

Chapter 3

Focusing and Reference Resolution

It has been agreed by many researchers working on reference resolution for pronouns that a very effective and efficient strategy is to use ‘focus’ as the basis (Sidner 1983, Carter 1987, Grosz et al. 1983, 1995). However, the term ‘focus’ has been variously used in linguistic literature. In section 3.1, we discuss the meanings of the term ‘focus’, with the concept of ‘focus’ established, the chapter will proceed to the discussion of two major strategies for reference resolution: Sidner’s focusing algorithms and Centering Theory. It will be shown that as effective as they are, these mechanisms are not sufficient to handle the resolution of zero pronouns in Thai discourse. Based on previous research on discourse structure and anaphora, the hypothesis advanced in the present study is that the hierarchical structure of discourse contributes to zero pronoun resolution in Thai. The chapter will conclude with a proposal of an extended centering model that can work with hierarchical structure of discourse.

3.1 Focus

The term ‘focus’ used in this study has the same meaning as the term ‘in focus’ used in Gundel et al.’s (1993). According to Gundel et al., there is a correlation between forms of referring expressions and cognitive statuses of discourse entities.

Based on a study of naturally-occurring data from five languages (Chinese, English, Japanese, Russian and Spanish), Gundel et al. propose six cognitive statuses, namely ‘in focus’, ‘activated’, ‘familiar’, ‘uniquely identifiable’, ‘referential’, and ‘type identifiable’, which are relevant to the form of referring expressions. Each status is a necessary and sufficient condition for appropriate use of certain referring expressions. Below is the scale of givenness hierarchy and the summary of the six cognitive statuses and the corresponding forms in English taken from Gundel et al. (1993:275-279):

(47) The givenness hierarchy

	in		uniquely		type
	focus	>	activated	>	familiar
		>	identifiable	>	referential
				>	identifiable
	<i>that</i>				
<i>it</i>	<i>this</i>	<i>that</i> N	<i>the</i> N	indefinite <i>this</i> N	<i>a</i> N
	<i>this</i> N				

(Gundel et.al. 1993:275)

(48)

Type identifiable: The addressee is able to access a representation of the type of object described by the expression. This status is sufficient for appropriate use of indefinite article *a* in English.

Referential: The speaker intends to refer to a particular object or objects. This status is necessary and sufficient for appropriate use of indefinite *this* in English.

Uniquely identifiable: The addressee can identify the speaker’s intended referent on the basis of the nominal alone. This status is necessary and sufficient for appropriate use of the definite article *the*.

Familiar: The addressee is able to uniquely identify the intended referent because he already has a representation of it in memory. This status is sufficient for appropriate use of the demonstrative determiner *that*.

Activated: The referent is represented in current short-term memory. This status is necessary for appropriate use of all pronominal forms and the definite demonstrative determiner *this*, and it is sufficient for appropriate use of demonstrative pronoun *that* and for stressed personal pronouns.

In focus: The referent is not only in short-term memory, but is also at the current center of attention. This status is necessary for appropriate use of zero and unstressed pronominals.

According to Gundel et al., the higher cognitive status in the givenness hierarchy scale entails the lower status. For example, an entity that is in focus is also activated, familiar, uniquely identifiable, referential, and type identifiable, but not vice versa. The use of an unstressed pronoun in English is appropriate only if its referent has the cognitive status ‘in focus’. In (49), since *the bull mastiff* is in the subject position, its referent is in focus. Thus, it can be appropriately referred to with *it* or *that*. But in (50), *the bull mastiff* is in a prepositional phrase, its referent only has the cognitive status of ‘activated’. Thus, the use of *it* is inappropriate, marked here by the symbol #, since the referent is not in focus.

- (49) a. My neighbor’s bull mastiff bit a girl on a bike.
 - b1. It’s the same dog that bit Mary Ben last summer.
 - b2. That’s the same dog that bit Mary Ben last summer.
- (50) a. Sears delivered new siding to my neighbors with the bull mastiff.
 - b1. # It’s the same dog that bit Mary Ben last summer.
 - b2. That’s the same dog that bit Mary Ben last summer.

(Gundel et al. 1993:280)

Gundel et al. claim that a necessary condition for appropriate use of zeroes or unstressed pronouns in five languages (Chinese, English, Japanese, Russian and Spanish) is that the referent must have the cognitive status ‘in focus’. We will show that the same is true for Thai. Consider examples below:

(51)

- a. dɛɛŋ jɪŋ nók duâaj puunsân
 Daeng shoot bird with short-gun
 ‘Daeng shot a bird with a short gun.’
- b1. # ø pɛn puun khǒŋ phôo khǎw
 ø be gun of father his
 # ‘(It) is his father’s gun.’
- b2. man pɛn puun khǒŋ phôo khǎw
 it be gun of father his
 ‘It is his father’s gun.’
- b3. puun níi pɛn puun khǒŋ phôo khǎw
 gun this be gun of father his
 ‘This gun is his father’s gun.’

(52)

- a. muâawaanníi ʔaacaan thîi sǒon wíchaa níi mâj sàbaaj
 yesterday teacher COMP teach subject this not well
 ‘Yesterday, the teacher who teaches this subject was not well.’
- b1. ø ləəj mâj maa sǒon
 ø then not come teach
 ‘(He), then, did not come to teach.’
- b2. khǎw ləəj mâj maa sǒon
 he then not come teach
 ‘He, then, did not come to teach.’
- b3. ʔaacaan khon níi ləəj mâj maa sǒon
 teacher CL this then not come teach
 ‘This teacher, then, did not come to teach.’

In (51), since /puunsân/- ‘short-gun’ is in the preposition phrase, the cognitive status of its referent is ‘activated’ but not ‘in focus’. Thus, the use of the pronoun /man/-‘it’ in (51b2) and the use of demonstrative /níi/-‘this’ in (51b3) are appropriate, but the use of a zero in (51b1) is inappropriate. In (52), because /ʔaacaan /-‘teacher’ is

in the subject position, the cognitive status of its referent is ‘in focus’. Thus, the use of zero in (52b1) is appropriate. Since its cognitive status is ‘in focus’, the use of other linguistic forms of lower cognitive statuses will be appropriate too, as seen in (52b2) and (52b3).

It should be noted that the term ‘focus’ has a wide variety of meanings in the literature (cf. ‘topic’). While ‘focus’ in this study is concerned with the cognitive status of discourse entities, the term ‘focus’ has also been used to refer to ‘informational status’ of constituents in a sentence. For example, Chomsky (1971) and Jackendoff (1972) used the term ‘focus’ to refer to the complement of a ‘presupposition’. Focus is the linguistic expression containing the intonation center and presupposition is a proposition in which the focus can be replaced by a variable. In example (53) below, the presupposition of (a) may be represented by (b) while ‘John’ is the focus of the sentence.

- (53) a. Is it JOHN who writes poetry?
 b. Someone writes poetry. (Chomsky 1971: 199)

Prince (1986) used the term ‘focus’ in a similar way. However, she used the term ‘open proposition’ instead of ‘presupposition’. For Prince, focus is a stressed constituent which is new information, while open proposition is a proposition which is generally taken to be old information. Thus, Prince’s use of the term ‘focus’ is not directly related to discourse entities either. Her example is shown in (54). The

presupposition or open-proposition of (54a) may be represented by (b) while ‘the shirt’ is the focus of the sentence.

- (54) a. She gave the SHIRT to Harry.
 b. She gave x to Harry. (Prince 1986:209)

3.2 The role of focus in reference resolution

Many researchers, such as Gundel et al. (1993), Givon (1983), and Ariel (1991), have found a correspondence between linguistic forms and cognitive statuses of discourse entities. These researchers have found that unstressed pronoun or a zero pronoun in the languages they have studied, is usually used to represent a discourse entity that is ‘in focus’ (Gundel et al. 1993) or highly accessible (Ariel 1991). Therefore, if we can implement a computational model that can keep track of discourse saliency, the model should know what entities are in focus and should be able to identify preferred referents of a zero pronoun. Algorithms that are designed to keep track of discourse saliency are known as focusing algorithms.

However, two points should be mentioned here. First, reference resolution can be done without focusing algorithms. There are some computational models on reference resolution that do not use focusing mechanisms. For example, Hobbs (1977) uses a simple algorithm that tranverses syntactic parse trees to find an antecedent of a pronoun in English. His algorithm performed well on Hobbs’s small test set. It correctly resolved 88.3% of pronouns. When Hobbs included syntactic and semantic

information like selectional restriction constraints, the algorithm were able to correctly resolve 91.7% of the pronouns.²¹

Second, although focusing appears to be important in reference resolution, it is not sufficient. Inference mechanisms are also necessary for confirming or rejecting referents suggested by focusing algorithms. However, according to Carter (1987:118), using only inferencing for reference resolution is considered computationally expensive and difficult. The process of focusing, when implemented in a natural language processing system, should limit the number of possible discourse referents for a pronoun or a zero pronoun, or even provide preferred referents for these pronouns. Inference mechanisms ideally will be used only to confirm or reject the antecedent. A system using focusing is, in general, considered more efficient than a system using only inference mechanisms for anaphora resolution (Carter 1987:118).

