29b that serves to instantiate Taroo as the Cb. By our definition of CONTINUE, 29b is a continue transition, because Cb(29b) = Cp(29b) and there was no Cb in 29a. However, Kuno argues that referring to a discourse entity with a zero is equivalent to marking it as the grammatical topic with *wa* (Kuno 1972). Our interpretation of this argument is that the use of *wa* in a discourse-initial utterance instantiates the *wa*-marked entity as the Cb in one utterance. This claim is supported by the contrast with the GA-WA alternation in examples 30 and 31, where there is a shift in interpretation depending on whether *Taroo* is marked with *wa* in the first sentence.²¹

Example 30

- a. Taroo ga Ziroom o min'na no mae de tatakimasita.
 SUBJ OBJ all of front in hit.
Taroo hit Ziroom in front of all the other people.

Cb: [?]
Cf: [TAROO, ZIROO]

- b. Itiniti-zyuu, kanzen-ni 0 0 musu-simasita.
 all-day completely ignored
(Ziroom) ignored (Taroo) all day.

Cb: TAROO
Cf: [TAROO, ZIROO] 3
Cb: ZIROO
Cf: [ZIROO, TAROO] 8

In example 30, *Taroo* is introduced by *ga*. In this case, it appears that there is a tendency due to lexical semantics to instantiate *Ziroom* as the Cb in the second utterance.²²

By the centering definitions, taking either *Taroo* or *Ziroom* to be the Cb can result in a CONTINUE interpretation. However, assuming that the Cf ordering at example 30a is correct, constraint 3 is violated by the preferred interpretation of 30b. Since both of the entities in Cf(30a) are realized, the Cb in example 30b should be the most highly ranked one. There are two possible conclusions here: (1) In discourse-initial utterances, when

21 These examples were tested by asking survey participants to indicate preference rankings. The numbers given here are only for those subjects who expressed strong preferences; some subjects expressed no preference.

22 The number of subjects here are too small to test statistically.

no clear indication of topic is given, the Cf ordering alone is not a strong constraint; (2) the ordering of the Cf should be partly determined by lexical semantics or other knowledge about the situation being described. However, compare example 30 with example 31.

Example 31

- a. Taroo wa Ziroom o min'na no mae de tatakimasita.

SUBJ OBJ all of front in hit.

Taroo hit Ziroom in front of all the other people.

Cb:	[TAROO]
------------	---------

Cf:	[TAROO, ZIROO]
------------	----------------

- b. Itiniti-zyuu, kanzen-ni 0 0 musu-simasita.

all-day completely ignored

(Taroo) ignored (Ziroom) all day.

Cb:	TAROO
------------	-------

Cf:	[TAROO, ZIROO] 10
------------	-------------------

Cb:	ZIROO
------------	-------

Cf:	[ZIROO, TAROO] 4
------------	------------------

The use of *wa* in example 31 seems to override the semantic preference that was exhibited in example 30, so that subjects now prefer an interpretation in which Taroo is the Cb.²³ This shows that Taroo has not been instantiated as the Cb when it is time to interpret the two zeros in example 30b. We explain the contrast by assuming that the TOPIC instantiates the Cb when it is first introduced in a discourse-initial utterance, as in example 31a. Then the only way to get a CONTINUE interpretation for 31b is for Taroo to be the Cb at 31b.

Furthermore, we can detect no differences in the interpretation of the final utterance between three utterance sequences in which an entity is introduced by *wa*, and four utterance sequences in which an entity is first introduced by *ga* and then realized by a zero in the second utterance. This provides further support for the claim that the status of discourse entities realized as grammatical topics and those realized as zero subjects is equivalent.

4.1 Summary

In sum, we have argued that the use of *wa* in a discourse-initial utterance instantiates the *wa*-marked entity as the Cb. Cb instantiation can equivalently be done with a two-utterance sequence in which the entity is first introduced as a subject, *ga*-marked, and then established as the Cb in the following utterance with a zero referring to that entity. In addition, the fact that the Cb is uninstantiated in discourse initial utterances has the effect that the Cf ranking in a discourse initial utterance is not a strong constraint, as it is once a Cb is established.

5. Zero Topic Assignment

In this section we introduce the notion of a ZERO TOPIC and a rule or assumption that can be employed as part of the interpretive process called ZERO TOPIC ASSIGNMENT.

²³ The small number of subjects means that we can't provide statistical support for this claim.

The rule of ZERO TOPIC ASSIGNMENT defines our distinction between grammatical topic and zero topic. This rule allows a zero that has just been the Cb to continue as the Cp, even when it is not realized in a discourse-salient syntactic position such as subject. We will demonstrate this with examples that realize both grammatical and zero topics. In these cases, the discourse situation is such that the hearer may maintain multiple hypotheses about where the speaker’s attention is directed, and must determine whether to apply the default that the grammatical topic is usually the Cp.²⁴

Zero Topic Assignment

When a zero in U_{i+1} represents an entity that was the $Cb(U_i)$, and when no other CONTINUE transition is available, that zero may be interpreted as the ZERO TOPIC of U_{i+1} .

What this means is that, in certain discourse environments, the entity that was previously the Cb is predicted to continue as the Cb. We conjecture that ZTA is applicable in all free word-order languages with zeros.²⁵ However, ZERO TOPIC ASSIGNMENT is **optional**; here we have suggested two constraints on when it applies. We will give examples below of cases where it doesn’t apply.

The option of ZERO TOPIC ASSIGNMENT (henceforth ZTA) has been overlooked in previous treatments of zeros in Japanese. ZTA explains why the discourse entity Hanako, which is realized as OBJECT2 in example 32c is interpreted as the SUBJECT of example 32d.

Example 32

- a. Hanako wa siken o oete, kyoositu ni modorimasita.
Hanako TOP/SUBJ exam OBJ finish classroom to returned
Hanako returned to the classroom, finishing her exams.

Cb:	HANAKO
Cf:	[HANAKO, EXAM]

- b. 0 hon o locker ni simaimasita.
SUBJ book OBJ locker in took-away
She put her books in the locker.

Cb:	HANAKO
Cf:	[HANAKO, BOOK] CONTINUE

- c. Itumo no yooni Mitiko ga 0 mondai no tokikata o
always like SUBJ Mitiko OBJ2 problem solve-way OBJ
setumeisidasimasita.
explained
Mitiko, as usual, explained (to Hanako) how to solve the problems.

