Chapter 3

A Theory of Information Structure

In order to address the Identification Problem, we must first characterize information structure in terms of the properties of its components and the relation between the components. We adopt the notions of 'contextual link' and 'semantic composition' as key properties to define binomial partition of information structure, and explicate these notions. In particular, contextual link is defined as bounded inference, that is characterized in terms of discourse status, domain-specific knowledge, and linguistic marking. The chapter also demonstrates that the problems observed for binomial information structure can be overcome by adopting an appropriate grammar formalism and introducing an additional degree of freedom with structured meaning.

The chapter first presents our characterization of information structure. The next section discusses contextual link. We devote a section for linguistic marking of contextual link and analysis of special constructions in English. The last two sections introduce grammatical components of the theory and structured meaning.

3.1 Main Hypothesis: Semantic Partition between Theme and Rheme

Precise Formulation of The Main Hypothesis

In the previous chapter, we have seen that neither referential status nor linguistic form alone is sufficient to identify information structure. In this chapter, we attempt to incorporate these two properties with our main hypothesis (20). Although the main hypothesis is based on Vallduví's

[1990, p. 23] idea that "information structure is a relational notion", we depart from his analysis in several points. As we discussed in the previous chapter, we stick to the classical, simpler binomial partition of information structure. Although binomial partition is not without problems, other options appear to be more problematic, as discussed in Subsection 2.3.4. Another crucial difference from Vallduví [1990] is our position that linguistic structure alone does not fix the information structure. For this reason, analysis of 'contextual link' is essential for our solution to the Identification Problem.

As has been discussed in Subsection 2.3.1, we generally consider a theme as 'contextually linked', or 'presuppositional' [Chomsky, 1971; Jackendoff, 1972] although we cannot say that a rheme is *not* presuppositional or 'new'. The least amount we can say about this situation is that a theme *must* be contextually linked, but a rheme does not need to be. We have also associated rheme with a projection of a contrast, 'contrastiveness'. But this is not a requirement for a theme. For the moment, we call semantic, binomial partition of information structure 'semantic composition' in accordance with the view that semantic components are combined to become a more complex object. Before proceeding, let us rephrase the main hypothesis in a way convenient for the current purpose.

The main hypothesis about information structure is now characterized as follows (with symbolic representations):

(48) **Main Hypothesis** (information structure)

  a. The theme is necessarily contextually-linked, i.e., $\Box linked\,(Theme)$.

  b. The rheme is *not* necessarily contextually-linked, i.e., $\neg\Box linked\,(Rheme)$.

  c. The theme is *not* necessarily contrastive, i.e., $\neg\Box contrast\,(Theme)$.

  d. The rheme is necessarily contrastive, i.e., $\Box contrast\,(Rheme)$.

  e. A proposition is a semantic composition of a theme and a rheme, i.e.,
  $Prop = (Theme)\,(Rheme)$.

What (*a*) and (*b*) convey is that a contrast between a theme and a rheme is a contrast between the polarity of the necessity on the contextual-link property. Similarly, the contrast between (*c*) and (*d*) is the contrast between the polarity of the necessity on contrastiveness. The last statement (*e*) connects the theme and the rheme, representing the binomial relation between theme and rheme

in terms of semantic operation. The modality '□' involved in the above can be interpreted as quantification over the search process. For example, "□*linked* (*Theme*)" means that for every possible choice of theme-rheme pair, the theme is a contextual link. Thus, the hypothesis can be seen as a declarative form of such an identification process. Although we do not discuss theory-process relation in detail, the above main hypothesis can be seen as the backbone of such a relation.

Let us now examine some basic properties of the main hypothesis (48). It is consistent with the question test. The element of the response that is contextually linked to the question is a theme and the complement regardless of its referential status is a rheme. Since the notion of contextual link is more general than discourse oldness, inferrable theme is also possible. The hypothesis is equally applicable to analysis of extended texts, not just question-answer pairs. It is also consistent with generation process [e.g., Prevost, 1995], by specifying theme-rheme divisions based on the contextual link status assumed by the speaker.