3.2 Focusing algorithms

There are two primary models for focusing that have been proposed in the literature. One was proposed by Sidner (Sidner 1983, Carter 1987, Suri 1992, 1993, Suri and McCoy 1994, and Ersan and Akman 1994). The other is known as ‘Centering Theory’ and has been used by researchers such as Grosz et al. (1983, 1995), Walker,

²¹ Based on Ariel (1991:447) and Hobbs (1977:323), it is possible that the success of Hobb’s strategy may reflect the fact that antecedents of pronouns are often found in the same sentence or in the previous sentence.

Iida, and Cote (1990, 1994), Cote (1998), Eugenio (1990, 1996, 1998), Brennan, Friedman, and Pollard (1987), Kameyama (1985, 1986, 1998), Strube and Hahn (1996), Iida (1998), Hudson-D’Zmura (1998), and Turan (1998). It should be noted that neither of these two approaches has been applied to Thai. In fact, Sidner’s algorithms are designed especially for definite anaphora resolution in English. Her work includes the resolution of personal pronouns, definite noun phrases, noun phrases containing *this* and *that*, and *do*-anaphor. Only the algorithms which relate to pronoun resolution will be discussed here.

On the other hand, in addition to pronoun resolution in English (Grosz et al. 1983, 1995 and Brennan et al. 1987), Centering Theory has been used for zero pronoun resolution in some languages such as Japanese (Walker, Iida, and Cote 1990, 1994, Kameyama 1985, 1986, Iida 1998), Italian (Eugenio 1990, 1996, 1998), and Turkish (Turan 1998). In the following sections, we will discuss how the two focusing models work and show how they are still inadequate for the resolution of zero pronouns in Thai. This will give us a general idea of how focusing algorithms are used for reference resolution.

3.3.1 Sidner's focusing algorithms

Sidner (1983) proposed a set of algorithms for resolving definite anaphora, which use what she termed ‘local focusing’. Focus is regarded as a discourse entity that

speakers center their attention on (Sidner 1983:273). Two types of focus, ‘discourse focus’ and ‘actor focus’, are proposed by Sidner for anaphora resolution. Discourse focus is considered the main focus in a sentence while actor focus is an agent in the event. Sidner establishes these two types of focus because the actor focus and the discourse focus can be pronominalized in the same sentence, as shown in example (55) below (Sidner 1983:282). In (55b), *he* refers to the actor focus, ‘Jerome’, while *it* refers to the discourse focus, ‘pigeon’.

- (55) a. Jerome_i took his pigeon_j out on a leash
 b. Since he_i was trying to train it_j,
 c. he_i hollered "heel" and "run" at it_j,
 d. as they sauntered along.

The focusing algorithms are used to keep track of discourse focus, actor focus, and other focus registers such as focus stacks, potential focus lists, etc. Sidner argues that a pronoun is primarily resolved with either discourse focus or actor focus unless it is ruled out by syntactic or semantic constraints or by world knowledge. If the pronoun appears in the agent position, the actor focus will be suggested. Otherwise, the discourse focus will be suggested. If the suggested focus is rejected, an element from the potential focus list will be suggested one by one in order. If none of these elements are accepted, elements from the focus stack will be suggested next. Thus, we will first discuss how Sidner’s focusing algorithms work. Then, we will discuss how a pronoun is resolved in Sidner’s approach.

Sidner uses six types of register to keep track of discourse entities. They are discourse focus, actor focus, potential discourse focus list, potential actor focus list, discourse focus stack, and actor focus stack. There are two sets of focusing algorithms. One is for discourse focus and the other is for actor focus. Focusing algorithms for discourse focus are similar to focusing algorithms for actor focus. Thus, only algorithms for discourse focus will be discussed below.

Sidner's focusing model consists of three processes: the selection, the interpretation, and the updating of the focus. The first process, referred to as 'the expected focus algorithm' is used for establishing an initial focus from the discourse. This focus will become an expected focus for the next sentence. Sidner proposes that some constructions can be used to determine the expected focus of the sentence, such as the subject of an *is-a* sentence or the subject of a *there*-insertion sentence. In other sentences, the expected focus is determined from thematic roles in the sentence. An element which is the theme of the verb is likely to be the expected focus while an agent is the most unlikely expected focus.²² For example, in (56), the expected focus from the first sentence is 'some strawberries' since it is the subject of *there*-insertion sentence.

- (56) a. Last week there were some nice strawberries in the refrigerator.
 b. They came from our food co-op and were unusually fresh.
 c. I went to use them for dinner, but someone had eaten them all.
 d. Later I discovered it was Mark who had eaten them.

²² Since an agent is already the actor focus, it is unlikely to be the discourse focus.

- e. Mark has a hollow leg, and it's impossible to keep food around when his stomach needs filling.

(Sidner 1983:294)

The expected focus will be confirmed or rejected in the interpretation process, or 'the focusing algorithm'. To reject or confirm the expected focus, syntactic and semantic information, such as gender, number, selectional restriction, etc., is used. The inference mechanism, which has an important role in the interpreting process, is also used to check the consistency of the interpretation with world knowledge. After a referent is selected, the focus will be updated. These two processes, interpreting and updating, can be summarized in (57).²³ Before the algorithm is applied to a sentence, if the sentence is the first one, the current focus is set to the expected focus. Otherwise, the current focus is set to the discourse focus.

(57)

- If there are two anaphors, anaphor_1 and anaphor_2 , such that anaphor_1 co-specifies²⁴ the current focus and anaphor_2 co-specifies a member in the potential focus list,
 - retain the focus if anaphor_1 is not an agent or
both anaphor_1 and anaphor_2 are not an agent and
 anaphor_2 is not a pronoun
 - set the new focus as the member in the potential focus list if
 anaphor_1 is an agent or
 anaphor_2 is a pronoun

²³ The actual algorithms have more detail on different types of definite noun phrases. Pronouns, do-anaphors, and noun phrases containing *this* or *that*, require different operations. We only summarize the parts that relate to pronoun resolution.

²⁴ 'Co-specify' is used instead of 'co-refer' because Sidner wants to avoid the problem due to the lack of referents in the world. A linguistic form A cospecifies B if A shares the same discourse referent as B.

- If the anaphors only co-specify the current focus, retain the focus.
- If the anaphors only co-specify a member in the potential focus list, set the new focus as the member in the potential focus list.
- If the anaphors only co-specify a member in the focus stack, pop up the stack and set the new focus as the member in the focus stack
- If the focus movement occurs, the old focus will be pushed into the focus stack.

In example (56) above, after (56a) is processed, the expected focus is ‘some strawberries’ and the potential focus list contains ‘last week’ and ‘the refrigerator’.²⁵ After is (56b) processed, since there is only one anaphor (*they*) which co-specifies the current focus ‘some strawberries’, the focus is retained.

- (58) a. Cathy wants to have a big graduation party at her house.
 b. She cleaned it up
 c. so that there would be room for everyone.

(Sidner 1983:287)

In example (58), the expected focus from (58a) is the theme of the verb, i.e. ‘the graduation party’, and the potential focus list contains ‘Cathy’s house’ and ‘Cathy’. While (58b) is being processed, *She* co-specifies ‘Cathy’ and *it* co-specifies ‘Cathy’s house’. *It* cannot co-specify the focus ‘the graduation party’ because the world knowledge of cleaning up suggests that the object should not be a party. The new focus will be set as ‘Cathy’s house’ and the old focus ‘the graduation party’ will be pushed on the top of the focus stack.

²⁵ Elements in the potential focus list are collected from discourse entities from the previous sentence. According to Sidner (1983:296), elements in the potential focus list have a short lifetime. They will be dropped out if they do not become the focus in the next sentence.

- (59) a. Alfred and Zohar liked to play baseball.
 b. They played it everyday after school before dinner.
 c. After their game, Alfred and Zohar had ice cream cones.
 d. The boys though they tasted really good.

(Sidner 1983:306)

Pronoun interpretation in Sidner's approach uses the focus registers as a resource for pronoun resolution. In example (59), after (59a) is processed, 'baseball' will be the expected discourse focus and 'Alfred and Zohar' will be the expected actor focus. In (59b), there are two pronouns, *they* and *it*. But only *it* is considered by the discourse focusing algorithms since *they* is in agent position. The pronoun interpretation suggests the expected discourse focus 'baseball' as the co-specifier of *it*. And the expected focus is confirmed. Thus, the discourse focus is retained. *They* is considered by the actor focusing algorithms. The pronoun interpretation suggests the expected actor focus 'Alfred and Zohar' as the co-specifier of *they*. And the actor focus is confirmed. In (59c), the use of definite noun phrase *their game* co-specifies with the discourse focus. Thus, the discourse focus retains. After (59c) is processed, the discourse focus is still 'baseball' and the actor focus is 'Alfred and Zohar' and the potential discourse focus list contains 'ice cream cones' and 'Alfred and Zohar'. *They* in (59d) is first resolved with the current discourse focus ('baseball') since it is not in the agent position. But *they* cannot co-specify with 'baseball'. Thus, an element in the potential discourse focus list will be suggested next. And *they* can co-specify with 'ice cream cones' in the potential focus list. Thus, it is resolved as 'ice cream cones'. The

discourse focus then is changed to ‘ice cream cones’ and ‘baseball’ is pushed onto the discourse focus stack.