Cb:	HANAKO
Cf1:	[HANAKO, MITIKO, SOLUTION] ZTA CONTINUE TOP, SUBJ, OBJ
Cf2:	[MITIKO, HANAKO, SOLUTION] RETAIN SUBJ, OBJ2, OBJ

24 While some of the utterance sequences we examine are potentially ambiguous for native speakers, the examination of these discourse situations offers considerable insight into those where there is no ambiguity.

25 We only look at object topics here but there may be limits as to how lowly ranked on the Cf an entity can be and still be the zero topic, e.g. by-passive agentive.

- d. 0 0 ohiru ni sasoimasita.
 SUBJ OBJ lunch to invited
 (Hanako) invited (Mitiko) to lunch.

Cb1:	HANAKO	
Cf1:	[HANAKO, LUNCH, MITIKO] CONTINUE from Cf1(c)	28
	SUBJ, OBJ2, OBJ	

Cb2:	MITIKO	
Cf2:	[MITIKO, LUNCH, HANAKO] SMOOTH-SHIFT from Cf2(c)	6
	SUBJ, OBJ2, OBJ	

The possibility of ambiguity as to the attentional state of the speaker is reflected in the fact that there are two possible Cfs for example 32c; Cf2 of 32c is the only Cf possible without ZTA, and represents a RETAIN rather than a CONTINUE. By the formulation of the ZTA rule above, ZTA is triggered by the fact that no CONTINUE transition is available.

The availability of ZTA means that HANAKO can be the Cp even when MITIKO is realized as the subject. This leads to a potential ambiguity in example 32d, because it is possible for a hearer to simultaneously entertain both of the Cf(32c). In this case the ZTA interpretation is preferred ($Z = 4.95, p < .001$). The less preferred SMOOTH-SHIFT interpretation would result from the algorithm's application to Cf2 of 32c.²⁶

ZTA explains the contrast between the discourse segments in examples 32 above and 33 below. The only difference between 32 and 33 is that in 32c, MITIKO is a *ga*-marked subject, whereas in 33c, MITIKO is a *wa*-marked subject/grammatical topic. Utterances 32c and 33c have the same meaning. This minimal pair provides a test to see whether ZTA actually characterizes these discourse related effects.

Example 33

- a. Hanako wa siken o oete, kyoositu ni modorimasita.
 Hanako TOP/SUBJ exam OBJ finish classroom to returned
 Hanako returned to the classroom, finishing her exams.

Cb:	HANAKO
Cf:	[HANAKO, EXAM]

- b. 0 hon o locker ni simaimasita.
 SUBJ book OBJ locker in took-away
 (Hanako) put (her) books in the locker.

Cb:	HANAKO
Cf:	[HANAKO, BOOK] CONTINUE

- c. Itumo no yooni Mitiko wa 0 mondai no tokikata o
 always like TOP/SUBJ Mitiko OBJ2 problem solve-way OBJ
 setumeisidasimasita.
 explained
 Mitiko, as usual, started explaining (to Hanako) how to solve the problems.

Cb:	HANAKO
Cf1:	[HANAKO, MITIKO, SOLUTION] ZTA CONTINUE TOP, SUBJ, OBJ
Cf2:	[MITIKO, HANAKO, SOLUTION] RETAIN TOP, OBJ2, OBJ

²⁶ See Section 2 for an example of how a smooth-shift interpretation is calculated.

- d. 0 0 ohiru ni sasoimasita.
 SUBJ OBJ lunch to invited
(Hanako) invited (Mitiko) to lunch.
(Mitiko) invited (Hanako) to lunch.

Cb1:	HANAKO	
Cf2:	[HANAKO, LUNCH, MITIKO] CONTINUE from Cf1(c)	18
	SUBJ, OBJ2, OBJ	
Cb2:	MITIKO	
Cf2:	[MITIKO, LUNCH, HANAKO] SMOOTH-SHIFT from Cf2(c)	16
	SUBJ, OBJ2, OBJ	

The *wa* marking has the predicted effect. Using the grammatical topic marker *wa* in example 33c dampens ZTA and thus affects the interpretation of example 33d, which is now completely ambiguous ($Z = 0.34$, not significantly different than chance). Because the discourse entity realized as the grammatical topic and indicated by the *wa*-marked NP is the Cp by default, ten subjects who previously did so can no longer get an interpretation that depends on ZTA. It seems that the situation can be characterized as a case of competing defaults, so that in example 33, some hearers apply the default that the *wa*-marked entity is the Cp, and others apply the default that CONTINUE interpretations are preferred and that zeros realize discourse entities that are ranked highly on the Cf.

The RETAIN interpretation in example 33c, Cf2, indicates that these hearers expect the conversation to shift to being about Mitiko; the fact that Mitiko is the Cp(33c), along with constraint 3 will force a shift. Given a SHIFT, the *Mitiko invited Hanako to lunch* interpretation is preferred because it is the more highly ranked SMOOTH-SHIFT transition.²⁷

These examples clearly show that the *wa*-marked NP is not always the Cp and support Shibatani’s claim that the interpretation of *wa* depends on the discourse context (Shibatani 1990). The astute reader will have noticed that in the cases where Hanako is a zero topic, the *wa*-marked Mitiko discourse entity is ranked according to grammatical function. We conjecture that an inference of contrast is supported when the grammatical topic is not the Cp.

The following section discusses the interaction of ZTA with empathy. Then in Section 5.2, we discuss further the ramifications of our distinction between grammatical and zero topic.

5.1 Empathy and Zero Topic Assignment

This section investigates the interaction of EMPATHY and ZERO TOPIC ASSIGNMENT (ZTA). The discourse segment in example 34 is a minimal pair with that in example 35. In 34d the main verb is *setumeisita* (‘explain’) without any EMPATHY marking, whereas in 35d, the same sentence occurs with an auxiliary empathy verb as *setumeisitekureta*. Remember that *kureta* marks the OBJ or OBJ2 as the EMPATHY LOCUS.

27 If MITIKO could represent a topic object in 33d, there would be another equally ranked SMOOTH-SHIFT interpretation for 33d. However, according to the formulation of ZERO TOPIC ASSIGNMENT, MITIKO cannot be a zero topic because it was not the Cb of the previous utterance, 33c.

Example 34

- a. Taroo wa deeta o konpyuutaa ni utikondeimasita.
 Taroo TOP/SUBJ data OBJ computer in was-storing
Taroo was storing the data in a computer.

Cb: TAROO
Cf: [TAROO, DATA]

- b. 0 yatto hanbun yari-owarimasita.
 SUBJ finally half do-finished
Finally (Taroo) was half finished.

