# CONSTRAINTS ON THE GENERATION OF REFERRING EXPRESSIONS, WITH SPECIAL REFERENCE TO HINDI

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A DISSERTATION

in

Linguistics

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

2003

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To JT.

# Acknowledgements

I am very grateful to Ellen Prince for her guidance, both intellectually and personally. I have learnt a great deal from her and my hope is that I have been able to give this dissertation some of the intellectual depth and clarity that I have perceived in my discussions with her. She has also helped me enormously in shaping my dissertation and giving it focus. I fear I would have otherwise been forever swimming in the maze of linguistic phenomena, looking for explanations and answers in every corridor.

Aravind Joshi, in more ways than one, has been a source of inspiration for me ever since I became a part of IRCS. There are many insights I have gained from him, directly or indirectly, that are intrinsic to this dissertation. I am also very grateful to him for giving me the opportunity to be a part of IRCS and to further my interest to forge a strong connection between linguistics and computational linguistics.

With Robin Clark, I have learnt that many times, the clues for answering linguistic questions can be found by delving into other fields. I have learnt to be more daring with my ideas and this has helped me along a great deal in my research.

In addition to the members of my committee, I would like to thank Anthony Kroch, from whom I have learnt a lot about syntax as well as the field of linguistics. Bonnie Webber has given me very useful comments during the discussions I had with her about my topic. Thanks also to Kathleen McCoy for giving me very useful comments on my dissertation proposal. Also, thanks to Marilyn Walker for some useful discussions on my

dissertation.

I would like to especially thank Michael Strube, who came to IRCS a year before I proposed my dissertation topic. It was due to my discussions with him that I began to believe that I could, in fact, write a dissertation. I have worked with him very closely on some parts of my dissertation, and our discussions on Centering theory have been very invigorating and helpful. He has also been a very good friend all along, always ready to listen when things got tough.

There are several other people from UPenn who I would like to thank because they have in one way or another contributed to this dissertation through comments and discussions on Centering: Jason Baldridge, Cassandre Creswell, Katherine Forbes, Na-Rae Han, Elsi Kaiser, Nobo Komagata, Sophia Malamud, Eleni Miltsakaki, Kimiko Nakanishi, Keiran Snyder. Friends in the Linguistics department and at IRCS have made my stay in Philadelphia and my experience as a graduate student at UPenn all the more enjoyable. For this, I would like to thank John Bell, Rajesh Bhatt, Tonia Bleam, Chung-Hye Han, Julia Hockenmaeir, Roumi Izvorski, Alexandra Kinyon, Alan Lee, Mimi Lipson, Carlos Prolo, Maribel Romero, Anoop Sarkar, Alexander Williams, and Fei Xia.

My brother, Amresh Kumar, introduced me to Linguistics and I deeply thank him for this. He has also been there for me in my early graduate years, encouraging me constantly towards the higher end. My heartfelt thanks and gratitude to my parents for encouraging me and supporting me while I was “exploring” my options in life. Their open-mindedness and conscious interest in my initiatives have made it all the more easier for me, and while they have been very far away while I was writing my dissertation, I consider myself very fortunate that I have been able to motivate myself many a time by thinking of them.

Finally, JT, I could not done any of this if it hadn’t been for you. You have given me strength, stability, and I have learnt the meaning of persistence from you. Thank you for being there.

# ABSTRACT

CONSTRAINTS ON THE GENERATION OF REFERRING EXPRESSIONS,
WITH SPECIAL REFERENCE TO HINDI

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This dissertation makes a progress towards the generation of referring expressions in Hindi. We first make a proposal to exploit a combination of Gricean implicatures (Grice, 1975) and Centering theory constraints (Grosz et al., 1995) to formulate a generation algorithm for referring expressions whose domain of application is defined in terms of the Centering Transitions. The formulated algorithm is an abstraction over the cross-linguistic variability observed across languages. To set the language-specific parameters of the algorithm, in particular the parameter that decides the relative salience of the discourse entities in an utterance, we propose a corpus-based methodology to identify the ways in which discourse salience is realized linguistically in any language. We apply this method to a Hindi corpus to investigate three possible linguistic reflexes of discourse salience: *grammatical role*, *word order*, and *information status*, and show that Hindi does not display exhibit any correlation between discourse salience and either word order or information status, and that grammatical function emerges as the primary determinant of salience. Using the results of the proposed methodology for Hindi, we provide an analysis of Hindi zero pronouns. We argue that the constraints on the use of zeros in Hindi are neither syntactic (Kameyama, 1985) nor explicable purely in terms of the singular notion of the topic (Butt & King, 1997). Our analysis, provided in terms of Centering transition preferences, shows that pronouns can be dropped in Hindi only when they occur in an utterance following a CONTINUE or a SMOOTH-SHIFT transition, thus demonstrating the importance of the Preferred Center for zero pronoun realization. Finally, with respect to the problem of defining the utterance unit

for discourse, we provide an analysis of complex sentences containing relative clauses. We argue that different kinds of relative clauses have different utterance statuses as well as different effects on the hierarchical organization of discourse segments. Non-restrictive relative clauses form a *distinct* but embedded utterance unit, while restrictives are part of the main clause unit. Our data also provide support for partitioning the class of restrictive relatives into indefinite head and definite head restrictives (Prince, 1990), with indefinite head restrictives patterning like non-restrictives.

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# Chapter 1

# Introduction

## 1.1 The General Problem

Understanding and providing a formal explanation for why natural language users employ different types of expressions to talk about the things they do, such as objects, events, states, and propositions, is an important aspect of natural language research. Also of particular interest within this research area and the focus of much current research in linguistics, psycholinguistics, and computational linguistics is understanding how and why we use different types of expressions to *continue to talk about* things once they have been introduced into the conversation or the discourse. Such expressions, used to talk about previously mentioned things, are called anaphoric expressions.[1] Consider the English text segment (1), for example. This segment is taken from the middle of a text in which the individuals "Dr. Macphail" and "Horn" have already been introduced in the text prior to the segment

[1]There are certain constraints on the (non-)occurrence of anaphoric expressions that are assumed in this study but which will not be discussed in any detail. These are intra-sentential syntactic constraints imposed on certain expressions such as reflexives and pronouns which are dealt with through principles in Binding Theory (Chomsky, 1981) and are specified in terms of locality constraints. The interested reader is referred to the cited work and related literature.

shown. The question that is very simply posed is the following: how can we account for the different expressions – shown in bold face – used in the text segment to talk about "Dr. Macphail" and "Horn"? We are particularly interested in the alternation between the use of non-informative forms of expression, such as pronouns and null expressions ($\epsilon$), and more informative forms, such as proper names and definite descriptions.[2] The writer is seen to alternate between using different forms as he progresses through the utterances in the segment. Related to the question of what it is that governs the choice of such different forms is also the problem of formalizing how hearers understand the anaphoric expressions, especially the reduced, non-informative ones such as the pronouns.[3]

(1) a. **Dr. Macphail**$_i$, getting out of bed, saw that **he**$_j$ was heavily tattooed. (**he**$_j$ = **Horn**)

b. **Horn**$_j$ made **him**$_i$ a sign to come to the verandah.

c. **Dr. Macphail**$_i$ got out of bed

d. and $\epsilon_i$ followed **the trader**$_j$ out.

*Somerset Maugham; "Rain"*

It can be seen immediately that the choice of form is not arbitrary. The text in (2), which repeats the first and second utterances from (1), shows that the use of different expressions in the second utterance than the ones actually used either makes the wrong references (2bi) or makes the text sound incoherent (2bii).[4] In (2bi), where a pronoun is used to refer to "Dr. Macphail" and another pronoun to refer to "Horn", we note that, in the absence of

[2]In this thesis, we exclude pronouns from the class of definite descriptions. We will also use the term "full noun phrases" or " descriptive noun phrase" as covering both proper names and definite descriptions.

[3]We will use the term *speaker* and *hearer* to mean the *communicative participants* of a discourse, where the mode of communication may be written or spoken language, the participants may be single or multiple, and the communication style may be a monologue or a dialogue.

[4]We are deliberately using the term "utterance" instead of "sentence" to refer to the linguistic expression of propositional content, and will continue to do so throughout the thesis. The distinction between the two

the correct indices, there is a strong tendency to read the utterance with the references switched from the actual ones, i.e., with the subject pronoun referring to "Dr. Macphail" and the indirect object pronoun referring to "Horn", instead of the other way around. It seems, therefore, that proper reference to the two named individuals in this particular case requires that one of the NP forms be more informative. At the same time, (2bii) shows that there seems to be an additional constraint on which of the NP forms can be a pronoun: using a pronoun to refer to Horn and a proper name to refer to "Dr. Macphail" does get the references correct, but the text doesn't seem coherent.[5] The third option shown in (2biii), in which both individuals are referred to with a proper name is the only one that seems like a reasonably coherent alternative for this particular example.

(2) a. and **Dr. Macphail**$_i$, getting out of bed, saw that **he**$_j$ was heavily tattooed. (**he**$_j$ = **Horn**)

b. i. # **He** made **him** a sign to come to the verandah.

ii. # **He**$_j$ made **Dr. Macphail**$_i$ a sign to come to the verandah.

iii. **Horn**$_j$ made **Dr. Macphail**$_i$ a sign to come to the verandah.

Such non-arbitrary alternations in referring expression forms are not typical of English alone. Our goal in this dissertation is to investigate some of the constraints on the choices in reference form in Hindi, where similar alternations are observed, as shown in (3).[6] The segment in (3a) is taken from the beginning of a text and the first utterance of the segment

has a special significance in studies of discourse and dialog structure. This will become clear in later chapters. Also, we assume in this thesis that certain types of coordination of VP's should be treated structurally as S coordination, as for the coordination seen across (1c) and (1d). However, we are not concerned here with providing an account of which kinds of coordination should be treated as VP coordination and which as S coordination.

[5]The # sign prefixed to the examples indicates contextual/pragmatic infelicity

[6]ERG=ergative, ACC=accusative, POSS=possessive, SELF=reflexive pronoun, INF=infinitive, LOC=locative.

thus introduces (i.e., mentions for the first time) “the king” (*baadshaah*) and “the judge” (*qaazii*) into the discourse context. The writer continues to talk about these two individuals in (3bi), using a definite description to refer to “the judge” and a pronoun to refer to “the king”.[7] Like the English example above, the choice of other forms for the two individuals, such as the choice of pronouns for both (as in (3bii)), or the choice of a pronoun for “the judge” and a definite description for “the king” (as in (3biii)) yields the wrong references and makes the text incoherent, respectively. Finally, using definite descriptions for both the individuals (as in (3biv)) is the only other choice that allows the text to remain acceptable.

(3) a. **[ek baadshaah]**$_i$ **[ek qaazii]**$_j$ ko bahut maantaa thaa
**[a king]**$_i$ **[a judge]**$_j$ ACC much like-INF did
“A king was very fond of a judge.”

b. i. **[qaazii]**$_j$ ne **[uspar]** apnii vidvataa kaa aisaa raNg
**[judge]**$_j$ ERG **[him-LOC]**$_i$ SELF knowledge POSS such color
jamaa rakkhaa thaa ki baadshaah use sarvagyaanii samajhtaa
stuck-INF place-INF had that king him all-knowing understand
thaa
did
“The judge had influenced him with his knowledge so much that the king thought him to be all-knowing”

ii. # **[usne] [uspar]** apnii vidvataa kaa aisaa raNg jamaa rakkhaa thaa . . .

iii. # **[usne]**$_j$ **[baadshaah]**$_i$ par apnii vidvataa kaa aisaa raNg jamaa rakkhaa thaa . . .

iv. **[qaazii]**$_j$ ne **[baadshaah]**$_i$ par apnii vidvataa kaa aisaa raNg jamaa rakkhaa thaa . . .

The seemingly analogous examples from English and Hindi above might suggest that the same constraints, however they are formulated, will hold for both the languages. However, research on referring expression form in different languages such as Finnish, German,

[7] Hindi has null marking for the definite article.

Greek, Japanese, Italian, Turkish, Russian etc. has shown that some of the choices in referring expression form may be governed by constraints that vary cross-linguistically. It has been suggested that such variation depends mostly on the formal linguistic means that different languages employ for marking functional roles such as those of *topic*, *empathy*, *point of view* etc. In other words, the specification of the constraints on referring expression choice may vary from language to language "...depending on the means the language provides for marking discourse function." (Walker et al., 1994). In this thesis, we are thus interested in determining the linguistic correlates of discourse function in Hindi, but specifically those discourse functions that have been isolated in the literature as having an effect on referring expression form.

## 1.2 The Model Assumed for Discourse Interpretation and Anaphoric Reference

The phenomenon of anaphoric reference such as considered in the examples above constitutes only a part of reference phenomena in general. Below, we clarify what we mean by anaphoric reference within a representation model of discourse interpretation and then further narrow down the scope of this study as focusing on certain kinds of anaphoric reference.

In terms of the classification found in Prince (1992), we can say that anaphoric reference is the phenomenon of evoking *discourse-old* entities (with the arguable exception of *inferrables* – see fn. 11), where *discourse entities* are representations of objects in the world in our mental representation of the discourse, and are "evoked" in the mental representation by linguistic expressions.[8] Furthermore, the crucial property of such a representational

[8]In the text of the thesis, we will talk about discourse entities by enclosing them in double quotes, as in "John", and the forms used to refer to them will be given in italics, as in *John*, *He*, *him* etc. In the examples,

model is that the entities evoked in the discourse must be made "accessible" in the representation. An informal view of such an entity-based representation is found in Webber (1978):

- "...a discourse model may be described as the set of entities "naturally evoked" by a discourse and linked together by the relations they participate in. These entities I will call *discourse entities*."

Accessibility of discourse entities is important since they are used to determine the interpretation of anaphoric expressions in the subsequent discourse. In work related to the interpretation of indefinites, Karttunen (1976) is the first to suggest that discourse entities (called *discourse referents* by Karttunen) need to be made accessible in the discourse representation for subsequent reference. Such an entity-based representational view of the discourse is also seen in dynamic semantic theories such as the file change semantics of Heim (1982) and the discourse representation theory of Kamp (1981) and Kamp & Reyle (1993).[9] We will further assume that the mental representations of entities are those that the speaker believes the hearer to possess in his/her mind. While all the discourse participants are guided by their own individual mental representations of the discourse, we are particularly concerned with the mental representation of the hearer's knowledge and beliefs that

however, while the forms are still represented as italicized, the discourse entities will not be shown in quotes.

[9]The representational approach taken in DRT has been questioned by the later dynamic approaches such as Groenendijk & Stokhof (1991) which attempt to derive the same context-based interpretations of sentences without a DRT-like intermediate level of representation. They promote a theory of contextual meaning in which contexts are semantic objects, not linguistic ones (as the discourse representation structures (DRSs) of DRT are) and in which the objects that are manipulated dynamically are semantic objects, not representations. They argue that such a theory of meaning can "...remain neutral with respect to the existence and nature of a language of thought ..." (Groenendijk & Stokhof, 1996) which is what they regard the DRSs as. In this thesis, we will remain neutral with regard to this question.

the speaker assumes the hearer to possess during the ongoing discourse. It is this assumption that guides the linguistic choices that the speaker makes (Chafe, 1976; Prince, 1981; 1992).

Building up on and clarifying the general idea prevalent in the literature that discourse entities are *informationally* split between *old* and *new* (Halliday, 1967; Kuno, 1972; Chafe, 1976; Clark & Haviland, 1977; Prince, 1981), Prince (1992) proposes to view this informational classification in terms of the (speaker's beliefs about the) hearer's knowledge "prior to the discourse" – the *hearer-status* of entities – and knowledge being shared "during the ongoing discourse" – the *discourse-status* of entities. An entity can be then considered as old or new with respect to either their hearer-status or their discourse-status. An entity is *hearer-new* when the speaker believes that the hearer does not know about the entity being talked about from prior knowledge. Conversely, an entity is hearer-old if the speaker believes that the hearer does have prior knowledge of the entity mentioned. This difference brings out the contrast between (4) and (5) in their usual contexts (from Prince (1992)):

(4) I'm waiting for it to be noon so I can call *someone in California*.

(5) I'm waiting for it to be noon so I can call *Sandy Thompson*.

Viewed from the point of view of their discourse-status, an entity is *discourse-new* if it is evoked for the first time in the current discourse, whereas an entity is *discourse-old* if it was evoked previously (once or more) in the prior discourse.

These four information-statuses yield three interesting cross-classifications: *hearer-new & discourse-new*, *hearer-old & discourse-new*, and *hearer-old & discourse-old*. Hearer-new entities are also new in the current discourse and are therefore, by definition, discourse-new. Hearer-old entities, on the other hand, may be discourse-new or discourse-old depending on whether they are mentioned for the first time in the current discourse or not.[10]

[10]The fourth available cross-classification, that is *hearer-new & discourse-old* is of course not possible.

In this thesis, then, we will be focusing on studying the constraints on forms used to evoke discourse-old entities, which as noted above, are also hearer-old. Thus, we will not be looking at the forms used to evoke hearer-new or discourse-new entities.[11] Expressions evoking discourse-old entities were shown in our first example, (1), where the forms used to evoke the entities for both "Dr. Macphail" and "Horn" are all non-discourse-initial usages. In the Hindi example in (3), however, "the king" and "the judge" are both discourse-new

However, note that this claim makes an important assumption about the "shared knowledge" of the discourse participants in the discourse model. That is, all the discourse participants are assumed to be "present" (physically or otherwise) for the discourse from the time that it began. There are other kinds of interactional contexts in which the stated classification may be argued to hold, for example, in a dialogue, a person may walk into an ongoing conversation and thus certain entities which are *hearer-new* for the new participant might be argued to be *discourse-old*. At the same time, however, such a classification would depend on what the discourse model is construed to be for such contexts, that is, whether the discourse model for the new participant continues to be the one that started when the discourse began before the new participant's arrival, or whether a new discourse model gets created, or finally, whether there are multiple discourse models to be considered after the arrival of the new participant.

[11]There is another category of information-status that Prince discusses, namely, that of *inferrables*, and is exemplified by her example in (i):

(i) He passed by *the Bastille* and *the door* was painted purple.

In (i), the hearer does not have a mental representation for the door in question, but the hearer is assumed to *infer* the relation between "the door" and "the Bastille", and evoke the discourse entity for "the door" via this inferred relation.

Prince notes that it is "...difficult to collapse inferrables with any of the mentioned statuses. On the one hand, inferrables are like hearer-old entities in that they rely on certain assumptions about what the hearer does know, e.g., that buildings have doors, and they are like discourse-old entities in that they rely on there being already in the discourse model some entity to trigger the inference. On the other hand, inferrables are like hearer-new entities (and therefore discourse-new) in that the hearer is not expected to already have in his or her discourse model the entity in question." (Prince, 1992)

Because of the problem with classifying inferrables into one or the other informational categories, we will put the study of the referring forms for inferrables outside the scope of this study.

entities in the first sentence. They are discourse-old when they are evoked again in the subsequent sentence.

In investigating correspondences between all of her proposed information-statuses and linguistic form, Prince (1992) notes about the form of discourse-old entities that pronouns are highly probable indicators of this discourse status.[12] However, she also points out that "...while the use of a pronoun probably entails that the entity it represents is discourse-old, an entity's status as discourse-old does not entail that it will be represented by a pronoun" (Prince, 1992). In particular, definite noun phrases of all kinds can be used to evoke discourse-old entities. This point brings us back to our examples (1) and (3) again, where the NP forms used to evoke the discourse-old entities are seen to be either proper names, definite descriptions, pronouns, or null forms.

## 1.3 Discourse Entity Types and the Scope of this Study

We have already noted that we are not focussing on syntax-driven locality constraints on referring expression form (see fn. 1.). In addition, the scope of anaphoric reference in this study is restricted further in the following sense: as noted and described exhaustively in Webber (1978), discourse entities can be of various kinds. They can be representations of objects, individuals, events, states, properties, propositions etc. Furthermore, it is possible to evoke these entities with different types of linguistic expressions, such as noun phrases, verb phrases, sentences, etc. In this study, we will restrict ourselves to entities evoked by noun phrases. Needless to say, a complete understanding of what motivates the variation between all the different forms in any language is obviously desirable, but it is beyond the

[12] Note that pronouns can even be used for inferrables, as shown in (1).

(1) Mix the flour with the water and knead *it*

scope of the current study.

## 1.4 Cognitive Activation and Referring Expression Form

Various approaches and accounts have been proposed within research in discourse interpretation to explain the reference phenomena as described above from the point of view of natural language generation and interpretation. While they differ to varying degrees in the exact formulation of the constraints, they all agree on one key idea, namely, that the use of different forms must be explained in terms of some kind of "cognitive activation". This notion has been given different labels in the literature, such as *prominence*, *activation*, *accessibility*, *focus*, *salience*, etc. However, some of these approaches attempt to establish correlations between reference form and degree of activation that covers reference phenomena more general than the one considered here. The relationship in these approaches is presented as a hierarchy, such as in those of Givón (1983), Ariel (1990), and Gundel et al. (1993). The basic idea of the hierarchy-based correlation proposed by these approaches is that pronominal forms are used for the most highly activated entities in the discourse whereas definite NP forms are used for less activated ones.[13] In this study, we will adopt the notion of cognitive activation explicated in "Centering theory" (Grosz et al., 1983; 1995), which grew out of the work on focusing and discourse structure (Grosz, 1977; Grosz & Sidner, 1986), on focusing for the interpretation of pronouns (Sidner, 1979), and on the relationship between complexity of inference and the (local) discourse structure (Joshi & Kuhn, 1979; Joshi & Weinstein, 1981). Below, we describe the Centering model, how it formalizes the notion of cognitive activation, and how it attempts to account for choices in referring expression form.

[13] See Arnold (1998) and Eckert (1998) for detailed discussion of these approaches.

## 1.5 Centering Theory

### 1.5.1 Discourse Coherence, Cohesive Devices, and Centering

Centering theory is built around the view that aspects relating to the meaning of a discourse can be described in terms of its *coherence*. So in answer to the general question of what it means to understand a discourse, it could be said that a discourse is understood when all parts of the discourse are perceived as related to each other. This perception of connectedness makes the discourse coherent, and when coherence is perceived, the meaning of the discourse is understood. The next question to ask, then, is how is such coherence perceived? That is, what kinds of cohesive devices (Halliday & Hasan, 1976) are used to establish coherence? Also, how are these cohesive devices realized in natural language? Centering theory deals with one kind of cohesive device, namely, *focus/center of attention*. Thus, one kind of coherence is viewed as resulting from the ability to perceive *what a discourse is about*. The theory also deals with the way the focus of attention is realized and perceived linguistically, namely with *referring expressions*. Thus, in keeping with the issues related to discourse coherence mentioned above, the goal of Centering theory is to relate center of attention, choice of referring expression form, and the perceived coherence of utterances in the discourse segment (to be clarified below). The notion of cognitive activation that we discussed in Section 1.4 corresponds to the *center of attention* in Centering. We will show below how this notion of the center of attention is correlated with the form of referring expressions.

The notion of the "discourse segment" comes from the assumption made in Centering theory that discourses have a structure, with three components (Grosz & Sidner, 1986). One of these components, the linguistic structure (the others being intentional structure, and attentional state), serves to divide the discourse into constituent *discourse segments*, which may have embedding relationships between them. Coherence, then, is computed at the level

of the discourse segment, within as well as across the segments. That is, discourse segments exhibit both *local coherence* – i.e., coherence among the utterances in that segment – and *global coherence* – i.e., coherence with other segments in the discourse. The structure determined by attentional state, which is built from the center of attention as a cohesive device, also operates at the local (within the discourse segment) as well at the global level (across discourse segments).

Centering theory is a model of the local-level component of attentional state. As stated above, Centering theory is concerned with establishing the role of the attentional state as a cohesive device, and with explicating the linguistic realization of the attentional state as referring expressions. In addition, Centering theory makes a further claim that coherence is not an absolute property of discourse, but is rather gradable. That is, different discourses may have different degrees of coherence. This idea is based on earlier work (Joshi & Kuhn, 1979; Joshi & Weinstein, 1981) that was the precursor to Centering where the degree of coherence was correlated with the inference load on the hearer, or the perceiver of coherence. Based on this, Centering theory further claims that the structure of the attentional state, as well as the linguistic form of this cohesive realization, with referring expressions, affects the amount of inference load placed on the hearer, and thus also the degree of coherence of the discourse segment.

The idea of attentional state, or the center of attention, relates to the idea that speakers and hearers have their attention centered (or focussed) on certain entities at any given point of the discourse. At the global level, the centered entities, which may be one or more, are those that are relevant to the overall discourse and are determined by the intentional structure of the discourse (Grosz, 1977). At the local level, which pertains to utterance by utterance processing within the discourse segment, speakers' and hearers' attention is centered on a single entity. This centering of attention on a single entity at any given point in the discourse segment is the underlying premise of Centering theory, and it is

also the basis for the focusing model of Sidner (1979) and the model of complexity of inference in Joshi & Kuhn (1979) and Joshi & Weinstein (1981). In Sidner's model, such centering was used as a means to identify the referents of anaphoric expressions, whereas in the complexity model of Joshi et al., centering was used to show how the meaning of an utterance is integrated into discourse meaning.[14]

Centering theory was also motivated by the idea that modeling the center of attention, or the attentional state, allowed for limiting the number of inferences required for discourse interpretation. In Sidner's model, for example, centering was seen as providing a structured source for the interpretation of anaphors, and inference rules were applied in her algorithm only to confirm or reject a selected *co-specifier* (Sidner's term for *antecedent*). Such an approach was crucially contrasted with purely inference based systems (Hobbs, 1976; Charniak, 1972; Reiger, 1974) for anaphor interpretation, in which the process is simply too uncontrolled and complex. Joshi et al. used the notion of centering to determine an almost *monadic* predicate representation of an utterance in discourse which they used to reduce the complexity of inference.

### 1.5.2 Coherence and Attentional State

The relationship between centering of attention and coherence derives from the idea that coherence between utterances in the discourse segment is influenced in part by the degree of continuity in what the segment is about. Each utterance in the discourse segment is "about" one particular entity, and this "being about" one particular entity captures the idea discussed above that speakers' and hearers' attention is centered on one particular entity at any given point. Differences in the coherence of segments is affected by differences in continuity exhibited by successive utterances in terms of their "aboutness" of a given

[14] Sidner actually uses the term *discourse focus* for the centered entity, which was abandoned in its adaptation within Centering theory because of the potential confusion of the term with its other uses in the field.

entity. If successive utterances continue to be about the same entity, they will be more coherent as opposed to successive utterances that shift from being about one entity to another. The examples in (6) and (7) (from Grosz et al. (1995)) illustrate the relationship between coherence and aboutness/centering.

(6) a. **John** went to his favorite **music store** to buy **a piano**.

b. **He** had frequented the store for many years.

c. **He** was excited that he could finally buy a piano.

d. **He** arrived just as the store was closing for the day.

(7) a. **John** went to his favorite **music store** to buy **a piano**.

b. **It** was a store John had frequented for many years.

c. **He** was excited that he could finally buy a piano.

d. **It** was closing just as John arrived.

Discourse (6) is more coherent than discourse (7). Centering explains this difference as arising from different degrees in continuity in what the discourse is about. Discourse (6) centers around a single entity, whereas discourse (7) seems to flip back and forth among several different entities. That is, whereas discourse (6) is clearly about "John", discourse (7) has no single clear center of attention. (7a) seems to be centered on "John", but after that the center seems to shift to "the store" (7b), then back to "John" again (7c), and then again to "the store" (7d). This constant shifting of the center is what makes (7) less coherent compared to (6).[15]

[15]However, note that while shifting the center constantly from one entity to another degrades the coherence of a discourse, maximal coherence in a discourse in a discourse of extended length may be intentionally avoided because it may become monotonous.

### 1.5.3 Coherence and Referring Expression Form

Centering theory also relates the degree of coherence between utterances to the inference load placed on the hearer due to the speaker's choice of linguistic form to realize the same propositional content. Choices in linguistic form have to do with the syntactic form of the utterances as well as the form of referring expressions. According to Centering theory, pronouns and definite descriptions, for example, place different inference demands on the hearer. Consider for example the following discourse (from Grosz et al. (1995)) in (8).