In sum, Sidner’s focusing algorithms arrange discourse entities into different focus registers. Pronoun interpretation will suggest a discourse entity from these focus registers as the co-specifier of the pronoun. If the pronoun occurs in the agent position, the suggested co-specifier is taken from the actor focus, the potential actor focus list, or the actor focus stack. Otherwise, the suggested co-specifier is taken from the discourse focus, the potential discourse focus list, or the discourse focus stack.

3.3.1.1 Problems

Though Sidner’s algorithms may be useful for resolving pronominal reference in English, some issues were left for further research. First, as pointed out by Carter (1987:119) and Suri (1993:77), Sidner seems to be inconsistent when handling compound and complex sentences. It is unclear whether the ‘sentence’ in Sidner’s work is defined by clause boundaries or by full stops. For example, while Sidner analyzes the coordinate sentence (60) (in Sidner 1979:53) as one ‘sentence’, she analyzes the coordinate sentence (61) (in Sidner 1979:213) as two ‘sentences’, (61a) and (61b).

(60) I want to use them for dinner, but someone had eaten them all.

(61) a. That cocker is very feisty,
b. but that doesn’t seem to interfere in the games they play.

Second, Sidner's algorithms do not handle anaphors whose antecedents are in the same sentence. Unlike Hobbs' algorithms, which prefer antecedents in the same sentence to antecedents in previous sentences, Sidner's algorithms always prefer antecedents in previous sentences. Carter (1987) tried to extend Sidner's algorithms to account for anaphors with antecedents in the same sentence. His algorithms prefer the discourse focus to candidates within the sentence, and candidates within the sentence to elements in potential discourse focus list. But he notes that the preference is not 'strong' (Carter 1987:145). This is clearly an area for further research.

Another problem that Sidner left for further research is the effect of discourse structure on focusing (Sidner 1983:300-302). As shown in Chapter 1, there are cases in which an antecedent of a zero pronoun in Thai is in a distant sentence rather than in the immediately preceding sentence. The similar example is also found in Grosz (1977). This is what Sidner called 'focus popping'. Sidner pointed out that focus popping is possible because there might be a structural clue for hearers to recognize. However, she did not include structural effects in her study.

To sum up, while Sidner's algorithms can be used for resolving anaphoric phenomena in English, some issues remain. These are focusing in complex and compound sentences, anaphora with antecedents in the same sentence, and the effect of discourse structure on focusing.

3.3.2 Centering Theory

Centering Theory (Grosz, Joshi, and Weinstens 1983, 1995, Walker, Iida, and Cote 1990, 1994, Cote 1998, Walker, Joshi, and Prince 1998, Kameyama 1985, 1986, 1998, Iida 1998, Eugenio 1990, 1996, 1998, Brennan, Friedman, and Pollard 1987, Hudson-D’Zmura 1998, Turan 1998, and Strube and Hahn 1996) is a computational model that accounts for local coherence in a discourse segment. It is claimed to work in a discourse segment as defined in Grosz and Sidner’s (1986) discourse structure theory. Like Sidner’s focusing algorithms, Centering Theory is concerned with local focusing.

Centering Theory explicates coherence in a discourse segment in terms of centers. Centers are discourse entities that serve to link utterances in a segment. The theory assumes that an utterance contains one backward looking center (Cb) and a set of forward looking centers (Cf). Cb is regarded as the center of attention of the utterance while Cf is an ordered list of discourse entities realized in the utterance. Elements in Cf are partially ordered according to discourse salience (Grosz et al. 1995:209). One entity in the Cf is expected to become the Cb of the utterance. According to Grosz et al. (1983:48), Cb corresponds roughly to Sidner’s discourse focus. It is defined as the highest ranked entity of the immediately preceding utterance’s Cf that is realized in the current utterance. This reflects the assumption that the more salient the discourse entity, the more likely it will be the center of attention

(Cb) of the next utterance. Thus, the highest-ranked entity in the Cf is regarded as the preferred center for the next utterance (Cp). Constraints and rules in Centering Theory are stated below:

(62)

Constraints:

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

1. There is precisely one backward-looking center Cb.
2. Every element of the forward centers list, $Cf(U_i)$, must be realized²⁶ in U_i .
3. The center, $Cb(U_i)$, is the highest-ranked element of $Cf(U_{i-1})$ that is realized in U_i .

(Walker et al. 1994:198)

(63)

RULE 1: If any element of $Cf(U_n)$ is realized by a pronoun in U_{n+1} , then the $Cb(U_{n+1})$ must be realized by a pronoun also.

RULE 2: Sequences of continuation are preferred over sequences of retaining; and sequences of retaining are to be preferred over sequences of shifting.²⁷

In particular, a pair continuous across U_n and across U_{n+1} , represented as $Cont(U_n, U_{n+1})$ and $Cont(U_{n+1}, U_{n+2})$ respectively, is preferred over a pair of Retainings, $Ret(U_n, U_{n+1})$ and $Ret(U_{n+1}, U_{n+2})$. This case is analogous for pairs of retainings and pair of shifts.

(Grosz et al. 1995:214-215)

²⁶ The term ‘realize’ was first defined in Grosz et al. (1986) based on situation semantics. ‘An utterance U realizes a center c if c is an element of the situation described by U , or c is the semantic interpretation of some subpart of U ’ (Walker et al. 1994:198). However, the definition may vary depending on the semantic theory adopted in the framework. In general, *U directly realizes c if U is an utterance of some phrase for which c is the semantic interpretation.*’ (Grosz et al. 1995:208-209)

²⁷ In earlier works of centering (Walker et al. 1990, 1994, Eugenio 1990, Kameyama 1985, 1986), preferences of transition states are determined by comparing a single transition, not a sequence of transitions. For example, Walker et al. (1994:199) defined the second rule of centering as below:

Rule 2: Transition states are ordered: CONTINUE is preferred to RETAIN is preferred to SMOOTH-SHIFT is preferred to ROUGH-SHIFT.

‘Continuation’, ‘retaining’, and ‘shifting’ are transition states between a pair of utterances. They are determined from the realization of Cb and Cp as below:

(64)

Continuation: $Cb(U_i) = Cb(U_{i-1})$ and $Cb(U_i) = Cp(U_i)$

Retaining: $Cb(U_i) = Cb(U_{i-1})$ and $Cb(U_i) \neq Cp(U_i)$

Smooth-shift: $Cb(U_i) \neq Cb(U_{i-1})$ and $Cb(U_i) = Cp(U_i)$

Rough-shift: $Cb(U_i) \neq Cb(U_{i-1})$ and $Cb(U_i) \neq Cp(U_i)$

A pair of utterances, U_i and U_{i-1} , is continuous when both utterances have the same Cb and Cb of U_i is the same as Cp of U_i . Continuation represents a transition state in which the center of attention is the same in both utterances. In example (65), Cb in each utterance is the first element of the previous Cf, that is realized in the current utterance. Thus, the Cb of (65b), (65c), and (65d) is ‘John’, while the Cb of (65e) is ‘Mike’. The transition state between (65b) and (65c) is continuation since the Cbs of both utterances are the same and the Cb of (65c) is the same as the Cp of (65c). When Cb of U_i is different from Cp of U_i while both U_{i-1} and U_i have the same Cb, the transition state is called ‘retaining’. Retaining represents a transition state in which the center of attention is retained in the current utterance (U_i) but it is likely to be changed in the next utterance. In example (65), the transition state between (65c) and (65d) is retaining since the Cb of both utterances are the same but the Cb of (65d), ‘John’, is different from the Cp of (65d), ‘Mike’. When Cb of U_i is different from Cb of U_{i-1} , shifting of attention occurs. In (65e), shifting occurs because the Cb of (65e) is not the

same as the Cb of (65d). Although Grosz et al. (1983, 1995) does not distinguish between ‘smooth-shift’ and ‘rough-shift’, the difference between these two shifting has been discussed in Brennan et al. (1987) and in Walker et al. (1994). We will follow Brennan et al. (1987) and Walker et al. (1994) in using two kinds of shifting in this study.