Before proceeding, we should note the following. Our main hypothesis (48) does not make a reference to direct information-structure marking. We do not emphasize this point in this thesis because the focus of information-structure analysis here is written English where direct information-structure marking is rather impoverished. But the information-structure identification for spoken English and other languages can definitely take advantage of such marking. For example, Steedman [1999] presents a theory of information structure that projects theme and rheme status from intonation (in English). A similar process of projecting theme/rheme status from word order (e.g., Catalan) or particles (e.g., Japanese) is quite possible. Our proposal is compatible with such analyses. When direct marking of information structure is available, its status can simply overwrite the current analysis. In this respect, the main hypothesis (48) is a general statement that applies to underspecified cases, and subsumes more specific cases.

In the rest of this chapter, we explicate the involved notions used in the main hypothesis (48), i.e., contextual link and semantic composition. A successful completion of this process coupled with reasonable evaluation will constitute a support for the hypothesis as a theory of information structure. At this point, we make a qualification about the working domain.

Working Domain: Medical Case Reports

For the development and evaluation of the theory, we concentrate on a single working domain involving medical case reports, a type of expository texts, from a journal called "The Physician and Sportsmedicine". The choice of expository texts is natural considering the range of applications we have discussed in the Introduction. While analysis of question-answer corpora is another possibility, we consider this as a special case of the Identification Problem and attempt to solve a more general case where the context is not fixed by a question. The reasons we focus on medical case reports are as follows. First, the terminology is relatively unambiguous and referents can be identified relatively easily. Second, the domain knowledge involved in the texts is relatively limited, e.g., presence of the physician (the author of the report). Finally, a sample of medical case reports has been found on-line.

In expository texts, we can safely assume that every utterance is 'informative' at the propositional level.[1] We may add this assumption in the following form:

(49) The proposition (for an utterance) is necessarily *not* contextually-linked, i.e.,

$$\Box \neg linked\,(Prop).$$

In a sense, the relation between the status of a rheme, $\neg\Box linked$, and that of an utterance, $\Box\neg linked$, is a more accurate characterization of saying that a rheme is 'new' found in, e.g., Jackendoff [1972]. That is, a rheme is an essential component to make the proposition 'new' regardless of its own status.

As we mentioned in Section 2.2 (p. 22), we do not elaborate on contrastiveness for the rest of this thesis mainly for practical reasons. First, an analysis of contrastiveness is difficult to implement. Second, for expository texts, the materials are predominantly discourse-new. Thus, it is more critical to identify a contextual link for a theme (see in Chapter 7). As a consequence, the identification process ignores (48c, d).

The question whether the theory and the practice in the present work generalizes to other

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[1]This is in contrast to the spoken form where informationally-redundant utterances are not uncommon [Walker, 1992]. Even for this case, we may still maintain that every utterance is informative by adopting the theory of conversational implicature [Grice, 1975] and arguing that a redundant proposition actually infers something new.

domains remains to be answered. Although different types of linguistic constructions may be involved in different domains, this component seems more consistent than the difference in domain-specific knowledge and inference. Since our theory is not bound to a specific inference mechanism unlike, e.g., Hahn et al. [1996], adjustment to a new domain seems feasible.

3.2   Contextual Link

In the previous section, we have placed the notion of contextual link at a critical position for the Identification Problem. This section explores an idea that contextual link is a bounded sequence of inference. We then make a point that such a bound on inference comes from outside the logic of inference.

3.2.1   Contextual Link and Inference

In order to explore the notion of 'contextual link', let us recall the following two examples:

(50)   *i.*   John has a house.

    ii.   [The house]$_{Theme}$ [looks exotic]$_{Rheme}$.

(51)   *i.*   John has a house.

    ii.   [The door]$_{Theme}$ [looks exotic]$_{Rheme}$.