Cb: TAROO
Cf: [TAROO] CONTINUE

- c. Ziroom ga 0 hurui deeta o misemasita.
 Ziroom SUBJ OBJ2 old data OBJ showed
Ziroom showed (Taroo) some old data.

Cb: TAROO	
Cf1: [TAROO, ZIROO, DATA]	ZTA CONTINUE
	TOP, SUBJ, OBJ
Cf2: [ZIROO, TAROO]	RETAIN
	SUBJ, OBJ2, OBJ

- d. 0 0 ikutuka no kuitigai o setumeisimasita.
 SUBJ OBJ2 several of differences OBJ explained
(Ziroom) explained several differences to (Taroo).
(Taroo) explained several differences to (Ziroom).

Cb1: TAROO		
Cf1: [TAROO, ZIROO, DIFFERENCES]	CONTINUE from Cf1(c)	12
	SUBJ, OBJ2, OBJ	

Cb2: ZIROO		
Cf2: [ZIROO, TAROO, DIFFERENCES]	SMOOTH-SHIFT from Cf2(c)	22
	SUBJ, OBJ2, OBJ	

The interpretations of example 34d show that it is possible for some subjects to interpret Taroo as the zero topic in example 34c. This is possible because Taroo was both the Cp and the Cb for 34a and 34b. The two Cfs of 34c reflect multiple possibilities in attentional state.²⁸ The competing defaults consist of the assumption that ZTA applies, versus the assumption that subjects are more highly ranked than objects on the Cf. In this case no preference between the two interpretations can be demonstrated ($Z = 1.79$, not significant).

Example 35 is a minimal pair with example 34. In 35d, the speaker provides more syntactic information by using the empathy verb *kureta* to indicate that the discourse entity realized as the OBJECT2 is the EMPATHY locus.

Example 35

- a. Taroo wa deeta o konpyuutaa ni utikondeimasita.
 Taroo TOP/SUBJ data OBJ computer in was-storing
Taroo was storing the data in a computer.

28 Although both possibilities have the same semantic interpretation.

Cb:	TAROO
Cf:	[TAROO, DATA]

- b. 0 yatto hanbun yari-owarimasita.
 SUBJ finally half do-finished
Finally (Taroo) was half finished.

Cb:	TAROO
Cf:	[TAROO] CONTINUE

- c. Ziroo ga 0 hurui deeta o misemasita.
 Ziroo SUBJ OBJ2 old data OBJ showed
Ziroo showed (Taroo) some old data.

Cb:	TAROO
Cf1:	[TAROO, ZIROO, DATA] ZTA CONTINUE TOP, SUBJ, OBJ
Cf2:	[ZIROO, TAROO, DATA] RETAIN SUBJ, OBJ2, OBJ

- d. 0 0 ikutuka no kuitigai o setumeisite-KURE-masita.
 SUBJ OBJ2/EMP several of differences OBJ explained-gave
(Ziroo) did (Taroo) a favor of explaining several differences.

Cb1:	TAROO
Cf1:	[TAROO, ZIROO, DIFFERENCES] CONTINUE from Cf1(c) 33 EMP-OBJ2, SUBJ, OBJ
Cb2:	ZIROO
Cf2:	[ZIROO, TAROO, DIFFERENCES] SMOOTH-SHIFT from Cf2(c) 1 EMP-OBJ2, SUBJ, OBJ

Empathy associates with the previous Cb to yield a CONTINUE transition, and the interpretation changes so that the utterance is no longer ambiguous ($Z = 16.24$, $p < .001$). In this case it is possible to interpret both example 35c and example 35d as CONTINUES by assuming ZTA at 35c. This example also validates ZTA because empathy associates with the zero topic (Kuno 1976b, 1987). Furthermore, this minimal pair highlights aspects of the interaction between syntax and inference. The fact that the empathy verb in 35d is the only difference between examples 34 and 35 shows that the preference in interpretation does not follow from inferences based on information about who is likely to explain what to whom, depending on who showed who the data, or whether the data is new or old.

Example 36 contrasts minimally with example 35 but on another dimension. In this case, 36c is a CONTINUE with Taroo realized in subject position, rather than a CONTINUE based on ZTA. The *Ziroo explained to Taroo* interpretation is again clearly preferred here as in 35d ($Z = 3.638$, $p < .001$).

Example 36

- a. Taroo wa deeta o konpyuutaa ni utikondeimasita.
 Taroo TOP/SUBJ data OBJ computer in was-storing
Taroo was storing the data in a computer.

Cb:	[TAROO]
Cf:	[TAROO, data]

- b. 0 yatto hanbun yari-owarimasita.
 SUBJ finally half do-finished
Finally (Taroo) was half finished.

Cb:	TAROO
Cf:	[TAROO] CONTINUE

- c. 0 Ziroo ni hurui deeta o misemasita.
 SUBJ Ziroo OBJ2 old data OBJ showed
(Taroo) showed Ziroo some old data.

Cb:	TAROO
Cf1:	[TAROO, ZIROO, DATA] CONTINUE SUBJ, OBJ2, OBJ

- d. 0 0 ikutuka no kuitigai o setumeisite-KURE-masita.
 SUBJ OBJ2/EMP several of differences OBJ explained-gave
(Ziroo) did (Taroo) a favor of explaining several differences.

Cb1:	TAROO
Cf1:	[TAROO, ZIROO, DIFFERENCES] CONTINUE 26 EMP-OBJ2, SUBJ, OBJ

Cf2:	[ZIROO, TAROO, DIFFERENCES] RETAIN 8 EMP-OBJ2, SUBJ, OBJ
-------------	---

In 36 as in 35, EMPATHY associates with the previous Cb, ie. Taroo. This follows from the ordering of the Cf and hearers' preferences for a CONTINUE interpretation.

Note that the interpretation of the last utterance in example 36d remains the same as that in example 35d, although in this case it is Taroo that shows Ziroo some old data in example 36c; nevertheless Ziroo is the one who does the explaining. It seems that inference from world knowledge and domain information alone is unlikely to predict which interpretations hearers will prefer. Inferential processes and discourse structure are mutually constraining (Joshi and Weinstein 1981; Nadathur and Joshi 1983; Hudson-D'Zmura 1988).

5.2 Summary

We proposed a discourse rule of ZERO TOPIC ASSIGNMENT and showed that ZTA is conditioned by the rules and constraints of centering theory: (1) ZTA only applies to discourse entities that were previously the Cb; (2) ZTA is constrained to cases where the only transition available otherwise would be a RETAIN.