- (65) a. John has been having a lot of trouble arranging his vacation.
- b. He cannot find anyone to take over his responsibilities.
 Cb = ‘John’; Cf = (John)
- c. He called up Mike yesterday to work out a plan.
 Cb = ‘John’; Cf = (John, Mike); Continue
- d. Mike has annoyed him a lot recently.
 Cb = ‘John’; Cf = (Mike, John); Retain
- e. He called John at 5 am on Friday last week.
 Cb = ‘Mike’; Cf = (Mike, John); Shift

(Grosz et al. 1995:217)

Like Sidner’s focusing algorithms, Centering Theory can be used for pronoun resolution because it keeps track of discourse salience by using some registers like Cb and Cf. In addition, the first centering rule states that if an entity from the immediately preceding utterance is realized as a pronoun, the Cb of the current utterance must be realized as a pronoun too. And the Cb of an utterance is the highest ranked entity of the previous Cf, that is realized in the current utterance. Thus, if we assume that antecedents of pronouns are found in the immediately preceding utterance, we can use Centering Theory for pronoun resolution.

When an utterance (U_i) has one zero pronoun, if we assume that its referent could be found in the immediately preceding utterance (U_{i-1}), according to Rule 1, it is not possible for the Cb to be any other entity else besides the referent of the zero. When an utterance (U_i) has more than one zero, if we assume that all the referents could be found in the immediately preceding utterance (U_{i-1}), one of the referents must be the Cb. Therefore, algorithms for pronoun resolution can suggest a referent of a pronoun from the $Cf(U_{i-1})$ with respect to the ranking of entities in the $Cf(U_{i-1})$ and the preference of transition states. The centering algorithm will suggest entities that are not yet referred to in the utterance as the referents of zeroes. There may be more than one possible interpretation. But the one that observes constraints and rules and the preferred transition state will be selected as the preferred interpretation. For example, to observe Constraint 3, the referent of one zero must be the Cb which is the highest ranked entity from the previous Cf. To observe Rule 2, sequences of continuation are preferred to retaining, which are in turn preferred to shifting. Example (66) is an example in which two pronouns are used in (66c).

- (66) a. I haven't seen Jeff for several days.
 b. Carl thinks he's studying for his exams.
 c. He thinks he studies too much. (Carter 1987:117)

In (66b), *he* refers to 'Jeff' and 'Jeff' is the Cb of (66b). If we assume that the main clause subject has a higher rank, the Cf of (66b) will be (Carl, Jeff, Exam) and the transition state of (66b) is a retaining state (since $Cb(66b) \neq Cp(66b)$). Then, there will

be two interpretations for (66c) as shown in (67c1) and (67c2). Interpretation of sentence (66c) depends on the preferred sequence of transition states. In (67), centering will predict the correct interpretation *Carl thinks that Jeff studies too much* (Cf of (66c) is (Jeff, Carl)) if smooth-shift is preferred to rough-shift. Brennan et al. (1987) have shown that smooth-shift is preferred to rough-shift.

(67)b.	Cb = 'Jeff',	Cf = (Carl, Jeff)	Retain
c1.	Cb = 'Carl',	Cf = (Carl, Jeff)	Smooth-shift
c2.	Cb = 'Carl',	Cf = (Jeff, Carl)	Rough-shift

On the other hand, if we assume that the main clause subject has a lower rank, the Cf of (66b) will be (Jeff, Carl, Exam) and the transition state of (66b) will be a continuation. Then, there will be two interpretations for (66c) as shown in (68c1) and (68c2).

(68)b.	Cb = 'Jeff',	Cf = (Jeff, Carl)	Continue
c1.	Cb = 'Jeff',	Cf = (Carl, Jeff)	Retain
c2.	Cb = 'Jeff',	Cf = (Jeff, Carl)	Continue

In (68), centering will predict that continuation is preferred to retaining and the Cf of 66c) is (Jeff, Carl). Thus, whether the main clause subject has a higher rank or a lower rank, the sentence (66c) will be read as *Carl thinks Jeff studies too much*. Therefore, in this example, Centering Theory can resolve the referents of the two pronouns by the use of Rule 1 and Rule 2.

To demonstrate how Centering Theory can be implemented for pronoun resolution, we will discuss Brennan et al.'s (1987) algorithm for pronoun resolution,

which is based on Centering Theory. There are three modules in Brennan et al.'s algorithm: constructing anchors, filtering anchors, and ranking anchors. An anchor is defined by Brennan et al. as a pair of Cb and Cf of an utterance. The first module constructs all possible anchors for an utterance. The second module filters out anchors that do not observe constraints and rules in Centering Theory. The last module ranks the proposed anchors according to transition states. The highest ranked anchor will be selected as the Cb and Cf of the utterance. If an utterance has a pronoun, the suggested referent of a pronoun will be taken from this anchor. If inference mechanisms reject the suggested referent, the next lower ranked anchor will be considered until the suggested referent is not rejected by the inference mechanisms. Brennan et al.'s (1987) algorithm for pronoun resolution is summarized below:

(69)

Construct anchors for U_n

- Construct Cf(U_n) by taking all entities in U_n and order them by grammatical roles.
- If Cf(U_n) contains a pronoun, replace a pronoun with an entity from U_{n-1} .
Thus, there may be many possible Cfs for U_n
- Construct a list of possible Cbs from entities from Cf(U_{n-1}). Add NIL at the end to allow the Cb to be empty.
- Create proposed anchors. An anchor is a pair of Cb and Cf. If there is m possible Cfs for U_n and there is n possible Cbs for U_n , there will be $m \times n$ possible anchors for U_n .

Filter the proposed anchors

- Filter by contraindices. If the same entity is proposed for two different pronoun in U_n , eliminate that anchor.
- If the proposed Cb is not the first element in Cf(U_{n-1}) that is realized in the proposed Cf, eliminate that anchor. (This filter observes Constraint 3 of the Centering Theory.)

- If none of the entities realized as pronouns in the proposed Cf equals the proposed Cb, eliminate that anchor. (This filter observes Rule 1 of the Centering Theory.)

Rank the proposed anchors

- Determine transition state for each anchor.
- Rank the proposed anchors with respect to the preferred transition as defined in Rule 2 of the Centering Theory.

In example (65), repeated below as (70), when (70d) is being processed, the algorithm would perform actions as illustrated in (71):

- (70) a. John has been having a lot of trouble arranging his vacation.
 b. He cannot find anyone to take over his responsibilities.
 Cb = 'John' Cf = (John)
 c. He called up Mike yesterday to work out a plan.
 Cb = 'John' Cf = (John, Mike) Continue
 d. Mike has annoyed him a lot recently.
 Cb = 'John' Cf = (Mike, John) Retain
 e. He called John at 5 am on Friday last week
 Cb = 'Mike' Cf = (Mike, John) Smooth-shift

(71)

- Construct Cf(U_d) as (Mike, PRON1).
- Replace PRON1 with an entity from Cf(U_c). There will be two possible Cfs:²⁸
 Cf1: (Mike, John)
 Cf2: (Mike, Mike)
- Construct a list of possible Cb for U_d as ('John', 'Mike', NIL)
- Construct possible anchors as <Cb, Cf>
 Anc1: <'John', (Mike, John)>
 Anc2: <'Mike', (Mike, John)>
 Anc3: <NIL, (Mike, John)>
 Anc4: <'John', (Mike, Mike)>
 Anc5: <'Mike', (Mike, Mike)>
 Anc6: <NIL, (Mike, Mike)>

²⁸ Actually, there should be three possibilities if *a plan* in U_c is taken into account. But to simplify the explanation here, we will ignore the discourse entity of *a plan*.

- Filter by contra-indices. This process eliminates Anc4, Anc5, and Anc6 since the referent of *him* cannot be 'Mike'.
- Filter by Constraint 3. This process eliminates Anc2 and Anc3. Since Cf(U_c) contains both 'John' and 'Mike', the first element that is realized in U_d for both Anc2 and Anc3 is 'John'. Thus, the Cb(U_d) should be 'John'. Only Anc1 is left after this filter is applied.
- Filter by Rule 1. No anchor is eliminated here.
- Determine transition states of anchors. Only Anc1 is left. And the transition state is 'retaining' because Cb(U_d) is the same as Cb(U_c) but Cb(U_d) is not the first element in Cf(U_d).
- Rank anchors. Since there is only one anchor left (Anc1), the suggested referent for *him* will be 'John'.

The above explanation demonstrates how Centering Theory can be used for pronoun resolution.²⁹ Like Sidner's focusing algorithms, Centering Theory can be used for pronoun resolution because it keeps track of discourse salience by using some registers like Cb and Cf. The mechanism can suggest referents of pronouns based on discourse salience and the constraints and rules in the theory.

3.3.2.1 Problems

Unlike Sidner's focusing algorithms, which have been applied only to English, Centering Theory has been applied to a variety of languages, including Japanese (Walker, Iida, and Cote 1990, 1994, Kameyama 1985, 1986, Iida 1998), Italian (Eugenio 1990, 1996, 1998), German (Strube and Hahn 1996), and Turkish (Turan

²⁹ It should be noted that the algorithm above was not designed for efficiency but for clarity (see Brennan et al. 1987:160).