(8) a. **Terry** really goofs sometimes.

b. Yesterday was a beautiful day and **he** was excited about trying out his new sailboat.

c. **He** wanted **Tony** to join him on a sailing expedition.

d. **He** called **him** at 6am.

e. **He** was sick and furious at being woken up so early.

The use of the pronoun in (8e) to refer to "Tony" is confusing. According to Centering theory, this is explained by the fact that through utterance (8d), "Terry" has been the center of attention and hence is the most likely referent of *he* in utterance (8e). It is only when the word *sick* is processed and the inference is made that it is unlikely that "Terry" is the one who is sick (since he is eager to go on a sailing expedition) that the interpretation of the pronoun is shifted from "Terry" to "Tony". A much more natural sequence results if a proper name is used for "Tony", as shown in (9). While the segment still displays low coherence in (9) because of the sudden shift that the hearer needs to make in his/her center of attention from "Terry" to "Tony", it is still better than (8) in that the hearer has to make one less inference, namely, the one related to the interpretation of the pronoun. Furthermore, unlike (8), there is also no garden path resulting from this discourse.

(9) a. **Terry** really goofs sometimes.

b. Yesterday was a beautiful day and **he** was excited about trying out his new sailboat.

c. **He** wanted **Tony** to join him on a sailing expedition.

d. **He** called **him** at 6am.

e. **Tony** was sick and furious at being woken up so early.

Note, however, that the unnaturalness of (8) is due also to the fact that both the entities "Terry" and "Tony" are ambiguous with respect to their grammatical features of person, number and gender. If "Tony" were replaced by a female entity "Antonia", the use of a pronoun in the (e) utterance would be quite natural, as shown in (10).

(10) a. **Terry** really goofs sometimes.

b. Yesterday was a beautiful day and **he** was excited about trying out his new sailboat.

c. **He** wanted **Antonia** to join him on a sailing expedition.

d. **He** called **her** at 6am.

e. **She** was sick and furious at being woken up so early.

According to Centering, such a discourse would still be less coherent than (8) because it would still involve a shift in the center of attention from "Terry" to "Antonia", but Centering does not say anything about why it sounds much better than (9). In Chapter 2, we account for the difference between the three discourses shown here within our generation algorithm.

### 1.5.4 Centering Definitions and Constraints

The basic definitions and assumptions of Centering theory are shown in Figure 1.1.

(1) Each utterance $U_i$ in a discourse segment, $U_1$,...,$U_m$, evokes a set of discourse entities which are called the *forward-looking centers*, $C_f$'s, of that utterance.

(2) Utterances other than the segment initial utterance have a *Backward-looking Center*, $C_b$.

(3) The $C_b$ of an utterance $U_{i+1}$ connects with one of the $C_f$'s of utterance $U_i$.

(4) The set of forward-looking centers, $\{C_f\}$, is *partially ordered* according to discourse salience.

(5) The highest ranked member of $\{C_f\}$ is referred to as the *Preferred Center*, $C_p$ Brennan et al. (1987).

(6) The more highly ranked an element of $\{C_f(U_i)\}$, the more likely it is to be the $C_b(U_{i+1})$.

(7) The most highly ranked element of $\{C_f(U_i)\}$ that is *realized* in $U_{i+1}$ is, by definition, the $C_b(U_{i+1})$.

Figure 1.1: Centering Definitions

The Backward-looking Center represents the discourse entity that the utterance most centrally concerns, and is similar to what has been elsewhere called the *topic* (Strawson, 1964; Reinhart, 1981; Horn, 1986). Centering further stipulates that each utterance $U_i$ has at most Backward-looking Center. This captures the claim of Joshi & Kuhn (1979) and Joshi & Weinstein (1981) that discourses have a *monadic tendency*, i.e., the tendency to be about one thing at a time. This claim has also received psycholinguistic support (Hudson-D'Zmura, 1988; Gordon et al., 1993) in the literature.

The term *realizes* (in Definition 7) is defined as follows[16]: an utterance U *realizes* a center **c** if **c** is an element of the situation described by U, or if **c** is the semantic interpretation of some subpart of U. Thus, the relation *realizes* describes pronouns, zero pronouns, explicitly realized discourse entities, and those implicitly realized centers that are entities

[16]The use of the term draws on notions from situation theory (Barwise, 1999).

inferrable from the discourse situation (Prince, 1981; 1992).

The determination of the Backward-looking Center of an utterance depends crucially on the ranking of the forward-looking centers of the previous utterance in the segment. A number of factors play a role in determining this ranking. We will discuss this point further below. However, it is important to note here that it is the $C_f$ list ranking/ordering that is argued to be the primary basis for the cross-linguistic variation in referring expression form. In the original Centering formulation, which was based on examples from English discourses, it was assumed that the ranking of the forward-looking centers was structurally determined in large part by the grammatical roles of the expressions that realized the centers. In the rest of this section, we will rank the $C_f$ list according to grammatical role for expository purposes.

To capture the relationship between the degree of aboutness (of a single entity) of a discourse segment and the coherence of the segment, Centering defines three types of Transition relations across pairs of utterances, which was later extended to four types in Brennan et al. (1987). We present the extended Transition types below. The Transitions, shown in Table 1.1, are determined by two factors: whether the $C_b(U_{i+1})$ is the same as the $C_b(U_i)$ or not, and whether the $C_b(U_{i+1})$ is the same as the $C_p(U_{i+1})$ or not. The different Transition types capture or reflect the degree(s) to which discourse segments or sequence of utterances continue to be about the same entity. For example, a CONTINUE Transition reflects the fact that speakers center on the same entity across an utterance pair and will most likely continue to center on the same entity in the subsequent utterance. A RETAIN Transition reflects the fact that while being centered on the same entity from one utterance to the next, the speaker's attention will most likely shift to another entity in the subsequent utterance. In a SMOOTH-SHIFT Transition, the speaker actually shifts the center to a different entity than the previous utterance and creates an expectation that s/he will continue to talk about this new entity. Finally, in the ROUGH-SHIFT Transition, the speaker shifts

the center to a different entity than in the previous utterance, but at the same time does not create an expectation of further continuation of centering. ROUGH-SHIFT Transitions have been argued in the literature to be one of the indicators of discourse segment boundaries.

| | $C_b(U_{i+1}) = C_b(U_i)$ OR $C_b(U_i) = [?]$ | $C_b(U_{i+1}) \neq C_b(U_i)$ |
|---|---|---|
| $C_b(U_{i+1}) = C_p(U_{i+1})$ | CONTINUE | SMOOTH-SHIFT |
| $C_b(U_{i+1}) \neq C_p(U_{i+1})$ | RETAIN | ROUGH-SHIFT |

Table 1.1: Transitions in the Centering Model

The use of different types of Transitions are illustrated by the discourse (from Grosz et al. (1995)) in (11).

(11) a. **John**$_i$ has been having a lot of trouble arranging his vacation.

b. **He**$_i$ cannot find anyone to take over his responsibilities.

[$C_b$ = John; $C_f$ = {John, ...}; Tr = CONTINUE]

c. **He**$_i$ called up **Mike**$_j$ yesterday to work out a plan.

[$C_b$ = John; $C_f$ = {John, Mike, ...}; Tr = CONTINUE]

d. **Mike**$_j$ has annoyed **him**$_i$ a lot recently.

[$C_b$ = John; $C_f$ = {Mike, John}; RETAIN]

e. **He**$_j$ called **John**$_i$ at 5 am on Friday last week. (he = Mike)

[$C_b$ = Mike; $C_f$ = {Mike, John, ...}; Tr = SHIFT]

Utterance (11b) establishes "John" as both the $C_b$ as well as the most highly ranked element of the $C_f$ list. In utterance (11c) "John" continues as the $C_b$, but in utterance (11d) he is only retained; "Mike" has become the most highly ranked element of the $C_f$. Finally, in utterance (11e) the Backward-looking Center shifts to being "Mike".

Centering stipulates two constraints, one on center realization and the other on center movement. The first constraint, given below as **Rule 1**, is the only constraint in Centering theory that explicitly influences the choice of reference form.

- **Rule 1:** If some element of $C_f(U_i)$ is realized as a pronoun in $U_{i+1}$, then so is the $C_b(U_{i+1})$.

This constraint stipulates that no element in an utterance can be realized as a pronoun unless the Backward-looking Center of the utterance is realized as a pronoun also. Rule 1, sometimes called the pronoun rule, represents one function of pronominal reference: the use of a pronoun to realize the $C_b$ signals to the hearer that the speaker is continuing to talk about the same thing. Note that Rule 1 does not preclude using pronouns for other entities so long as the $C_b$ is realized with a pronoun.

From Rule 1 it follows that if there are multiple pronouns in an utterance (both of which realize entities from the previous utterance), then one of these must be the $C_b$. It also follows from this same rule that if there is only one pronoun in an utterance, then this pronoun must be the $C_b$.

A violation of Rule 1 occurs if a pronoun is not used for the Backward-looking Center when some other entity is realized by a pronoun. Such a violation occurs in the following sequence in (12), which is presumed to be in a longer segment currently centered on John.

(12) a. **He**$_i$ has been acting quite odd lately.

[$C_b$ = John (*he*); $C_f$ = {John}]

b. **He**$_i$ called up **Mike**$_j$ yesterday.

[$C_b$ = John; $C_f$ = {John, Mike}; Tr = CONTINUE]

c. **John**$_i$ wanted to meet **him**$_j$ urgently.

[$C_b$ = John; $C_f$ = {John, Mike}; Tr = CONTINUE]

The violation of Rule 1 leads to the incoherence of the sequence. The only possible interpretation is that the "John" referred to in (12c) is a second person named *John*, not the one referred to earlier in the sequence. However, even under this interpretation the sequence is very odd.

It is important to realize that Rule 1 constrains the realization of the most highly ranked element of the $C_f(U_i)$ *that is realized in* $U_{i+1}$ *given that pronominalization is used*. Obviously any entities realized in $U_i$ that are not realized in $U_{i+1}$, including the $C_b(U_i)$ as well as the highest ranked element of $C_f(U_i)$, do not effect the acceptability of Rule 1. Likewise, if no pronouns are used, then Rule 1 is not applicable.

The second constraint is given by **Rule 2** below:

- **Rule 2:** Sequences of continuation are preferred over sequences of retaining, and sequences of retaining are to be preferred over sequences of shifting.

Rule 2 reflects the intuition that continuation of the center and the use of retentions when possible to produce smooth transitions to a new center provides a basis for local coherence. In a locally coherent discourse segment, shifts are followed by a sequence of continuations characterizing another stretch of locally coherent discourse. Frequent shifting leads to lack of coherence as was illustrated by the contrast between Discourse (6) and Discourse (7).

## 1.6 Outline of the Dissertation

Our first goal in this thesis, which is subject of Chapter 2, is to discuss the limitations of Centering theory in terms of providing an explanation for a wide range of alternations in the use of referring expression forms. As we discussed in Section 1.5.3, the only constraint on referring expression form formulated within Centering theory is in the encoding of Rule 1. However, this rule can only be applied to a restricted set of cases. The goal of this chapter is to explicitly specify constraints on the generation of referring expressions. These constraints borrow ideas only implicitly stated in Centering theory and also draw on ideas relating to Gricean principles of interpretation (Grice, 1975). In doing this, we are interested in showing that these constraints can be applied to understanding referring

expression phenomena in a wide variety of cases. In addition, the constraints can also be used for modeling referring expressions in generation systems. And finally, as we will see in the remaining chapters, they can also be applied to specify general and language-specific parameters within Centering theory so that the theory can itself then be usefully applied to different languages.

In Chapter 3, we present a study of referring expressions in Hindi. Languages have been shown to vary with respect to the constraints that govern the use of referring expressions, and one of the sources of variation lies in the different means that languages have at their disposal for the marking of discourse salience. In other words, we need to determine how to rank the forward-looking centers list of an utterance at any given point of the discourse. Centering constraints, as well as the generation constraints that we formulate in Chapter 2, can only be applied to a language after this language-specific parameter has been set. In this chapter, we first present a corpus-based language-independent methodology that will allow us to identify the structural linguistic factors that determine the relative salience of discourse entities in an utterance. The methodology exploits a specific formulation of Rule 1 of Centering without being circular in its application. We apply this method to a Hindi corpus and investigate the effect of three factors on discourse salience: *grammatical role*, *word order*, and *information status*. The results of our study show that Hindi, despite being a free-word order language, does not display any effect of word order on salience. Free word order in languages like German has been argued to have an effect on salience (Rambow, 1993). Our results thus bring out a significant contrast between Hindi and German, in that it calls for viewing scrambling or other word order phenomena across the two languages differently, at least to the extent that the same syntactic form does not necessarily map onto the same discourse function in the two languages. Information status has also been argued, most notably in Strube (1998), to affect discourse salience. The initial results in Strube (1998) were based on evidence from German, and was later extended to be a

universal factor. However, results from our Hindi corpus show that the information status of discourse entities does not exhibit any salience affecting characteristics, suggesting a reassessment of the universality claim with respect to information status. For Hindi, then, grammatical role emerges as the most significant factor.

In the same chapter, following the results obtained from the application of the methodology above, we use the grammatical role as the primary ranking in Hindi to provide an analysis of the use of Hindi zero pronouns. Contrary to earlier proposals, we argue that the constraints on the use of zeros in Hindi are neither syntactic (Kameyama, 1985), nor explicable purely in terms of the singular notion of the topic, especially one that is defined syntactically (Butt & King, 1997). Our study is conducted within the Centering framework, using the Hindi-specific ranking results, and the analysis is provided in terms of Centering Transition preferences. We show that pronouns can be dropped in Hindi only when they occur in an utterance following a CONTINUE or a SMOOTH-SHIFT Transition, thus demonstrating the importance of the preferred center, the $C_p$, for zero pronoun realization. We also formulate a *zero pronoun rule* that must be used in tandem with the rules for overt pronoun interpretation or generation in Hindi.

In conducting the corpus analysis to identify the linguistic determinants of salience, one of the first issues we faced was that of specifying the utterance unit for local discourse processing. In the model of discourse interpretation that is assumed here, discourses are composed of utterances and discourse entities are added to the discourse representation when the utterance they are part of is syntactically and semantically processed. The question then is, what constitutes the utterance? Is it the sentence, or some smaller unit like the tensed clause? Is the representation of the utterances in the discourse model hierarchical? If so, what determines the hierarchical discourse representation of the ongoing discourse? These are issues that have been explored extensively in previous research. However, there is no consensus yet reached. In order to continue with the work presented in this thesis,

however, we adopted what we believed to be the correct results from the literature, with different assumptions coming from different research sources. In Chapter 4, however, we present an analysis of the utterance status of complex sentences containing relative clauses since no extensive work on relative clause containing sentences is available (except for suggestions made in Kameyama (1998) and Hurewitz (1998)). With respect to relative clause sentences, we argue that different kinds of relative clauses have different effects on the hierarchical organization of discourse segments. Using anaphoric evidence from discourse, we first show that non-restrictive relative clauses pattern differently from restrictive relative clauses, and we argue that non-restrictives, but not restrictives, should form a *distinct* but embedded utterance unit. For restrictive relative clauses, however, we motivate a further partitioning between indefinite head restrictives and definite head restrictives, so that the indefinite head restrictives are grouped together with the non-restrictives with respect to their utterance status, i.e., as forming a distinct but embedded utterance unit. Our approach towards the treatment of relative clauses in discourse is in line with the approach seen in syntactic accounts (Demirdache, 1991) and other discourse accounts (Prince, 1990) of relative clauses for English and Yiddish.

# Chapter 2

# Formulation of Constraints for Generating Referring Expressions

In Chapter 1, we described the Centering model (Grosz et al., 1983; 1995), discussing how the model formalizes the notion of cognitive activation as the attentional state of speakers and hearers and establishes relationships between attentional state and discourse coherence on the one hand and between discourse coherence and the form of referring expressions on the other hand.

Apart from the Rule 1 constraint, however, Centering does not explicitly tell us much more about how speakers are guided in their use of referring expression forms. Rule 1 imposes a constraint on the form of the Backward-looking Center in a restricted set of contexts:

- **Rule 1 Constraint on Referring Expression Form:**
  If some element of $C_f(U_i)$ is realized as a pronoun in $U_{i+1}$, then so is the $C_b(U_{i+1})$.

Rule 1 makes the prediction that, in the discourse in (13), (13ci) sounds much better than (13cii). (13cii) is less coherent since the Backward-looking Center, "John", is not

pronominalized whereas some other entity, “Mike”, is. It is important to note that both (13ci) and (13cii) instantiate a CONTINUE Transition, so that the Rule 1 constraint in this case operates independently of the type of Transition.

(13) a. **He**$_i$ has been acting quite odd lately. (He$_i$ = John)

[C$_b$ = John (*he*); C$_p$ = John]

b. **He**$_i$ called up **Mike**$_j$ yesterday.

[C$_b$ = John (*he*$_i$); C$_p$ = John; Tr = CONTINUE]

c. i. # **John**$_i$ wanted to meet **him**$_j$ urgently.

[C$_b$ = John; C$_p$ = John; Tr = CONTINUE]

ii. **He**$_i$ wanted to meet **him**$_j$ quite urgently.

[C$_b$ = John (*He*$_i$); C$_p$ = John; Tr = CONTINUE]

In this chapter, we develop an algorithm for generating referring expression forms used in natural language discourse. We will start with specifying primitive constraints in terms of Gricean principles (Grice, 1975) and then show how the Centering principles, in particular Rule 1 and Definition 6, can be added naturally to these primitive constraints. Our approach is meant to present a comprehensive account of how referring expression forms are used in natural language discourses. Ultimately, we explicitly formulate an algorithm for generating referring expression forms based on the Centering principles. The constraints specified in the algorithm are much wider in the domain of their application than Rule 1. The domain of application of the algorithm is defined in terms of Centering Transition sequences. The algorithm is designed in such a way as to be useful for generation systems, while keeping structural and inferential mechanisms neatly distinct.

## 2.1 Gricean Principles and Anaphoric Usage

According to Grice (1975), communication is driven by a cooperative effort on the part of discourse participants, such that they attempt to convey what they mean in the most optimal way. Underlying this general *cooperative principle* are more specific rules that are argued to be characteristic of linguistic utterances. Grice groups them into the four maxims of *quantity*, *quality*, *relation* and *manner*. For our purposes, the first and the last are most relevant for referring expression forms and are given in (14) and (15).

(14) **Maxim of Quantity:**

a. Make your contribution as informative as is required.

b. Do not make your contribution more informative than is required.

(15) **Maxim of Manner:**

a. Avoid obscurity and ambiguity.

These two maxims can be seen to function in the way speakers use anaphoric expressions (as in other dimensions of communication), and for each of the maxims, the rules can be formulated more precisely to show how they work in the domain of discourse anaphora. The "quantity" principle is reformulated in (16):

(16) **The Maxim of Quantity in Anaphoric Usage:**

Use the non-informative pronominal form to refer to an entity when

a. its reference can be unambiguously determined and

b. when no additional information needs to be conveyed about the entity (that can be conveyed through a descriptive noun phrase).

(16a) follows from (14b) and is able to account for the oddness of the repetition of the proper name *Billy* in (17b). Since there is no other entity in this simple discourse that the

pronoun *he* could refer to, and because the speaker can be certain that the hearer will be able to determine its interpretation, the choice of the pronoun to refer to "Billy" turns out to be the form that is no more informative than necessary.[1]

(17) a. **Billy**$_i$ knocked on the door.

b. **He**$_i$**/#Billy**$_i$ rang the bell.

c. But no one answered.

(16b) is a specific case of (14a) is instantiated in cases like (18b), with the use of the definite description *the snarling beast*. The use of the pronoun instead would have been just as sufficient for identifying the entity to which it refers, but the speaker chooses to use a more informative expression. However, rather than constituting a violation of the quantity maxim, this kind of over-informativeness actually has a particular function. It is often the case that speakers use the alternative definite description form to convey additional information to the hearer. In this example, the definite description is used because the speaker intends the hearer to acquire more knowledge about the particular dog in question, and to make an additional inference, namely, that something unpleasant is in the offing. (18c) confirms this inference.[2]

(18) a. Susan looked at **the dog**$_i$.

b. **The snarling beast**$_i$**/It**$_i$ was approaching her slowly.

c. She quickly decided to step into the store.

[1] In languages such as Japanese, which allows unrestricted use of zero pronominals, a zero pronoun would be used for the unambiguous reference (Kameyama, 1985).

[2] This example is adapted from Grosz et al. (1995), who also note this kind of over-informativeness:

i. **My dog**$_i$ is getting quite obstreperous.
ii. I took **him**$_i$ to the vet the other day.
iii. **The mangy old beast**$_i$ always hates these visits.

The maxim of manner comes into play when multiple entities compete for the interpretation of anaphoric forms. As a first approximation, the reformulation of this maxim for anaphoric use can be stated as follows:

(19) **Maxim of Manner for Anaphoric Usage: First Version**

a. Use more informative form(s) of reference when more than one entity qualifies as the interpretation of the pronominal form(s) (where satisfying person, number, gender (etc..) features of the pronoun counts as "qualifying").

Simply read, what this rule says is that if more than one entity can match the grammatical features of the pronominal form, then the use of the pronoun is not felicitous and a more informative form of reference must be used. However, this behavior is not consistently observed in naturally occurring discourse. For example, in (20d), the pronoun *they* is used even though both "field mice" and "wax and paraffin", evoked in (20c), qualify as its referents. A similar scenario is seen in (21), where both "a rat" and "a package of bread", evoked in (21a), qualify as referents of the possessive pronoun in (21b), and in (22), where "a gust", "the lake" as well as "the framed glass", evoked in (22a), qualify as referents of the pronoun in (22b). In all these examples, the less informative pronominal form is used despite the apparent ambiguity of reference, thus violating the maxim of manner stated above. Notice, also, that in each case, the use of the pronoun is perfectly natural and interpretable.

(20) a. and Herzog sometimes wiped mouse droppings from the table with his sleeve,

b. calmly wondering why **field mice**$_i$ should have such a passion for **wax and paraffin**$_j$.

c. **They**$_i$ gnawed birthday candles down to the wicks.

*Saul Bellow; Herzog*

(21) a. **A rat**$_i$ chewed into **a package of bread**$_j$,

b. leaving the shape of **its**$_i$ body in the layers of slices.

*Saul Bellow; Herzog*

(22) a. **A gust**$_i$ from **the lake**$_j$ made **the framed glass**$_k$ tremble in Herzog's arms.

b. He propped **it**$_k$ carefully against the porch and took off his canvas gloves but not his beret, . . .

*Saul Bellow; Herzog*

On the other hand, examples (23)-(24) below show the Manner Maxim being respected in that more informative forms of expression are used in case of ambiguity.

(23) a. **Herzog**$_i$ wrote to Chicago about jobs.

b. **He**$_i$ had to find a position for **Valentine Gersbach**$_j$, too.

c. **Valentine**$_j$ was a radio announcer, a disk-jockey in Pittsfield.

*Saul Bellow; Herzog*

(24) a. **A frowzy doorman**$_i$ let **Herzog**$_j$ into the crumbling vault of the lobby.

b. **Herzog**$_j$ undressed in the examining room – a troubled, dire green.

*Saul Bellow; Herzog*

The conflicting patterns seen in the examples above seem to suggest that the Manner Maxim as formulated above cannot be correct. However, a closer look at the discourses reveals a behavior that is in fact consistent and requires only a refinement of the maxim. Notice that, in each of the final utterances in (20)-(22) in which the pronominal form is used, there is some additional information available in the same utterance that helps to disambiguate the reference of the pronoun. In (20c), it is the lexical semantic information

associated with the main verb *gnawed* which the hearer uses together with his/her repository of world knowledge to determine that "mice" but not "wax" or "paraffin" are gnawing things. In (21b), it is the head noun (of the possessive pronoun) *body*, which again triggers a world knowledge inference on the part of the hearer to determine that "rats" and not "packages of bread" have bodies. Finally, in (22b), the verb *propped* triggers the inference that "framed glasses" and not "gusts" or "lakes" can be propped against something. In Examples (23)-(24) on the other hand, no inference seems to be easily triggered by any element in either (23b) or (24b) if the proper name is replaced with a pronoun. Based on this distinction between the two sets of examples, we can make a refinement to the first version of the Manner Maxim as shown in (19) by adding another clause to it, clause (b), to give (25):

(25) **Maxim of Manner for Anaphoric Usage: Revised Version** Use more informative form(s) of reference

   a. when more than one entity qualifies as the interpretation of the pronominal form(s) (where satisfying person, number, gender (etc..) features of the pronoun counts as "qualifying"), and

   b. when no other aspect of the utterance in which the referring expression occurs provides additional information to help the hearer in disambiguating the expressions.

Let us now see whether the revised maxim allows us to account for certain other kinds of discourses, namely those in which more than one discourse entity mentioned in an utterance is spoken of in the following one. If the entities are grammatically ambiguous in the first utterance in which they are realized, then pronominal forms used to refer to each of them in the subsequent utterance would be ambiguous. According to the maxim as stated above, then, the speaker would be under an obligation to use more informative forms of expression

to facilitate understanding by the hearer. Furthermore, by the Maxim of Quantity as stated in (16), we would also expect the speaker *not* to be more informative than required. And one way in which this expectation could be met is by the use of over-informativeness with respect to only one of the entities, which would be just the sufficient amount of contribution. This behavior is indeed found in naturally-occurring discourse. Consider (26) in which the speaker uses a definite description *the old man* in (26b) to refer to "Herzog's father". Both "Herzog" and "Herzog's father" are evoked in (26a) and again in (26b). Using pronouns to refer to the entities would have led to an ambiguity, and the hearer either would not be able to interpret the pronouns, or else would assign them the incorrect interpretation. The same situation is seen in (26c), in which the more informative proper name for one of the entities is used to avoid ambiguity or incorrect referent assignment.

(26) a. **Herzog**$_i$ was broke, and asked **his father**$_j$ to underwrite a loan.

b. **The old man**$_j$ questioned **him**$_i$ narrowly, about **his**$_i$ job, **his**$_i$ expenses, **his**$_i$ child.

c. **He**$_j$ had no patience with **Herzog**$_i$.

*Saul Bellow; Herzog*

The Gricean maxims discussed above thus seem to be respected even in these more complex discourses in which several entities are talked about at once over successive utterances. The question to be asked next is whether, in the case of ambiguities such as those shown in (26), there is any constraint that forces the speaker to be over-informative with certain kinds of entities and not others. For instance, in (26b), why did the speaker choose to be more descriptive when referring to "Herzog's father" (*the old man*) and not when referring to "Herzog" (*him*)? Similarly, does anything govern the opposite choice for over-informativeness in (26c)? The Maxims that we have formulated cannot answer this question and we must therefore look elsewhere for an explanation of how the referring ex-

pression forms have been used. In fact, this is where Rule 1 of Centering comes into play. Using the ranking of entities by grammatical function for English, the Backward-looking Center of (26b) is "Herzog" and that of (26c) is "Herzog's father". According to Rule 1, if anything is realized as a pronoun, then it must be the Backward-looking Center. As a result, when the speaker makes a choice to use a more informative expression for one of the entities in either utterance, s/he can only do so with the entity that is *not* the Backward-looking Center.

So we have shown in the above discussion how we can formulate the constraints on the choice of referring expression forms comprehensively by starting out with primitive constraints stated in terms of Gricean principles and adding on Rule 1 to these principles. In the next section, we proceed to the main goal of this Chapter, which is to explicity formulate an algorithm for generating referring expressions that are wider in their domain of application than Rule 1.

## 2.2 Center-movement and Center-realization based Algorithm for Referring Expression Generation

Apart from the formulation of Rule 1, there is no other explicit formulation of a constraint on the use of referring expression forms. To some extent, this lack is justified since all other constraints if formulated can only be stated as preferences and do not operate in discourse as strictly as Rule 1.[3] However, there is one suggestion in the Centering model of how speakers may choose forms to realize entities. This suggestion was illustrated with example (8 - Chapter 1), repeated here as (27).

(27) a. **Terry**$_i$ really goofs sometimes.

[3]Centering in fact claims that even Rule 1 can be violated.

b. Yesterday was a beautiful day and **he**$_i$ was excited about trying out his new sailboat.

c. **He**$_i$ wanted **Tony**$_j$ to join him on a sailing expedition.