ZTA arises from the interaction between preferences for CONTINUE transitions (Rule 2) and the fact that Cbs are often zeros (Rule 1). The interaction of these two factors leads to the speculation that when the Cb is realized by a pronoun in a lower ranked Cf position, which gives rise to a RETAIN transition state, that this type of transition is inherently ambiguous. Since different factors contribute to the salience of discourse entities, such as 'subjecthood' and 'pronominalization' (Grosz, Joshi, and Weinstein unpublished), conflicting defaults can arise when these are in conflict with one another. This may be especially true in Japanese since another factor that should contribute to Cf ranking, word order, is not present whenever zeros are involved.

These examples highlight the relation between centering and global coherence in discourse. A RETAIN is proposed as a way for a speaker to mark a coordinated transition to a new topic; it predicts a shift (Grosz, Joshi, and Weinstein unpublished; Brennan, Friedman, and Pollard 1987). However, the way in which centering SHIFT transitions are related to larger structures in discourse has not been specified. If a

shift functions as a boundary between segments (Walker 1993b), then the hearer's application of ZTA means that the hearer is assuming that the next utterance will be part of the same discourse segment. In contrast, a hearer's assumption that the current centering transition is a RETAIN means that the hearer assumes that the next utterance will begin a new discourse segment.

The relationship between segmentation and hearer's preferences for ZTA or RETAIN interpretations may be affected by other discourse factors. Among these factors, intonation may indicate whether the current utterance should be taken as initiating a new segment and predicting a SHIFT, or continuing the previous one (Silverman 1987; Cahn, 1992; Swerts and Geluykens 1992; Walker and Prince 1994). Another factor may be the inferred relationship that holds between adjacent utterances such as whether it is possible to interpret (d) as Ziroo's reason for having done (c) (Hobbs 1985b). However this is clearly not the only factor, or even necessarily the dominant one, as we have demonstrated. Future research must provide additional constraints on when ZTA is applicable.

6. Related Research

Other researchers working on the interpretation of anaphors have focused on the role of inference from world knowledge (Hobbs 1985b, 1979). While it is important to elucidate the information needed for inference and the type of inferential process involved in discourse interpretation, it is clear from our examples that syntactic realization has a strong effect on the interpretive process and provides processing constraints on inferential processes. We have focused on the interaction between syntax and inference.

Our treatment of Japanese discourse phenomena builds on earlier work by Kuno (Kuno 1972, 1973, 1987, 1989). Our Cf ranking is consistent with Kuno's Empathy and Topic Hierarchies and we incorporate a number of Kuno's observations on the function of the grammatical topic marker *wa* and the role of zeros. We have also incorporated Kuno's notion of EMPATHY by using EMPATHY in the Cf ranking (Kuno 1976a; Kuno and Kaburaki 1977).

In recent work, Kuno proposes an algorithmic account of the interpretation of zeros. He claims that there are two types of zero pronouns, PSEUDO-ZERO-PRONOUNS and REAL-ZERO-PRONOUNS (Kuno 1989). REAL-ZERO-PRONOUNS are supposed to have a *wa*-marked NP or a presentational NP as an antecedent (Yoshimoto 1988). PSEUDO-ZERO-PRONOUNS are actually examples of deletion, and must follow the same order and the same syntactic function as their source NPs. They must obey constraints on deletion such as Kuno's Pecking Order of Deletion Principle: *Delete less important information first and more important information last*. According to Kuno, the position just to the left of the verb is the default focus position in Japanese, unless the verb itself is the focus. Therefore, since the verb in example 37b is the information focus, the zeros are assumed to be PSEUDO-ZERO-PRONOUNS.

Example 37

- a. Taroo ga Hanako ni nani o sita no desu ka.
 Taroo SUBJ Hanako to what OBJ do COMP COPULA Q
What did Taroo do to Hanako?
- b. 0 0 kisu o sita no desu.
 kiss OBJ did COMP COPULA
 (lit.) (*Taroo*) *did a kissing (to Hanako)*.

The combination of these two types of zeros can explain examples like the following:

Example 38

- a. Taroo wa Hanako ga sukida.
 Taroo TOP/SUBJ Hanako fond-of-is
Taroo likes Hanako.
- b. Ziroo wa Natuko ga sukida.
 Ziroo TOP/SUBJ Natuko fond-of-is
Ziroo likes Natuko.
- c. 0 Saburoo mo sukida.
 Saburoo also fond-of-is
(Ziroo) also likes Saburoo.
 **Saburoo also likes (Natuko).*

Kuno's account treats Ziroo in example 38c as a REAL-ZERO-PRONOUN. In this case we would predict the preferred interpretation based on our distinction between CONTINUE and RETAIN. However, consider the following example:

Example 39

- a. Taroo wa Hanako ga sukida.
 Taroo TOP/SUBJ Hanako fond-of-is
Taroo likes Hanako.
- b. Ziroo wa kirai da.
 Ziroo TOP/SUBJ 0 fond-of-is
(Taroo) dislikes Ziroo.
Ziroo dislikes (Hanako).
 **Ziroo dislikes (Taroo).*

The *Taroo dislikes Ziroo* interpretation would be an example of ZTA. However, we would predict that the *Ziroo dislikes Hanako* interpretation would be dispreferred, but this does not seem to be the case. Kuno's analysis treats the zero in the second reading of example 39b as a PSEUDO-ZERO-PRONOUN, which means that it must be interpreted as Hanako since Hanako was the object of the previous utterance.

The interpretation of 39b that we would predict as possible would be the *Ziroo dislikes Taroo* (RETAIN), which native speakers rarely get. However, Kuno's analysis does not block this reading either; the zero in 39b could also be a REAL-ZERO-PRONOUN, with *Taroo* as its antecedent. Kuno says that this interpretation is dispreferred because of a preference for parallel interpretation (Grober, Beardsley, and Caramazza 1978; Sidner 1979; Kameyama 1988; Kuno 1989). We have claimed here and elsewhere (Brennan, Friedman, and Pollard 1987; Walker, Iida, and Cote 1990) that the preference for parallelism is an epiphenomenon of the ordering of the Cf and the preference for CONTINUE interpretations.

Our account cannot explain the contrast between examples 38 and 39. It seems that what is at issue here is the fact that a set of discourse entities plus an open proposition such as *X likes Y* is what is discourse-old in these examples and not just a discourse entity (Prince 1981a, 1986, 1992). Our conclusion is that these enumerated lists and question-answer discourse segments may need an account of discourse center that is broader than that needed for discourse entities realized as NPs. Kuno's constraints on

deletion must also be integrated to fully explain when entities or propositions in the discourse may be unexpressed.