1998). In addition, Centering Theory has been adapted for languages which have zero pronouns, such as Japanese, Italian, and Turkish.

Therefore, we will use Centering Theory as the basis of the focusing model to be adopted in this study. But, like Sidner's focusing algorithms, Centering Theory is still not sufficient for handling naturally occurring data. Centering Theory cannot be used for pronoun resolution when the antecedents of these pronouns are not in the immediately preceding utterance.

As shown in examples (65-66), Centering Theory can be used for pronoun resolution if the antecedents of the pronouns can be found in the immediately preceding utterance. But when no pronoun has an antecedent in the immediately preceding utterance (U_{n-1}), Rule 1 is not applicable. This means that the referent of a pronoun does not have to be the Cb of the current utterance (U_n). In addition, when no entity from U_{n-1} is realized in U_n , $Cb(U_n)$ is undefined. In these cases, we cannot use constraints and rules in the theory for pronoun resolution. If the referent of a pronoun is referred to in the immediately preceding utterance, we can use Rule 1 to resolve the pronoun as the Cb of the utterance. But when the referent of a pronoun is not referred to in the immediately preceding utterance, the theory gives us no clue where the antecedent of the pronoun should be.

A question to be concerned with here is whether an antecedent of a pronoun must always be found in the immediately preceding utterance. In Thai, it was shown that antecedents of zero pronouns do not always occur in the immediately preceding utterance. Thus, Centering Theory must be extended to handle resolution of pronouns with distant antecedents. Distant antecedents are also possible in English, as we can see from example (72) discussed in Suri (1993:65).

- (72) a. With a strain, he could see a glimpse of the river to the northwest.
- b. The walls were Sheetrock and bare.
- c. She had picked out some artwork.
- d. He determined that the Ego Wall would face the desk, behind the wing chairs.

(*The Firm*, Grishman 1991:1339)

He in (72d) does not refer to any entity realized in (72b) or (72c). Rather, it co-specifies *he* in (72a). Either Centering Theory needs to keep track of discourse entities beyond the immediately preceding utterance or it has to be extended to handle higher level structures. The latter strategy is adopted for this study. In section 3.4.3, we will discuss how Centering Theory can be extended to work with higher level structure.

As for the handling of complex sentences, both Sidner's focusing algorithms and Centering Theory are problematic. Most of the examples discussed in the centering literature involve simple sentences. Some analysts have discussed centering in complex sentences, but not in great detail. For example, Kameyama (1985, 1986) and Walker et al. (1990) claim that a subordinate clause can be treated as a separate utterance.

(73)

Assuming that each clause may be associated with its Cb, a plausible hypothesis would be that a subordinate clause relates itself to the immediately superordinate clause in the manner parallel to how a (simple) sentence in discourse relates itself to the immediately preceding one. (Kameyama 1986:61)

(74)

The centering algorithm can also be applied successfully to intrasentential anaphora, by treating the subordinate clause as though it were a separate utterance for the purposes of pronoun interpretation. (Walker et al. 1990:4)

Kameyama observed that in Japanese, a coreference between a zero pronoun in a subordinate clause and a full NP in a superordinate clause is similar to a coreference between a zero pronoun and a full NP in two contiguous simple sentences. Below are some of her examples (Kameyama, 1986:62-63)³⁰.

(75) *John_i wa [Bill ga ø_i oinuku koto] o kitaisite-iru.

TB-SB SB OB surpass NOM OB anticipates
'John anticipates that Bill will surpass [him]'

(76) John_i wa [ø_i Bill o oinuku koto] o kitaisite-iru.

TB-SB SB OB surpass NOM OB anticipates
'John anticipates that [he] will surpass Bill'

(77) a. John_i niwa [ø_i e kitaisiteiru] koto ga aru

TB-SB SB OB is-anticipating thing SB exists
'For John, there is something that [he] anticipates'

b. ?*Bill ga ø_i oinuku koto da.

SB OB surpass NOM is
'[It] is Bill's surpassing [him]'

(78) a. John_i niwa [ø_i e kitaisiteiru] koto ga aru

TB-SB SB OB is-anticipating thing SB exists
'For John, there is something that [he] anticipates'

³⁰ The following abbreviations are used in the example: SB(subject), OB(direct object), TP(topic), NOM(nominalizer).

- b. Bill ni \emptyset_i oinukarero koto da.
 by SB be-surpassed NOM is
 ‘[It] is [his] being surpassed by Bill’

Examples (75)-(78) show a parallelism of intrasentential and intersentential coreferences. Sentence (75) is less acceptable in the same manner as a sequence of sentences in (77), while sentence (76) and a sequence of sentences in (78) are perfectly good. Centering can explain why sentence (77b) is less acceptable when it follows (77a), while (78b) is acceptable when it follows the same sentence (78a). In both (77b) and (78b), ‘John’ is the Cb. But the preferred center of (77b), Cp(77), is ‘Bill’ while the Cp(78b) is ‘John’. Since a continuation state is preferred to a retaining state, (77b) is less acceptable than (78b). In this regard, Kameyama argues that Centering Theory can be used for intrasentential phenomena. Walker et al. (1990:4) gave another example of this sort:

- (79) Taroo wa Kim ni [\emptyset \emptyset bengosuru] koto o hanasita
 ‘Taroo told Kim that he would defend her’
 Cb: Taroo
 Cf1: (Taroo, Kim) Continuation
 subj/top obj2
 Cf2: (Kim, Taroo)³¹ Retaining
 subj/top obj2

Assuming that a complex sentence can be analyzed as multiple utterances, there will be two interpretations for this example. But the first interpretation (Cf1) is

³¹ Walker et al. have Cf2: (Hanako, Kim), but we believe that it is a typographical error. The correct version should be Cf2: (Kim, Taroo).

preferred since it reflects the continuation state (between the superordinate clause and the subordinate clause) while the second (Cf2) reflects the retaining state.

Examples (75), (76) and (79) suggest that centering may be applied within the sentence. However, it is not clear whether intrasentential centering is a part of intersentential centering or a separate process. For example, after processing the subordinate clause of (79), what should be the previous Cf for the next sentence: the Cf of the subordinate clause or the Cf of superordinate clause? If the Cf of the subordinate clause provides the Cf for the next utterance, then, there will be no difference between intrasentential and intersentential centerings because a subordinate clause is treated as a separate utterance with respect to the overall discourse.

However, evidence suggests that it is likely that the Cf of the subordinate clause cannot be analyzed as the Cf for the next utterance.³² Example (80) indicates that the subordinate clause (80b) does not behave like a separate utterance, but rather like a part of the main clause (80a).

- (80) a. John met Adam
Cb = ?, Cf = (John, Adam)
- b. when Bill gave a party.
Cb = Null, Cf = (Bill)
- c. He invited him to a movie.

³² Suri (1993:135-136) also discussed the issue of extending centering to handle complex sentences. However, she concluded that the Centering Theory cannot be modified for handling complex sentences. Her explanation on centering was based on the view that preference of transition state is considered from a single state. If preferences of transition states are considered from a sequence of transition state, centering could be used to explain the examples she discussed too.

If (80b) is analyzed as a separate utterance, the previous Cf for (80c) will be Cf(80b). In this case, ‘Bill’ is the only entity that could be the Cb of (80c). However, it is likely that neither *he* or *him* in (80c) refers to ‘Bill’ and the Cb(80c) would be undefined (cf. example (72)). Similarly, if we allow the subordinate clause (80b) to be a subsegment and if the previous utterance for (80c) is (80a), the pronouns *he* and *him* in (80c) will be resolved. However, not all subordinate clauses can be analyzed this way. In example (81), it is likely that the Cf of the subordinate clause (81b) provides the Cf for (81c) so that *he* in (81c) can be resolved with ‘Chomsky’. Examples (80-81) suggest that a subordinate clause cannot always be analyzed as a separate utterance or as a subsegment.³³

- (81) a. It was in 1962
- b. that Chomsky made his first great contribution
- c. He was very pleased.

In summary, Centering Theory appears to be simpler than Sidner’s algorithms. But it has not been fully developed to handle naturally-occurring data. Since centering does not keep track of entities beyond the immediately preceding sentence, it cannot resolve cases involving distant antecedents. Centering Theory must also be extended to handle complex sentences. It is likely that not all complex sentence can be analyzed as multiple utterances which are linearly ordered.

³³ These examples are provided by the author’s advisor to indicate this point.

We shall propose a solution to these problems that involves treating the clause as the primary unit of discourse. We shall argue that clauses, like sentences, participate in a hierarchical discourse structure, and that their relationships with respect to reference resolution can be appropriately explicated by a theory such as Rhetorical Structure Theory (Mann and Thompson 1987, Mann, Matthissen, and Thompson 1992). We shall propose that Centering Theory and RST can work together to constrain the interpretation of pronouns in discourse.