[$C_b$ = Terry (*he*$_i$); $C_p$ = Terry; Tr = CONTINUE]

d. **He**$_i$ called **him**$_j$ at 6am.

[$C_b$ = Terry (*He*$_i$); $C_p$ = Terry (*him*$_j$); Tr = CONTINUE]

e. i. **He**$_j$ was sick and furious at being woken up so early.

[$C_b$ = Tony (*he*$_j$); $C_p$ = Tony; Tr = SMOOTH-SHIFT]

ii. **Tony**$_j$ was sick and furious at being woken up so early.

[$C_b$ = Tony; $C_p$ = Tony; Tr = SMOOTH-SHIFT]

As discussed before, the use of the pronoun in (27ei) to refer to "Tony" is confusing because "Terry" has been the center of attention through utterance (27d) and is also the most likely referent of *he* in utterance (27e) since it is the Preferred Center in (27d). If the pronoun is replaced by the full NP *Tony*, this confusion is avoided, as in (27eii). The natural language discourses in (28) and (29) show that speakers avoid using pronouns in such contexts, i.e., where a Non-preferred Center in an utterance is realized as the $C_b$ and $C_p$ of the subsequent utterance, thus marking a SMOOTH-SHIFT Transition. In both (28b) and (29e), "Bateman" is a Non-preferred Center and when the speaker shifts the center to "Bateman" in the subsequent utterances, (28ci) and (29fi) respectively, the form used to realize the entity is a full NP, even though no other entity is realized from the previous utterances. Furthermore, the use of a pronoun in both cases leads to the wrong interpretation, as seen in (28cii), where the pronoun would incorrectly refer to "Edward", and in (29fii), where the pronoun would incorrectly refer to "Jackson".

(28) a. **Edward** slipped on a coat

b. and, putting on **his** hat, accompanied **Bateman** out of the store.

[$C_b$ = Edward (*his*); $C_p$ = Edward; Tr = CONTINUE]

c. i. **Bateman** attempted to put the matter facetiously.

[$C_b$ = Bateman; $C_p$ = Bateman; Tr = SMOOTH-SHIFT]

ii. # **He** attempted to put the matter facetiously.

*Somerset Maugham; The Fall of Edward Bernard*

(29) a. **Arnold Jackson's** remark seemed to have aroused in him a train of recollections,

b. for **he** began to talk of his prison days.

[$C_b$ = Jackson (*he*); $C_p$ = Jackson; Tr = CONTINUE]

c. **He** talked quite naturally, without malice,

[$C_b$ = Jackson (*he*); $C_p$ = Jackson; Tr = CONTINUE]

d. as though **he** were relating his experiences at a foreign university.

[$C_b$ = Jackson (*he*); $C_p$ = Jackson; Tr = CONTINUE]

e. **He** addressed himself to **Bateman**

[$C_b$ = Jackson (*he*); $C_p$ = Jackson; Tr = CONTINUE]

f. i. and **Bateman** was confused and then confounded.

[$C_b$ = Bateman; $C_p$ = Bateman; Tr = SMOOTH-SHIFT]

ii. # and **he** was confused and then confounded.

*Somerset Maugham; The Fall of Edward Bernard*

Two points are to be noted with the above examples. First, unlike (27ei), where the hearer could have still interpreted the pronoun correctly based on additional inferences available later on in the utterance, namely the inference that "Terry" could not possibly have been sick, no such inference is easily available in (28cii) and (29fii).[4] At the same time, like

[4]There is a slight possibility of an inference obtaining from (29fii). The writer has been talking about Arnold Jackson relating his experiences in a totally relaxed manner so that it is unlikely that it is Jackson

(27ei), naturally occurring discourses provide ample evidence of a pronoun being used to realize a Non-preferred Center of the previous utterance if there is some structural or inferential information available in the utterance that will allow the hearer to assign the correct interpretation to the pronoun – though this will still place increased inference demands on the hearer. (30) supplements the constructed Centering example to show that speakers do indeed capitalize on inferential information to violate expectations. The relevant utterance is (30f) in which a subject pronoun is used to realize a Non-preferred Center from (30e), namely, "Constantine" (the Preferred Center being "Enver"). The inference that very easily yields the correct interpretation for the pronoun is that the speaker has been talking earlier (in (30a)) about "Constantine" as the person who's going to be traveling, and since there is no mention of "Enver" as having anything to do with traveling, the hearer is able to assign "Constantine" as the interpretation of the pronoun when s/he encounters the travel related verbs *sailing* and *landing*.

(30) a. . . . a man called **Constantine Andreadi**$_i$ is on his way from Constantinople with certain documents that we want to get hold of.

b. **He's**$_i$ a Greek.

[$C_b$ = Constantine (*He's*$_i$); $C_p$ = Constantine; Tr = CONTINUE]

c. **He's**$_i$ an agent of **Enver Pasha**$_j$

[$C_b$ = Constantine (*He's*$_i$); $C_p$ = Constantine; Tr = CONTINUE]

d. and **Enver**$_j$ has great confidence in **him**$_i$.

who would be then confused or confounded. However, notice that it is quite possible to imagine a context in which something does lend to Jackson's confusion as for example, Bateman's rude behavior in the following possible continuation of (29).

(i) **He**$_i$ addressed himself to **Bateman**$_j$

(ii) and **he**$_i$ was confused and then confounded because Bateman seemed to have completely ignored everything he had just related.

[$C_b$ = Constantine (*him*$_i$); $C_p$ = Enver; Tr = RETAIN]

e. **He's**$_j$ given **him**$_i$ verbal messages that are too secret and too important to be put on paper.

[$C_b$ = Enver (*He's*$_j$); $C_p$ = Enver; Tr = SMOOTH-SHIFT]

f. **He's**$_i$ sailing from the Piraeus, on a boat called the Ithaca, and will land at Brindisi on his way to Rome.

[$C_b$ = Constantine (*He's*$_i$); $C_p$ = Constantine; Tr = SMOOTH-SHIFT]

*Somerset Maugham; The Hairless Mexican*

Examples (27) and (30) show how inferences that can be easily derived from utterances can lead to a violation of expectation and thus to the use of pronouns which would have otherwise been infelicitous. In addition to inferential information, there are also structural aspects that lead to a violation of expectation in the choice of referring expression forms. The simplest type of such structural features is grammatical markings for person, number, gender, and sortal features (for languages that have them). For example, gender and number markings on pronouns in English are one source of structural information that allows Non-preferred Centers to be realized as pronouns. Gender and number disambiguation is shown in (31c) and (32b) respectively.

(31) a. For a little while **Doris**$_i$ did not speak.

b. **She**$_i$ was surprised at **her husband's**$_j$ tone.

[$C_b$ = Doris (*She*$_i$); $C_p$ = Doris; Tr = CONTINUE]

c. **He**$_j$ spoke tersely.

[$C_b$ = Doris's husband (*He*$_i$); $C_p$ = Doris's husband; Tr = SMOOTH-SHIFT]

*Somerset Maugham; The Force of Circumstances*

(32) a. And on **their**$_i$ way home **they**$_i$ met **her**$_j$ strolling towards the quay. (their, they = Mrs. Davidson and Mrs. Macphail; she = Miss Thompson)

[$C_b$ = Mrs. Davidson and Mrs. Macphail (*their*$_i$, *they*$_i$); $C_p$ = Mrs. Davidson and Mrs. Macphail; Tr = CONTINUE]

b. **She**$_j$ had all her finery on.

[$C_b$ = Miss Thompson (*She*$_j$); $C_p$ = Miss Thompson; Tr = SMOOTH-SHIFT]

*Somerset Maugham; Rain*

The second point to be noted about (28) and (29) is that Rule 1 does not apply in either case since the final utterances realize only one of the entities from the previous utterances in their respective discourse segments. Furthermore, according to Definition 7 in Centering (see Figure 1.1), these entities are the backward-looking centers of their utterances since *they are the maximally salient entities from the previous utterance realized in the current utterance*. As such, Rule 1 does not apply here and the speaker is free to use a pronoun to realize these Backward-looking Centers. The constraints that we want to formulate should answer the question as to when and why the speaker chooses to use a full noun phrase instead of a pronoun for these Backward-looking Centers. We will suspend formulation of the constraints until later because as it will turn out, many more types of cases can be accounted for by these constraints. For now, we provide an explanation of the tendency seen in the above examples.

What is distinctive about the examples in (28) and (29) is that only one of the entities from $U_i$ ((28b) and (29e)) has been realized in $U_{i+1}$ ((28c) and (29f)) and that this is a non-preferred center. In Centering, a corollary of Rule 1 and Definition 6 are sufficient to explain the use of the definite description in these examples. The Rule 1 corollary and Definition 6 (see Figure 1.1) are presented below.

- *Rule 1 corollary:* if there is a single pronoun in an utterance $U_i$, then it is the Backward-looking Center of $U_i$.

- *Definition 6:* The more highly ranked an element of $\{C_f(U_i)\}$, the more likely it is to be the $C_b(U_{i+1})$.

Definition 6 captures the idea that the Preferred Center in $U_i$ is the entity that is most likely to be the Backward-looking Center of $U_{i+1}$. This preference has implications both for how hearers tend to interpret pronouns as well as for how speakers generate the referring expressions. In the examples above in particular, in the absence of any evidence to the contrary, hearers will tend to interpret a single pronoun in an utterance as referring to the Preferred Center of the previous utterance. Speakers, on the other hand, will tend to use full noun phrases to realize Backward-looking Centers that are not the Preferred Center of the previous utterance.

The Centering model, while suggesting an indication of a constraint on referring expression form in such contexts, never actually formulated it. It seems, however, that given the tendency found in naturally occurring discourses, we can indeed formulate constraints on reference form for such contexts.

In Figure 2.1, the entity-centering expectations are stated and the constraints are formulated as based on center-realization and center-movement (CR-CM). The specified constraints hold for a much wider range of cases than the ones considered above. We will first explain the above examples in terms of the CR-CM algorithm and then discuss other cases.

Note that C1a and C1b are mutually dependent constraints and that C2 is a constraint that operates exclusively of C1a and C1b. E1 is a restatement of the underlying idea of Definition 6 which we discussed above. E2 captures the idea, again inherent in Centering, that in the absence of any contrary evidence, hearers will expect the speaker to keep talking about the same entity. This is the expectation for maximal continuity in the discourse segment which lends to maximal coherence. We discussed this at length in Chapter 1, Section 1.5.2. In terms of the Centering Transition definitions, maximal continuity is obtained with CONTINUE Transitions, which implies that the backward-looking centers of all the

**Center-realization and Center-movement based Algorithm for Generating Referring Expression Forms**:

*Expectations:* (hearer-based)

**(E1):** the speaker will realize the Preferred Center of $U_i$ as the Backward-looking Center of the subsequent utterance $U_{i+1}$, and

**(E2):** the speaker will continue to center this entity thereon from $U_{i+1}$.

*Constraints:* (speaker-based)

**(C1a):** If $U_{i+1}$ indeed conforms to expectations (E1) and (E2), use pronouns for the entities realized from $U_i$ to $U_{i+1}$ just in case no additional inference needs to be conveyed with a more descriptive expression;

**(C1b):** else, use a descriptive noun phrase for one (or more) entity (or entities) to the extent that the hearer does not assign an interpretation to some pronoun following E1 and E2, but just in case no structural or inferential disambiguation is possible.

**(C2):** Where applicable, do not violate Rule 1 after C1a or C1b are applied.

**(C3):** After the application of C1b (if it applies), if additional inferences need to be conveyed that can be derived from the remaining pronouns, use more descriptive noun phrases for those pronouns where appropriate

Figure 2.1: Center-realization and Center-Movement (CR-CM) Algorithm for Referring Expression Form Generation

utterances in the segment will end up also being the Preferred Center of their utterances. Of course, this is only an expectation: discourse segments are most often not maximally coherent in terms of the Centering Transitions. What is crucial to note, however, is that this expectation influences the choices in referring expression form. In the examples that we looked at above, E2 does not apply because the Preferred Center was not continued as the center at all, so the question of expectations of further continuation of the center in subsequent utterances does not arise. E2 will, however, apply in other cases that we will look at later.

The constraint C1a says that if the expectations E1 and E2 are met, pronouns can be used to realize the centers. However, C1a contains a conditional clause (*just in case no additional inference needs to be conveyed with a more descriptive expression*) that requires explanation. This has to do with the fact that descriptive referring expressions are not just used to respect the Centering principles and constraints. Often, more descriptive forms may be used even for Backward-looking Centers that were the Preferred Center of the previous utterance, or in the more general case, in instances where both expectations E1 and E2 are met. Centering theory recognizes such uses of referring expressions and states that such expressions do more than just refer. That is, they convey some additional information and thus lead the hearer to draw additional inferences that would not have been obtainable otherwise. We saw an example of such a case in (18).

Constraint C1b captures the relationship between inference demands that are placed on hearers via the use of referring expressions. If the expectations in E1 and E2 are not met, and if pronouns are used to realize the centers, hearers will most likely start with assigning incorrect interpretation(s) to the pronoun(s) following their expectations and will be forced to make additional inferences later on during utterance processing. The constraint on the generation of referring expressions attempts to avoid this additional inference by specifying that the speaker use more descriptive forms for one or more entities to inform the hearer that his/her expectation is not being met and that s/he should change interpretation assignments accordingly. Of course, as the conditional clause of the constraint specifies, the application of the constraint varies depending how much inferential information might be already inherent in the utterance to allow the hearer to easily change his/her interpretation. We discussed such examples in (30-32).

Rule 1 in C2 applies after C1a or C1b is applied, but in a restricted set of cases, namely, where more than one entity is realized from $U_i$ to $U_{i+1}$. Note that if the conditional clause in C1a applies, and that if, following this, Rule 1 applies, then we have an interesting

prediction. Namely, if the speaker intended to trigger some additional inference by using a descriptive noun phrase for the backward-looking center, then the only way the speaker could generate the utterance without violating Rule 1 is to also use a descriptive noun phrase for the entity or entities that is (or are) not the backward-looking center(s).

Finally, C3 applies after (and if) C1b has been applied. This constraint accounts for cases in which none of the evoked entities are realized as pronouns. It takes care of the speaker's intention to convey more information about an entity than would conveyed by merely using a pronoun. Note that a similar constraint applies in C1a (with the highest conditional clause) but that C1a and C1b are mutually exclusive constraints.

We now explain the examples in (28) and (29) in terms of the CR-CM algorithm. In (28b), "Edward" is the preferred center and, according to E1, should be the Backward-looking Center of (28c). The speaker, however, does not realize "Edward" in (28c) at all, instead realizing the Non-preferred Center "Bateman". C1a now does not hold, so the speaker is constrained to use a proper name to realize "Bateman", since no inference would be available with the use of a pronoun. Similarly, in (29f), the Non-preferred Center of the previous utterance is the only entity that is realized in (29), and in the absence of any easily available inference for the interpretation of a pronoun, we see the speaker's obligation to use a proper name being realized.

## 2.3 Centering Transition Sequences and the CR-CM Algorithm

In the CR-CM algorithm formulated in the previous section, the main expectation that was proposed for the choices in referring expression form was that the Preferred Center of an utterance is most likely to be the Backward-looking Center of the subsequent utterance, and that the speaker is most likely to continue to center this entity. Constraints on referring

expression form were then specified as following from these expectations. However, the examples that were explained in terms of the algorithm, while being naturally occurring examples, do not convey to what extent the CR-CM algorithm can be applied. In this section, we define the domain of the algorithm's application in terms of the Centering Transition sequences. This strategy allow us to apply the algorithm as exhaustively as possible to the extent that the Centering Transitions completely characterize the Transitions occurring in discourse segments. In the examples in the previous section, we looked at the Transition sequence CONTINUE > SMOOTH-SHIFT (> indicates precedence). The four Transitions defined in Centering in fact allow us to postulate 16 different types of Transition sequences. These are given in Figure 2.2. The sequences are generated as a simple permutation on the four Centering Transitions and yield a 4x4 matrix.

| | | | |
|---|---|---|---|
| CONT > CONT | CONT > RET | CONT > SM-SH | CONT > RGH-SH |
| RET > CONT | RET > RET | RET > SM-SH | RET > RGH-SH |
| SM-SH > CONT | SM-SH > RET | SM-SH > SM-SH | SM-SH > RGH-SH |
| RGH-SH > CONT | RGH-SH > RET | RGH-SH > SM-SH | RGH-SH > RGH-SH |

Figure 2.2: Matrix of Transition Sequences

In the texts that we analyzed, we could not find instances of four of the Transition sequences. These are given below, with constructed examples for illustration. For each, we briefly discuss the application of the algorithm.[5]

- SMOOTH-SHIFT > ROUGH-SHIFT:

(33) a. **John**$_i$ went to the store.

[5]Note that we were looking for instances in our texts that contained structural ambiguity between entities that were realized across the utterances. As was shown with examples (31) and (32), structural disambiguating features often lead to a violation of expectations because the necessary inferences can be very easily drawn on this basis. We excluded such samples from our analysis. Needless to say, including these for independent reasons will most likely bring up many instances of the Transitions that we could not find in the texts, given our criteria.

b. **Bill**$_j$ was supposed to meet **him**$_i$ there at 5pm.

[$C_b$ = John (*him*$_i$); $C_p$ = Bill]

c. **He**$_j$ arrived with **Max**$_k$ at 5:30pm.

[$C_b$ = Bill (*He*$_j$); $C_p$ = Bill; Tr = SMOOTH-SHIFT]

d. **John**$_i$ had not expected **Max**$_k$ to come.

[$C_b$ = Max; $C_p$ = John; Tr = ROUGH-SHIFT]

In (33c), "Bill" is the Preferred Center of (33c) and the Transition instantiated by the utterance is a SMOOTH-SHIFT. According to E1, therefore, "Bill" is expected to be the Backward-looking Center of (33d), and further, according to E2, it is also expected to lay out a further expectation of continuation by being the Preferred Center of (33d). However, neither E1 and E2 are satisfied since (33d) doesn't realize "Bill" at all. Note that non-realization of the Preferred Center of (33c) in (33d) defines the Transition sequence we are considering in the example, namely, SMOOTH-SHIFT followed by a ROUGH-SHIFT. The Transition sequence type is also defined by the fact that the non-preferred center of(33c) that is realized in (33d) is not the Preferred Center of (33d). Our example instantiates this by realizing the Preferred Center of (33d) with an entity that was not realized in (33c). This entity is "John", who was evoked in (33a) and (33b). Now, since E1 and E2 have not been met, C1a does not hold and C1b applies so that the speaker is obliged to use full noun phrases for one or more of the entities in (33d). As C1b specifies, the speaker should use full noun phrases to the extent that the hearer does not assign interpretations to any pronouns by following E1 and E2. Let us see how this works with the different alternative realizations with pronouns. In each case, we will consider the interpretation of the pronoun(s) that the hearer arrives at following E1 and E2. If pronouns are used for both the entities, as in *He had not expected him to come*, the hearer would interpret the subject pronoun *he*

as referring to “Bill” and the the object pronoun *him* as referring to “Max”, which is incorrect with respect to the subject pronoun. If only the subject pronoun is used, as in *He had not expected Max to come,* the hearer would interpret the subject pronoun as referring to “Bill”, which is again incorrect. Finally, if an object pronoun is used, as in *John had not expected him to come*, while the speaker deduces that “John” is evoked from a prior utterance (33a) or (33b), the two entities “Bill” and “Max” from (33c) still compete for the pronoun’s interpretation. The hearer will, following E1, pick “Bill”, the Preferred Center of (33c), which is again incorrect. Note that in neither case is there any structural or inferential information easily available from the utterance for pronoun disambiguation. So the only choice the speaker has is to use proper names for both “John” and “Max”, or some other disambiguating NP forms.

(34) is like the examples (28) and (29) that we have looked at above. “Max” is the Preferred Center of (34c) and thus the expected center (of (34d)) which is subject to further continuation. Realization of the Non-preferred Center, “Bill”, in a preferred center position in (34d) forces the use of a proper name since otherwise, the hearer would, following E1 and E2, arrive at the incorrect reading for the pronoun, i.e., as “Max”.[6]

- ROUGH-SHIFT $>$ CONTINUE:

(34) a. **John**$_i$ went to the store.

b. **Bill**$_j$ was supposed to meet **him**$_i$ there at 5pm.

[6]Note that in this case, there is an inference that the hearer could make if a pronoun was used, as in *He had a flexible schedule*, namely that since “Max” is the person who is expected to arrive late, “Bill”, and not “Max”, is more likely to have the more flexible schedule. On the other hand, it is quite possible to see how the hearer may still expect “Max” to have a flexible schedule, as can be seen with the following possible continuation:

(i) Max/He had a flexible schedule but today he had to meet a deadline.

[$C_b$ = John (*him*$_i$); $C_p$ = Bill]

c. **Max**$_k$ was to arrive later than **Bill**$_j$.

[$C_b$ = Bill; $C_p$ = Max; Tr = ROUGH-SHIFT]

d. **Bill**$_j$ had a flexible schedule.

[$C_b$ = Bill; $C_p$ = Bill; Tr = CONTINUE]

- ROUGH-SHIFT $>$ RETAIN:

(35) a. **John**$_i$ went to the store.

b. **Bill**$_j$ was supposed to meet **him**$_i$ there at 5pm.

[$C_b$ = John (*him*$_i$); $C_p$ = Bill]

c. **Max**$_k$ was to arrive later than **Bill**$_j$.

[$C_b$ = Bill; $C_p$ = Max; Tr = ROUGH-SHIFT]

d. **John**$_i$ saw **Bill**$_j$ arriving at 5:15pm

[$C_b$ = Bill; $C_p$ = John; Tr = RETAIN]

(35) is exactly like (33) in that an entity from an utterance prior to (35c) is realized as the Preferred Center in (35d) and a Non-preferred Center in (35c) is retained as the Backward-looking Center.

- ROUGH-SHIFT $>$ SMOOTH-SHIFT:

(36) a. **John**$_i$ went to the store.

b. **Bill**$_j$ was supposed to meet **him**$_i$ there at 5pm.

[$C_b$ = John (*him*$_i$); $C_p$ = Bill]

c. **Max**$_k$ was to arrive later than **Bill**$_j$.

[$C_b$ = Bill; $C_p$ = Max; Tr = ROUGH-SHIFT]

d. **He**$_k$ was the weather man.

[$C_b$ = Max (*He*$_k$); $C_p$ = Max; Tr = SMOOTH-SHIFT]

In (36), "Max" is the Preferred Center of (36c), which instantiates a ROUGH-SHIFT Transition and sets up an expectation for "Max" to be the backward-looking center and the Preferred Center of the next utterance. Since E1 and E2 are thus met, the use of the pronoun in (36d) to refer to Max is perfectly felicitous and interpretable.

- ROUGH-SHIFT $>$ ROUGH-SHIFT:

(37) a. **John**$_i$ went to the store.

b. **Bill**$_j$ was supposed to meet **him**$_i$ there at 5pm.

[$C_b$ = John (*him*$_i$); $C_p$ = Bill]

c. **Max**$_k$ was to arrive later than **Bill**$_j$.

[$C_b$ = Bill; $C_p$ = Max; Tr = ROUGH-SHIFT]

d. but **John**$_i$ found **him**$_k$ already waiting at the store.

[$C_b$ = Max (*him*$_k$); $C_p$ = John; Tr = ROUGH-SHIFT]

In (37), the use of the pronoun for "Max" in (37d) is perfectly natural and correctly interpreted by the hearer since "Max" was the Preferred Center of (37c). Note, however, that a pronoun cannot also be used in the subject position for John, since then the hearer would be confused.

While we have been able to account for above constructed examples with the CR-CM algorithm, it would be more instructive to look at naturally occurring texts. We do this below for the Transition sequences that we were able to identify.

- CONTINUE > CONTINUE:

  CONTINUE Transition sequences are those in which the hearer expectations E1 and E2 are maximally satisfied. The speaker realizes the Preferred Center as the Backward-looking Center of the subsequent utterance and also indicates an expectation of further continuation. This is seen in (38), where the speaker continues to talk about "Walker" throughout the segment and also realizes "Walker" as the Preferred Center in each utterance. This example, furthermore, illustrates the simplest and least conflicting case for referring expression generation: since there is only one entity realized from (38b) to (38c), so there are no competing entities for the interpretation of the pronoun and the speaker has no reason to not use a pronoun.

  (38) a. **He**$_i$ had no doubt it was **Manuma**$_j$ who had flung the knife. (He$_i$ = Walker)

  [C$_b$ = Walker (*He$_i$*); C$_p$ = Walker]

  b. **He**$_i$ had escaped death by three inches.

  [C$_b$ = Walker (*He$_i$*); C$_p$ = Walker; Tr = CONTINUE]

  c. **He**$_i$ was not angry

  [C$_b$ = Walker (*He$_i$*); C$_p$ = Walker; Tr = CONTINUE]

  *Somerset Maugham; Mackintosh*

  In (39), a second entity, "Mackintosh", is evoked in (39b). E1 and E2 set up an expectation for the Preferred Center, "Walker", to be realized as the backward-looking center of (39c). The speaker realizes both entities, "Walker" and "Mackintosh", as centers in (39d). Now, unlike the examples that we have seen above with competing entities as the interpretation of the multiple pronouns, here the use of the pronouns for both entities would confirm to the hearer's expectations and allow him/her to arrive at the correct reading by following E1 and E2. The Preferred Center of (39c) is

also realized as the Preferred Center of (39d) and the speaker thus does not need to use a full noun phrase for the other entity since the Non-preferred Center is now the only remaining interpretation available. As the segment shows, the speaker indeed chooses to use pronouns for both the entities in (39d).

(39) a. **His**$_i$ little eyes twinkled. (His$_i$ = Walker)

b. **He**$_i$ blew himself out like a turkey-cock,

[$C_b$ = Walker (*He*$_i$); $C_p$ = Walker]

c. and for the second time $\epsilon_i$ insisted on telling **Mackintosh**$_j$ every detail of the sordid affair.

[$C_b$ = Walker ($\epsilon_i$); $C_p$ = Walker; Tr = CONTINUE]

d. Then **he**$_i$ asked **him**$_j$ to play piquet.

[$C_b$ = Walker (*he*$_i$); $C_p$ = Walker; Tr = CONTINUE]

*Somerset Maugham; Mackintosh*

- CONTINUE $>$ RETAIN:

In (40), E1 and E2 set up an expectation for "Crosbie" in (40b) to be the Backward-looking Center in (40c). However, (40c) evokes an entity from (40a) in the Preferred Center position, and the speaker cannot use a pronoun for this since the hearer would then interpret it as referring to "Crosbie". Moreover, the second pronoun in the prepositional phrase would further perpetuate the mistake since there would be a likelihood of getting a reading in which "Crosbie" was exasperated by himself (locality constraints on coindexation holding). No inference is also easily available in the utterance, so the speaker is obliged to use a proper name for "Joyce" to disambiguate the reference. Note, however, that the speaker is free to use a pronoun for "Crosbie", since being the only pronoun, the hearer would interpret it as referring to

the Preferred Center, “Crosbie”, which would be the correct reading. Also note that Rule 1 is applicable here and has not been violated.

(40) a. **Crosbie**$_i$ did not speak.

b. **His**$_i$ large, red face bore an expression of complete bewilderment,

[$C_b$ = Crosbie (*His*$_i$); $C_p$ = Crosbie; Tr = CONTINUE]

c. and **Mr. Joyce**$_j$ was at once relieved and exasperated by **his**$_i$ lack of comprehension.

[$C_b$ = Crosbie (*his*$_i$); $C_p$ = Mr. Joyce; Tr = RETAIN]

*Somerset Maugham; The Letter*

- CONTINUE > SMOOTH-SHIFT:

(41c) instantiates a CONTINUE Transition, with “Mackintosh” as the Preferred Center. In addition, another competing entity is also realized in this utterance, namely, “Manuma”. (41d) realizes the Non-preferred Center in the preferred center position, which is contrary to E1 and E2, given the CONTINUE Transition in (41c). As a result, the speaker is obliged to use a descriptive noun phrase to prevent the wrong reading (i.e., the Preferred Center, “Mackintosh”), which is what we see with the proper name in (41d). Again, no inference would be easily available if a pronoun was used. “Mackintosh” has been acting very shifty and uncomfortable and he could have been equally likely to take the medicines and skip the scene.[7]

[7]The treatment of complex sentences such as in (41c) is a major problem in Centering related studies, the issue being whether to break up complex sentences into separate utterance units or to treat them as a single unit. The results of the application of the Centering principles and constraints will vary depending on how such sentences are treated. This question has received a lot of attention but no definitive conclusion has been reached. Often, different researchers work with different assumptions about what qualifies as the utterance unit. Some, like Kameyama (1998) break up complex sentences into separate units, whereas others

(41) a. **He**$_i$ did not know what it was that made it impossible for **him**$_i$ to look at **the Kanaka**$_j$. (He$_i$ = Mackintosh; Kanaka = Manuma)

[$C_b$ = Mackintosh (*He*); $C_p$ = Mackintosh]

b. While **he**$_i$ was speaking to **him**$_j$, **he**$_i$ kept **his**$_i$ eyes on **his**$_j$ shoulder.