Here, "*the house*" in (50*ii*) is discourse-old and "*the door*" in (51*ii*) is discourse-new but IN-FERRABLE [Prince, 1981; Prince, 1992]. Despite this difference, it is natural to identify the analogous information structures, as shown above.

As we have reviewed in Subsection 2.3.1 (p. 28), the basic idea of contextual link (in different names) has been discussed in many previous proposals [Chomsky, 1971; Jackendoff, 1972; Sgall et al., 1986; Rochemont, 1986; Prince, 1992]. A common observation is that inference is involved in the case like (51*ii*) above. Such an inference mechanism can be 'open-ended' [Brown and Yule, 1983, p. 269]. Thus, as a backbone, we need to assume a general mechanism of inference.

Let us first consider that referents of various semantic types (individuals, properties, events, etc., as discussed on p. 42 in Subsection 2.3.4) are textually or situationally EVOKED at the time of utterance. For example, at the time of uttering (51*ii*), the referent corresponding to "*a house*"

is textually EVOKED and available.[2] This *base* set of available referents can be extended by an inference mechanism. As we have set out (Section 2.2), the inference mechanism itself is a big problem, and not our central concern. But, for the sake of precision, we assume the following simple, but general inference mechanism.

(52) (assumption) Inference mechanism:

  a. Textually or situationally EVOKED referents are available for processing (zero inference).

  b. Relations that hold for an available referent are available. In addition, the results of composing any of these relations and referent(s) are available.

  c. Referents that satisfy an available property are available. In addition, the results of composing them are available.

Note that the availability of referents and relations are constrained by various factors. Here, we assume that availability is limited to those which the speaker believes that the hearer knows, i.e., 'common ground' [Clark, 1996, for discussion].

For example, at the time of uttering (51*ii*), all the relations holding for "*the house*" are available (52*b*). Among them, there is a 'part-whole' relation applicable to "*the house*". The result of composing "*the house*" and this relation yields a property "the house has (as a part) *X*", as specified by the second clause in (52*b*). The referent corresponding to "*the door*" in (51*ii*) satisfies this property, and thus is available. Although the speaker knows that "the door looks exotic", it is not in the common ground. Thus, the inference process stops here, and the entire utterance is not considered inferrable.[3]

The above inference mechanism is recursive. Therefore, the set of available referents resulting from the process is in general unbounded. This point is made to cover inference generally, and does not claim that such an unbounded set is processed automatically. In addition, not all the available referents are equally salient in a specific context [Brown and Yule, 1983, Section 7.8]. But these are issues beyond the current scope.

We now present the notion of contextual link.

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[2]In the present work, we exclude intra-utterance reference for simplicity. The process may well involve both inter- and intra-utterance reference as in Strube [1998].

[3]For a related implementation, see Dahl et al. [1987] and Palmer et al. [1993].

(53) (hypothesis) **Contextual link** is a relation between a referent in the utterance under consideration and a textually or situationally EVOKED referent where the relation is a bounded (including zero) sequence of inference steps.

We may also refer to a referent available through a contextual-link relation as a 'contextual link'. For example, we can say that "*the door*" in (51*ii*) is a contextual link. This process basically covers both EVOKED and INFERRABLE.[4] We may consider a BRAND-NEW referent as those which is not available even through an unbounded sequence of inferences. The status of UNUSED referents in the current formulation is not so clear. One possibility is that they are available in some 'extended situation'. But this point is not critical because UNUSED referents are not common in our domain.

The above characterization of contextual link has some properties distinct from proposals of Bos et al. [1995] and Hahn et al. [1996]. Unlike theirs, a general inference mechanism is assumed in a modular fashion. No a priori limit on inference steps is made. Another distinction from Bos et al. [1995] is that accommodation is not unconditionally supported (see p. 30 in Section 2.3.1). We could deal with it in a way similar to the case of UNUSED referents with 'extended situation', as mentioned in the previous paragraph.