3.4 Extending focusing algorithms

It is evident that focusing algorithms must be extended to handle pronoun resolution in complex sentences. We will argue that the process of focusing on complex sentences can be described on the basis of the hierarchical structure of clauses. Rhetorical Structure Theory (Mann and Thompson 1987) and Fox's (1987) analysis of English written texts will be discussed in section 3.4.1 to show the relationship between hierarchical structure of clauses and anaphora. Then, an extended focusing algorithm will be proposed based on the Centering Theory and the result of Fox's analysis in 3.4.2.

3.4.1 Focusing and Discourse Structure

In this study Rhetorical Structure Theory (Mann and Thompson 1987, Fox 1987) is used to explicate the relationship between anaphora and the hierarchical

structure in a discourse.³⁴ An overview of Rhetorical Structure Theory (RST) as proposed by Mann and Thompson (1987) will be presented first and followed by an example of an analysis of English written texts by Fox (1987), which illustrates the relationship between discourse structure and anaphora. Fox's analysis indicates that pronouns are constrained by the hierarchical structure of clauses.

RST represents a discourse as a hierarchical structure of rhetorical units, or 'spans', where 'a text span is any portion of text that has an RST structure (and thus has a functional integrity, from a text-organizational point of view), or that is realized by a unit. Units are typically clauses' (Mann, Mattiessen and Thompson 1992:47). Rhetorical units are held together by rhetorical relations. Rhetorical relations are defined as the functional relations between two spans, e.g., elaboration, justification, circumstance, etc. The list of relations, as stated by Mann and Thompson (1987:48) and Mann et al. (1992:46), remains open. Most of the rhetorical relations are asymmetrical. They hold between nucleus and satellite spans. However, some relations, e.g., sequence, joint, and contrast, are symmetrical. They can hold between two nucleus spans. Below is an example of a discourse analyzed in terms of RST (Fox 1987:13-14).

³⁴ The relationship between discourse structure and anaphora has also been studied in other theories of discourse structure, such as Segmented Discourse Representation Theory (Asher 1993), Linguistic Discourse Model (Polanyi 1988).

(82)

- u1. Bob "Smitty" Smith will be installed as the 1984 president of the Monrovia Chamber of Commerce at the annual January dinner.
- u2. He has been a partner in the Monrovia Travel Agency with Bob Bennett since 1974,
- u3. but after the first year, when Bennett retires, Smith will become the sole power.
- u4. An 11-year member of the Chamber, Smith serves on the Ambassadors committee, a group which systematically visits the over 600 members of the Chamber in a series of two- or three-day "blitzes".
- u5. He has served on the Chamber's Board of Directors for three years,
- u6. and he is a member of the public relation committee.
- u7. His most recent community involvement has been appointment to the Centennial Committee. ... *(Monrovia Today, January 1984)*
(Fox 1987:103)

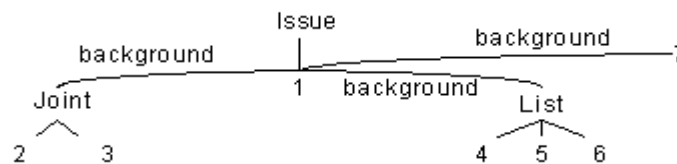


Figure 3: Rhetorical sttucture of example (82)

Fox (1987) uses Mann and Thompson's RST to explain the distribution of pronouns and full NPs in four American English written texts. In her study, pronouns are restricted to those referring to people. Fox found that the structure of discourse affects anaphora. The choice of referring expression depends on the structure of discourse.

Fox argues that anaphora cannot be explained simply by measuring distance between anaphors and antecedents. Rather, it should be explained in structural terms.

For example, using a full NP instead of a pronoun when a pronoun could be used would indicate a beginning of a new rhetorical unit. From the analysis of four expository texts, Fox (1987:95) found the distribution of pronouns and full NPs to be as follows:

(83)

1. A pronoun is used to reference a person mentioned in an active or controlling proposition.
2. All other mentions are done with full NPs.

According to Fox, an antecedent of a pronoun is usually found in an active or a controlling proposition. A proposition is the smallest unit of text 'that enters into informational and/or interactional relationship with other parts of the text'. It is roughly equivalent to a clause (Fox 1987:78). Thus, Fox's term 'proposition' is equivalent to the smallest span in a rhetorical structure (R-structure). The term 'active' proposition refers to a proposition in an R-structure whose partner is being produced. An active proposition can be either a nucleus or a satellite in an R-structure. Fox's examples of active propositions are provided in (84-85). In these examples, the proposition (u1) is active while the proposition (u2) is being processed. In (84), the active proposition (u1) is the nucleus. The pronoun *she* in (u2) refers to 'MacPike' in the active proposition. In (85), the active proposition (u1) is a satellite. The pronoun *him* in (u2) refers to the same referent as *he* in the active proposition.

(84)

- u1. MacPike will use the second half of her day to complete an administrative fellows program.
- u2. She will work under vice president Gerald Scherba in the areas of resource allocation and academic personnel. (*The Sun*, July 1983)
(Fox 1987:97)

Issue

3

(1)ÄÄÄelaborationÄÄÄ(2)

Figure 4: Rhetorical structure of example (84)

(85)

- u1. But as he was approaching 60,
- u2. a chance encounter with humanistic psychologist Dr. Carl Rogers made him think about a change. (*Los Angeles Times*, July 11, 1983)
(Fox 1987:98)

Circumstance

|

(1)ÄÄÄcircumstanceÄÄÄ(2)

Figure 5: Rhetorical structure of example (85)

A ‘controlling’ proposition is a proposition whose partner is active. Fox’s example of controlling propositions is provided in (86). While the proposition (u3) is being processed, the proposition (u2) will be an active proposition, and the proposition (u1) will be a controlling proposition. *His* in (u3) does not refer to any entity in (u2), but refers to an entity in a controlling proposition (u1), ‘Leonard’.

(86)

- u1. Leonard saw these as a "series of psychological curtains which one interposed between oneself and the outside world of other people."
- u2. It was all part of the process of growing up and also a means of self-concealment and self-defense.
- u3. Particularly valuable in this process was his learning of a peculiar ecstasy which comes from "feeling the mind work smoothly and imaginatively upon difficult and complicated problems." (*A House of Lions*, p.25)
(Fox 1987:100)

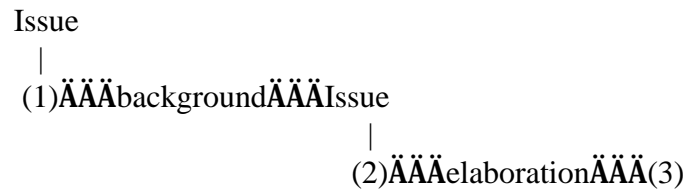


Figure 6: Rhetorical structure of example (86)

In addition to active and controlling propositions, Fox also found that a pronoun can sometimes be used in a case of 'return pop'. Return pop is a case where a proposition is tied to a distant proposition. On Fox's analysis, example (82), repeated as (87) below, is an example of return pop because (u7) is tied to (u1). There are two R-structures, (u2-u3) and (u4-u6), intervening between (u1) and (u7). According to Fox, a pronoun can be used in a return pop if the previous satellite unit (or adjunct) contains the referent of the pronoun, or does not have a complex structure. This is shown in examples (87-88). In (87), *his* can be used in (u7) to refer to 'Smith' because the referent 'Smith' is contained in the first (u2-u3) and the second adjuncts (u4-u6). In (88), *he* can be used in (u5) because the adjunct (u2-u4) does not have a complex structure.