[$C_b$ = Mackintosh (*he*$_i$); $C_p$ = Mackintosh; Tr = CONTINUE]

c. **Manuma**$_j$ took the medicine and slunk out of the gate.

[$C_b$ = Manuma; $C_p$ = Manuma; Tr = SMOOTH-SHIFT]

*Somerset Maugham; Mackintosh*

- CONTINUE > ROUGH-SHIFT:

(42) is an example which shows that the availability of inferential information allows the speaker to use a pronoun, even though the hearer's expectations have been violated.[8] In (42b), "the boy" is the Preferred Center and "Cooper" is the second entity embedded in the complement clause, thus being lower ranked. In (42c), a new entity, "Abas", has been evoked in the Preferred Center position. The (only) pronoun that is used in the utterance would be interpreted as referring to "the boy", which would be incorrect. However, the inference that the pronoun could only refer to "Cooper", the Non-preferred Center, is easily available from the verbal predicate in the clause. That is, the hearer knows from (42b) that it is "Cooper" who has been having trouble

like Miltsakaki (1999) treat them as a single unit. In Chapter 3 and 4, we provide more extended discussion of issued relating to complex sentences. For the purpose of the current example, we simply state that we assume the analysis in Miltsakaki (1999) for subordinate clauses and take subordinate clauses to be part of the utterance unit created by the main clause in which they occur. Further, we assume that entities evoked in subordinate clause(s) are ranked lower than entities evoked in the main clause. For multiple subordinate clauses, we assume a left to right ordering.

[8]We were not able to identify any instances of CONTINUE > ROUGH-SHIFT Transitions where a full noun phrase was used for both the entities.

with his boys, and the act of 'leaving' X is naturally entailed due to some trouble with the X. Furthermore, there is no indication of "the boy" mentioned in (42a) and (42b) as having gotten into any trouble because of which anyone may have left him. And finally, the inference yielded by the verbal predicate in (42c) is made available "before" the pronoun is encountered by the hearer, so that the entity to be mentioned as the object of the verb is probably already anticipated.

(42) a. in their interval since their arrival, **he**$_i$ had been gossiping in the servants' quarters. (he$_i$ = the boy)

b. **He**$_i$ had learnt that **Cooper**$_j$ had had trouble with **his**$_j$ boys.
[$C_b$ = boy (*he*$_i$); $C_p$ = boy; Tr = CONTINUE]

c. All but **the youth Abas**$_k$ had left **him**$_j$.
[$C_b$ = Cooper (*him*$_j$); $C_p$ = Abas; Tr = ROUGH-SHIFT]

*Somerset Maugham; The Outstation*

- RETAIN > CONTINUE:

(43) a. This time **Mackintosh**$_i$ gave **him**$_j$ **his**$_j$ whisky neat.
[$C_b$ = Walker (*him*$_j$, *his*$_j$); $C_p$ = Mackintosh; Tr = RETAIN]

b. **Walker**$_j$ collected his strength in a final effort of will.
[$C_b$ = Walker; $C_p$ = Walker; Tr = CONTINUE]

*Somerset Maugham; Mackintosh*

(43) is an excellent example of the singular dominating influence of the Preferred Center expectation as the driving force behind the constraints on referring expressions. It shows that though maximal coherence has been defined in terms of maximal continuity, whereby utterance sequences continue to center the same entity, the form

of referring expression is independent of this effect.[9] (43a) instantiates a RETAIN Transition in which "Walker" is realized as the Backward-looking Center. The next utterance (43b) continues "Walker" as the centered entity, and also places it in the Preferred Center position, thus instantiating a CONTINUE Transition. However, the use of a proper name in (43b) for the retained center of (43a) shows that it is the Preferred Center which is in fact expected as the Backward-looking Center of (43b). A pronoun, if used, would lead the hearer to incorrectly interpret it as referring to "Mackintosh" and not "Walker". The speaker is thus obliged to use a more informative expression.

- RETAIN $>$ RETAIN:

  The pattern in the RETAIN $>$ RETAIN sequence in (44) is simple to see. The entity, "Campion", is retained in (44b) and a new entity from an utterance prior to (44a) is evoked as the Preferred Center. In (44c), this Preferred Center is realized but only retained, and another new entity is evoked as the Preferred Center. The speaker is free to use a pronoun for the retained center since the hearer would interpret it correctly as the Preferred Center of (44b), namely "Hutchinson". A pronoun cannot be used for the subject entity, "Izzart", because this violates E1 and E2 and would confuse the hearer who would interpret it as referring to the Preferred Center, "Hutchinson".

  (44) a. presently, after yawning a good deal, **he**$_i$ said **he**$_i$ would go to bed. (he$_i$ = Campion)

  [$C_b$ = Campion (*he*$_i$); $C_p$ = Campion]

[9] In fact, this is the erroneous assumption made in the BFP algorithm for pronoun interpretation (Brennan et al., 1987), where one of the criteria for interpreting pronouns is defined in terms of maximal coherence as maximal continuity in terms of the Transition ranking in Rule 2. In Prasad & Strube (2000), it is shown that this assumption either leads to incorrect resolution with pronouns or creates an ambiguity in the resolution mechanism that perpetuates throughout the text.

b. **Hutchinson**$_j$ showed **him**$_i$ to **his**$_i$ room

[$C_b$ = Campion (*him*$_i$); $C_p$ = Hutchinson; Tr = RETAIN]

c. and when **he**$_j$ returned, **Izzart**$_k$ said to **him**$_j$, "You don't want to turn in yet, do you?"

[$C_b$ = Hutchinson (*he*$_j$); $C_p$ = Izzart; Tr = RETAIN]

*Somerset Maugham; The Yellow Streak*

- RETAIN > SMOOTH-SHIFT:

(45) is a clear case of the hearer's expectations being totally met, and due to which the speaker is seen to use pronouns freely. The Transition sequence instantiated is RETAIN > SMOOTH-SHIFT, and the utterances (45b) and (45c) realize multiple entities. (45b) sets up an expectation that "Bateman", the Preferred Center, will be the Backward-looking Center of (45c) – following E1 – and that further the speaker will continue to center this entity – following E2. Both E1 and E2 are met in (45c). The speaker is thus seen to use pronouns for both the entities. Note that the interpretation of the pronouns could, in principle, go the other way too, with the subject pronoun referring to the man and the object pronoun referring to "Bateman", so the use of the pronouns here provides robustness to the expectation specified in the CR-CM algorithm as being the driving force behind the constraints on referring expression form.[10]

(45) a. **A man**$_i$ was advancing towards them on the terrace,

b. but **Bateman's**$_j$ back was turned to **him**$_i$

[$C_b$ = man (*him*$_i$); $C_p$ = Bateman; Tr = RETAIN]

[10] If the speaker had intended the alternative interpretation, we would, given the CR-CM algorithm, expect the following realization of (c):

(i) and **the man** could not see **him**.

c. and **he**$_j$ could not see **him**$_i$

[$C_b$ = Bateman (*he*$_j$); $C_p$ = Bateman; Tr = SMOOTH-SHIFT]

*Somerset Maugham; The Fall of Edward Bernard*

- RETAIN > ROUGH-SHIFT:

The example in (46) is the one we presented in Chapter 1, and we are now in a position to explain the acceptability and unacceptability of the alternative realizations of the referring expression forms.[11]

(46) a. and **Dr. Macphail**$_i$, getting out of bed, saw that **he**$_j$ was heavily tattooed.

($he_j$ = Horn)

[$C_b$ = Horn (*he*$_j$); $C_p$ = Dr. Macphail; Tr = RETAIN]

b. i. **Horn**$_j$ made **him**$_i$ a sign to come to the verandah. (actual utterance)

[$C_b$ = Dr. Macphail (*him*$_i$); $C_p$ = Horn; Tr = ROUGH-SHIFT]

ii. # **He** made **him** a sign to come to the verandah.

[$C_b$ = Dr. Macphail (*him*$_i$); $C_p$ = Horn; Tr = ROUGH-SHIFT]

[11]Since this example contains all the alternative realizations for the referring expression, we can explicitly discuss the application of the Centering constraints on the different forms. Centering, as it stands, can use the Rule 1 constraint to explain the acceptability of (46bi), which is the utterance actually used in the text segment, and the unacceptability of (46biii). That is, the same rule predicts that (46bi) is acceptable since the Backward-looking Center is realized as a pronoun and that (46biii) is not acceptable since the Backward-looking Center, "Dr. Macphail", is realized as a full NP while some other entity, "Horn", which is not the backward-looking center, is realized as a pronoun. However, Centering cannot explain the oddness (leading to the tendency to assign the incorrect interpretation to the pronouns) of (46bii) or the acceptability of (46biv). Consider (46bii), for example. According to Rule 1, which comes into operation when there is more than one center realized from one utterance to the next, there is nothing in principle wrong about this alternative. This is because the constraint does not preclude the realization of any other entity as a pronoun *as long as the Backward-looking Center is also realized as a pronoun*. And indeed, in this case, the Backward-looking Center, "Dr. Macphail", *is* realized as a pronoun (as well as the non-centered entity, "Horn").

iii. # **He**$_j$ made **Dr. Macphail**$_i$ a sign to come to the verandah.

[$C_b$ = Dr. Macphail; $C_p$ = Horn; Tr = ROUGH-SHIFT]

iv. **Horn**$_j$ made **Dr. Macphail**$_i$ a sign to come to the verandah.

[$C_b$ = Dr. Macphail; $C_p$ = Horn; Tr = ROUGH-SHIFT]

The first utterance (46a) realizes "Horn" as the Backward-looking Center but it instantiates a RETAIN Transition, setting up an expectation of another entity, "Dr. Macphail", as the Backward-looking Center of the next utterance.[12] All the alternative realizations of (46b) instantiate a ROUGH-SHIFT Transition: both entities, "Dr. Macphail" and "Horn", are realized in the these utterances, but since "Dr. Macphail" is the Preferred Center in (46a), he is expected to be the Backward-looking Center in the (46b) utterances. So the expectation E1 is met in this case. However, E2 is not satisfied, since in fact, the speaker only retains "Dr. Macphail" as the center. As a result, C1a does not hold and C1b must apply. That is, the speaker must use a full noun phrase for one or more of the entities to prevent the hearer from making incorrect inferences. Thus we have explained why (46bii) cannot occur. Now we are left with (46bi), (46biii) and (46biv). The choice between (46bi) and (46biii) is made by Rule 1. Rule 1 directs the speaker to choose (46bi), and this is what we indeed observe. This leaves us with (46biv). The use of full noun phrases for both the entities in this example is acceptable, though less so than (46bi). We can explain this with the C3 constraint which can apply in this case since C1b has been applied too. Since this example did not actually occur, it is hard to imagine (and it is also not clear from the example itself) what additional inference the speaker could have intended to convey, but if at all there was any additional inference to be abstracted from the utterance, then it would have to do with the use of full noun phrases for any remaining pronouns

[12] "Horn" is the only entity realized in the previous utterance in the segment, the utterance being *He looked suddenly savage*, where *he* = Horn.

in the utterance. This is what is encapsulated in the C3 constraint. In this example, after the application of the C1b constraint, there is only one pronoun remaining in the utterance, namely, the pronoun used to realize "Dr. Macphail". And we can explain this example by appealing to the hypothetical possibility that the speaker has intended some additional inference that can only obtain by using the proper name for "Dr. Macphail".

Two points need to be noted about this example. Firstly, in addition to explaining why the incorrect reading is obtained for the pronouns in (46bii), we are also able to predict why the speaker in fact chose to use a full noun phrase for one of the entities. It was precisely to prevent the hearer from arriving at the incorrect reading for the pronouns. This is a prediction that we were able to derive from the Centering definitions, but which were not explicitly formulated within the theory itself. So we see Gricean (Grice, 1975) principles about assumptions about shared knowledge (Chafe, 1976) at work here. Secondly, Rule 1 has only a secondary role in these cases, and that is to provide the decision about which entity to pronominalize and which to realize as a full noun phrase.

- SMOOTH-SHIFT $>$ CONTINUE:

  (47b) instantiates a SMOOTH-SHIFT Transition, and the Preferred Center, "Abas", is the only entity realized in its utterance. The speaker continues to center this entity as the Backward-looking Center as well as the Preferred Center in (47c), so both E1 and E2 are met, and the speaker is free to use a pronoun to realize "Abas".[13] Note that a discourse-new entity is evoked in (47c) as a containing inferrable (Prince, 1992) and cannot be pronominalized for independent syntactic reasons.[14]

[13]Following Prince & Walker (1995), we are assuming a left-to-right of complex NP's for English, so that possessives are ranked higher than head nouns.

[14]No doubt, the generation constraints that we have formulated here will have to be integrated with other

(47) a. All but **the youth Abas**$_i$ had left **him**$_j$.

[$C_b$ = Cooper (*him*$_j$); $C_p$ = Abas]

b. **Abas**$_i$ had desired to go too,

[$C_b$ = Abas; $C_p$ = Abas; Tr = SMOOTH-SHIFT]

c. but **his**$_i$ **uncle**$_l$ had placed **him**$_i$ there on the instructions of the Resident

[$C_b$ = Abas (*his*$_i$, *him*$_j$); $C_p$ = Abas; Tr = CONTINUE]

*Somerset Maugham; The Outstation*

- SMOOTH-SHIFT > RETAIN:

(48) is like (47) except that after the SMOOTH-SHIFT Transition in (48c), the speaker retains rather than continues the centered entity, "Mackintosh". (48d). In this case, the speaker cannot use a pronoun for the new entity evoked in (48d), "the chinese cook", since it is in the Preferred Center position: the hearer would be led to the wrong interpretation, i.e., the subject pronoun would be interpreted as referring to the Preferred Center of (48c), "Mackintosh" and the object pronoun would be interpreted as referring to the only other available entity in the segment, "Walker". Note, also, that Rule 1 is not violated.

(48) a. **He**$_i$ closed his eyes, (He$_i$ = Walker)

b. and **Mackintosh**$_j$ thought that **he**$_i$ would never open them again.

[$C_b$ = Walker (*he*$_i$); $C_p$ = Mackintosh]

c. **His**$_j$ mouth was so dry that **he**$_j$ had to go to get himself something to drink.

[$C_b$ = Mackintosh (*His*$_j$, *he*$_j$); $C_p$ = Mackintosh; Tr = SMOOTH-SHIFT]

mechanisms to be able to account for the full range of referring expression phenomena. We do not overlook the need for such an effort.

d. **The Chinese cook**$_k$ silently put a chair for **him**$_j$.

[$C_b$ = Mackintosh (*him*$_j$); $C_p$ = Cook; Tr = RETAIN]

*Somerset Maugham; Mackintosh*

- SMOOTH-SHIFT $>$ SMOOTH-SHIFT:

In the final Transition sequence in (49), it is easy to see how E1 and E2 are not met from (49b) through (49c). The speaker does not realize the Preferred Center of (49c), "Walker", in (49d), and is thus obliged to use a proper name for the Non-preferred Center that is in fact realized.[15]

(49) a. **Walker**$_i$, shaking **his**$_i$ fist at **him**$_j$, called **him**$_j$ every name **he**$_i$ could think of. (him$_j$ = Manuma)

[$C_b$ = Manuma (*him*$_j$); $C_p$ = Walker]

b. **He**$_i$ riddled **him**$_j$ with scorn.

[$C_b$ = Walker (*He*$_i$); $C_p$ = Walker; Tr = SMOOTH-SHIFT]

c. **Manuma**$_j$ sat still and smiled.

[$C_b$ = Manuma; $C_p$ = Manuma; Tr = SMOOTH-SHIFT]

*Somerset Maugham; Mackintosh*

[15] In this case, there is a possibility of an inference obtaining in (49d) with the use of a pronoun, though. "Walker" has been portrayed in the previous utterances as being very agitated, and as such is unlikely to be the one who could be sitting still. This raises an interesting question with regard to how speakers decide how much inferential information is enough such that they can generate the pronoun. Generation systems that make use of CR-CM algorithm will need to define these inference-based thresholds. At this point, it is not clear whether these choices are principled or random.

## 2.4 Conclusion

In this chapter, we started out with showing that Centering specifies only one constraint that can be used to determine the choices made by speakers for referring expression forms. We then showed that if we started out with primitive Gricean principles of cooperative behavior, we could then incorporate, in addition to Rule 1, other implicit suggestions made within Centering to explicitly formulate an algorithm for the generation of referring expression forms. The algorithm was formulated in terms of hearer-based expectations and speaker-based constraints.

In order to show how well the algorithm could be applied to natural language, we defined the domain of its application in terms of the Centering Transition sequences and illustrated with naturally occurring discourses (as well as constructed examples for the Transition sequences that we were not able to identify) that the algorithm was able to account for the observed patterns of anaphoric reference.

We also pointed out that the CR-CM algorithm could be used for modelling generation systems. However, it must be kept in mind that such generation systems need to separate the tasks of structural processes and inferential reasoning. In the CR-CM algorithm, three of the four constraints, that is, C1a, C1b, and C3, have a conditional clause that is intended to capture this separation between the structural and inferential mechanisms.[16] To the extent that a generation system has been successful in modeling inferential reasoning, we believe that the CR-CM algorithm can be usefully applied to generate the appropriate referring expressions in natural language discourses. In the last Transition sequence, i.e., for SMOOTH-SHIFT $>$ SMOOTH-SHIFT, we noted that there was a possible inference that could have obtained from utterance (49) if a pronoun had been used instead of the proper

[16]The idea of separating the structural mechanisms from inferential ones, especially at the discourse level, has also been advocated elsewhere in work related to the modeling of discourse structure and meaning (Webber & Joshi, 1998).

name *Manuma* (see fn. 15). The current state of the art in the modeling of inferential reasoning, at least with respect to referring expression forms, does not allow us to predict how much inference is sufficient for the generation of a pronoun instead of a descriptive noun phrase. In Centering, the relationship that is established between coherence and referring expression forms (see Chapter 1, Section 1.5.3) predicts that some inferences are harder than others. The amount of inference that a hearer needs to make is not quantified in any way within Centering, so modeling the application of the CR-CM conditional clauses that embody inference-related constraints can only result in an approximation of how referring expressions are used in naturally occurring discourse.

Finally, it is not the case that inferences in natural language are just "easy" or "hard", as Centering claims, for this entails that there is always some source in the discourse from which the necessary inferences can be drawn, especially when pronouns are used where structural Centering constraints rule this out. However, there is also the possibility that there is no available source, easy or hard to find, that hearers can use to make the necessary inferences. In natural language, this typically results in "misunderstandings". Of course, for the creation of artificial generation systems, we are probably better off in not modeling such naturally occurring instances!

# Chapter 3

# Relative Salience and Anaphoric Reference in Hindi

In the previous chapter, we developed a constraint-based algorithm for generating referring expression forms based on primitive Gricean principles and the Centering model. We also pointed out that in order to use the algorithm, generation systems need to recognize the need for separating structural processes from inferential mechanisms, and that they need to have successfully modeled an inferential reasoning component.

Our particular goal in this thesis is to address issues related to the generation of referring expression forms in Hindi. In the previous chapter, the generation algorithm was formulated using evidence from English, and this raises the question of whether the same algorithm can be used across languages. We believe that the algorithm is general enough to be applied to any language to the extent that the expectations and constraints formulated in the algorithm are based on speaker and hearer behavior, and it is unlikely that languages will exhibit variation in this respect. However, there is one parameter in the algorithm that is language-specific. This is the linguistic criterion that determines the ranking of the forward-looking centers list. A look at the algorithm shows the predominance of the *Pre-*

*ferred Center* – appearing in expectation E1 – the constraints which ultimately decide the form of referring expressions. This means that in order to apply the algorithm in any language, we need to be able to first identify the Preferred Center of utterances. The Preferred Center is the most highly ranked entity of the forward-looking centers list, with the ranking being determined by the degree of discourse salience associated with the entities or centers. Previous research has established that languages exhibit variation in this respect, i.e., the factors that are responsible for ranking discourse entities evoked in utterances vary from language to language. As such, in order to apply the algorithm for generation in Hindi, we need to first identify the factors that determine discourse salience in the language, so that the Preferred Center can then be identified.

This chapter first makes a contribution towards setting the salience determining language-specific parameter for Hindi. In Section 3.1, we propose a language-independent corpus-based method for identifying the factors that determine discourse salience. The methodology we propose utilizes Rule 1 of Centering theory. In Section 3.2, we apply the proposed methodology to investigate three linguistic factors as the determinants of relative salience in Hindi: grammatical function, word order, and information status. Our results show that grammatical function has a significant effect on discourse salience and that word order and information status do not any show any effect.

Using the results from the $C_f$ list ranking criteria for Hindi, in Section 3.3 we provide a Centering analysis of zero pronouns in Hindi.

## 3.1 Determination of Relative Salience

### 3.1.1 Related Cross-linguistic Work

A good deal of cross-linguistic research on discourse anaphoric relations has been conducted within the framework of Centering theory and much of this has focused on how the ranking of the forward looking centers list varies from language to language. The original suggestion in Centering was that grammatical function was the determining factor. However, this conclusion was based on English, a fixed word order language. Later work in different languages has suggested that different criteria may be at play cross-linguistically. For instance, Walker et al. (1994) show that in addition to grammatical function, the $C_f$ list ranking in Japanese is also determined by *topic* and *empathy*. The topic may be a grammatical topic (marked by *wa* in Japanese) or a zero topic, which is inferred relative to other overt forms in the utterance. Empathy is marked on verbs to indicate "...the speaker's identification with a person or thing that participates in the event or state that he describes in a sentence..." (Kuno, 1987). Walker et al. (1994) argue for the following ranking criteria for Japanese: *topic (grammatical/zero)* $>$ *empathy* $>$ *subject* $>$ *object* $>$ *other(s)*. Based on this, they also propose, more generally, that the $C_f$ ranking is language-specific depending on the means the language provides for indicating discourse function. Research on other languages suggest the effect of still other factors. Rambow (1993) argues that the ranking in German follows the *surface order position* for entities evoked in the Mittelfeld, and Gordon et al. (1993) suggest for English that *sentence-initial position* seems to contribute to salience, even in the case of non-subjects. Turan (1995) argues that the $C_f$ ranking in Turkish is associated with either *grammatical relation* or a *semantic role* hierarchy. She also provides evidence to show that word order is not a determining factor for Turkish. In work earlier to Centering, Sidner (1979) suggested that *thematic relations* are used for determining the salience of discourse entities, and Stevenson et al. (1993),

Stevenson & Urbanowicz (1995) also show that thematic role has an effect on which entity is likely to be spoken of next, arguing that the entity that is the GOAL of the predicate is more salient than the entity that is the SOURCE, irrespective of the grammatical function associated with the entities.

While most of the research for determining the ranking of the $C_f$ list has assumed that the criteria are language-specific, Strube & Hahn (1996), on the basis of empirical evidence from German, a free word order language, make the claim that the ranking criteria for the $C_f$ list should be determined by the functional status of the discourse entities, not only for German, but also for other languages. In other words, they argue that such a ranking may be a cross-linguistic universal, claiming in particular that it is extendable to fixed word order languages like English. The functional distinctions they use for their ranking is in terms of the Praguian notions (Hajičová et al., 1992; 1995) of *context-boundedness* versus *context-unboundedness*, which they state corresponds to the distinction between *given information/theme* and *new information/rheme*.[1] Context-bound elements are ranked higher than context-unbound elements. Bound elements are further divided into different types and ranked in the following manner: *anaphora* $>$ *possessive pronoun or elliptical antecedent* $>$ *elliptical expression or head of anaphoric expression*.[2] Finally, for the cases where they may be multiple occurrences of the elements with the same information status, they provide a ranking in terms of linear order, from left to right.

[1]These notions are reformulated in terms of Prince (1992)'s classification of information status in Strube (1998).

[2]The terms *elliptical antecedents* and *elliptical expressions* refer to *inferrables* ((Prince, 1981; 1992)) and are not to be confused with the phenomenon of ellipsis which relates to elided elements.

### 3.1.2 Methodology for Determining Salience

All previous efforts that have applied methods and strategies to determine the relative salience of discourse entities in terms of linguistically encoded properties have used constructed examples together with native speaker judgments of preferred interpretations to determine the ranking of the $C_f$ list. Broadly, these methods can be grouped into two types. In one kind of method (Walker et al., 1990; 1994), applied to Japanese, examples were constructed as discourses consisting of four utterances. The first utterance introduces a discourse entity, which is established as the Backward-looking Center in the second utterance. In the third utterance, there is a zero pronominal that refers to the Backward-looking Center of the second utterance, and also a new entity is introduced in the same utterance. Finally, the fourth utterance contains two zeros, intended to create ambiguity between the two entities in the third utterance. The test for salience was conducted by manipulating factors related to the two entities in the third and fourth utterances, i.e., by varying whether an entity was realized in subject or object position in the third utterance, whether an entity realized in subject position was *ga*-marked or *wa*-marked in the third utterance, and whether an entity realized in the fourth utterance in object position was marked as the locus of the speaker's empathy. Native speaker judgments were then elicited for the interpretation of the two zeros in the fourth utterance. However, since the variable of interest in these discourses was the ranking of the two entities in the third utterance, rather than have the native speakers rank the entities, first a BFP algorithm style (Brennan et al., 1987) of generating multiple possible $C_f$ lists for the third and the fourth utterances was employed and then the native speakers were asked to pick the correct interpretation for the fourth utterance. Since each different interpretation yielded a different $C_f$ list, this procedure essentially pointed to the ranking of the entities in the $C_f$ list.

The example in (50) from Walker et al. (1994) illustrates the application of their method for comparing zero topics with subjects.

(50) a. **Hanako**$_i$ wa siken o oete, kyoositu ni modorimasita
**Hanako**$_i$ TOP/SUBJ exam OBJ finish classroom to returned

"Hanako returned to the classroom, finishing her exams"
$C_b$ = Hanako;
$C_f$ = {Hanako, exam}

b. **0**$_i$ hom o locker ni simaimasita
**SUBJ**$_i$ book OBJ locker in took-away

"She put her books in her locker"
$C_b$ = Hanako;
$C_f$ = {Hanako, Book};
Tr = CONTINUE

c. Itumo no yooni **Mitiko**$_j$ ga 0 mondai no tokikata **o**$_i$
always like **Mitiko**$_j$ SUBJ OBJ2 problem solve-way **OBJ**$_i$
setumeisidasimasita
explained

"Mitiko, as usual, explained (to Hanako) how to solve the problem"
$C_b$ = Hanako;
**C$_f$1** = {Hanako, Mitiko, solution} **ZTA** (TOP, SUBJ, OBJ);
**Tr1** = CONTINUE;
**C$_f$2** = {Mitiko, Hanako, solution} (SUBJ, OBJ2, OBJ);
**Tr2** = RETAIN

d. **0**$_{i/j}$ **0**$_{i/j}$ ohiru ni sasoimasita
**SUBJ**$_{i/j}$ **OBJ**$_{i/j}$ lunch to invited

"(Hanako) invited (Mitiko) to lunch"
**C$_b$1** = Hanako;
**C$_f$1 from C$_f$1(c)** = {Hanako, lunch, Mitiko} (SUBJ, OBJ2, OBJ);
**Tr1** = CONTINUE;
**C$_f$2 from C$_f$2(c)** = {Mitiko, lunch, Hanako} (SUBJ, OBJ2,OBJ);
**Tr2** = SMOOTH-SHIFT

In (50c), there are two possible $C_f$s, using different rankings for the subject, "Mitiko", and the zero object, "Hanako". With this example, Walker et al. (1994) establish the zero topic assignment (ZTA) rule so that zero topics take precedence over the subject when the two don't coincide. With the ZTA in effect, the zero (object) topic is ranked higher than the subject, and the Transition for (50c) is a CONTINUE. Without the ZTA, the subject is ranked higher than the object and the Transition is a RETAIN. In (50d), which has no topic or empathy marking, the subject takes precedence over the object. However, there are

two possible interpretations for the zeros, yielding two different $C_f$ lists. The results from native speaker judgments about the interpretation of the zeros in (50d) show that the $C_f 1$ interpretation is preferred, i.e., the one that results from the ZTA ranking in (50c), with the zero topic entity ranked higher than the subject entity.