Our analysis also builds on an earlier analysis put forth by Kameyama (Kameyama 1985, 1986, 1988). Although Kameyama uses the centering terminology, her account is not based on the constraints and rules of centering theory as developed here and presented in (Grosz, Joshi, and Weinstein 1983, unpublished; Brennan, Friedman, and Pollard 1987). Kameyama proposed that the interpretation of zeros in Japanese depends on a default preference hierarchy of syntactic properties to be shared between the antecedent and the zero (Grober, Beardsley, and Caramazza 1978). Kameyama's account of zero interpretation consists roughly of a PROPERTY-SHARING CONSTRAINT, henceforth PS, and an EXPECTED CENTER ORDER, henceforth ECO, which may be paraphrased as follows:

PROPERTY-SHARING CONSTRAINT: Two zero-pronouns in adjacent utterances, which co-specify the same Cb-encoding discourse entity, should share one of the following properties (in descending order of preference): 1) both IDENT and SUBJECT, 2) IDENT alone, 3) SUBJECT-alone, 4) both NONIDENT and NONSUBJECT, 5) NONSUBJECT alone, or 6) NONIDENT alone.

EXPECTED CENTER ORDER RULE: In a sentence that contains a center-establishing zero, if it is to have a full NP as its antecedent, the default preference order among its potential antecedent NPs is: Topic > Ident > Subject > Object(2) > Others.

As noted earlier, we use a modified version of Kameyama's EXPECTED CENTER ORDER as the ordering of the Cf, but Kameyama's treatment differs from ours in a number of respects.

First, Kameyama used the property IDENT to describe something similar to Kuno's notion of EMPATHY, and has an added assumption of a SUBJECT IDENT default, i.e. subjects are considered to be EMPATHY loci by default. This means that her theory also includes a neutralization device for cases where this default is not in effect (Kameyama 1988). In contrast, our theory explains examples covered by the SUBJECT IDENT default by including EMPATHY in the ranking of the Cf list and by the distinction between CONTINUE and RETAIN, as illustrated in example 24.

We have also expanded Kameyama's treatment of TOPIC. We have elucidated the interaction of topic with subject and empathy markers and supported our claim that the topic marker *wa* functions similarly to pronominalization in instantiating the Cb. In addition, ZTA and the distinction that we make between grammatical and zero topic is new to our account.

Furthermore, since Center Instantiation is a side effect of the application of the centering algorithm, we treat 40c and 41c with the same mechanism. In Kameyama's analysis, the PS constraint applies to example 40, while the ECO applies in example 41.

Example 40

- a. Hanako wa repooto o kakimasita.
Hanako TOP/SUBJ report OBJ wrote
Hanako wrote a report.
- b. 0 Taroo ni aini-ikimasita.
SUBJ-IDENT Taroo OBJ2 see-went
She went to see Taroo.

- c. Taroo wa 0 kibisiku hihansimasita.
 Taroo TOP/SUBJ OBJ severely criticized
Taroo severely criticized her.

Example 41

- a. Hanako wa Taroo ni aini-kimasita.
 Hanako TOP/SUBJ Taroo OBJ2 see-came
Hanako came to see Taroo.
- b. Taroo wa 0 hon o yonde-kure-masita.
 Taroo TOP/SUBJ OBJ2 book OBJ read-gave
Taroo did her a favor of reading a book.

Note that we annotate example 40b with Kameyama's IDENT property, which corresponds to EMPATHY. Kameyama's account predicts that there are different processes going on in the resolution of zeros depending on the environments where the zero appears. PS applies in the case of example 40c because the previous utterance has a zero, but it doesn't apply in the case of example 41b. PS would seem to predict that the zero pronoun in 40c should not be interpreted as Hanako, since the zero carries the properties [SUBJ, IDENT] in 40b and [NONSUBJ, NONIDENT] in 40c. In other words, none of the required properties of SUBJ, IDENT, NONSUBJ, NONIDENT, which 'should' be shared according to the PS constraint, are shared. But in fact 40c is perfectly acceptable under the intended reading of *Taroo severely criticized Hanako*, and 41b is likewise acceptable under the reading *Taroo did Hanako a favor of reading a book*.

Also, as pointed out in Kuno (1989), Kameyama's theory makes no predictions about the interpretation of some of the zeros in examples such as 5, repeated here for convenience as example 42.

Example 42

- a. Taroo wa saisin no konpyuutaa o kaimasita.
 TOP/SUBJ newest of computer OBJ bought
Taroo bought a new model of computer.

Cb:	TAROO
Cf:	[TAROO, COMPUTER]

- b. 0 John ni sassoku sore o misemasita.
 SUBJ John OBJ2 at once that OBJ showed
(Taroo) showed it to John.

Cb:	TAROO
Cf:	[TAROO, JOHN, COMPUTER] CONTINUE

- c. 0 0 atarasiku sonawatta kinoo o setumeisimasita.
 SUBJ OBJ2 newly equipped function OBJ explained
(Taroo) explained the newly equipped functions to (John).

Cb:	TAROO		
Cf1:	[TAROO, JOHN]	CONTINUE	27
	SUBJ OBJ		
Cf2:	[JOHN, TAROO]	RETAIN	1
	SUBJ OBJ		

The PS Constraint applies only to two zeros in adjacent sentences, and the ECO applies only when a Cb is to be established. Example 42c is not a Cb-establishing utterance since the Cb has already been established in 42b, so the ECO should not apply. The PS constraint does apply and predicts that the subject zero must have the subject of 42b as its antecedent, but the theory makes no predictions about the possible interpretations for the zero object.

Many of the examples that are explained in Kameyama's theory by the PS constraint are handled on our account by the distinction between CONTINUE and RETAIN. However, there are a number of cases where PS makes different predictions than our account. In particular, note that for examples 32 and 35, Kameyama's SUBJECT IDENT default makes exactly the opposite prediction. Example 35 is repeated below as example 43 and annotated with the SUBJECT IDENT default feature.

Example 43

- a. Taroo wa deeta o konpyuutaa ni utikondeimasita.
 Taroo TOP/SUBJ data OBJ computer in was-storing
Taroo was storing the data in a computer.
- b. 0 yatto hanbun yari-owarimasita.
 SUBJ/IDENT finally half do-finished
Finally he was half finished.
- c. Ziroo ga 0 hurui deeta o misemasita.
 Ziroo SUBJ/IDENT OBJ2 old data OBJ showed
Ziroo showed him some old data.
- d. 0 0 ikutuka no kuitigai o setumeisite-KURE-masita.
 SUBJ OBJ2/IDENT several of differences OBJ explained-gave
(Ziroo) did (Taroo) a favor of explaining several differences.