3.2.2 Logic-External Properties for Bounding Inference

In the previous section, we have only said that inference is bounded. In this section, we discuss the way such inference is bounded. Our hypothesis is as follows:

(54) (hypothesis) Bounds on inference are conditioned by properties *external* to the logic of inference.

In other words, the above statement corresponds to the view that a general logic, for the purpose of identifying contextual links, does not have a means to terminate by itself. The current proposal hypothesizes the following properties for this purpose:

(55) *a*. Linguistic marking: e.g., definiteness in English

   b. Discourse status: i.e., discourse-old referent is a contextual link

   c. Domain-specific knowledge: e.g., presence of a physician and a patient in medical reports

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[4]Nevertheless the above definition may not exactly correspond to the intuition given in Prince's [1981].

The above classification is not exclusive. A contextual-link referent may possess multiple properties. In order for this set of specifications to be useful, they must at least be sound. While the specification may never be complete, it must be as much complete as possible.

Among the mechanical algorithms we have reviewed in the previous chapter, Hajičová et al. [1995] focus on linguistic marking (*a*) and Hahn [1995] focuses on discourse-oldness (*b*) and domain-specific knowledge (*c*). Hoffman [1996] focuses on linguistic marking (*a*) and discourse status (*b*). The current position is that all of these must be taken into consideration.

On a more linguistic side, Birner [1997] argues that inferrables are linguistically marked. Her argument is based on several distinct linguistic phenomena including topicalization and VP preposing. But this statement is too strong. There are examples of indefinite inferrables that appear as a contextual link although this is not always the case (see Chapter 7).

In the following, we discuss the last two properties. Linguistic marking for contextual link is discussed in the next section as it requires more space.

Discourse Status

The notion of discourse status that we are talking about is basically the same as Prince [1992] (see Subsection 2.3.1). But there are two points to note. First, we deal with discourse referents [Karttunen, 1976] of a general kind, ranging over various semantic types (p. 42 in Section 2.3.4). That is, discourse statuses of not only individual types but also properties, propositions, etc. are also considered.

Second, we assume a simple notion of context that is compatible with the idea of general discourse referents. Each successfully interpreted referent is simply added to the context (if it is not already there). As we do not assume intra-utterance reference, the addition of new referents can be done once for each utterance. The context is then a heterogeneous set of discourse referents, monotonically extended as utterances are processed.[5] This is a generalization of Stalnaker's [1978, p. 321] 'context set', which is a set of propositions. As we have mentioned in Section 2.2, we do not focus on the process of reference resolution. Thus, there may be cases where (actually) identical referents are present in the context set at the same time without being resolved. Our

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[5]Monotonic models of contexts are in general too simplistic, but the problem with monotonicity is left for future work.

assumption is that such a case is linguistically marked and can be analyzed as contextually-linked.

The idea of discourse-oldness is characterized as the identity relation between a referent in the current utterance and another referent in the context. A more formal representation of discourse status is described in Sections 3.4 and 4.2, after the grammatical component is discussed.

In one respect, the above idea is a cruder picture than various theories of discourse, e.g., File Change Semantics (FCS) [Heim, 1982] and Discourse Representation Theory (DRT) [Kamp, 1981]. It is because no hierarchical structure among referents is assumed. It is tempting to consider some kind of structure among referents, e.g., partial ordering by 'informativeness' relation [van Eijck, 1996, p. 89]. This may also be relevant to disambiguation of information structure. But it is beyond the scope of the current work.

Domain-Specific Knowledge

Inference may also be bounded by limited use of domain-specific knowledge. While discourse-oldness is an identity relation to a referent in the discourse, we consider a type of domain-specific knowledge that is an identity relation to a referent in the situation. Domain-specific knowledge is a prerequisite for logical inference, but the point here is that a logic does not define domain-specific knowledge. By assuming such referents in the initial situation, the inference process involving them can be effectively bounded by checking the identity relation. Such situationally-available referents also constitute the context along with the discourse referents (as discussed above).