In the other method, seen in the work for Turkish (Turan, 1998), German (Rambow, 1993) etc., constructed examples are again used to determine the preferred interpretation of a single pronoun that is ambiguous syntactically and semantically between two entities realized in the previous utterance. The assumption followed here is Gricean in that, in an ambiguous context, the speaker is expected to use an underspecified expression such as a pronoun to provide the default interpretation to the hearer. The default interpretation means resolution of the pronoun to the maximally salient entity of the previous utterance. When comparing the salience of two entities, this method provides the relative ranking for the two entities, which can then be further analyzed in terms of their linguistic properties.

The examples in (51) and (52) from Rambow (1993) illustrates the application of such a method to determine the ordering of the entities in the Mittelfeld in German. The example discourses are constructed as question-answer pairs. The question contains a subject NP and an indirect object NP, and both are of feminine gender. The answer contains a feminine nominative pronoun. The only difference between (51) and (52) is that the two entities "Maßnahme" and "russischen Wirtschaft" are realized in different orders. The coindexing of the pronoun in the (b) utterances shows that the order in which the entities are realized in the (a) utterances affects the interpretation of the ambiguous pronoun. From such examples, Rambow (1993) concludes that the word order of the entities in the Mittelfeld in German takes precedence over their grammatical function.

(51) a. *Frage:* Glauben Sie, Daß **[eine solche Maßnahme]**$_i$
*Question:* Think you, that **[a such measure]**$_i$
**[der russischen Wirtschaft]**$_j$ helfen kann?
**[the Russian economy]**$_j$ help can?

"Do you think that such a measure can help the Russian economy?"

b. *Antwort:* Nein, **sie**$_i$ ist viel zu primitiv
*Answer:* No, **she**$_i$ is much too primitive
"No, it is much too primitive"

(52) a. *Frage:* Glauben Sie, Daß **[der russischen Wirtschaft]**$_i$ **[eine solche Maßnahme]**$_j$ helfen kann?

b. *Antwort:* Nein, **sie**$_i$ ist viel zu primitiv

While the methods used above are reliable for the determination of salience, we are interested in looking at naturally-occurring discourses to the extent that they provide us with the best kind of empirical evidence, especially with respect to discourse-related phenomena. We therefore start with the assumption that the form of referring expressions used by speakers in naturally-occurring discourse are valuable sources of information about the degree of salience attributed to discourse entities. Furthermore, a closer study of the linguistic properties of the phrases realizing these entities will ultimately allow us to abstract the features that are responsible for determining salience. We propose to use a reformulation of Rule 1, as stated in Figure 3.1.

**Reformulated Rule 1:**

If there are two entities realized in utterance $U_i$ and also in $U_{i+1}$, and if one of them is realized with a pronoun, then this entity must be the more salient of the two in $U_i$.

Figure 3.1: Reformulated Rule 1 for Determining Relative Salience

In Chapter 2, Section 2.1, we showed how the Gricean principles, when reformulated with respect to anaphoric expressions, could explain to quite an extent when and why speakers choose to use more informative forms or less informative forms of reference. We also showed that, for cases where two entities were realized across (adjacent) utterances

and where using pronouns for both entities would lead to an ambiguity in the interpretation of the pronouns, those same principles only constrained the speaker to use a more informative expression for one of the entities, but did not specify for the speaker *which* of the two entities this should be.[3] We pointed out that the choice depended on the relative (discourse) salience of the entities and that this was captured by Rule 1. Given that the Backward-looking Center of $U_{i+1}$ points to the maximally salient entity of $U_i$ that is realized in $U_{i+1}$, and Rule 1 itself, which states that if anything is realized as a pronoun, the Backward-looking Center is, we can predict that when the Gricean conditions for over-informativeness hold, speakers will be over-informative with the entity that is less salient, since otherwise it would constitute a Rule 1 violation. Rule 1 in this sense is generative since it is a constraint on speakers. Our reformulation of Rule 1 is intended to capture this idea. The above-described preconditions/criteria for the choice of over-informativeness are stated explicitly in Figure 3.2. That is, the criteria apply to utterance pairs, $U_i$ and $U_{i+1}$, in which speakers have made an over-informativeness choice with one of the entities in $U_{i+1}$. In addition, however, the reformulated rule holds only for utterance pairs in which two entities are realized in $U_i$ as well as in $U_{i+1}$ and the two entities are ambiguous in $U_i$ in terms of their grammatical features so that using pronouns for both the entities in $U_{i+1}$ would lead to incorrect interpretation assignments or would confuse the hearer.

The exact procedure for determining the relative salience of entities in any utterance $U_i$ is as follows: if two discourse entities $X$ and $Y$ in $U_i$ are both realized in $U_{i+1}$, with only $Y$ being realized as a pronoun (in $U_{i+1}$), then $Y$ must be the $C_b$ of $U_{i+1}$ and must refer to the highest ranked of all the entities in $U_i$ that are realized in $U_{i+1}$. Since $X$ and $Y$ are the only two entities in $U_i$ realized in $U_{i+1}$, $Y$ must be ranked higher than $X$ (or be more salient than $X$). Conversely, if it is $X$ (and not $Y$) that is realized as a pronoun in $U_{i+1}$, then by the same reasoning, $X$ must be more salient than $Y$ in $U_i$.

[3]Note that the same problem would arise if there were more than two entities realized across the utterances.

*In an utterance pair, $U_i$ and $U_{i+1}$:*

(1.) There are at least two entities realized in $U_i$ and they are ambiguous with respect to grammatical features such as number, gender, person, honorificity (for languages like Hindi in which honorificity is grammaticized).

(2.) $U_{i+1}$, realizes *only two* of such ambiguous entities from $U_i$.

(3.) In $U_{i+1}$, only one of the NPs realizing these entities is pronominalized.

Figure 3.2: Criteria for Utterance Pairs for Reformulated Rule 1

Applying this rule in the discourse in (53), which satisfies the utterance pair criteria in Figure 3.2, we can conclude from the referring expression forms in (53b) that in (53a), "Herzog" is more salient than "Herzog's father". Using pronouns for both the entities in $U_{i+1}$ would have led to an incorrect interpretation, or would at least confuse the hearer. Gricean principles constrain the hearer to use a more informative expression for one of the entities, and Rule 1 directs the speaker to be over-informative with the less salient entity. In the observed utterance, since it is "Herzog's father" that is realized by the speaker as a full noun phrase, we can infer that he is the less salient of the two entities in $U_i$. Similarly, the use of the over-informative form *Moses* and the pronominal form *he* in (53c) indicates that in (53b), "Herzog's father" is more salient than "Herzog" (or "Moses").[4]

[4]Since this is an English example, and since we are following the assumption that the ranking of entities in English utterances is mainly determined by grammatical function, then according to the CR-CM algorithm, the expectations E1 and E2 are met in (53c). As such, the speaker is free to use pronouns for both the entities. However, we can explain this example by C1a, which says that if E1 and E2 are met, then realize both entities as pronouns *just in case* no additional inference needs to be conveyed. If some additional inference does need to be conveyed, the speaker does this by using a full noun phrase for the relevant entity. In (53c), we argue that there is indeed some additional inference that the writer makes by using the alternative proper name used for "Herzog" in the text, namely, *Moses*. *Moses* is "Herzog's" first name and since the utterance is from the point of view of "Herzog's father", the writer presumably intended to convey a personalization of "Herzog" from the point of view of his father.

(53) a. **Herzog**$_i$ was broke, and asked **his father**$_j$ to underwrite a loan.

b. **The old man**$_j$ questioned **him**$_i$ narrowly, about **his**$_i$ job, **his**$_i$ expenses, **his**$_i$ child.

c. **He**$_j$ had no patience with **Moses**$_i$. (Moses = Herzog)

*Saul Bellow; "Herzog"*

Given the reformulation of Rule 1 and its relevance for salience determination, we can then search corpora for utterance pairs $U_i$ and $U_{i+1}$ which satisfy the conditions given in Figure 3.2. Once the utterance pairs have been identified in the corpus, they can be encoded for various linguistic features that are hypothesized to have a bearing on discourse salience. These features can then be analyzed to ascertain which features turn out to be significant for the relative salience of entities in each pair, and subsequently, across the entire sample.

We emphasize that the use of Rule 1 of the Centering model in this method does not make the method circular. The circularity argument could be made in the following way: we are using the $C_b(U_{i+1})$ for the computation of the $C_f(U_i)$ list ranking, *but* according to the statement in Rule 1, the identification of the $C_b(U_{i+1})$ is itself dependent on the ranking of the discourse entities in $C_f(U_i)$ list. Anticipating this argument, we note that there is indeed a possible scenario of pronominalization where this circularity would arise; this is the case where, given a pair of utterances $U_i$ and $U_{i+1}$, there is more than one pronoun in $U_{i+1}$. In this situation, identifying the $C_b(U_{i+1})$ (which, of course, has to be one of the pronouns) is wholly dependent on the ranking of the $C_f(U_i)$ list. However, our method exploits the scenario in which there is only one pronoun in $U_{i+1}$, and in this case, the $C_b(U_{i+1})$ can be identified as the pronoun itself, *without relying on knowing the ranking of the $C_f(U_i)$ list*. The identification of the $C_b(U_{i+1})$ in this way is also directly justified by a corollary of Rule 1: *if there is a single pronoun in $U_{i+1}$, then it is the $C_b$ of $U_{i+1}$*. Note that our method also imposes another requirement on the type of utterance pairs selected, namely, that there be two (and only two) entities realized from $U_i$ to $U_{i+1}$

with (only) one of them being realized as a pronoun in $U_{i+1}$. This is a crucial requirement in that it allows us to compare the relative salience of any two entities in any given utterance pair, and finally, in the corpus.

## 3.2 Relative Salience in Hindi

In this section, we apply the method proposed in the previous section for determining some of the factors that affect discourse salience in Hindi, a free word order language. We first give a brief description of some key grammatical aspects of the language, then describe the corpus from which the sample utterance pairs were extracted, and finally present the results obtained with respect to the salience-determining factors in the language.

### 3.2.1 Language Description and Data Extraction

#### Language Description

The default word order in Hindi is subject – indirect object – direct object – verb (S-IO-DO-V). However, the language allows many other permutations, as shown in (54). Word order variation in Hindi has been argued to signal distinctions in meaning relating to information structure (Gambhir (1981), among others). Hindi also has a rich case system, though case marking is not obligatory.

(54) a. malay-ne sameer-ko kitaab dii (S-IO-DO-V) – DEFAULT
malay-ERG sameer-DAT book-ACC gave
"Malay gave the book to Sameer"

b. malay-ne kitaab sameer-ko dii (S-DO-IO-V)

c. sameer-ko malay-ne kitaab dii (IO-S-DO-V)

d. sameer-ko kitaab malay-ne dii (IO-DO-S-V)

e. kitaab malay-ne sameer-ko dii (DO-S-IO-V)

f. kitaab sameer-ko malay-ne dii (DO-IO-S-V)

Pronouns in Hindi exhibit a great deal of ambiguity. Third person pronouns[5] are not fully marked for number, honorificity[6], and not at all marked for gender[7] (unlike English, cf. *He/She*). With respect to number marking, while some forms, like *usne* 'he', *usko* 'him', are unambiguously singular, some forms can be both singular and plural, like *unhone* 'he/they', or *unko* 'him/them'. Table 3.1 shows the third person pronouns and the nominal features for which they are specified.[8] A look at the table reveals that there are no unambiguous pronouns in Hindi.

| Pronouns | number | gender | honorificity |
|---|---|---|---|
| *vah* | sg. | masc./fem. | hon |
| | sg. | masc./fem. | nhon. |
| *ve* | pl. | masc./fem. | hon. |
| | pl. | masc./fem. | nhon. |
| | pl. | fem. | nhon. |
| | sg. | masc./fem. | hon. |
| *us-ne* | sg. | masc./fem. | nhon. |
| *unho-ne* | pl. | masc./fem. | hon. |
| | sg. | masc./fem. | hon. |
| *us-X* | sg. | masc./fem. | nhon. |
| | sg. | masc./fem. | nhon. |
| *un-X* | pl. | masc./fem. | hon. |
| | pl. | masc./fem. | nhon. |
| | sg. | masc./fem. | hon. |

Table 3.1: Pronominal Features in Hindi for the 3rd Person Paradigm

The verbal agreement paradigm in the language reduces some of the ambiguity introduced by the pronominal system. Hindi has verb agreement with the subject or the direct object. The agreement inflection is marked for person, number, and gender. Agreement oc-

[5]First and second person pronouns are systematically excluded from this study.

[6]Honorificity is marked on animate nouns.

[7] However, all the nouns have semantic gender (masculine or feminine), though there are no overt morphological reflexes of this.

[8]*ne*=Ergative case; X=Other cases; hon.=honorific; nhon=non-honorific; sg.=singular; pl.=plural; masc.=masculine; fem.=feminine

curs with the subject in the imperfective aspect and with the object in the perfective aspect. The verb also agrees with the object when the subject is dative. The verb may also bear the default neuter affix which is 3rd person masculine singular. This occurs in the perfective aspect, when the object is marked with the postposition *-ko*, which blocks verbal agreement. Table 3.2 presents the third person inflectional features of the verbal suffixes. As can be seen in the table, the unambiguous gender marking with the verbal suffixes completely compensates for the absence of gender marking on pronouns. However, ambiguity remains with some of the other features, especially number. As we saw above, number marking is only partially specified with pronouns as well.

| verbal suffixes | number | gender | honorificity |
|---|---|---|---|
| *-aa* | sg. | masc./neuter | nhon. |
| *-e* | pl. | masc. | hon. |
| | pl. | masc. | nhon. |
| | sg. | masc. | hon. |
| *-ii* | sg. | fem. | nhon. |
| | sg. | fem. | nhon. |
| *-iin* | pl. | fem. | hon. |
| | pl. | fem. | nhon. |
| | sg. | fem. | hon. |

Table 3.2: Verbal Inflection in Hindi for the 3rd Person Paradigm

The following examples show the interaction of the pronominal system with the verbal agreement system in Hindi for the disambiguation of the pronouns. The examples show that, despite the interaction of the two inflectional paradigms in the language, there is grammatical ambiguity for the pronouns in all cases except for (55) and (56).

(55) *vah* jaa rahaa-hai
PRO-NOM-3.sg.masc/fem.nhon. go be-PROG-3.sg.masc.nhon.
"He is going"

(56) *vah* jaa rahii-hai
PRO-NOM-3.sg.masc/fem.nhon. go be-PROG-3.sg.fem.nhon.

“She is going”

(57) *ve* jaa rahe-haiN
PRO-NOM-3.sg/pl.masc/fem.nhon/hon. go be-PROG-3.sg/pl.masc.nhon/hon.
“He/They (masc.) are going”

(58) *ve* jaa rahii-hain
PRO-NOM-3.sg/pl.masc/fem.nhon/hon. go be-PROG-3.sg/pl.fem.nhon/hon.
“He/They (fem.) are going”

(59) *usne* khaanaa khaayaa
PRO-ERG-3.sg.masc/fem.nhon. food ate-PERF-3.sg.masc/fem.nhon.
“He/She ate food”

(60) *unhone* khaanaa
PRO-ERG-3.sg/pl.masc/fem.nhon/hon. food
khaayaa
ate-PERF-3.sg.masc/fem.nhon/hon.
“He/She/They ate food”

(61) *usne* kitaab paRhii
PRO-ERG-3.sg.masc/fem.nhon. book-3.sg.fem. read-PERF-3.sg.fem.
“He/She read the book”

(62) *unhone* kitaab
PRO-ERG-3.sg/pl.masc/fem.nhon./hon. book-3.sg.fem.nhon.
paRhii
read-PERF-3.sg.fem.nhon.
“He/She/They read the book”

(63) *usko* kitaab mil-rahii-hai
PRO-DAT-3.sg.masc/fem.nhon. book-3.sg.fem. get-PROG-3.sg.fem.
“He/She is getting the book”

(64) *usko* ghar mil-rahaa-hai
PRO-DAT-3.sg.masc/fem.nhon. house-3.sg.masc. get-PROG-3.sg.masc.
“He/She is getting the house”

(65) *unko* kitaab mil-rahii-hai
PRO-DAT-3.sg/pl.masc/fem.nhon/hon. book-3.sg.fem. get-PROG-3.sg.fem.
“He/She/They is getting the book”

(66) *unko* ghar mil-rahaa-hai
PRO-DAT-3.sg/pl.masc/fem.nhon/hon. house-3.sg.masc. get-PROG-3.sg.masc.
"He/She/They is getting the house"

(67) raam *usko* dekh
raam-NOM-3.sg.masc.nhon. PRO-ACC-3.sg.masc/fem.nhon. see
rahaa-hai
be-PROG-3.sg.masc.nhon.
"Ram is looking at him/her"

(68) raam *unko* dekh
raam-NOM-3.sg.masc.nhon. PRO-ACC-3.sg/pl.masc/fem.nhon/hon. see
rahaa hai
be-PROG-3.sg.masc.nhon.
"Ram is looking at him/her/them"

(69) raam-ne *usko* dekhaa
raam-ERG-3.sg.masc.nhon. PRO-ACC-3.sg.masc/fem.nhon. see-PERF-neut.
"Ram saw him/her"

(70) raam ne
raam-ERG-3.sg.masc.nhon. PRO-ACC-3.sg/pl.masc/fem.nhon/hon.
*unko* dekhaa
see-PERF-neut.
"Ram saw him/her/them"

(71) *usne* *usko* dekhaa
PRO-ERG-3.sg.masc/fem.nhon. PRO-ACC-3.sg.masc/fem.nhon. see-PERF-neut.
"He/She saw him/her"

(72) *unhone* *unko*
PRO-ERG-3.sg/pl.masc/fem.nhon/hon. PRO-ACC-3.sg/pl.masc/fem.nhon/hon.
dekhaa
see-PERF-neut.
"He/She/They saw him/her/them"

Possessive pronouns in Hindi show gender agreement with the head nouns, which arises from the inherent gender in Hindi nouns (also see fn 7). (73) gives examples of possessive-

head gender agreement.[9] Note, however, the noun agreement does not provide any grammatical information for the interpretation of the pronoun.

(73) a. uskii maa
PRO-POSS-3.sg.fem. mother-3.sg.fem.
"Ram's mother"

b. uskii kitaabeN
PRO-POSS-3.pl.fem books-3.pl.fem
"Ram's books"

c. uske pitaa
PRO-POSS-3.sg.masc.hon. father-3.sg.masc.hon.
"Ram's father"

d. uske kapRe
PRO-POSS-3.pl.masc. clothes-3.pl.masc.
"Ram's clothes"

e. uskaa sar
PRO-POSS-3.sg.masc. head-3.sg.masc.
"Ram's head"

Hindi also has zero pronouns, but their occurrence is heavily constrained, unlike in Italian (Jaeggli & Safir (1989)) or Japanese (Kameyama (1985)). In Section 3.3, we look at the constraints on the use of zero pronouns in Hindi.

Noun phrases in Hindi may be bare or may appear with a demonstrative article like *ye/yah* 'this', *vo/vah* 'that', and *ve* 'those'. There is an indefinite article *ek* which is morphologically identical to the numeral 'one'. Following the classification in Prince (1992), the NPs with the indefinite article usually refer to hearer-new and discourse-new entities, whereas NPs with the null/overt definite article usually refer to hearer-old and/or discourse-old entities.

[9]The honorific marking in Hindi is homonymous with the plural marking.

**Corpus and Data Extraction**

For the Hindi corpus, we collected 40 short stories and 10 news articles. The stories and articles were chosen such that (a) they contained at least two characters who appear throughout the text, and (b) these two characters were referred to in third person and in the same gender. These conditions provided a qualitative bottom threshold for the extraction of utterance pairs satisfying the criteria specified in Figure 3.2.

For identifying and extracting the utterance pairs in the selected texts, we first had to decide what counted as an utterance. One of the very important issues for a theory of discourse is to determine what constitutes the *utterance unit* for generating the $C_f$ list in complex sentences. In early work in Centering, the notion of the *utterance* was left loose, and the conclusions that were drawn about the use of referring expressions and the effect of this on discourse coherence were based on simple sentences without any complex/embedded structures. In particular, for most of the work, the utterance was identified with either the tensed clause or the sentence, without there being any motivated criteria for why one or the other qualified as the utterance unit for discourse processing. The results of the application of the Centering principles and the CR-CM algorithm will, however, vary depending on how complex sentences are treated, both for the calculation of coherence as well as for the generation and resolution of referring expressions.

The specification of the utterance unit also becomes particularly important for determining the ranking of discourse entities. Since discourse entities are evoked by utterance units, no ranking methodology can be applied unless the basic unit from which the forward-looking centers list is created is properly delimited. This issue of specifying the utterance units has received a lot of attention in the literature, and radically different accounts are found for the treatment of complex sentences. Some, like Kameyama (1998), break up complex sentences into separate units, whereas others like Strube (1998) and Miltsakaki (1999), treat some or all of them as a single unit. For the purposes of applying our method

for determining salience, however, we were faced with the problem of how to proceed without a proper specification of what counts as an utterance. In Chapter 4, we provide an analysis for the proper treatment of relative clauses, suggesting an approach where relative clauses are distinguished into two different classes, each class to be treated differently with respect to their utterance status. Here, we merely identify the two classes and provide the specification of their utterance status. The reader is referred to Chapter 4 for the motivation behind this classification.

- *Class 1:* comprises non-restrictives, appositives, and indefinite restrictives, and these should be treated as forming an independent but embedded utterance unit.
- *Class 2:* comprises the definite restrictives and these should be treated as part of the unit created by the clause in which they occur.

For other types of complex sentences, we make the following assumptions, adopting results from work done by different researchers but based on what we believe to be the correct approach for each type of sentence.

- Simple sentences are utterances.
- Subordinate clauses are part of the main clause unit and entities in subordinate clauses are ranked lower than entities evoked in the main clause.
- Tenseless adjunct clauses are part of the main clause unit and entities in these clauses are lower ranked than entities in the main clause.
- Conjunct clauses form separate utterance units at the same level of embedding.
- Nonreport complements are part of the main clause unit and entities in the complement clause are ranked lower than entities in the main clause.

- Reported complements are part of the main clause unit but entities in these complements are inaccessible to the higher level of embedding.

We restricted the extraction of utterance pairs to those in which one of the entities in $U_i$ was the subject. In Prasad & Strube (2000), we looked at a larger set of utterance pairs including comparison between grammatical categories that did not include the subject. However, since we are here primarily interested in the comparison and interaction between the different salience affecting factors, we focus on the subject cases only for the purpose of comparison among the different factors.

### 3.2.2 Salience Determining Factors

Following the specifications and restrictions given in the previous section, we extracted 414 utterance pairs from the corpus. These pairs were then studied for the linguistic properties that we were interested in, namely, grammatical function, word order, and information status. In this section, we present and discuss the results of our analysis. The main conclusion that we were able to draw from our findings was that grammatical role is the main determining factor of discourse salience in Hindi, and that word order and information status has no significant effect.

In the following examples, the two entities evoked in each of the utterances are indicated in boldface and in square brackets, and coreference is indicated by coindexation. As noted above in the criteria for the extraction of utterance pairs, in each pair the single pronoun is ambiguous with respect to the grammatical features of the two entities whose salience is being compared.

**Grammatical Function**

With the subject as the grammatical role of one of the entities in $U_i$, the other grammatical categories that we were able to compare the subject with were direct object, indirect object, PP object, and adjunct (adjuncts included noun phrase adjuncts or noun phrases occurring inside phrasal or clausal adjuncts).[10]

Example (74) illustrates an example of an utterance pair containing the subject and the direct object as the grammatical roles of the two entities realized in $U_i$. Applying the Rule 1 reformulation, we can conclude that in (74a), the entity "savaariyaaN" is more salient or highly ranked than "chaate" since both entities are realized in (74b) and it is "savaariyaaN"

[10]We also found many cases in which other categories could be compared with the subject. For example, we found 50 instances in which the non-subject entity in $U_i$ was realized as the possessor of some argument. While we have excluded such cases from the discussion here since they are not crucial to our point, we did in fact find that the subject was categorically more salient than the possessor in each case. (1) and (2) provide examples of such cases:

(1) a. thoRe hii dinoN meN **[**$_S$ **vah]**$_i$ [$_{DO}$ **[**$_{POSS\_DO}$ **samraaT]**$_j$ kaa vishvaaspaatra] ban gayaa
few EMPH days in **[**$_S$ **he]**$_i$ [$_{DO}$ **[**$_{POSS\_DO}$ **king]**$_j$ of confidant] become went

"In just a few days, he became the King's confidant"

b. **[samraaT]**$_j$ ne **[usko]**$_i$ koshaadhyaksha banaa diyaa
**[King]**$_j$ ERG **[him]**$_i$ treasurer be gave

"The king made him the treasurer."

(2) a. yah kahtaa huaa **[**$_S$ **kanhaiiyaalaal]**$_i$ [$_{PPO}$ **[**$_{POSS\_PPO}$ **mahaaraaj]**$_j$ ke carRNoN] par gir paRaa
this saying happen **[**$_S$ **Kanhaiiyaalaal]**$_i$ [$_{PPO}$ **[**$_{POSS\_PPO}$ **King]**$_j$ of feet] on fall did

"Saying this, Kanhaiyalal fell at the King's feet."

b. **[mahaaraaj]**$_j$ **[uskii]**$_i$ saccaayii se prabhaavit ho gayaa
**[king]**$_j$ **[his]**$_i$ honesty with impressed be went

"The King was impressed with his honesty."

that is realized with a pronoun and not “chaate”. “savaariyaaN” is thus the Backward-looking Center of (74b). To the extent that we are studying the grammatical role feature of these entities at this stage, we can further conclude that it is the property of being the subject in (74a) that makes “savaariyaaN” more salient than “chaate”, which is realized as the direct object.

(74) a. aise maukoN par **[**$_S$ **savaariyaaN]**$_i$ **[**$_{DO}$ **chaate]**$_j$ taan letii haiN
such occasions on **[**$_S$ **passengers]**$_i$ **[**$_{DO}$ **umbrellas]**$_j$ open take 3pl.fem.prs
“On such occasions the passengers open umbrellas”

b. kabhi-kabhi tej havaa se **[chaate]**$_j$ **[their]**$_i$ haath se urr bhii jaate
sometimes fast wind with **[umbrellas]**$_j$ **[their]**$_i$ hands from fly also go
haiN
3pl.fem.prs
“Sometimes, because of the strong winds, the umbrellas even fly away from their hands”

Example (75) shows another comparison of the subject and the direct object for their effect on salience. In (75b) it is the subject entity of (75a), “baadshaah”, and not the direct object entity that is realized as the pronoun, and therefore, being the Backward-looking Center of (75b), it counts as the more salient of the two entities in (75a).

(75) a. **[ek baadshaah]**$_i$ **[ek qaazii]**$_j$ ko bahut maantaa thaa
**[a king]**$_i$ **[a judge]**$_j$ ACC much like-INF did
“A king was very fond of a judge.”

b. **[qaazii]**$_j$ ne **[uspar]** apnii vidvataa kaa aisaa raNg jamaa
**[judge]**$_j$ ERG **[him]**$_i$ SELF knowledge POSS such color stuck-INF
rakkhaa thaa ki baadshaah use sarvagyaanii samajhtaa thaa
place-INF had that king him all-knowing understand did
“The judge had influenced him with his knowledge so much that the king thought him to be all-knowing”

By the same argument, example (76) shows that the entity realized as the subject, “shramik”, is ranked higher than the one realized as the object of the prepositional ar-

gument of the verb, “yuvak”. Both the subject as well as the prepositional object in (76a) are realized in (76b), but it is the subject that is pronominalized and therefore, it qualifies as the Backward-looking Center of (76b) and as more highly ranked than the prepositional object in (76a).