According to PS, the interpretation in which the property IDENT is shared is preferred to the one with SUBJECT shared, and hence, the interpretation *Taroo did Ziroo a favor in explaining several differences* is preferred. However our survey shows that native speakers prefer the *Ziroo did Taroo a favor* reading; this is explained by our discourse rule of ZTA and by including empathy in the ranking of the Cf list.

7. Conclusion and Future Work

In this paper, we have attempted to elucidate the interaction of syntactic realization and discourse salience in Japanese using the discourse-processing framework of CENTERING. In our theory discourse salience is operationalized by the ranking of the forward centers for an utterance. We explored speakers' options for indicating salience in Japanese discourse, especially the interaction of discourse markers for TOPIC and EMPATHY. We then posited a ranking and used it to explain some facts about the interpretation of zeros in Japanese.

While there is clearly a correlation between syntax and discourse function, we show that discourse context plays an important role. We proposed a discourse rule of ZERO TOPIC ASSIGNMENT (ZTA), which distinguishes grammatical and zero topic. We showed that centering allows us to formalize constraints on when ZTA can apply. However, future work must determine additional constraints on when ZTA applies, and which language families support ZTA.

The preferred interpretation of zeros and the discourse factors that are responsible for each interpretation are summarized below. Remember that in each case the zero in the third utterance was established as the Cb by the previous two utterances:

Third Utterance SUBJECT OBJECT(2)		Fourth Utterance SUBJECT OBJECT(2)		Discourse Factor	Example
zero(i)	NP(j)	zero(i)	zero(j)	Continue/Retain	5
zero(i)	NP(j)	zero(j)	zero(i),empathy	empathy, Continue/Retain	36
NP(ga)(i)	zero(j)	zero(j)	zero(i)	ZTA	32, 34
NP(wa)(i)	zero(j)	zero(i) zero(j)	zero(j) zero(i)	WA-effect ZTA	33
NP(ga)(i)	zero(j)	zero(i)	zero(j),empathy	ZTA and empathy	35

This analysis suggests that centering may be a universal of context-dependent processing of language, although so far this theory has only been applied to English, German, Turkish, Japanese, and Italian (Brennan, Friedman, and Pollard 1987; Walker 1989; Walker, Iida, and Cote 1990; Di Eugenio 1990; Cote 1992; Rambow 1993; Nakatani 1993; Hoffman 1995; Turan 1995). We proposed that the centering component of a theory of discourse interpretation can be constructed in a language-independent fashion, up to the declaration of a language-specific value for one parameter of the theory, i.e., Cf ranking (as in Section 2). This parameter is language-dependent because different languages offer different means of expressing discourse function. We conjecture that ZTA may apply in any free-word order language with zeros.

Future work must examine the interaction between centering and discourse segmentation in both monologue and dialogue (Whittaker and Stenton 1988; Walker and Whittaker 1990; Walker 1993b), and the role of deictics, lexical semantics, one anaphora, and propositional discourse entities in centering (Webber 1978; Sidner 1979; Walker 1992, 1993a; Cote 1995). It is also important to examine the interaction of zeros with overt pronouns and with deictics and the interaction of pronominalization with accenting (Terken 1995). In addition, the semantic theory underlying centering must be further developed (Roberts 1995). Finally, centering transitions are currently defined by an equality relation between discourse entities, but POSET relations and functional dependencies often link entities in discourse (Prince 1978b, 1981a; Ward 1985; Grosz, Joshi, and Weinstein unpublished). The predictions made here should also be tested on a large corpus of naturally occurring Japanese discourse (Hurewitz and Linson 1995).

Acknowledgments

We would like to thank Aravind Joshi and Ellen Prince for their insight, useful discussions, and support for making it possible to have the workshop on Centering Theory in Naturally-Occurring Discourse at the Institute for Cognitive Science at the University of Pennsylvania. In addition, discussions with Dave Bernstein, Susan Brennan, Hitoshi Isahara, Megumi Kameyama, Susumu Kuno, Christine Nakatani, Hiday Nakashima, Carl Pollard,

Owen Rambow, Peter Sells, Mike Tanenhaus, Bonnie Webber, and Steve Whittaker contributed to the development of this work. We would also like to thank the anonymous reviewers who provided many helpful suggestions. NSF's Summer Science and Engineering Institute in Japan made it possible to present this work and receive useful feedback at ICOT, JEIDA working group on Machine Translation, NTT's Basic Research Labs, and ATR's Interpreting Telephony Lab. We would also

like to thank the readers of comp.research.japanese and sci.lang.japan who participated in our survey.

This research was partially funded by NSF Science and Engineering Award for the Summer Institute in Japan, by ARO grant DAAL03-89-C-0031, DARPA grant N00014-90-J-1863, NSF grant IRI90-16592, and Ben Franklin grant 91S.3078C-1 at the University of Pennsylvania, and by Hewlett Packard Laboratories.