The only domain-specific knowledge currently considered for our domain is the situational availability of physicians (e.g., *physician(s)*, *clinician(s)*) and patients (i.e., *patient(s))*. This kind of domain-specific knowledge is justifiable because each domain has its own *typical* situational setting. If such a setting is applicable to every text in the domain, it is acceptable to apply the knowledge.

3.3   Linguistic Marking in English

This section specifies linguistic marking for contextual links, and then examines several special constructions in English where we observe subtle distinctions between the linguistic marking for contextual link and that for information structure.

3.3.1 Linguistic Marking for Contextual Links

Assignment and Projection of Contextual-Link Status

A representative case of linguistic marking for contextual link is definite determiners [e.g., Heim, 1982; Poesio et al., 1997]. In Subsection 2.3.3, we have pointed out that direct linguistic marking of information structure is available only at the matrix level and non-recursive. Thus, there is no projection problem. On the other hand, linguistic marking for contextual links can appear recursively at all levels of linguistic structure. Accordingly, we need a systematic way to analyze projection of a contextual link for an arbitrary linguistic structure. This is in a sense response to Levinson's [1983, p. x] question about the projection problem for information structure in an indirect way.

For analysis of presupposition, Karttunen [1973, p. 173] introduced the ideas of 'hole' and 'plug' for presupposition projection. Informally, presupposition survives a hole, e.g., a verb *know*, but not a plug, e.g., a verb *say*. The problem of contrast projection (see Subsection 2.3.2) may also be analyzed in terms of survival of projection under various conditions.

We extend this survival-or-no classification to a more general one involving contextual links, as shown below.

(56) *a.* **Assignment**: The contextual-link status of a phrase is set/reset by one of its components.

b. **Projection**: The contextual-link status of a phrase is projected from one of its components.

For example, assignment is typically done by a function word such as a definite or indefinite determiner. Projection is typically done from a content word through a composition with certain function words. By studying contextual-link status for different linguistic structures, we can tell the consequence compositionally.

Now, there remains the main task of identifying whether a certain linguistic form is a contextual link or not. That is, we must judge whether the phrase requires a bounded sequence of inferences from an available referent. This requires linguistic analyses for various constructions. Fortunately, this is a well-studied area, e.g., Heim [1982] for definite/indefinite NP's. In the following, we examine various linguistic structures with respect to assignment/projection of contextual links. This includes contextual-link assignment by definite determiner and utterance-initial modifiers;

non-contextual-link assignment by indefinite determiner; and projection of contextual link through nominal pre-modifiers and coordinators.

Before proceeding, we must make a few remarks. The present work is incomplete in that we could not examine all the possible linguistic structures. But, even though the description can be as complex as a complete grammatical description (and thus generative), the description is bounded by the complexity of the grammar and thus presumably finite. The current coverage focuses on the constructions commonly found in medical reports in English. We observe that the coverage for our training data generalizes fairly well to reserved test data (see Chapter 7).

Definite Determiner

First, we need to clarify that we use the term 'definite' as a formal property [Prince, 1992, Section 2.1]. For example, a noun phrase "the social cost" is definite because it has the definite determiner, *the*. This is distinct from Chafe [1976, p. 39], who considers definiteness as a conceptual notion.

The role of definite determiners with respect to referential status has been investigated for a long time. For example, Brown and Yule [1983, p.170] cite an analysis that goes back to 1751 about the relation between known/unknown and definite/indefinite articles. For the present purpose, we follow more recent work [e.g., Hawkins, 1978; Heim, 1982; Quirk et al., 1985] and consider definiteness as a source of contextual-link status.

The assignment mechanism by definite determiner can be seen below. Here, a contextual link and a non-contextual link are abbreviated as *CL* and *NL*, respectively.