(76) a. kuch der pashchaat, **[**$_S$ **ek shramik]**$_i$ [$_{PP}$ **[**$_{PO}$ **us yuvak]**$_j$ ke paas] aayaa
some time after, **[**$_S$ **a laborer]**$_i$ [$_{PP}$ **[**$_{PO}$ **that youth]**$_j$ near to] came
“After some time, a laborer came up to the youth”

b. **[He]**$_i$ **[yuvak]**$_j$ se puuchaa ki “kyaa aagyaa hai?”
**[He]**$_i$ **[youth]**$_j$ of asked that “what wish is?”
“He asked the youth, “what is your wish?” ”

(77) and (78) provide further examples of the comparison between the subject and the prepositional object, in both cases showing that the subject entity is more highly ranked than the prepositional object entity.

(77) a. **[**$_S$ **yamduut]**$_i$ fir [$_{PP}$ **[**$_{PO}$ **gorelaal]**$_j$ ke darvaaze par] aa dhamkaa
**[**$_S$ **death-messenger]**$_i$ again [$_{PP}$ **[**$_{PO}$ **Gorelaal]**$_j$ of door at] come did
“The death-messenger turned up at Gorelal’s door again”

b. **[uske]**$_i$ pairoN kii aahaT se **[gorelaal]**$_j$ kii dhukdhukii dhaRakne lagii
his feet of movement with gorelaal of heart beating start-did
“Gorelal’s heart started beating at the sound of his feet.”

(78) a. andheraa ho calaa thaa
darkness happen left had
“It had become dark”

b. **[**$_S$ **samraaT]**$_i$ ghuumtaa-firtaa [$_{PP}$ **[**$_{PO}$ **ek diin grihasta]**$_j$ ke darvaaze par] gayaa
**[**$_S$ **king]**$_i$ roaming one day [$_{PP}$ **[**$_{PO}$ **a poor householder]**$_j$ of door on] went
“One day, the king, roaming around, went up to the door of a poor householder”

c. **[grihasta ne]**$_j$ **[usko]**$_i$ dekhte hii puuchaa, “kaho bhaai, tum
**[householder ERG]**$_j$ **[him]**$_i$ seeing EMPH asked, “say brother, you
kaun ho, kahaaN jaaoge?”
who are, where going?”
“The householder, as soon as he saw him, asked, ”say, brother, who are you and where will you go?””

Example (79) illustrates the comparison between the subject and the direct object of an adjunct clause. Here again, the subject entity (in (79b)) emerges as being more salient than the object inside the adjunct clause.

(79) a. savere vahaaN se satkaarpuurvak vidaa hokar **[vah]**$_i$ aage baRhaa
morning there from respectfully farewell having he forward grew
“In the morning, having received a respectful farewell, he moved ahead”

b. **[**$_S$ **grihasta]**$_j$ bhii kuch duur tak [$_{ADJU}$ **[**$_D$**O use]**$_i$ pahuNcaane]
**[**$_S$ **householder]**$_j$ also some distance till [$_{ADJU}$ **[**$_D$**O him]**$_i$ reaching]
aayaa
came
“The householder also came for some distance to drop him off.”

c. alag hote samay **[usne]**$_j$ **[samraaT]**$_i$ se puuchaa, “bhaiiyaa,
separation being time **[he]**$_j$ **[king]**$_i$ of asked, Brother,
sevaa-satkaar me koii truTii huii ho to use kshamaa karnaa aur idhar
hostpitality in any lack happened be then it forgive do and here
se jab kabhi aanaa, hamaarii kuTii meN jaruur Thaharnaa”
with when ever come, our cottage in surely stay
“Before separating, he asked the king, “Brother, if there was anything lacking in our hostpitality, then forgive it, and when you come this way again, be sure to stay at our cottage.”

Table 3.3 shows the distribution we found in the data with respect to the different pairs of grammatical categories that we compared. In each row, we list the numbers and percentages for the hypothesis that the subject was ranked higher than the category it was being compared with. The second column contains the number/frequency for the subject being

ranked higher and the third column gives the total number of those cases that occurred in the sample. The results show that the subject has a significantly greater influence on salience than the other grammatical function categories.

| **Ranking** | Number (%) | Total |
|---|---|---|
| Subject > Direct Object | 144 (96) | 149 |
| Subject > Indirect Object | 50 (87) | 57 |
| Subject > PP Object | 128 (100) | 128 |
| Subject> Adjunct | 72 (90) | 80 |
| Total | 394 (95) | 414 |

Table 3.3: Frequencies for Relative Salience of Grammatical Functions

The fact that the percentages in each row of the table are not 100% provide an indication of the claim made in Centering that Rule 1 can be violated by speakers, as shown by the utterance pair in (80), where the object entity in (80a) is realized as a pronoun in (80b) rather than the subject entity. However, the high percentages in each row also show that while speakers can be expected to violate Rule 1, they will more often *not* violate the rule. Theoretically, this gains support again from Gricean expectations about speaker-hearer cooperative behavior. Since Gricean principles are not laid out as categorical constraints, the fact that the subject does not get picked out as the pronominalized entity all the time is understandable.

(80) a. raajkaaj ke maamloN meN **[**$_S$ **vah]**$_i$ **[**$_{DO}$ **usko]**$_j$ baRhaavaa
royal-administration of matters in **[**$_S$ **he]**$_i$ **[**$_{DO}$ **him]**$_j$ encouragement
bhii dene lagaa
EMPH giving did
"He also started giving him encouragement in matters of royal administration"

b. thoRe hii dinoN meN **[vah]**$_j$ **[samraaT]**$_i$ kaa vishvaaspaatra ban
few EMPH days in **[he]**$_j$ **[king]**$_i$ of trusted-person become
gayaa aur anya darbaariyoN se kahiiN-adhik yogya pramaaRNit hua.
went and else officials than much-more able proven became
"In just a few days he became the king's trusted person and proved to be much more able than the other officials"

At the same time, the less than 100% frequency of the higher ranking of the subject entities raises the possibility of other factors overriding the effect of grammatical function. For example, we might entertain the possibility that the Rule 1 violations are not really that, but simply exhibit the more dominant effect of word order if we found in those apparent violation cases that the non-subject entity was in fact preposed to a position before the subject. This would put Hindi in the same class as other languages such as German, in which word order has been shown to play role in discourse salience. Similarly, we might also be able to explain the apparent violations in terms of the information status of the discourse entities, which has been claimed to have an effect on salience. In the next section, we address this issue by looking directly at the effect of word order and information status, and answer the question as to whether the Rule 1 violations are real, or whether they are the result of other factors overriding the grammatical function factor.

**Word Order and Information Status**

The surface order of constituents has been argued to be a determining factor for relative salience in German (Rambow (1993), Strube & Hahn (1996), Strube (1998), Strube & Hahn (1999)), with the $C_f$ list ranking being partially determined by the left to right ordering of the constituents. Since Hindi is a free word order language like German, this raises the issue of whether the word order criteria for ranking the $C_f$ list might hold for Hindi as well. This expectation, however, is not borne out for Hindi. In our sample of utterance pairs, there was a fair amount of word order variation in the realization of the entities in the different grammatical function categories we looked at. Table 3.4 shows the interaction of grammatical function with word order with respect to discourse salience. The first column is the header for the two different word orders for each pair of grammatical categories from Table 3.3. The second column gives the distribution of the different word orders and in combination with numbers for the ranking. X in this second column stands for

the non-subject grammatical categories. A look at the table shows that in none of the cases is the preposed non-subject constituent ranked higher than the subject. Furthermore, the distribution in the table also answers the question that we posed regarding the Rule 1 violations in the previous section. All of the Rule 1 violations shown in the table obtain for those cases in which the subject appears before the non-subject constituent. So, whatever the explanation for the Rule 1 violations may be, we know for certain that they do not occur because of the overriding effect of word order.

| Word Order | Ranking | | Totals | |
|---|---|---|---|---|
| | S > X | X > S | | |
| S-DO | 100 | 5 | 105 | (149) |
| DO-S | 44 | 0 | 44 | |
| S-IO | 46 | 7 | 53 | (57) |
| IO-S | 4 | 0 | 4 | |
| S-PPO | 50 | 0 | 50 | (128) |
| PPO-S | 78 | 0 | 78 | |
| S-ADJU | 33 | 8 | 41 | (80) |
| ADJU-S | 39 | 0 | 39 | |
| Totals | 394 | 20 | 414 | |

Table 3.4: Interaction of Grammatical Function and Word Order for Discourse Salience

It has been claimed in Strube (1998) that information status is an important criteria for the $C_f$ list ranking in German as well as English. An extension to this claim is also made in the same work that information status may be a linguistically universal criterion. This claim however, is not borne out in the Hindi data. To test the claim, we looked at a subset of the information status distinctions, comparing hearer-new, discourse-new entities with hearer-old, discourse-old entities. Since we were primarily interested in the interaction of grammatical function with information status, we identified utterance pairs in which the subject was hearer-new and discourse new, and some non-subject constituent was hearer-old, discourse-old. This case provides us with the clearest case of whether the non-subject, when *old*, becomes more salient. We found that in all the 93 such utterance pairs that

we were able to identify, the *new* subject entity was categorically selected as the one that was pronominalized in the following utterance, and not the *old* non-subject entity. This provides robust evidence for a counterargument to the language universality of information status with respect to discourse salience.

Based on the above findings, we are now in a position to propose a $C_f$ list ranking criteria for Hindi. Excluding the role of word order and information status, the ranking is given in terms of grammatical function, as follows:[11]

- **$C_f$ list ranking criteria for Hindi:**

  SUBJECT $>$ DIRECT OBJECT $>$ INDIRECT OBJECT $>$ ADJUNCTS $>$ OTHER

## 3.3 Zero Pronouns in Hindi

This section presents a corpus-based investigation of the use of zero pronouns in Hindi. After establishing that the antecedents of these null arguments cannot be recovered syntactically (Rizzi, 1986), we propose an account in terms of Centering theory. Given the Hindi-specific ranking criteria proposed in the previous section, we argue that the discourse constraint to license the felicitous use of Hindi zero pronouns should be formulated as a combination of preferences for sequences of Transitions and a "zero pronoun rule", adapted from Rule 1 of Centering theory. More generally, the proposed account will explain (a) why null elements are most frequently the subject, (b) why object drop in Hindi occurs only when the subject is also dropped.

Hindi allows major grammatical relations such as subject and object to be covert in finite clauses and these unexpressed relations function as pronouns. This raises the question of how the reference for these zero pronouns is determined. We first show that Hindi zero

[11] As we noted before, Prasad & Strube (2000) provide the results for the rankings between the non-subject categories.

pronouns are not recoverable via identification with rich AGR, as is argued for languages like Italian and Spanish ((Rizzi, 1986), among others) . This is despite the fact that Hindi has morphologically uniform and rich inflectional paradigms for verbal agreement. In such a case, the recoverability of these pronouns for reference is assumed to be constrained by rules of discourse. In previous work, (Butt & King, 1997) also make this assumption and further, specify a discourse constraint that relates the use of zeros to word order and information structure, in particular, to topicalization. We argue that the proposal made by Butt & King (1997), namely that arguments can be dropped when they are the continuing topic, with the topic equated with the topicalized constituent (if any) of a sentence, cannot account for all the observed facts. Finally, we provide an alternative (corpus-based) account of the discourse constraints on zero pronouns in Hindi tensed main clauses.[12] The account is couched within the framework of Centering theory and the constraint is stated in terms of the *Transition pair preferences* and the *zero pronoun rule*, adapted from Rule 1 of Centering theory.

### 3.3.1 Hindi in a Typology of Null Argument Languages: On Identification via Agreement

Kameyama (1985) groups Hindi with Type II languages such as Italian and Spanish with respect to the extent to which major grammatical functions can be non-overt in tensed clauses. Following Rizzi (1986) and Jaeggli & Safir (1989), such languages have a verbal morphology that is sensitive to one or more grammatical features (person, number, gender, aspect, etc..). Furthermore, since these languages have only subject-verb agreement, object drop is disallowed, and this fact is immediately explained by the requirement that the person/number/gender features of the zero pronoun should be recoverable by agreement,

[12] Arguments are rarely dropped in subordinate clauses. The constraints on their occurrence are not addressed in this study.

in order for referent identification to take place. This behavior contrasts with what is seen in languages like Japanese and Chinese, which display a syntactically unconstrained use of zero pronouns, in that person, number and gender features of null arguments are not associated with verbal agreement. Recoverability of these arguments then is argued to rely on discourse factors and not on syntax at all.

Hindi is like Spanish, Italian and Latin in having a rich verbal agreement system but is different from them in that the verb can agree with both the subject and the object, as was described in the previous section, and is also evident in (81) and (82).

(81) malay kitaab paRh rahaa hai
malay-3sg.M book-3sg.F read-INF stay-PROG.M be-PRES.3sg
"Malay is reading the book"

(82) malay ne kitaab paRhii
malay-3sg.M ERG book-3sg.F read-PERF.3sg
"Malay read the book"

Given the classification of languages in terms of the rich AGR licensing condition, Kameyama (1985) claims that Hindi behaves like Italian and that it allows an argument to be dropped if the verb was inflected for its person/number/gender features. So, for example, if the verb agreed with the subject, as in (81), the subject should be able to appear as null and if the verb agreed with the object, as in (82), there would be nothing ruling out the object from being realized as null. At the same time, however, what she claims is not possible for Hindi is for the subject to be null when the verb agrees with the object, and vice versa. This is illustrated in the examples in (83) and (84) (adapted from Kameyama (1985)):

(83) a. **Q:** kyaa **[malay]**$_i$ ne kitaab paRhii?
QPL **[malay]**$_i$-3sg.M ERG book-3sg.F read-PERF.3sg.F?
"Did Malay read the book?"

b. **A: [malay/*0]**$_i$ ne kitaab/0 paRhii
**[Malay/*0]**$_i$-3sg.M ERG book/0-3sg.F read-PERF.3sg.F
"Malay read the book"

(84) a. **Q:** kyaa **[malay]**$_i$ kitaab paRh rahaa hai?
QPL **[malay]**$_i$-3sg.M book-3sg.F read-INF stay-PROG.M be-PRES.3sg
"Will Malay read the book?"

b. **A: [malay/0]**$_i$ kitaab/*0 paRh rahaa hai
**[Malay/0]**$_i$-3sg.M book/*0-3sg.F read-INF stay-PROG.M be-PRES.3sg
"Malay is reading the book"

Counterexamples to these expectations, however, are abundant in naturally occurring data, as examples (85) and (86) show:

(85) a. **[fanTuush]**$_i$ ne aadmiyoN kaa gussaa saamaan par
**[FanTuush]**$_i$-3sg.M ERG men-3pl.M of anger furniture-3sg.M on
utaaraa.
took-down
"Fantuush took out his anger with the men on the furniture."

b. **[0]**$_i$ vahaaN kii sab **[kursiyaaN]**$_j$ toR daaliiN.
**[0]**$_i$-3sg.M there of all **[chairs]**$_j$-3pl.F break-INF put-PERF.3pl.F
"(Fantuush) broke all the chairs there."

(86) a. **[unhone]**$_i$ shahar me makaan banvaa liyaa
**[he]**$_i$**-3sg.M** city in house make-CAUS take-PERF-.3sg.M
thaa (unhone$_i$ = Gajadhar Baabu)
be-PAST.3sg.M
"He had got a house made in the city"

b. **[0]**$_i$ **[baRe laRke amar aur laRkii kaantii kii shaadiyaaN]**$_j$ kar
**[0]**$_i$ **older son amar and daughter kantii of marriages]**$_j$-3pl.F do-INF
dii thiiN
give-PERF-3pl.F be-PAST.3pl.F
"(Gajadhar Babu) had done the marriages of his older son Amar and daughter Kaantii"

In both (85b) and (86b), the person, number and gender features of the null subjects

cannot be determined by the verb because the verb agreement is with the object. In (85b), the verb agrees with the direct object *kursiyaaN*$_j$ 'chairs', and in (86b), the verb agrees with the head noun of the complex direct object noun phrase *shaadiyaa*$_j$ 'marriages'. So despite the rich agreement inflection on the verb, we cannot maintain that there is an agreement based licensing constraint on the use of Hindi zeros.[13] We therefore need to look elsewhere for the constraints that govern the use of null pronouns. In this sense, Hindi groups together more closely with Japanese and Chinese, although the use of zeros in the latter is more unrestricted than in Hindi.

### 3.3.2 Previous Research on the Discourse Constraints Licensing Hindi Zero Pronouns

In their study of null elements in Hindi and Urdu discourse, Butt & King (1997) also argue that the interpretation of null elements in Hindi lies outside the realm of syntax and that the felicitous use of zero pronouns is instead governed by the discourse context in which the utterance is used. In particular, they attempt to relate argument drop in Hindi with the free word order that is characteristic of the language. The different word orders in Hindi have been shown to relate to different discourse functions Butt & King (1997). Furthermore, Butt & King (1997) attempt to relate word order, information structure (Vallduví, 1990; Vallduví & Engdahl, 1996) and referentiality. They draw on Gambhir's account of the discourse functions of word order variants in Hindi, but focus primarily on four discourse functions: (a) Topic (b) Focus (c) Background and (d) Completive Information:

1. **Topic:** the *topic* in their account is identified with the clause-initial constituent in matrix clauses. Structurally, this position is identified as [Spec, IP]. According to

[13]Note that Georgian is one language that patterns like Hindi in its verb agreement paradigm (see Kameyama (1985)), and also respects the licensing constraint of null argument in terms of identification by agreement.

this proposal then, *topicalizations* are assumed to be hosted by [Spec, IP] and are therefore the *topic* of the clause. This is shown in (87):

(87) [IP [SPEC,IP hassan ko-TOPIC ] naadiyaa ne Tofii dii ]
To Hassan Naadiyaa gave a toffee
"Hassan gave a toffee to Nadiya"

2. **Focus:** The focus is the pre-verbal position if there is only one focused element. However, if there are multiple foci, where one would receive the neutral focus, and the other would receive what has been termed as Contrastive focus, then the contrastive focus element can be focused in situ.

3. **Backgrounded Material (BM):** The backgrounded material is the post- verbal position. This is similar to topicalized information in that both have the status of "old" or "known" information, but they are different from topics in that while topics are the pointer to the relevant information to be accessed by the hearer, the BM only provides more detailed information as to how the new information fits in with the already known information. That is, the BM provides the info. that may be necessary for a good understanding of the new (focussed) information supplied. (see. Hoffman (1995)).

4. **Completive Information:** The completive information is the preverbal in situ backgrounded material.

As for the licensing constraint on zero pronouns, Butt & King essentially claim that an argument can be dropped if it is a *continuing topic* (i.e., if it is the topic of the current as well as the previous utterance) or if it is the *backgrounded information*.

Their example (88) below gives an example of a *continuing topic*: the topic is the same from utterance (a) to (b) and can thus be felicitously dropped.

(88) a. **[main]**$_i$-TOPIC baais baras se yahaan rah rahaa huun

"**[I]**$_i$-TOPIC have been living here for 22 year"

b. **[0/main]**$_i$-TOPIC rozaanaa is hii saRak se guzartaa huun

"**[0/I]**$_i$-TOPIC go by this street daily"

(89) gives an example of a *shifting topic*: the topic in the (b) utterance has been shifted to a different entity than in the (a) utterance and thus cannot be dropped.

(89) a. to **[(hum)]**$_i$-TOPIC uspe ek naaTak likhte hain.

"So let **[(us)]**$_i$-TOPIC write a play about that"

b. **[main/*0]**$_j$-TOPIC erfors kaa aadmii huun

"**[I/*0]**$_j$-TOPIC am an airforce man"

### 3.3.3 Dissociating Word Order and Information Structure from the Form of Referring Expressions

While the account proposed by Butt & King (1997) is an attractive one in that it relates word order, information structure, and the form of referring expressions used in discourse, especially in light of such established correlations for other languages such as German (Rambow, 1993; Strube & Hahn, 1999), this three-way correlation cannot be maintained for Hindi. Further motivation for the absence of such correlations comes from our findings related to the $C_f$ list ranking criteria for Hindi in the previous section. There we showed that word order and information status has no significant effect on discourse salience and therefore also on pronominalization. In the study presented in the previous section, however, we did not investigate the interpretation and constraints on the use of zero pronouns.[14]

[14]It is legitimate to assume that the constraints on overt pronouns are not the same as the ones on zero pronouns, primarily because they are not necessarily in free variation.

In what follows, we argue that word order and information structure (associated with the word order) have no bearing on the felicitous use of zero pronouns in Hindi.

A look at the examples in Butt & King (1997) containing a continuing topic shows that in each case, the topic coincides with the subject. Since there is no reliable way of telling whether the subject is indeed in the TOPIC position in the clause, the real test of the effect of the topic on null anaphora lies in clauses where some non-subject constituent has been topicalized. The following examples taken from the corpus used for this study show that a null argument can be licensed when it does not refer to the topicalized element. In (90a), the prepositional object "Alladiya" is the topicalized entity (where topicality is indicated by the topic marker *to* (Kidwai, 1997; Prasad, 1997) in addition to its clause initial position). The zero pronoun in (90b), however, cannot refer to this entity and instead picks the grammatical subject denoted entity as its antecedent.

(90) (A group of people are talking about the appalling behavior of a man called Alladiya and suddenly recall Alladiya's father, Hamiidaa..)

a. **[is haraamzaade allaadiyaa se to]**$_i$-TOPIC **[hamiidaa]**$_j$-SUBJ laakh
**[this bastard alladiya from TOP]**$_i$-TOPIC **[hamiidaa]**$_j$-SUBJ million
darze acchaa thaa
times better was
[Roughly] "Hamiidaa was a million times better than this bastard Alladiyaa"

b. **[0]**$_{\#i/j}$ fakat ek hii baar kafan churaataa thaa
**[0]**$_{\#i/j}$ EMPH once only time coffin steal did
"(#Allaadiyaa/Hamiidaa) stole the coffin only once"

An important point to note here is that both the "topicalized constituent" as well as the "subject" are equally likely candidates for antecedents of the zero pronoun. So, the zero pronoun not only can be licensed when it refers to some non-topicalized constituent, but in fact cannot refer to this clause-initial topicalized element, even when the person, number, and gender features are perfectly compatible with it. This point will be discussed further in

the later sections.

In the next example, the prepositional phrase is topicalized and though the topicalized constituent is not a likely candidate for the zero pronoun, the example still illustrates that the zero can be licensed when it refers to the non-topicalized element.

(91) a. **[apnii duukaan se]**$_i$-TOP **[Kishan]**$_j$-SUBJ param santushT va sukhi thaa
**[self's store with]**$_i$-TOP **[Kishan]**$_j$-SUBJ totally satisfied and happy was
"Kishan was totally satisfied and happy with his store"

b. **[0]**$_{\#i/j}$ raat khaaT par jaataa to na jaane kitne sapne aate
**[0]**$_{\#i/j}$ night cot on went-HAB then (he) didn't know how many dreams
came (to him)
"When (Kishan) went to his bed at night, there was no telling how much he dreamt"

Examples such as those given above indicate that word order/topicalization cannot be a strong licensor of zero pronouns in Hindi. In the next section, we turn to our analysis of a hand collected corpus and propose an alternative account of null arguments in Hindi.

### 3.3.4 The Discourse Constraint on Hindi Zero Pronouns: A Centering Account

So far, we have established that Hindi Zero pronouns are neither identifiable by syntactic constraints such as the requirement for identification by rich AGR, nor by discourse constraints that attempt to relate their felicitous use to word order and information structure. In this section, we present a Centering-based analysis of a Hindi corpus which we have hand created and annotated for purposes of this study. We have analyzed the corpus for the effect of Transition preferences between utterances on whether a zero pronoun was used or not, and the results show a distinct correlation between certain Transition pairings and the occurrence of the zero pronouns.

Following the results on the Hindi salience ranking in the previous section, we assume that the elements of the $C_f$ list in Hindi are ranked by grammatical function (subject $>$ direct object $>$ indirect object $>$ adjuncts).

### 3.3.5 Corpus and Coding

The corpus used for this study was a collection of 6 short stories and 3 newspaper articles. The total number of sentences was 2192. Each sentence in the corpus was coded for:

- Clause type (declarative, imperative, interrogative).
- Main vs. subordinate clause.
- Position of the grammatical functions of subject, object and indirect object (when they are overt).
- Overt/null realization of the grammatical functions.
- The cospecifier of the null elements with respect to grammatical function and position.
- Three Centering variables: (a) the $C_p$, (b) the $C_b$, (c) and the Transition marked by the clause.

Clause types such as imperatives and interrogatives were excluded from the analysis, as were direct speech segments (which most often included the previous two types). Following Kameyama (1998), we assume direct speech segments to be inaccessible to the utterances in the next higher level of segmented discourse, so their exclusion does not upset the computation of the Transitions, which is the main point of this study. After exclusion of these clause types the sentences in the corpus totaled 1332. In coding for the elements that are potential candidates for subsequent reference, we have also excluded the annotation

of things such as events, states, propositions, or phrases. Null arguments in subordinate clauses were found to be very rare (we counted only 4) and we have excluded these from the annotation too.

### 3.3.6 Analysis and Results

Out of the 1332 clauses that were finally coded for the Centering variables and for which the Transitions were computed, there were 466 clauses in which there was no continuing reference from the previous utterance.[15] In the remaining 866 clauses, only 209 had one or more zero pronouns whereas the remainder had either a full NP or a overt pronominal form. A quick look at the distribution of zero pronouns with respect to the major grammatical functions showed that most of these zero pronouns were subjects (199), very few were direct objects (10) and there were none corresponding to any other grammatical function. While we will not attempt to answer the question of why no grammatical function other than the subject and the object are realized as null, the constraint that will be formalized below does explain the low number associated with zero objects. In fact, in the corpus, the zero objects occurred only when there was also a zero subject in the clause. we return to this presently.

After computing the Transitions between all the utterances in the corpus, the first preliminary finding was that all the utterances containing zero pronouns were marked with the CONTINUE Transition. Though this finding was interesting, it did not say much about what kinds of entities in the previous utterance could be realized as zero in the current one. A CONTINUE Transition is obtainable after all the other three Transitions, which means that any entity in the $C_f$ list of the previous utterance has the potential of being realized as a zero in the current utterance. Furthermore, this also does not answer the puzzle indirectly

[15] This could be said to mark the beginning of a new discourse segment in Centering terms. However, we do not address this question here.

posed earlier, namely, that if it is not the topicalized constituent of an utterance that can be realized as a zero in the next one, then what is?

The next step of the analysis therefore involved extraction of *Transition pairs* rather than just single Transitions. Thus, if an utterance had a zero pronoun, we recorded the Transition marked on it as well as the one marked on the previous utterance. The distribution of Transition preferences this time was the following:

- There were only three kinds of Transition pairs associated with the zero pronouns:

  (92) CONTINUE + CONTINUE

  (93) SMOOTH-SHIFT + CONTINUE and

  (94) RETAIN + CONTINUE

The distribution of each pair for the 199 zero subject pronouns is shown in Figure 3.5.

| | |
|---|---|
| CONTINUE + CONTINUE | 106 (53%) |
| SMOOTH-SHIFT + CONTINUE | 85 (42%) |
| RETAIN + CONTINUE | 8 (4%) |

Table 3.5: Distribution of Zero Subject Pronouns in Hindi Corpus

Note that in determining the frequencies above, the zero objects have not been excluded intentionally from the total number of zero pronouns, but rather for statistical reasons: as mentioned above, zero objects always occurred with the zero subjects, and furthermore, only with the CONTINUE + CONTINUE or the SMOOTH-SHIFT + CONTINUE Transition pairs. Since the subjects are ranked higher than the objects in the ranking hierarchy of the $C_f$ list, these zero objects will never figure in the computation of the Transitions. We have therefore excluded them to prevent any distortion of the frequencies (even though this may not be significant enough).

One of the first things that is obvious from the distribution seen above is the significance of the *Preferred Center*, the $C_p$, in Hindi for the realization of zero pronouns in discourse. The percentages of the CONTINUE Transitions following a CONTINUE and following a SMOOTH-SHIFT are roughly the same. The low percentages of a RETAIN followed by a CONTINUE also indicates that the *continuing topic*, if defined in Centering terms as the *backward looking center* (Prince, 1998), has very little likelihood of being realized as a zero pronoun unless it is also the *preferred center* of the previous utterance.