References

- Brennan, Susan E. (submitted). Centering attention in discourse.
- Brennan, Susan E.; Friedman [Walker], Marilyn W.; and Pollard, Carl J. (1987). "A centering approach to pronouns." In *Proceedings, 25th Annual Meeting of the ACL, Stanford*, 155-162.
- Cahn, Janet (1992). An investigation into the correlation of cue phrases, unfilled pauses and the structuring of spoken discourse. In *Workshop on Prosody in Natural Speech*, 19-31. Institute for Research in Cognitive Science, University of Pennsylvania, TR IRCS-92-37.
- Carter, David M. (1987). *Interpreting Anaphors in Natural Language Texts*. Ellis Horwood.
- Clancy, Patricia M., and Downing, Pamela (1987). "The use of wa as a cohesion marker in Japanese oral narratives." In *Perspectives in Topicalization: The Case of Japanese Wa*, 3-56. Academic Press.
- Clark, Herbert H., and Haviland, Susan E. (1977). "Comprehension and the given-new contract." *Discourse Production and Comprehension*, edited by R. O. Freedle, 1-40. Ablex Publishing.
- Clark, Herbert H., and Marshall, Catherine R. (1981). "Definite reference and mutual knowledge." In *Elements of Discourse Understanding*, edited by Joshi, Webber, and Sag, 10-63. Cambridge University Press.
- Cote, Sharon (1992). "Discourse functions of two types of null objects in English." In *Linguistic Society of America Annual Meeting*, 12.
- Cote, Sharon (in press). Ranking forward-looking centers. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Di Eugenio, Barbara (1990). "Centering theory and the Italian pronominal system." In *Proceedings, 13th International Conference on Computational Linguistics, (COLING-90)*, 270-275.
- Gordon, Peter C.; Grosz, Barbara J.; and Gilliom, Laura A. (1993). "Pronouns, names and the centering of attention in discourse." *Cognitive Science*, 17-3, 311-348.
- Grober, Ellen H.; Beardsley, William; and Caramazza, Alfonso (1978). "Parallel function strategy in pronoun assignment." *Cognition*, 6, 117-131.
- Grosz, Barbara J. (1977). "The representation and use of focus in dialogue understanding." Technical Report 151, SRI International, 333 Ravenswood Ave, Menlo Park CA 94025.
- Grosz, Barbara J., and Sidner, Candace L. (1986). "Attentions, intentions and the structure of discourse." *Computational Linguistics*, 12, 175-204.
- Grosz, Barbara J.; Joshi, Aravind K.; and Weinstein, Scott (1983). "Providing a unified account of definite noun phrases in discourse." In *Proceedings, 21st Annual Meeting of the Association for Computational Linguistics*, 44-50.
- Grosz, Barbara J.; Joshi, Aravind K.; and Weinstein, Scott (unpublished). Towards a computational theory of discourse interpretation.
- Hajicova, Eva, and Vrbova, Jarka (1982). "On the role of the hierarchy of activation in the process of natural language understanding." In *Proceedings, 9th International Conference on Computational Linguistics (COLING-84)*. Prague, 107-113.
- Hasegawa, Nobuko (1984). "On the so-called zero pronouns in Japanese." *The Linguistic Review*, 289-341.
- Hobbs, Jerry R. (1976a). "A computational approach to discourse analysis." Technical Report 76-2, Department of Computer Science, City College, City University of New York.
- Hobbs, Jerry R. (1976b). "Pronoun resolution." Technical Report 76-1, Department of Computer Science, City College, City University of New York.
- Hobbs, Jerry R. (1979). "Coherence and coreference." *Cognitive Science*, 3, 67-90.
- Hobbs, Jerry R. (1985a). "The logical notation: Ontological promiscuity," Chapter 2 of *Discourse and Inference*. Technical report, SRI International, 333 Ravenswood Ave., Menlo Park CA 94025.
- Hobbs, Jerry R. (1985b). "On the coherence and structure of discourse." Technical Report CSLI-85-37, Center for the Study of Language and Information, Ventura Hall, Stanford University.
- Hobbs, Jerry R., and Martin, Paul (1987). "Local pragmatics." Technical report, SRI International, 333 Ravenswood Ave.,

- Menlo Park CA 94025.
- Hobbs, Jerry R.; Croft, William; Davies, Todd; Edwards, Douglas; and Laws, Kenneth (1987). "The tacitus commonsense knowledge base." Technical report, SRI International, 333 Ravenswood Ave., Menlo Park CA 94025.
- Hoffman, Beryl (in press). Word order, information structure and centering in turkish. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Horn, Laurence R. (1986). "Presupposition, theme and variations." In *Chicago Linguistic Society*, 22, 168–192.
- Hudson-D'Zmura, Susan, and Tanenhaus, Michael K. (in press). Assigning antecedents to ambiguous pronouns: The role of the center of attention as the default assignment. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Hudson-D'Zmura, Susan B. (1988). *The structure of discourse and anaphor resolution: The discourse center and the roles of nouns and pronouns*. Doctoral dissertation. University of Rochester.
- Hurewitz, Felicia, and Linson, Brian (in press). A quantitative look at discourse coherence. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Iida, Masayo (1993). *Context and binding in Japanese*. Doctoral dissertation, Linguistics Department, Stanford University.
- Joshi, Aravind K. (1982). "Mutual beliefs in question-answer systems." In *Mutual Knowledge*, edited by Neil V. Smith, 181–199. Academic Press.
- Joshi, Aravind K., and Kuhn, Steve (1979). "Centered logic: The role of entity centered sentence representation in natural language inferencing." In *Proceedings, International Joint Conference on Artificial Intelligence*, 435–439.
- Joshi, Aravind K., and Weinstein, Scott (1981). "Control of inference: Role of some aspects of discourse structure centering." In *Proceedings, International Joint Conference on Artificial Intelligence*, 385–387.
- Kameyama, Megumi (1985). *Zero anaphora: the case of Japanese*. Doctoral dissertation, Linguistics Department, Stanford University.
- Kameyama, Megumi (1986). "A property-sharing constraint in centering." In *Proceedings, 24th Annual Meeting of the Association for Computational Linguistics*, New York, 200–206.
- Kameyama, Megumi (1988). "Japanese zero pronominal binding, where syntax and discourse meet." In *Papers from the Second International Workshop on Japanese Syntax*, edited by William Poser, 47–74. Stanford: CSLI.
- Kuno, Susumu (1972). "Pronominalization, reflexivization, and direct discourse." *Linguistic Inquiry*, 3, 161–195.
- Kuno, Susumu (1973). *The Structure of the Japanese Language*. The MIT Press.
- Kuno, Susumu (1976a). "The speaker's empathy and its effects of syntax: A re-examination of *Yaru* and *Kureru* in Japanese." *Journal of the Association of Teachers of Japanese*, 11, 249–271.
- Kuno, Susumu (1976b). "Subject, theme and speaker's empathy: A reexamination of relativization phenomena." In *Subject and Topic*, edited by C. Li, 417–444. Academic Press.
- Kuno, Susumu (1987). *Functional Syntax*. Chicago University Press.
- Kuno, Susumu (1989). "Identification of zero-pronominal reference in Japanese." Unpublished manuscript. Presented at ATR workshop on Machine Translation.
- Kuno, Susumu, and Kaburaki, Etsuko (1977). "Empathy and syntax." *Linguistic Inquiry*, 8, 627–672.
- Kuroda, Sige-Yuki (1965). *Generative grammatical studies in the Japanese language*. Doctoral dissertation, MIT.
- Martin, Samuel (1976). *A Reference Grammar of Japanese*. Yale University Press.
- Nadathur, Gopalan, and Joshi, Aravind K. (1983). "Mutual beliefs in conversational systems: Their role in referring expressions." In *Proceedings, International Joint Conference on Artificial Intelligence*, Austin, TX, 603–605.
- Nakagawa, Hiroshi (1992). "Zero pronouns as experiencer in Japanese discourse." In *Proceedings, Fourteenth International Conference on Computational Linguistics*, 324–330.
- Nakashima, Hideyuki (1990). "Commonsense reasoning with multiply embedded contexts." In *Pacific Rim Conference on Artificial Intelligence*, 414–419.
- Nakatani, Christine H. (1993). Global and local functions of topic marking in Japanese. In *Institute for Research in Cognitive Science Workshop on Centering Theory in Natural-Occurring Discourse*.
- Prince, Ellen F. (1978a). "On the function of existential presupposition in discourse." In *Papers from the 14th Regional Meeting*. CLS, Chicago IL.
- Prince, Ellen F. (1978b). "On the function of