(87)

- u1. Bob "Smitty" Smith will be installed as the 1984 president of the Monrovia Chamber of Commerce at the annual January dinner.
- u2. He has been a partner in the Monrovia Travel Agency with Bob Bennett since 1974,
- u3. but after the first year, when Bennett retires, Smith will become the sole power.
- u4. An 11-year member of the Chamber, Smith serves on the Ambassadors committee, a group which systematically visits the over 600 members of the Chamber in a series of two- or three-day "blitzes".
- u5. He has served on the Chamber's Board of Directors for three years,
- u6. and he is a member of the public relation committee.
- u7. His most recent community involvement has been appointment to the Centennial Committee. ... *(Monrovia Today, January 1984)*

(Fox 1987:103)

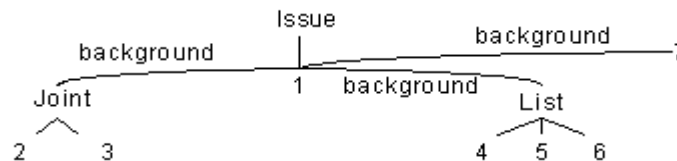


Figure 7: Rhetorical structure of example (87)

(88)

- u1. Like most hedonists, he preferred to look neither backward nor forward.
- u2. The here and now, the picture in front of him, the woman he was with, the bird in flight - this was life:
- u3. the rest was history.
- u4. The future could assuredly take care of itself.
- u5. He found himself at one with Proust in the thought that "the only certainty in life is change." *(A House of Lions, p.28)* *(Fox 1987: 106)*

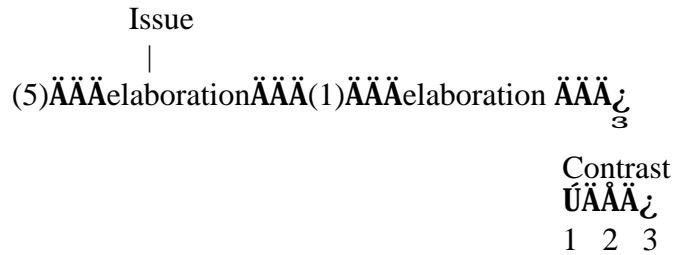


Figure 8: Rhetorical structure of example (88)

These three conditions for using a pronoun (active, controlling, and return pop) will be used to extend focusing algorithms in the next section. Fox's study focused on English, in terms of other languages, Choi (1991) also found that rhetorical structure affects the choice of referring expression in Korean. Choi found that the use of a full NP instead of a zero pronoun where a zero pronoun could be used indicates the beginning of a new rhetorical unit in Korean. Moreover, a full NP is used when the referent is not accessible in the same rhetorical unit. Choi concludes that referential choices should be studied in terms of hierarchical structure rather than linear order. Though Choi did not discuss the resolution of zero pronouns with respect to rhetorical structure, it is plausible that rhetorical structure is also relevant in zero pronoun resolution. These studies (Fox 1987, and Choi 1991) suggest that anaphora should be studied in terms of discourse structure.

3.4.3 A proposal for an extended centering model

In section 3.3.2, we discussed problems of applying Centering Theory to naturally-occurring data. In section 3.4.1, we indicated that discourse structure is relevant for anaphora. In this section, we will propose a model of extended centering that incorporate the structure of discourse. The extension is based on Fox's (1987) proposal of 'active', 'controlling', and 'return pop' patterns as conditions for using a pronoun.

Although Fox discusses both rhetorical structure and rhetorical relations, the condition of 'active', 'controlling', and 'return pop' patterns she proposed do not crucially involve specific rhetorical relations. Therefore, we will simplify the structure of discourse by ignoring rhetorical relation names in the structure. A discourse structure, then, will look like a hierarchical tree structure. The smallest span (i.e., a clause) would be represented as a terminal node, while a larger span would be represented as a non-terminal node. For example, the discourse (87), repeated as (89) below, will be represented as in Figure 9.

(89)

- u1. Bob "Smitty" Smith will be installed as the 1984 president of the Monrovia Chamber of Commerce at the annual January dinner.
- u2. He has been a partner in the Monrovia Travel Agency with Bob Bennett since 1974,
- u3. but after the first year, when Bennett retires, Smith will become the sole power.

- u4. An 11-year member of the Chamber, Smith serves on the Ambassadors committee, a group which systematically visits the over 600 members of the Chamber in a series of two- or three-day "blitzes".
- u5. He has served on the Chamber's Board of Directors for three years,
- u6. and he is a member of the public relation committee.
- u7. His most recent community involvement has been appointment to the Centennial Committee. ... (Monrovia Today, January 1984)
- (Fox 1987:103)

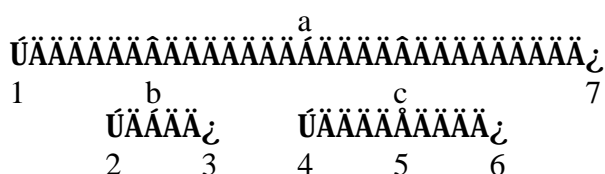


Figure 9: Discourse structure of example (89)

It should be noted that Fox analyzed only four expository prose texts in American English. Thus, it is possible that specific rhetorical relations might prove relevant for pronoun resolution if a larger corpus is analyzed. In addition, though rhetorical relations may not be relevant for pronoun resolution in English, they might be relevant for zero pronoun resolution in Thai. Nevertheless, in this study, we would like to begin the study of relationship between discourse structure and pronoun resolution by concentrating only on the hierarchical structure of discourse. The results of this study will indicate whether the use of discourse structure without rhetorical relations is sufficient for zero pronoun resolution in Thai.

To summarize Fox's findings on her data, the following patterns are identified by Fox:

(90)

1. Active pattern: A proposition is active when its R-structure partner is being produced.
2. Controlling pattern: A proposition is controlling when its R-structure partner is active.
3. Return pop pattern: Return pop is a case where a proposition is tied to a proposition which is not the immediately previous proposition.

Fox claims that the use of pronouns in English is constrained by these patterns.

Antecedents of pronouns will be found in an active, a controlling, or a return pop pattern. Thus, we can use these patterns to identify the scope of focusing algorithms: where they should look for referents of pronouns. In an active pattern, a pronoun can be used in U_i when its referent is referred to in an active unit, which is also the immediately preceding unit (U_{i-1}) of the current utterance (U_i). Thus, the immediately preceding unit will be the scope in which focusing algorithms should look for antecedents. And the immediately preceding unit can be either a clause or a rhetorical structure.

In a controlling pattern, antecedents of pronouns are in a controlling proposition. The three types of controlling pattern presented in Fox (1987:100-101) map to two types of hierarchical structure, as shown in Figure 10 to Figure 12. In these examples, a pronoun is in U_3 and its antecedent is in U_1 . U_2 is the active proposition and U_1 is the controlling proposition. In the first and second types of Fox's controlling pattern (see Figure 10 and Figure 11), a controlling proposition is an immediately

preceding unit of U_x , which is composed of U_2 and U_3 . The active proposition (U_2) is the immediately preceding unit of the current utterance (U_3). Thus, to handle this case, the focusing algorithm has to be implemented to look back two steps. When the referent cannot be found in the immediately preceding unit (U_2), the next preceding unit (U_1) should be the scope in which the focusing algorithm looks for the referent. In the third type of controlling pattern, Figure 12, a controlling proposition (U_1) is combined to the active proposition (U_2) as a larger unit (U_x), and this unit (U_x) is the immediately preceding unit of the current utterance (U_3). Thus, focusing algorithms can find the referent of pronoun in one step within this immediately preceding unit (U_x).

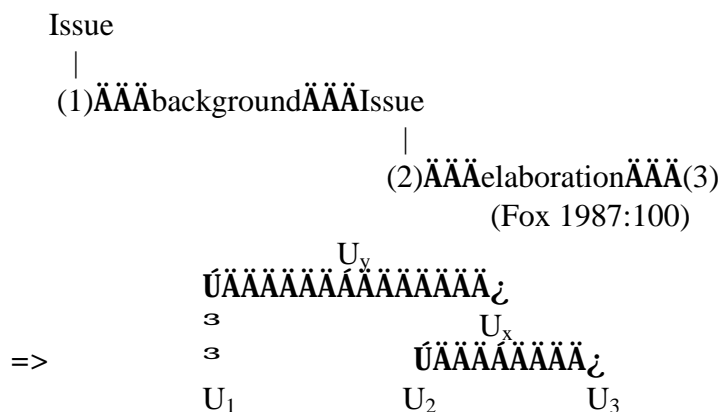


Figure 10: Mapping of the first type of controlling pattern

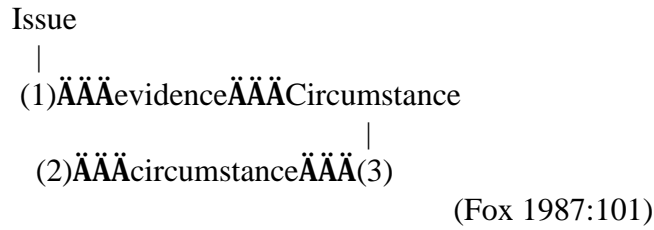


Figure 11: Mapping of the second type of controlling pattern

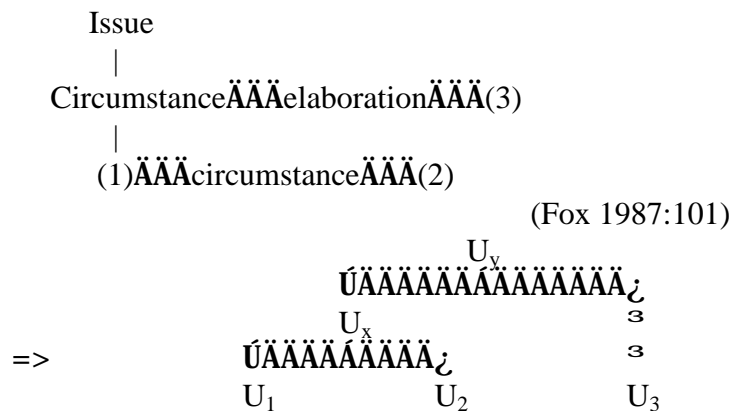


Figure 12: Mapping of the third type of controlling pattern

In a return pop pattern, though antecedents of pronouns are found in a distant unit, Fox notices that a pronoun can be used in U_i when its referent is referred to not only in the nucleus of U_i , but also in an adjunct unit between U_i and the nucleus. However, since the presence of the referent in the previous adjunct is necessary for a pronoun to be used, we prefer to view the use of a pronoun in this case as a