The figures also explain why the subject is the grammatical function most often realized as null. Given the $C_f$ list ranking criterion for Hindi, where the subject is always most highly ranked in the $C_f$ list, and the categorical preference for a CONTINUE Transition that we have seen above, the subject is the only grammatical function that can generate a CONTINUE Transition. For the same reason, the objects cannot be dropped, because it would lead to either a RETAIN or a Rough shift Transition which is dispreferred. At the same time, we can also now explain why objects can be dropped when the subjects are also dropped. This follows from Rule 1 of Centering theory which we can reformulate for zero pronouns for Hindi, shown in Figure 3.3.

**Zero pronoun rule for Hindi:**

If anything is realized as a zero pronoun in the utterance, then the $C_p$ must be.

Figure 3.3: Zero Pronoun Rule for Hindi

According to this rule, if there is a single zero pronoun in the utterance, then it must be the previous $C_p$ (thus generating a CONTINUE Transition). The Object-drop is observed in the data because there is nothing ruling it out as long as the previous $C_p$ is also dropped. However, it is less likely to occur by itself because it would then violate the zero pronoun rule. Finally, we can also address the absence of the correlation between word order, namely, topicalization, and the realization of zero pronouns. This is because topicalized

*Optionally drop an argument in $U_{i+1}$ if*:

the Transition marking the previous utterance $U_i$ is a CONTINUE or a SMOOTH-SHIFT,
the Transition marked by the current utterance, $U_{i+1}$, is a CONTINUE, and
the Zero Pronoun Rule is not violated.

Figure 3.4: Constraint on Zero Pronouns in Hindi

constituents, unless the subject itself is topicalized, do not rank as the highest entity in the $C_f$ list in Hindi and can therefore never generate the two preferred Transition pairs if they are realized as null in the next utterance.

We can now state the discourse constraint that licenses the occurrence of zero pronouns in Hindi. This is shown in Figure 3.4.

One question still remains, however. There were a large number (247) of the preferred Transition pairings (CONTINUE + CONTINUE and Smooth Shift + CONTINUE) listed above that did not realize the $C_p$ of $U_{i+1}$ as null. A detailed study of this disparate pattern has been beyond the scope of this study, but is the focus of future research.

## 3.4 Conclusion

In this Chapter, we first addressed the question of the observed cross-linguistic variability in the way referring expression forms are realized and we pointed out that one of the most important sources of this variability lies in the way different languages rank the forward-looking centers lists. Since this dissertation is concerned with the generation of referring expressions in Hindi, we were particularly interested in identifying the linguistic correlates of the criteria for ranking the forward-looking centers list in Hindi. To this end, we first proposed a language-independent corpus-based method for identifying the factors that determine discourse salience. The proposed methodology utilized a reformulation of Rule 1 of Centering theory. We then applied the method for investigating three linguistic factors,

namely grammatical function, word order, and information status, to determine whether they count as the criteria for the ranking. Our results showed that grammatical function is the primary determinant of discourse salience and that word order and information status do not show any significant effect.

Using the results from the $C_f$-list ranking criteria for Hindi, we provided a Centering analysis of zero pronouns in Hindi. We argued that the interpretation of and the licensing conditions on Hindi zero pronouns cannot be done in terms of syntactic constraints and that, despite the rich agreement inflectional paradigm of the language, arguments may be dropped even when the identification via agreement requirement is not met. The statement of the constraints for the interpretation of these null elements needs to be made in terms of the discourse context. We discussed previous efforts in this direction and showed that these accounts were insufficient in explaining all the observed facts about argument drop. In particular, we argued against a discourse constraint that motivated a correlation between word order, information structure, and the form of referring expressions. Finally, we presented a corpus based Centering analysis of Hindi texts and showed that zero pronouns occurred most often with certain Transition pairings over utterances. In addition, we explained the difference in the frequency of occurrence found between subject and object pronouns in terms of the "zero pronoun rule" for Hindi.

# Chapter 4

# Relative Clauses and the Utterance Unit in Centering

## 4.1 The Problem

One of the very important issues that arises in the modeling of discourse phenomena is the delimitation of the *utterance unit* in discourse. This has received special attention in studies grounded in Centering theory which models attentional state at the local level. Centering principles and constraints apply on an utterance by utterance basis, and therefore it is of some importance to specify what counts as an utterance. This problem is harder for utterances than for other types of linguistic units, such as those for sentences and words. Sentence and word boundaries are easily determined because they have an overt reflex that can be precisely identified, but not so with discourse units. Units in discourse are defined in more abstract terms. In the Centering model, for example, an utterance as a unit is defined as being about *something*, where this "something" is the *topic* (or the Backward-looking Center) of the utterance. So it would seem that, if we could track the topics in a discourse, we would be able to easily identify the utterance units. However, this seemingly

easy task acquires great complexity because it is not very easy to determine what the topic is at any given point of the discourse. Most of the time, this is done intuitively, and there is yet no reliable procedure outlined for accomplishing this task. In fact, ironically, one of the appealing aspects of the Centering model is that it can itself be used to identify the topic of utterances, which may be then used to explain other discourse phenomena. Sidner's focusing algorithm (Sidner, 1979; 1983), for example, of which Centering is an abstraction, is used to track the topic (her *discourse focus*), which she then uses for identifying the referents of certain kinds of anaphoric expressions. Thus, such an approach will obviously not work, as things stand, and it seems that we need an independent way of identifying the utterance.

## 4.2 Related Work on Complex Sentences

### 4.2.1 Clause-based Approaches

There are to date two kinds of approaches that have been discussed or proposed in the literature on delimiting the utterance unit. In one approach, utterances are identified with the tensed clause. As a result, complex sentences are broken up into separate units by identifying the tensed clauses in the sentence, and each of these counts as a separate utterance. This is seen in early work in Centering, such as Sidner (1983), and is shown with the discourse segment (95).

(95) a. Wilbur is a fine scientist and a thoughtful guy.

b. He gave me a book a while back which I really liked.

c. It was on relativity theory,

d. and talks mostly about quarks.

e. They are hard to imagine,

f. because they indicate the need for elementary field theories of a complex nature.

Sidner (1983)

In this work, however, no explicit distinction was made between different kinds of complex sentences, and as such the criteria followed for splitting up complex sentences was rather arbitrary. In later work, Kameyama (1998) provided the first extensive account of various types of complex sentences, bringing to attention the notion of the update unit, i.e., the unit on which the Forward-looking Centers lists are created. She proposed an *intra-sentential centering hypothesis* (ICH) which states that a complex sentence should be split into a set of center-updating units corresponding to "utterances" in inter-sentential Centering. The central motivating aspect of this hypothesis (as of the stipulation made in Sidner's work) was that it allowed for the processing of intra-sentential anaphoric dependencies in the same way as for inter-sentential dependencies without any extension to the original Centering model. The relevance of the notion of the update unit comes into play when we consider what to count as the Forward-looking Centers list for an utterance before which a complex sentence occurred. According to Kameyama's ICH, after a complex sentence S, the next utterance picks the Forward-looking Centers list as the one resulting from breaking up S into a (structured) sequence of sub-sentential units rather than the one which results from treating S as a whole as a unit.

The break-up of complex sentences, according to Kameyama, could yield a possibly nested structure yielding a hierarchical ordering rather than a linear ordering. Following this, she proposes two types of structures that could be possibly created by complex sentences – sequential and hierarchical. If the break up yields a sequential ordering of the utterances, the update unit for the utterance after the complex sentence is the last utterance in the linear ordering of the utterances resulting from the break up of the complex sentence. However, if the break up yields a hierarchical structure, then this raises the question

of which level of embedding provides the output update unit for the next utterance. The update unit could result from the last utterance in the top level in the hierarchical structure, or it could result from the last utterance at some embedded level in the structure.

Kameyama proposes a classification of different complex sentence types in terms of (a) whether their break up results in a sequential or a hierarchical structure, and (b) which level of embedding to consider to retrieve the update unit. Her hypotheses, with (her) examples, are provided below:

- **Sequential Structures:** Coordinated clauses (conjuncts) and adverbial subordinated clauses (adjuncts), according to Kameyama, break up into *sequential* structures:

  - **Tensed Clausal Conjuncts:** Tensed clausal conjuncts $Cl_1$,...,$Cl_n$ break up into a sequence of utterances $U_1$,...,$U_n$ at the same level of embedding at which $Cl_1$ starts out in the segment.

    (96) **Her** mother was a Greer

    (97) *and* **her** father's family came from the Orkney Isles.

  - **Tenseless Conjuncts:** Tenseless subordinate clausal conjuncts do not update the center, and belong to the same utterance unit as the immediately superordinate clause.

    (98) I wanted [ to grab **her** by the arm and beg **her** [ to wait, to consider, to know for certain ] ].

  - **Tensed or Tenseless Parallel Conjuncts:** Two adjacent conjuncts (tensed or tenseless) induce parallelism.

    (99) **She** had held to the letter of **her** contract

    (100) *and* $\epsilon$ didn't come onto the stage.

- **Tensed Adjuncts:** Tensed clausal adjuncts (i.e., adverbial subordinate clauses) form separate utterance units at the same level of embedding as their immediately super-ordinate clauses.

  (101) *Although* **she's** still a teenager who looks like a baby,

  (102) **she** is getting married

- **Tenseless Adjuncts:** Tenseless clausal and phrasal adjuncts belong to the same utterance unit as the immediately super-ordinate clause.

  (103) [ In the fullness of **her** vocal splendor ], however, **she** could sing the famous scene magnificently.

- **Hierarchical Structures:** Hierarchical structures are created by two kinds of complex sentences which Kameyama considers. One is reported (direct) speech and the other is the non-report (indirect) speech complement.

  - **Reported Speech Complements:** Reported speech is an embedded centering segment that is inaccessible to the super-ordinate centering level.

    (104) Hughes said Monday,

    a. "It is the apparent intention of the Republican Party to campaign on the carcass of what **they** call Eisenhower Republicanism.

    b. *but* **the heart** stopped beating

    c. *and* **the lifeblood** congealed

    d. *after* Eisenhower retired.

    e. *Now* **he's** gone

    f. the Republican Party is not going to be able to sell the tattered remains to the people of the state."

(105) Sunday, **he** added,

a. "We can love Eisenhower the man

b. *even if* we considered **him** a mediocre president

c. *but* there is nothing left of the Republican Party without **his** leadership."

– **Non-reported Speech Tensed Clausal Complements:** Tensed clausal non-report complements create embedded discourse segments. (Kameyama however left it an open question as to what the relative salience of the entities in the embedded segment was as compared to the higher clause.)

(106) **Her** choice of color means

a. **she** is simply enjoying the motor act of coloring without having reached the point of selecting suitable colors for different objects.

– **Tenseless Complements:** Tenseless clausal complements belong to the same utterance units as their super-ordinate clauses.

(107) We watched **them** [ set out up the hill in hand on a rainy day in **their** yellow raincoats [ $\epsilon$ to finger paint at the grammar school ]]

As noted above, breaking up complex sentences in this way is appealing in that it allows us to handle intra-sentential phenomena with the same principles that apply to inter-sentential processes. Of particular interest in this respect are anaphoric dependencies that occur intra-sententially. Kameyama showed that following her hypotheses, pronouns could be disambiguated with the same principles that she applied to the inter-sentential level within the Centering framework.

In a separate study of certain kinds of adjunct clauses, Suri & McCoy (1994) provided an analysis of 'SX because SY ($S_n$)' sentences within the framework of RAFT/RAPR (Re-

vised Algorithm for Focus Tracking and Revised Algorithm for Pronoun Resolution).[1] Suri & McCoy (1994) analyzed '($S_{n-1}$), SX because SY ($S_n$), ($S_{n+1}$)' sequences to study how readers resolved the subject pronouns of SX, of SY, and of $S_n$ (occurring after the complex subordinate clause). Their goal was to ascertain where to look for the update unit (that would be the input for resolving pronouns) in and around these complex structures. Their results are summarized as follows:

(108) a. Readers prefer to resolve Subject(SX) with Subject($S_{n-1}$).

b. Readers prefer to resolve Subject(SY) with Subject(SX) (over Subject($S_{n-1}$)).

c. Readers prefer to resolve Subject($S_{n+1}$) with Subject(SX)

Based on the above results, they propose to process sentences of the form 'SX because SY' as follows:

(109) a. For resolving a Subject(SX) pronoun, first propose SF($S_{n-1}$) as the referent.

b. For resolving a Subject(SY) pronoun, first propose Subject(SX) as the referent.

c. Compute the SF of a sentence of the form 'SX because SY' to be Subject(SX).

So in the work of Suri & McCoy (1994) too, a proposal is made to partition a complex sentences into constituent utterances. Like Kameyama (1998), they propose that tensed adjunct clauses should be treated as separate utterance units at the same level of embedding. However, they differ from Kameyama in that the unit that counts as the update unit for the utterance occurring after the complex structure is the super-ordinate clause rather than the last utterance unit in the linear ordering resulting from a break up of the sentence.

[1]This framework is closer to Sidner's focusing algorithm than to Centering theory in that RAFT/RAPR maintains two foci for each utterance, a subject focus (SF) and a current focus (CF), whereas Centering maintains a single focus, the $C_b$, or the Backward-looking Center.

### 4.2.2 Sentence-based Approaches

Contrary to the above approach where complex sentences are split up into separate sequential or hierarchical units, other works such as Strube (1998) and Miltsakaki (1999) attempt to define the utterance either as the "sentence" or adopt an approach towards a less fine grained segmenting (than Kameyama's, in particular) of the sentence into smaller units. Strube (1998) motivates his definition by comparing his anaphora resolution algorithm, where an utterance is defined as the sentence, with two versions of the BFP algorithm (Brennan et al., 1987). The two versions are based on two different ways of segmenting a sentence into smaller utterance units. In one version, he defines an utterance as a simple sentence, a complex sentence, or each full clause of a compound sentence, whereas in the other version, he extends the algorithm with Kameyama's hypotheses for intra-sentential centering. Strube's results show that a sentence-based approach towards the treatment of utterances yields the best results for pronoun resolution.

While the above result is worth some consideration, it suffers from the drawback that it does not offer any insights into whether there were any observed differences in the algorithms' performance across the different types of complex sentences. As Prince points out (pc. Ellen Prince), complex sentences perform several different functional roles in language and discourse, and in order to explicate these roles, we need to study them separately rather than collapse all the different types into a single category a priori. An indirect effect of this will obviously be a proper treatment of utterances for anaphora resolution algorithms.

A functional approach towards the treatment of complex sentences is taken in Miltsakaki (1999). Miltsakaki argues that an "utterance" consists of a matrix clause and all the dependent clauses associated with it.[2] Her primary data comes from complex sentences that contain subordinate clauses introduced by subordinating conjunctions like *because*,

[2]Coordinated clauses would be treated as distinct utterances according to this definition, although this is not stated explicitly in the mentioned work.

*so*, *when* etc. Functionally, she defines the utterance using the notion of *topic continuity*, and she argues that only matrix clauses can establish topics (be it a continuation or a shift in the topic). She provides empirical support for this view using cross-linguistic pronoun interpretation results from English, Greek, and Japanese. Furthermore, she also claims that entities evoked in the subordinate clauses are less salient than the entities evoked in the matrix clauses.

It may seem that we have come back to using the notion of topic-hood for defining the utterance unit, which we said above was a difficult task. However, there is a crucial point to be made here. Traditional tests of topic-hood involve explicit identification of the topical element, so that in the following example, the *As for X, . . .* test is applied to isolate *John* as the topic of the sentence.

(110) John went to the store.

(111) *As for John*, he went to the store (*As for X* test for topic-hood)

Contrary to the above goal of identifying the topic of a sentence/utterance explicitly, the approach in Miltsakaki (1999) merely aims to suggest that certain kinds of clauses either do or do not have a topic. It turns out that, for the purpose of delineating utterances in complex sentences, this is enough.

Miltsakaki's approach for the treatment of sentences with subordinated clauses is contrary to the approach taken by Kameyama. While Kameyama treats some subordinate clauses, namely the tensed adjuncts, as creating a distinct utterance unit and others, namely the tenseless adjuncts, as belonging to the same unit as their matrix clause, Miltsakaki treats all subordinate clauses as belonging to the same unit as their matrix clause. We adopt the approach taken by Miltsakaki towards the treatment of the above type of complex sentences. However, we note that the definition of the utterance provided by Miltsakaki must be extended to account for other types of complex sentences. A case in point is sentences

containing relative clauses, which is the focus of this chapter. We argue for a treatment of relative clauses where

- relative clauses are distinguished between restrictive and non-restrictive clauses,
- indefinite restrictives are further treated in the same way as definite non-restrictives,
- non-restrictive and indefinite restrictives are treated as was suggested by Kameyama for all relative clauses, that is, as creating a distinct but embedded utterance unit in which the entities, though accessible to the higher level, are not more salient than the entities at the higher level,
- and finally, definite restrictives are not treated as distinct utterance units: entities evoked within these clauses belong to the $C_f$ list of their matrix clause and are lower ranked than the entities evoked in their matrix clause.

The approach we are proposing reemphasizes the idea that discourse segments have a hierarchical structure. This view is consistent with the proposal made by Kameyama regarding the hierarchical structure of discourse segments.

## 4.3 Relative Clauses

Relative clauses are typically distinguished into two broad classes depending on their syntax and function. *Restrictive relatives* are closely connected to their head noun that they modify and further serve the purpose of identifying the referent of the head noun:

(112) John bought [ the book [ that he had seen in the store yesterday ]].

Non-restrictive clauses on the other hand, are parenthetic like comments which add further information about the noun they modify but do not in any way serve to identify the referent of the noun:

(113) At last he made up his mind to go to [ Jervis, [ who had a store about a mile away ]]. (he = Mackintosh)

The proposal that we will make for the treatment of relative clauses is similar to the one adopted in Hurewitz (1998) and Chae (2000), where non-restrictive clauses are treated as separate utterance units, and restrictive clauses are treated as part of the unit defined by the clause within which they occur.[3] However, these works do not provide any empirical or theoretical arguments for their proposal.[4] We present theoretical and empirical reasons to show that different kinds of relative clauses have different effects on the hierarchical organization of discourse segments.

### 4.3.1 Conjoined Clause Hypothesis for Non-restrictives

The first evidence for the difference in the treatment of restrictives and non-restrictives is the test of syntactic paraphrasability. The examples in (114) and (115) show that while the non-restrictive clause in (112) can be paraphrasable as a conjunct, the restrictive in (112) cannot. Of course, given the function of restrictive relative clauses, the restrictive paraphrase excludes the interpretation in which the hearer can uniquely identify the referent of *the book* in the first clause.

(114) # John bought the book. He had seen it in the store yesterday.

(115) At last he made up his mind to go to Jervis. (he = Mackintosh) Jervis/He had a store about a mile away.

[3]The proposal in Hurewitz (1998) and Chae (2000) acutally differs from ours to some extent. Both take the view that the non-restrictive clauses that form separate utterance units are only those that occur clause-finally. Clause-medial non-restrictives are treated like restrictives, i.e., as forming part of the main clause unit in which they occur syntactically. According to our proposal, all non-restrictives are treated as separate utterance units, irrespective of their syntactic position.

[4]Similarly, Kameyama (1998) also makes an unmotivated proposal for relative clauses.

The hypothesis that non-restrictives should be interpreted as distinct utterances also has support in the syntactic literature in the *Main Clause Hypothesis* (MCH) of Emonds (1979). This hypothesis is a formalization of the idea in Ross (1967) that non-restrictives are main clauses, although they have the appearance of *wh*-relative clauses. One of Ross's main arguments is that any parenthetical coordinate clause beginning with *and* can be paraphrased as a non-restrictive, as shown below (from Ross (1967)):

(116) a. Enrico, and he is the smartest of us all, got the answer in seven seconds.

b. Enrico, who is the smartest of us all, got the answer in seven seconds.

Emonds' defense of Ross's idea that non-restrictives are independent clauses is opposed to the competing analysis, *the subordinate clause hypothesis* (SCH) (Smith, 1964; Jackendoff, 1977). The SCH proponents argue that non-restrictives form a single constituent with their antecedent, at every level of representation. In contrast, Emonds' proposes that a non-restrictive does not form a single constituent with its antecedent, at any level of representation. Emonds argues that a non-restrictive is derived from a clause right-conjoined with the clause containing its antecedent. Non-restrictives are thus main clauses at D-structure whereas restrictives are embedded clauses. At S-structure, non-restrictives are derived via a coordinate deletion and S'-attachment transformation that first deletes the coordinating conjunction and then adjoins the non-restrictive to its antecedent within the clause (i.e., without forming a constituent with it).

Demirdache (1991) presents an analysis for non-restrictives which incorporates insights from both the MCH as well as the SCH.[5] Following SCH, she assumes that a non-restrictive

[5]Demirdache (1991) actually calls the non-restrictives *appositives*. We take this to be a terminological difference, and prefer to call her *appositives* as *non-restrictives* since appositives are usually treated syntactically as nominal modification. These could, of course, also be analyzed as reduced relatives in which the relative clause has a nominal predicate. Here, we do not consider there to be any syntactic or functional difference between appositives and non-restrictives.

is a subordinate clause at D-structure: it is base-generated adjoined to its antecedent. However, following MCH, she assumes that a non-restrictive is interpreted at LF (Logical Form) as an independent clause which follows the matrix clause. At LF, the non-restrictive is lifted out of the matrix clause, in which it was embedded at S-structure, and then adjoined to the latter.

Demirdache (1991) also treats the anaphoric relationship between the relative pronoun in the non-restrictive and its antecedent on a par with the anaphoric relationship established across discourse between a pronoun and its antecedent in a separate clause. However, she points out that the anaphoric nature of the relative pronoun does not imply that it establishes the same kind of anaphoric connections as pronouns that occur across two separate assertions. This distinction that she makes is based on the treatment of non-restrictives as *auxiliary assertions* (Jackendoff, 1977). She argues that this is because, given two separate assertions, realized syntactically as two distinct sentences in discourse, a pronoun in the second sentence could cospecify some constituent in the first sentence, but need not (117). In contrast, the relative pronoun in a non-restrictive must necessarily cospecify some constituent in the main clause (118), in particular, the constituent that it modifies syntactically. In other words, while the non-restrictive is interpreted as an independent clause, it is still more closely tied to its preceding clause than a truly independent sentence in discourse is.

(117) John$_i$ saw a man$_j$. He$_{i/j/k}$ is tall.

(118) John$_i$ saw a man$_j$, who$_{*i/j/*k}$ is tall.

For now, we leave the discussion of the syntactic approaches towards the treatment of non-restrictives as independent clauses. We will return to it after we present our analysis of relative clauses, Section 4.3.3.

### 4.3.2 Resumptive Pronouns and Relative Clauses

Non-restrictive relative clauses with both definite and indefinite heads are traditionally distinguished from restrictive relative clauses syntactically (with punctuation or with the lexical distinction between *which* and *that*). This has led to the treatment of relative clauses *not* marked in this way as restrictive relatives. However, Prince (1990) shows that relative clauses headed by an indefinite that pattern syntactically like restrictives, actually behave discoursally like non-restrictives, and she argues that indefinite head relative clauses should be classified with the non-restrictives rather than with the definite restrictives.

The argument made by Prince (1990) for the above classification comes from facts about the occurrence of "resumptive pronouns" in English and Yiddish. She points out that the standard treatment of resumptives is that they are used when the speaker has started uttering a sentence that is ungrammatical due to an extraction violation and attempts to salvage the sentence by using a pronoun in the illegally extracted site. Thus, resumptives have been shown (Langendoen, 1970; Kroch, 1981) to occur in island environments (Ross, 1967), such as indirect questions (119), left branching constructions (120) as well as relative clauses (121. (Examples are from Prince (1990)). In this sense, the appearance of resumptives has been given a *processing* explanation.

(119) There are always guests who I am curious about what they are going to say.

(120) The only one we could see her figure was Number 2.

(121) That asshole X, who I loathe and despise the ground he walks on, pointed out that ...

However, Prince shows with examples from the same corpus from the which the island violation resumptives were taken that resumptives can in fact occur even in environments where there is no extraction violation. This is shown in her examples (122-124).

(122) They were just towed across the Midway onto the bridle path, where they were just sitting there peacefully.

(123) That's a suggestion of yours which I followed, which I didn't even want to do that.

(124) I have a friend who she does all the platters.

A corpus study done by Prince (1990) on the distribution of resumptives in relative clauses in English and Yiddish shows that the resumptive pronouns in non-island environments occur mostly in either non-restrictives or else in restrictives with indefinite heads. No such correlation, however, is found with the resumptives in the island environments. Prince explains this observed distribution in terms of the *file card* account of the interpretation of definites and indefinites given by Heim (1982), arguing that

- for the indefinite restrictives, the head introduces or evokes a file card into the discourse model and that the relative clause merely adds a property to this card,
- for the non-restrictives, the head alone pulls out or activates the card in the discourse model to which again, the relative clause adds a property, and finally,
- for the definite restrictives, the card can only be pulled out after the entire NP (with the relative clause) has been processed.

Given this difference, she argues that, viewed from the point of the state of the discourse model, resumptives then seem to act like discourse anaphors. That is, they can be used only when the file card which these resumptives evoke has been activated (either by first mention or repeated mention) and that with respect to relative clauses, this can happen only in indefinite restrictives and non-restrictives; they are infelicitous in the case of definite restrictives because the file card cannot be activated until the end of the NP is reached and therefore the resumptive occurring inside the NP modifying restrictive relative has nothing to refer to.

The examples (125) and (126) illustrate the difference between indefinite head relatives and definite head relatives in the following way: in the indefinite head restrictive in (125), the head *a man* alone introduces a *new* file card into the discourse model, corresponding to "man". That is, by the time the relative clause modifying the head *a man* is encountered, the file card already exists in the model. The link between the file card activated by the mention of "Mary" inside the relative clause and the "man" file card is established as a *new* link.

(125) ... a man [ who loves Mary ] ...

(126) ... the man [ who loves Mary ] ...

In the case of the definite restrictive in (126), the card is not activated until the end of the NP is reached. That is, the card is not activated before the relative clause has been processed. When this happens, the card that is activated *already* has the property of *loving Mary* on it (with a possible *old* link to some other card).

Prince also captures this asymmetry structurally. In the case of the definite restrictives, the relative clause is a complement at the level of the head noun (excluding determiners) whereas for the indefinites, the relative clause adjoins to the complete NP projection. One of the things that is explained by allowing these two structures is the unavailability of resumptive pronouns in definite restrictives. Since the resumptive pronouns (excluding the ones that arise due to island violations or due to processing factors) are discourse pronouns, they need to look at an evoked file card to get a reference, and in the case of definites, the structure predicts the infelicity of the resumptive because there is no file card evoked until the end of the relative clause, and therefore a resumptive within the relative cannot refer. On the other hand, in the case of the indefinite, the file card gets pulled up or evoked as soon as the indefinite noun phrase is encountered, and therefore the resumptive can pick its

reference easily.[6]

To summarize, there are two key aspects of the analysis of resumptives in Prince (1990) that are relevant for the utterance status of relative clauses. First, the occurrence of the (non-island) resumptive pronouns in non-restrictives as well as indefinite head restrictives calls for, as Prince also argues, a grouping together of the two types and considering this group as behaving differently from the definite head restrictives. Second, the discourse status of the resumptives pronouns occurring in the non-island environments calls for a segmenting of such relative clause-containing sentences so that the resumptive discourse pronouns can be resolved like other discourse pronouns. However, recall that we said in the previous section that non-restrictives are *auxiliary assertions* that, while interpreted as independent clauses, are closely tied to the clause to which they are syntactically attached.

In the next section, we provide support from discourse anaphoric evidence for the grouping of the non-restrictives with the indefinite head restrictives. Also, with regard to the treatment of this group as independent utterances at the discourse level, we provide further evidence for this, but in addition argue that what Jackendoff (1977) and Demirdache (1991) are calling "auxiliary assertions" are, at the discourse level, embedded utterances within the discourse segment.