- wh-clefts and it-clefts in discourse." *Language*, 54, 883–906.
- Prince, Ellen F. (1981a). Topicalization, focus movement and Yiddish movement: A pragmatic differentiation. *Proceedings of the Seventh Annual Meeting of the Berkeley Linguistics Society*, 249–264, edited by Danny K. Alford, Karen Ann Hunold, Monica A. Macaulay, Jenny Walter, Claudia Brugman, Paula Chertok, Inese Civkulis, and Marta Tobey.
- Prince, Ellen F. (1981b). "Toward a taxonomy of given-new information." In *Radical Pragmatics*, 223–255. Academic Press.
- Prince, Ellen F. (1985). "Fancy syntax and shared knowledge." *Journal of Pragmatics*, 65–81.
- Prince, Ellen F. (1986). "On the syntactic marking of the presupposed open proposition." *Proceedings of the 22nd Annual Meeting of the Chicago Linguistic Society*.
- Prince, Ellen F. (1992). "The ZPG letter: Subjects, definiteness and information status." In *Discourse Description: Diverse Analyses of a Fund Raising Text*, edited by S. Thompson and W. Mann, 295–325. John Benjamins B.V.
- Rambow, Owen (1993). Pragmatic aspects of scrambling and topicalization in German. In *Institute for Research in Cognitive Science Workshop on Centering Theory in Naturally-Occurring Discourse*.
- Reinhart, Tanya (1976). *The Syntactic Domain of Anaphora*. Doctoral dissertation, MIT.
- Reinhart, Tanya (1981). "Pragmatics and linguistics, an analysis of sentence topics." *Philosophica*, 27, 53–94.
- Roberts, Craige (in press). Saliency, centering and anaphora resolution in discourse representation theory. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Shibatani, Masayoshi (1990). *The Languages of Japan*. Cambridge University Press.
- Sidner, Candace L. (1979). "Toward a computational theory of definite anaphora comprehension in English." Technical Report AI-TR-537, MIT.
- Sidner, Candace L. (1981). "Focusing for interpretation of pronouns." *American Journal of Computational Linguistics*, 7(4), 217–231.
- Sidner, Candace L. (1983). "Focusing in the comprehension of definite anaphora." In *Computational Models of Discourse*, edited by M. Brady and R. C. Berwick. MIT Press.
- Silverman, Kim (1987). *The Structure and Processing of Fundamental Frequency Contours*. Doctoral Dissertation, Cambridge University.
- Swerts, Marc, and Gelyuykens, Ronald (1992). "The prosodic structuring of information flow in spoken discourse." In *Workshop on Prosody in Natural Speech*, 221–230. Institute for Research in Cognitive Science, University of Pennsylvania.
- Terazu, Noriko; Yamanasi, Masaaki; and Inada, Toshiaki (1980). "Anaphora in Japanese." In *Studies in English Linguistics*, 8, 32–52.
- Terken, Jacques M. (in press). Accessibility, prominence, pronouns and accents. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Turan, Umit Deniz (in press). Prominence in Turkish discourse and forward looking center hierarchy. In Marilyn A. Walker, Aravind K. Joshi, and Ellen F. Prince, editors, *Centering in Discourse*. Oxford University Press.
- Walker, Marilyn A. (1989). "Evaluating discourse processing algorithms." In *Proceedings, 27th Annual Meeting of the Association of Computational Linguistics*, 251–261.
- Walker, Marilyn A. (1992). "Redundancy in collaborative dialogue." In *Proceedings, Fourteenth International Conference on Computational Linguistics*, 345–351.
- Walker, Marilyn A. (1993a). *Informational Redundancy and Resource Bounds in Dialogue*. Ph.D. thesis, University of Pennsylvania.
- Walker, Marilyn A. (1993b). Initial contexts and shifting centers. In *Institute for Research in Cognitive Science Workshop on Centering Theory in Naturally-Occurring Discourse*.
- Walker, Marilyn A., and Whittaker, Steve (1990). "Mixed initiative in dialogue: An investigation into discourse segmentation." In *Proceedings, 28th Annual Meeting of the Association for Computational Linguistics*, 70–79.
- Walker, Marilyn A.; Iida, Masayo; and Cote, Sharon (1990). "Centering in Japanese discourse." In *Proceedings, 13th International Conference on Computational Linguistics (COLING-90)*, Helsinki, 1.
- Ward, Gregory (1985). *The syntax and semantics of preposing*. Doctoral dissertation, University of Pennsylvania.
- Webber, Bonnie Lynn (1978). *A formal approach to discourse anaphora*. Doctoral dissertation, Harvard University. Garland Press.
- Whittaker, Steve, and Stenton, Phil (1988).

Cues and control in expert client dialogues. In *Proc. 26th Annual Meeting of the ACL, Association of Computational Linguistics*, pages 123–130.

Yoshimoto, Kei (1988). "Identifying zero

pronouns in Japanese dialogue." In *Proceedings, 12th International Conference on Computational Linguistics (COLING-88)*, Budapest, Hungary, 779–784.

Appendix A: Instructions to Survey Participants

Instructions for Survey 1 and 2

What interpretation do you get for the THIRD sentence of each set where there are two unexpressed arguments? 0(i) in the second sentence indicates that the unexpressed argument in the sentence should be interpreted as referring to the NP of the first sentence marked with (i). Please rank your preference: it's okay to have more than one equally preferred interpretation.

Instructions for Survey 3

Dear Participants. Thank you for serving as subjects for us for this informal experiment. You can help us most by following the directions here. Please read each sample discourse in turn and make your interpretation as rapidly as possible. Do not scroll back and forth in the file. Please indicate which interpretation, (a) or (b) you get by marking your choice with a 1. It is very important that you choose *one* interpretation only, and the one you choose should be the first one that you think of as you are reading the sample discourse. Send us back this file with your choices marked.