continuation of the focus of attention between units rather than as a direct connection between a nucleus and a return-pop as implied by Fox. For example, in example (87), repeated as (91) below, we view the use of pronoun in (u7) as a continuation of the entity 'Smith' from unit (uc) to (u7) rather than a reference between the nucleus (u1) and the return pop (u7). In this example, (uc) is the previous adjacent unit of (u7). (uc) comprises of three utterances, (u4-u6). In (u6), a pronoun *he* can be used because (u5) contains mentions of the referent 'Smith'. In (u5), a pronoun *he* can be used because (u4) contains mentions of the referent 'Smith'. As a result of the continuation of the entity 'Smith' from (u4) to (u6), it can be assumed here that 'Smith' will be the focus of attention of the unit (uc). Then, the use of a pronoun in (u7) to refer to 'Smith' is just a continuation of the focus of attention from (uc) to (u7).

(91)

- u1. Bob "Smitty" Smith will be installed as the 1984 president of the Monrovia Chamber of Commerce at the annual January dinner.
- u2. He has been a partner in the Monrovia Travel Agency with Bob Bennett since 1974,
- u3. but after the first year, when Bennett retires, Smith will become the sole power.
- u4. An 11-year member of the Chamber, Smith serves on the Ambassadors committee, a group which systematically visits the over 600 members of the Chamber in a series of two- or three-day "blitzes".
- u5. He has served on the Chamber's Board of Directors for three years,
- u6. and he is a member of the public relation committee.
- u7. His most recent community involvement has been appointment to the Centennial Committee(*Monrovia Today*, January 1984)
(Fox 1987:103)

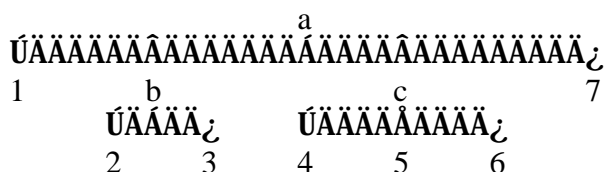


Figure 13: Discourse structure of example (91)

It appears that both ‘active’ and ‘return-pop’ patterns require the presence of a referent in the preceding unit. Thus, the immediately preceding unit should be the first place the focusing algorithms look for an antecedent. If antecedents of pronouns are not in the immediately preceding unit, the focusing algorithms then will look for antecedents in the next preceding unit. The latter operation is the implementation of the first and second types of controlling pattern. However, according to Fox (1987:102), the controlling pattern is found only in two percent of her data. Thus, if Fox’s finding is also true in other written texts, the focusing algorithms are likely to find antecedents of pronouns in the immediately preceding unit most of the time.

By taking discourse structure into account, the centering model can be extended to work beyond the scope of the current discourse segment along the following lines. Given that a discourse is analyzed as a hierarchical structure of discourse units (U_i), we propose that each discourse unit has one backward-looking center (C_b) and a set of forward-looking centers (C_f). A discourse unit can be either a single utterance or multiple utterances. C_f is an ordered list of discourse entities realized in that unit. We

now modify constraints and rules of the Centering Theory as shown in (62) and (63) earlier as follows:

(92)

Constraints:

For each discourse unit U_i in a discourse:

1. There is precisely one backward-looking center C_b .
2. Every element of forward centers list, $C_f(U_i)$, must be realized in U_i .
3. The center, $C_b(U_i)$, is the highest-ranked element of $C_f(U_{i-1})$ that is realized in U_i .

(93)

RULE 1: If any element of $C_f(U_i)$ is realized by a pronoun in U_{i+1} , then the $C_b(U_{i+1})$ must be realized by a pronoun also.

RULE 2: Sequences of continuation are preferred over sequences of retaining; and sequences of retaining are to be preferred over sequences of shifting.

The above constraints and rules require a different interpretation of variables. U is no longer an utterance, but a (discourse) unit. Given that U_i is a current discourse unit, U_{i-1} is an immediately preceding discourse unit and U_{i+1} is a following discourse unit. The definition of precedence is defined as follow:

(94)

Precedence

U_{i-1} precedes unit of U_i iff either

- a. U_{i-1} is the left adjacent unit of U_i .
- b. U_{i-1} is the left adjacent unit of U_k and U_i is the left most unit under U_k

Left adjacency

U_i is the left adjacent unit of U_j if U_i and U_j has the same parent, U_k , and there is no other unit between U_i and U_j , and U_i occurs before U_j .

The constraints and rules above are variants of those defined in Centering Theory. In this new extended model, the immediately preceding unit of U_i , is not

necessarily the immediately preceding utterance of U_i , but the immediately preceding discourse unit. U_i is the immediately preceding unit of U_j when both U_i and U_j have the same parent and U_i is the left adjacent unit of U_j ; or when U_j is the left most unit under U_k and U_k is the right adjacent unit of U_i . In example (91), the immediately preceding unit of (u4) is (ub) not (u3); and the immediately preceding unit of (u7) is (uc). Thus, the pronoun *he* in (u2) will be resolved with ‘Smith’ referred in the immediately preceding unit, (u1). The pronoun *he* in (u5) and (u6) will be resolved with ‘Smith’ referred to in the units (u4) and (u5) respectively. *His* in (u7) will be resolved with ‘Smith’ referred in the unit (uc). By using the constraints and rules above, the Cb and Cf of discourse units in example (91) may look like the following.

(95)

- u1. Cb=?, Cf=(Smith, PresidentOfMonrovia,
MonroviaChamberOfCommerce, JanuaryDinner)
- u2. Cb=‘Smith’, Cf=(Smith, Bennett, MonroviaTravelAgency, 1974)
- u3. Cb=‘Smith’, Cf=(Smith, Bennett, 1974)
- ub. Cb=‘Smith’, Cf=(Smith, Bennett, MonroviaTravelAgency, 1974)
- u4. Cb=‘Smith’, Cf=(Smith, AmbassadorCommittee,
MonroviaChamberOfCommerce)
- u5. Cb=‘Smith’, Cf=(Smith, BoardOfDirector,
MonroviaChamberOfCommerce,)
- u6. Cb=‘Smith’, Cf=(Smith, PublicRelationCommittee)
- uc. Cb=‘Smith’, Cf=(Smith, MonroviaChamberOfCommerce,
PublicRelationCommittee, BoardOfDirector, AmbassadorCommittee,)
- u7. Cb=‘Smith’, Cf=(Smith, CententialCommittee)
- ua. Cb=‘Smith’, Cf=(Smith, MonroviaChamberOfCommerce,
CententialCommittee, PublicRelationCommittee, BoardOfDirector,
AmbassadorCommittee, Bennett, MonroviaTravelAgency,
PresidentOfMonrovia, JanuaryDinner, 1974)

Cb of (u1) is marked ‘?’ because (u1) is the first unit here. We do not know what is the highest-ranked entity of the previous Cf. The order of entities in Cf is assumed here to be determined from grammatical function. An entity encoded in a subject position will have a higher rank than other entities. Cf of (ub) is a combination of Cfs from (u2) and (u3). (How the order of entities in multiple utterances is determined will be discussed further in Chapter 5.) Since ‘Smith’ is the highest-ranked entity of Cf(ub) that is realized in (u4) and (ub) is the immediately preceding unit of (u4), ‘Smith’ will be the Cb of (u4). In (u5), there is only one pronoun, *he*. So, according to Rule 2, its referent must be the Cb of (u5). And the continuation state is preferred to other states. Thus, the referent of *he* in (u5) is resolved with the same referent as the previous Cb, ‘Smith’. As for the rest, the Cb and Cf and the resolution of pronouns can be determined in the similar way.

3.5 Conclusion

In this chapter we have discussed the relationship between focusing and pronoun resolution. Two models of focusing algorithms, Sidner’s and that of Centering Theory, are reviewed and shown to be problematic. Based on Fox’s (1987) research using the RST proposed by Mann and Thompson (1987), we have established the relevance of discourse structure to anaphora resolution. An extended model of

Centering Theory is then proposed to take into account the hierarchical structure of discourse.

Since this study aims at investigating how the hierarchical structure of discourse contributes to focusing, the model of extended centering will be compared with another centering model which is not sensitive to discourse structure. Both models will be tested on the same corpus. The corpus design and analysis will be discussed in the next chapter. The testing and the results of applying both focusing algorithms will be discussed in Chapter 6.