[6]Further support for Prince's proposal for distinguishing indefinite head restrictives from definite head restrictives comes from facts about extraposition in relative clauses. As Manninen (2002) points out, extraposition of restrictive relative clauses is usually grammatical only when the nominal head is indefinite:

(1) a. A letter arrived yesterday which was addressed to Mary.

b. ?? The letter arrived yesterday which was addressed to Mary.

(2) a. A handsome man walked into the room who looked like Ewan McGregor.

b. ?? The handsome man walked into the room who looked like Ewan McGregor.

### 4.3.3 Anaphoric Evidence from Discourse

In the previous sections, we presented independent evidence from related work on relative clauses which suggests that non-restrictives should be treated as independent utterances for interpretation. Also of interest were facts about the occurrence of resumptive pronouns in certain kinds of relative clauses, in particular, in non-restrictives and indefinite head restrictives, which suggest that these types should be treated as forming a class distinct from the definite head restrictives. In this section, we present data from naturally occurring discourses that provide further evidence for making a distinction between the two aforementioned relative clause types, and furthermore, for treating one of the classes, namely, the class comprising non-restrictives and indefinite head restrictives, as forming an independent utterances for interpretation. Our evidence comes from the patterns of anaphoric reference across adjacent sentences, the first of which contains a relative clause, and the second of which contains a referring expression cospecifying with some expression in the previous complex sentence.

#### Grice Again

A robust assumption in Centering theory is a Gricean constraint on referring expression forms that was formulated in Chapter 2. In the same chapter, we showed at length how the constraint, when combined with the Centering principles, allows us to explicitly formulate an algorithm to predict referring expression form choices within the scope of the Centering transitions. Here, we use a summarized version of the algorithm to study referring expression forms in relative clauses and to arrive at conclusions about their utterance status. The summarized algorithm is given as a constraint below:

- **CR-CM Constraint:**

  The maximally salient entity in $U_i$ is expected to be the Backward-looking Center

in $U_{i+1}$ and is also expected to be pronominalized, unless additional inferences are intended to be conveyed by the referring expression. Furthermore, provided there is grammatical and sortal compatibility, speakers are expected to use pronouns for less salient entities only if there is "reasonable" structural or inferential evidence in the utterance to allow the hearer to make the necessary alternative inferences.

We looked at several examples in Chapter 2 which showed that the above constraint is truly satisfied in natural language discourses. We present an example here to reiterate our point. (127b) instantiates a CONTINUE transition, with "Mackintosh" as the Preferred Center. In addition, another competing entity is also realized in this utterance, namely, "Manuma". (127c) realizes only the Non-preferred Center (the less salient entity). As a result, based on the constraint above, the speaker is obliged to use a descriptive noun phrase, which is what we see with the use of the proper name in (127c). If a pronoun had been used, the hearer would interpret it incorrectly, i.e., as referring to the maximally salient entity, "Mackintosh". Note that no inference would be easily available if a pronoun were used. "Mackintosh" has been portrayed as acting very shifty and uncomfortable in the previous utterances in the segment, and he could have been equally likely to take the medicines and skip the scene.

(127) a. **He**$_i$ did not know what it was that made it impossible for **him**$_i$ to look at **the Kanaka**$_j$. (He = Mackintosh; Kanaka = Manuma)

[$C_b$ = Mackintosh (*He*$_i$); $C_p$ = Mackintosh]

b. While **he**$_i$ was speaking to **him**$_j$, **he**$_i$ kept **his**$_i$ eyes on **his**$_j$ shoulder.

[$C_b$ = Mackintosh (*he*$_i$); $C_p$ = Mackintosh; Tr = CONTINUE]

c. **Manuma**$_j$ took the medicine and slunk out of the gate.

[$C_b$ = Manuma; $C_p$ = Manuma; Tr = SMOOTH-SHIFT]

*Somerset Maugham; "Mackintosh"*

The above example shows that, in the absence of any structural or (sufficient) inferential evidence to the contrary, speakers use descriptive noun phrases to refer to less salient entities. Furthermore, speakers use pronouns to refer to the maximally salient entities just in case they did not intend to convey any additional inferences to the hearer. If the CR-CM constraint is not respected, then we might have reason to believe that one or more parameters in Centering may need to be changed in order to account for the facts. We believe that one of the results that the application of the constraint yields for us is the determination of the utterance status of different types of relative clauses.

**Non-restrictives and Indefinite-head Restrictives**

The naturally occurring examples provided this section present evidence to show that we cannot maintain the assumption about indefinite restrictives and non-restrictives being part of the main clause utterance unit.

Consider for example the discourse in (128). In (128b), the speaker continues to talk about "Moses Herzog" from (a) and realizes him as the maximally salient entity, i.e., in the Preferred Center position. Now (128b) contains an indefinite restrictive relative clause, which modifies the lower ranked entity in the main clause, namely, "Simkin". In (128c), we see that the speaker uses a pronoun (*He*) to refer to "Simkin". Based on the CR-CM constraint formulated above, the use of the pronoun in (128c) is hard to explain if we take "Simkin" to be lower ranked than "Moses" following the assumption that the relative clause unit is part of the main clause unit. Furthermore, note that the relative is embedded deep in the clause, under *a man*, and is thus, structurally very low in its salience.

(128) a. A fellow like **Moses Herzog**$_i$, a little soft headed or impractical but ambitious mentally, somewhat arrogant, too, a pampered, futile fellow whose wife had just been taken away from him under very funny circumstances ....

b. This **Moses**$_i$ was irresistible to [ a man [ like **Simkin**$_j$ [ who loved to pity and to poke fun at the same time ]]].

c. **He**$_j$ was a reality-instructor.

*Saul Bellow; "Herzog"*

The examples (129) and (130) show a similar pattern. In (129a), the lower ranked entity, "Mithridates", is the entity whose expression is modified by the relative clause, and utterance (129b) shows this lower ranked entity being referred to with a pronoun. Similarly, (130b) realizes the lower ranked entity "Hiram Shpitalnik" with a pronoun, and in (129a), the expression realizing this entity is modified by the non-restrictive relative clause.

(129) a. **He**$_i$ thought awhile of [ **Mithridates**$_j$, [ whose system learned to thrive on poison]]. (He$_i$ = Herzog)

b. **He**$_j$ cheated his assassins, who made the mistake of using small doses, and was pickled, not destroyed.

*Saul Bellow; "Herzog"*

(130) a. At last **he**$_i$ went to see [ **Hiram Shpitalnik**$_j$, [ who was an old old old man, very tiny, with a long beard down to his feet]]. (**he**$_i$ **= the boy**)

b. **He**$_j$ lived in a hatbox.

*Saul Bellow; "Herzog"*

Note that in both of the above examples (129) and (130), a pronoun is used in the (a) utterances for the maximally salient entity and not for any other entity, so that the Preferred Centers are also the Backward-looking Centers of their utterances. Both of these factors should have obliged the speaker a descriptive noun phrase to refer to the lower ranked entity. But this is not what is in fact observed.

(131b) contains a reduced non-restrictive relative modifying the lowest ranked entity "the vicar's predecessor", who is introduced in the discourse segment as a discourse-new

entity. Two other discourse-old entities mentioned in the sentence are higher ranked than this newly introduced entity, namely, "Albert Edward" and "the vicar" *his*$_i$ (which is also the backward-looking center of the utterance). The use of a pronoun in (131c) to refer to "the vicar's predecessor" shows that reduced relatives are also like the non-reduced non-restrictives we saw above. Not only is the pronoun in (131c) not the Preferred Center of the previous utterance (131b), it is also lower ranked than the Backward-looking Center of (131b).

(131) a. **The vicar**$_i$ had been but recently appointed, a red-faced energetic man in the early forties,

b. and **Albert Edward**$_j$ still regretted [ **his**$_i$ [ **predecessor**$_k$, [ a clergyman of the old school who preached leisurely sermons in a silvery voice and dined out a great deal with his more aristocratic parishioners. ]]]

c. **He**$_k$ liked things in church to be just so, but he never fussed;

*Somerset Maugham; "The Verger"*

(132) provides support for the Prince's (1990) argument that indefinite restrictives behave similarly to non-restrictives. In (132b), the speaker continues to talk about "Walker" from (132a), and realizes him as the maximally salient entity, i.e., in the Preferred Center position of the utterance. Now (132b) contains an indefinite restrictive relative clause, realizing the entity "Mackintosh" inside this relative clause. (Note that "Mackintosh" is not realized in (132a).) In (132c), we see that the speaker uses a pronoun (*He*) to refer to "Mackintosh".

(132) a. ...but **Walker**$_i$ had a gift of repartee, coarse and obvious, which gave him an advantage.

b. **His**$_i$ loud voice, **his**$_i$ bellow of laughter were [ weapons [ against which **Mackintosh**$_j$ had nothing to counter ]].

c. **He**$_j$ learned that the wisest thing was never to betray his situation.

*Somerset Maugham; "Mackintosh"*

The above examples all contain cases of peripheral non-restrictive clauses. The example below, (133), shows that even center-embedded non-restrictives exhibit the same effect. "George Hoberly", the lower ranked entity of (133a), is modified by the appositive and then referred to with a pronoun in (133b).[7] In addition, the example illustrates that including the relative clause unit in the main clause unit will also lead to a Rule 1 violation, as shown by the use of a proper name to refer to the Preferred Center of (133a).

(133) a. **Herzog**$_i$ had several times seen [ **George Hoberly**$_j$, [ Ramona's friend before him]], following him with his eyes from one or another of these doorways.

b. **He**$_j$ was thin, tall, younger than **Herzog**$_i$, correctly dressed in Ivy League Madison Avenue clothes, dark glasses on his lean, sad face.

*Saul Bellow; "Herzog"*

All of the above examples show that the observed patterns of pronoun use cannot be explained, assuming the validity of the Gricean and Centering-based CR-CM constraint. The examples have demonstrated that the entity or entities realized in the non-restrictives and indefinite head restrictives are somehow are more salient than the other entities realized in the main clause of the sentence. The first hypothesis that we could put forth to explain these patterns of reference is that these relative clauses make the elaborated entity more salient in the utterance than others. This would further the idea that all embedded clauses are part of the clause in which they occur. It would also be consistent with approaches suggested for other types of constructions where the structural determinants of salience, such as grammatical function, are overridden by other factors such as empathy, certain thematic roles, etc. However, while this account may seem appealing, it does not account for all

[7] We are treating appositives on a par with non-restrictive relatives.

the facts. The counter-argument comes from examples like (132). In this example, the entity "Mackintosh" that the speaker refers to with a pronoun in (132c) is not the elaborated entity in (132b). That is, the nominal expression used to realize "Mackintosh" is not the noun that the relative clause modifies. The modified noun in fact realizes another entity, "weapons", and furthermore, "Mackintosh" is not realized in the main clause at all. It is not clear how we could explain that entities that are realized in these types of relative clauses but are also not at the same time realized in the main clause somehow become maximally salient in the sentence. We instead propose that a more plausible account is provided by an approach that treats such relative clauses as forming independent utterance units that then define their own ordering on the centering update unit that is used to interpret pronouns in the subsequent utterance.

Example (134) provides further evidence that the sentence-based approach for complex sentences containing non-restrictive relatives (and also indefinite restrictives) should be rejected in favor of a clause-based approach. The example shows that when the speaker does wish to continue to talk about an entity in the main clause rather than an entity inside the non-restrictive, such as when Edward in (134a) is continued as the topic in (134b), the speaker uses a non-pronominal – in this case, a proper name. (Note that we are assuming that the relative clause modifies "something" in the main clause and that the entity "Edward" is not realized in the relative clause.)

(134) a. There was [ something in **Edward's**$_i$ tone [ that made **Bateman**$_j$ look up quickly ]].

b. But **Edward's**$_i$ eyes were grave and unsmiling.

*Somerset Maugham; "The Fall of Edward Bernard"*

Of course, we did find cases in which a pronoun was used to refer to an entity that was realized in the main clause of the previous sentence even when a non-restrictive (or an indefinite restrictive) occurred in the sentence. However, such cases involve the presence

of additional inferential or structural evidence that occurs in the utterance in which the pronoun is used, and this provides the hearer with the resources needed to interpret the pronoun appropriately. In addition, there are also examples in which a full noun phrase is used to refer to the entity that is realized in the non-restrictive. But, again, these are cases where the speaker intends to make additional inferences that would not be obtainable with a pronoun alone. The first kind of case is seen in the discourse in (135). The pronoun in (135c) is used to realize "Herzog", which is realized in the main clause, and this is contrary to the pattern seen in (134) following which we claimed that a non-pronominal form should be used in such cases. However, a closer look at the example shows that the speaker has used a clause-initial participial adjunct, that is, *Reaching the corridor*, which provides the hearer the source for the interpretation of the pronoun. The previous utterances (135a) and (135b) are talking about "Herzog" walking in some direction, and thus the participial, which can only be interpreted with the (pronominal) subject of the sentence, steers the hearer away from "the judge" as the most likely interpretation of the pronoun.

(135) a. When the witness stood, **Herzog**$_i$ stood up, too. **He**$_i$ had to move, **he**$_i$ had to go. . . . **He**$_i$ walked heavily and quickly.

b. Turning once in the aisle, **he**$_i$ saw only the lean gray head of [ **the judge**$_j$, [ whose lips silently moved as he read one of his documents]].

c. Reaching the corridor, **he**$_i$ said to himself, "Oh my God!" and in trying to speak discovered an acrid fluid in his mouth that had to be swallowed.

*Saul Bellow; "Herzog"*

The second case discussed above can be seen in (136) and (137). In (136), a proper name is used to refer to "Elias" which is realized as the only entity in the peripheral non-restrictive in the previous sentence (136b). This is contrary to the expectation that we have argued for above. However, we claim that the syntactic construction used by the speaker

to convey the intended meaning/inference is not (syntactically) compatible with a pronoun, as the marginal example in (136) shows.

(136) a. In **it**$_i$ **he**$_k$ looked like [ **his cousin Elias Herzog**$_l$, [ the flour salesman who had covered the northern Indian territory for General Mills back in the twenties]].

b. **Elias**$_l$ with his earnest Americanized clean-shaven face ate hard-boiled eggs and drank prohibition beer – home-brewed Polish piva.

c. ?? **He**$_l$ with his earnest Americanized clean-shaven face ate hard-boiled eggs and drank prohibition beer – home-brewed Polish piva.

*Saul Bellow; "Herzog"*

(137) also shows the use of a proper name to refer to the lower ranked entity, "a stoutish gentleman", modified by a non-restrictive reduced relative. This counterexample is explained by the fact that the writer has introduced the gentleman in question for the first time, and intends to inform the hearer of the name of this gentleman before continuing to talk about him – hence, the use of the proper name to convey this additional information to the reader.

(137) a. **Longmore**$_i$ beheld in the fading light [ **a stoutish gentleman**$_j$, [ on the fair side of forty, in a high light hat, whose countenance, indistinct against the sky, was adorned by a fantastically pointed moustache]].

b. **M. de Mauves**$_j$ saluted his wife with punctilious gallantry, and having bowed to **Longmore**$_i$, asked her several questions in French.

*Henry James; "Madame De Mauves"*

So far we have established that non-restrictive and indefinite restrictive relative clauses should be treated as creating a separate utterance unit if we are to account for the facts about the use of referring expressions in subsequent utterances. However, this still leaves open the question about whether there is any hierarchical structure created by such clauses,

that is, whether these clauses form independent units at the same level of embedding as the main clause or whether they form an embedded unit. While there is no strong evidence with which we can provide a definitive answer to this question, we believe that such relative clauses form embedded utterance units. Functionally, the types of relative clauses considered above provide further information about some particular entity in the sentence but this information has the quality of being parenthetical in that it temporarily diverts the hearer's attention from the main topic of the discourse (segment). In this sense, these relative clauses introduce *subordinated topics* which the speaker can talk about for a while in the segment before switching back to the main topic. This can be seen in the discourse in (138) which is an extension of (131). The speaker, after taking about "the vicar's predecessor" (the subordinated topic) in the relative clause in (b) and (c) and (d), switches back to talking about "Albert Edward", the immediately previous most salient entity before the embedded segment.[8]

(138) a. **The vicar**$_i$ had been but recently appointed, a red-faced energetic man in the early forties,

b. and **Albert Edward**$_j$ still regretted [ **his**$_i$ [ **predecessor**$_k$, [ a clergyman of the old school who preached leisurely sermons in a silvery voice and dined out a great deal with his more aristocratic parishioners. ]]]

c. **He**$_k$ liked things in church to be just so, but he never fussed;

d. **he**$_k$ was not like this new man who wanted to have his finger in every pie.

e. But **Albert Edward**$_j$ was tolerant.

*Somerset Maugham; "The Verger"*

[8]Though it cannot count as strong evidence for the embedding created by the relative clause, the discourse in (138) (as also the discourse in (134) shows that the embedded structure of the discourse is made evident by the use of a non-pronominal to switch back to the last most maximally salient entity after the embedded segment is complete.

In treating the non-restrictives and indefinite head restrictives as creating an embedded segment and introducing a subordinated topic, we are also able to explain the syntactic analysis of Demirdache (1991) and the analysis of the resumptives in Prince (1990). What Demirdache and others have called "auxiliary assertions" for interpretation at LF constitutes the "embedded discourse segment" in our approach. The formation of the embedded segment is signaled by syntactic cues such as relative pronouns which also serve to point out the entity about which the auxiliary assertion is being made.

Our approach also provides force to the findings and conclusions made in Prince (1990) with respect to the occurrence of resumptives in these clause types. Since non-restrictives and indefinite restrictives form independent utterances (albeit embedded), the speaker is free to generate a pronoun in the syntactically empty position.

**Restrictive Relative Clauses**

The patterns of anaphoric reference seen in restrictive relative clauses are very different from what we saw above with the non-restrictives and the indefinite restrictives. First, a pronoun used after a sentence containing a restrictive relative clause tends to be used for referring to an entity evoked in the main clause rather than one evoked in the restrictive relative clause. Furthermore, there is also a dispreference for using a pronoun for referring to an entity evoked by the head of the nominal that is modified by the relative clause, in case there is a competing entity that is more salient in the clause than the modified noun. The example in (139) shows the first kind of pattern:

(139) a. . . . but also for his upright character, he was arrested one day on a charge of fraud.

b. and [ **the dishonesty**$_i$ [ which **the trial**$_j$ brought to light ]] was not of the sort which could be explained by a sudden temptation.

c. **It**$_i$ was deliberate and systematic.

*Saul Bellow; "Herzog"*

Functionally, we can explain the patterns seen in restrictive relative clauses in the following way. Restrictive relative clauses are used for identifying the referent of the head noun which they modify. Unlike the non-restrictives or indefinite restrictives, they do not provide further information about some entity that has already been evoked by some expression in the sentence. In fact, their purpose is precisely to enable the hearer to evoke the relevant entity intended by the speaker. In this sense, then, it is understandable that restrictive relative clauses could not create an independent utterance unit. In particular, in terms of the notion of *subordinated topics* that we introduced above, restrictives do not introduce a topic (new or subordinate) and therefore do not create an independent utterance unit. They should therefore be considered as part of the unit created by the main clause in which they occur.

## 4.4 Conclusion

In this chapter, we have addressed the problem of delimiting the utterance unit for discourse processing. For the application of the Centering principles as well as of the CR-CM constraint formulated in this dissertation, different ways of defining the utterance will yield different results.

While dealing with all types of complex sentences is beyond the scope of this dissertation, we have provided an analysis of complex sentences containing relatives clauses. With supporting evidence and arguments from related research on relative clauses, both from a syntactic point of view as well as from the discourse point of view, we have argued that relative clauses should be distinguished into two classes, one comprising the non-restrictives and indefinite head restrictives, the other comprising the definite head restrictives. Our ev-

idence consisted of naturally occurring instances of adjacent utterances in which the first constituted a complex sentence containing a relative clause, and the next sentence contained a referring expression (pronoun as well as definite description) that referred to some entity evoked in the previous sentence. We observed that, in the case of non-restrictives and indefinite head restrictives, the form used by speakers to refer to an entity in the relative clause was a typically a pronoun, whereas the form used to refer to an entity in the main clause was typically a full noun phrase. We argued that this could not be explained by the idea that a noun phrase of the main clause becomes more salient when it is modified by one of these relative clause types, and that a more plausible explanation is provided by our approach in which such relative clauses create an embedded discourse segment, introducing what we call "subordinated topics". We also showed that our approach was consistent with other treatments of such types of relative clauses, and in particular, it provided additional force to (a) the syntactic analysis of non-restrictive relative clauses where the non-restrictive is raised out at LF and adjoined and interpreted as an independent clause, and (b) to the treatment of resumptive pronouns in both non-restrictives and indefinite head restrictives as discourse pronouns.

With respect to definite head restrictives, we observed the opposite pattern of anaphoric reference from the above. We argued that these restrictives do not form an independent utterance and therefore should be treated as part of the main clause unit.

# Chapter 5

# Conclusions

Our primary goal in this thesis was to make a contribution towards the generation of referring expressions in Hindi. Beginning with the work of Grosz (1977) and Sidner (1979), it has been recognized that anaphoric usage and interpretation in discourse is significantly constrained by the way entities (Karttunen, 1976; Webber, 1978) in the evolving model of discourse are structured, both at the local and at the global level (Grosz, 1977; Grosz & Sidner, 1986). This structural organization of the discourse entities is argued to be a reflection of, among other things, their *salience* status, which an anaphoric generator or interpreter makes crucial reference to in order to find the *co-specifiers* (in the sense of Sidner (1979)) of anaphoric elements. This same assumption is made in Centering theory (Grosz et al., 1995), in which the relative salience of discourse entities is claimed to impose constraints on the form of referring expressions to the extent of affecting the local coherence (or the processing complexity) of the discourse.

In Chapter 2, we started by discussing the limitations of Centering theory in terms of providing an explanation for a wide range of alternations in the use of referring expression forms, and we pointed out that the only constraint Centering theory explicitly formulates is given in the encoding of Rule 1, which can only be applied to a restricted set of cases.

The goal of this chapter was to explicitly specify constraints on the generation of referring expressions. These constraints borrowed ideas only implicitly stated in Centering theory and also ideas relating to Gricean principles of interpretation (Grice, 1975). In doing this, we were interested in showing that these constraints can be applied to understanding and modeling referring expression phenomena in a wide variety of cases.

In Chapter 3, we presented a study of referring expressions in Hindi. Languages have been shown to vary with respect to the constraints that govern the use of referring expressions, and one of the sources of variation lies in the different means that languages have at their disposal for the marking of discourse salience. In other words, we need to determine how to rank the forward-looking centers list of an utterance at any given point of the discourse. Centering constraints, as well as the generation constraints that we formulated in Chapter 2 can only be applied to a language after this language-specific parameter has been set. To this end, in this chapter we first presented a corpus-based language-independent methodology to identify linguistic factors that determine relative salience. The methodology exploited a specific formulation of Rule 1 of Centering without being circular in its application. We then applied this method to a Hindi corpus and investigated the effect of three factors on discourse salience: *grammatical role*, *word order*, and *information status*. The results of our study showed that Hindi, despite being a free-word order language does not display any effect of word order on discourse salience. In free word order languages like German, word order has been argued to have an effect on salience (Rambow, 1993). Our results thus bring out a significant contrast between Hindi and German, in that it calls for viewing scrambling or other word order phenomena across the two languages differently, at least to the extent that the same syntactic form does not necessarily map onto the same discourse function in the two languages. Information status has also been argued, most notably in Strube (1998), to affect discourse salience. The initial results in Strube (1998) were based on evidence from German, and information status was later extended to

be a universal factor. However, results from our Hindi corpus show that the information status of discourse entities does not exhibit any salience-affecting characteristics, suggesting a reassessment of the universality claim with respect to information status. For Hindi, then, grammatical role emerges as the most significant factor.

In the same chapter, following the results obtained from the application of the methodology above, we use grammatical role as the primary ranking criterion to provide an analysis of the use of zero pronouns in Hindi. Contrary to earlier proposals, we argue that the constraints on the use of zeros in Hindi are neither syntactic (Kameyama, 1985), nor can they be explained purely in terms of the singular notion of the *topic*, especially one that is defined syntactically (Butt & King, 1997). Our study is conducted within the Centering framework, using the Hindi specific ranking results, and the analysis is provided in terms of Centering Transition preferences. We show that pronouns can be dropped in Hindi only when they occur in an utterance following a CONTINUE or a SMOOTH-SHIFT Transition, when they are coreferential with the preceding Preferred Center. We also formulate a *Zero Pronoun Rule* that must be used in tandem with the rules for overt pronoun interpretation or generation in Hindi.

With respect to the corpus analysis to identify the linguistic determinants of salience, one of the first issues we faced was that of specifying the utterance unit for local discourse processing. In the model of discourse interpretation that is assumed here, discourses are composed of utterances and discourse entities are added to the discourse representation when the utterance they are part of is syntactically and semantically processed. The question then is, what constitutes the utterance? Is it the sentence, or some smaller unit like the tensed clause? Is the representation of the utterances in the discourse model hierarchical? If so, what determines the hierarchical discourse representation of the ongoing discourse? These are issues that have been explored extensively in previous research. However, there is no consensus yet reached. In order to continue with the work presented in this the-

sis, however, we adopted what we believed to be the correct results from the literature, with different assumptions coming from different research sources. In Chapter 4, however, we presented an analysis of the utterance status of complex sentences containing relative clauses since no extensive work on relative clause containing sentences is available (except for suggestions made in Kameyama (1998) and Hurewitz (1998)). With respect to relative clause sentences, we argued that different kinds of relative clauses have different effects on the hierarchical organization of discourse segments. Nonrestrictive relative clauses form a *distinct* but embedded utterance unit, while restrictives are part of the main clause unit in which they occur. Our data also provided support for the partitioning of the class of restrictive relatives into indefinite head restrictives and definite head restrictives. The partitioning was motivated by anaphoric patterns in discourse, which showed that the indefinite head restrictives behaved like the non-restrictives. Our analysis for relative clauses provides further support for the analysis of resumptive pronouns in non-island environments in Prince (1990) and the syntactic treatment of appositives in Demirdache (1991).

Our ultimate goal is to be able to account for the full range of discourse anaphora in Hindi, especially on the generation side. However, the domain of analysis for a study of discourse phenomena is quite large and intricate. We have pointed out at various points in the dissertation that several aspects of discourse structure and discourse interpretation need to be modeled before we can even hope to provide a comprehensive account of discourse anaphoric phenomena. For example, given that we are concerned with anaphoric usage on an utterance by utterance basis, as would have to be the case if one were working within the Centering framework, we would first need to determine how to segment complex sentences. A treatment of the full range of complex sentences, was, however, beyond the scope of this dissertation. However, this remains an important subject for us in future work. In addition, in developing a generation algorithm for referring exprssions, we pointed out that inference was an important component of a generation system. While developing a model

for inferential reasoning was beyond the scope of this dissertation, we believe that we have made a significant contribution with the generation algorithm, to which the inferential module need merely be added when it has reached a satisfactory point in its explication. In teasing out inference from the structural processes in our algorithm, we believe that we are in agreement with several other approaches to the derivation of meaning, both at the sentence and the discourse level.

We have several further issues that we are hoping to address in future work. First, we would like to investigate the discourse functions of word order variation in Hindi in light of the results in this dissertation, namely that there is no significant correlation between word order and discourse salience. The particular issue we would like to pursue is that given word order variation is commonly seen as a way to bring entities into focus, the absence of the aforementioned correlation is curious, especially since Centering also purports to deal with focusing phenomena. One possible solution to this dilemma is that word order variation in languages like Hindi might be doing something other than the kind of focusing described in Centering. The second issue we would like to address has to do with the axiomatization of the Transition sequence occurrences in discourse. In applying the CR-CM algorithm to natural language English texts, we discovered that there were some Transition sequences that we could find no instances of. We would like to address the idea that certain Transition sequences are more likely than others in discourse, and attempt to model this as a set of rules. Centering does propose a ranking of the Transitions, but not of the full scale of Transitions that we have analyzed in this dissertation. Finally, we hope to do further work on zero pronouns in Hindi and account for why there were several cases in which the Preferred Center in an utterance $U_{i+1}$ was not realized as a zero in a CONTINUE-CONTINUE and SMOOTH-SHIFT-CONTINUE Transition sequence. These cases suggest to us that the constraints for generating zeros in Hindi might be more strict than has appeared to us so far.

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