(57)

	Definite determiner	Noun
Example:	*the*	*door*
Contextual-link status:	–	*CL* or *NL*
Contextual-link status:	$\boxed{CL}$	

The contextual-link status of the definite determiner, *the*, itself is not critical here. The point is that it assigns a contextual-link status to the NP, shown as $\boxed{CL}$, regardless of the status of the noun, *door*.

Now, suppose that some kind of *door* that is uniquely identified is already in the discourse, it is a contextual link through discourse-oldness. The definite determiner carries on the status to the NP. If such unique identity is not guaranteed, the NP would fail to refer to a particular referent.

This position does not reject the idea that the definite determiner assigns a contextual link because the reference failure can be explained as a result of this (impossible) assignment.

On the other hand, suppose that no *door* is in the discourse or in the situation. The noun *door* is a non-contextual link. But the definite determiner still assigns a contextual-link status to the NP. This is where inference is called for, as discussed in Heim [1982]. Definite reference with a non-contextual-link noun is acceptable only when the referent corresponding to the NP is inferrable from the context. If not, reference failure may occur. This point contrasts with Bos et al. [1995], who propose that 'accommodation' always saves the reference process. In either case, a definite expression often becomes a theme, especially at the matrix level, due to its strong property to be a contextual link.

The same analysis holds for the case where the involved noun is complex, e.g., post-modified by a PP or a relative clause. Thus, nested instances of definite determiners assign contextual link status for each time, but the assignment by the embedded definite determiner does not affect the assignment of the outer definite determiner.

Other types of definite determiners include demonstrative and possessive. Demonstratives do not allow inferrables as referents, but assigns a contextual link status to the noun phrase in a manner similar to the above case. For possessive, I attempt a slightly different analysis later in this subsection.

While definite expressions are almost always contextually-linked, it is not completely so. There are cases where definite expressions express non-contextual links as follows:[6]

(58) *i.* Both buses and trolleys are operating here.

　　 ii. Take <u>the first bus</u>. (a non-contextual link)

This contrasts with the corresponding contextual-link case as follows:

(59) *i.* You see three buses and a trolley over there.

　　 ii. Take <u>the first bus</u>. (a contextual link)

In (58*ii*), the definite determiner, *the*, is required for the logical reason encoded in the phrase [Quirk et al., 1985, p. 270]. Thus, the expression "*the first bus*" is ambiguous between a logical use of definite determiner (58*ii*) and a contextual-link assignment (59*ii*). But this class of expressions involves a linguistic cue such as *first* or *next*, and thus can be separated from other definite

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[6]Related examples are also found in Brown [1995].

expressions. In our experiment data, there is no instance of this type that affects identification of information structure. Quirk et al. [1985, p. 271] also states that body parts generally require *the*. We will come back to this case when we discuss indefinite article.

Quirk et al. [1985, p. 269] discuss yet another case of 'sporadic' referents. The situation seems idiosyncratic and differences between British and American English have also been reported. We do not discuss this case any further.

Utterance-initial Modifiers

Although English has a relatively fixed word order, there are cases where word order is flexible. We consider two such cases. One is sentential adverbials and the other is subordinate clauses. The following two examples are taken from our experiment data, and shown with the alternative word order.

(60) *a*. Until the early 1980s, tuberculosis was considered a minor, controllable public health problem.

b. Tuberculosis was considered a minor, controllable public health problem until the early 1980s.

(61) *a*. As it is used here, the term "injury" means any cheerleading injury that forces the person to miss at least 1 day of participation.

b. The term "injury" means any cheerleading injury that forces the person to miss at least 1 day of participation as it is used here.

For this matter, de Swart [1999, p. 359] analyzes temporal adverbs and argues that preposed time adverbials are themes (but postposed ones are not necessarily rhemes). The present work regards de Swart's [1999] analysis as evidence for the *contextual-link* status of preposed time adverbials, but not for theme marking. This is because adverbials can be freely preposed in an embedded clause and do not meet our requirement for direct theme marking.

The argument of de Swart is natural: preposed time adverbials set the time reference. We may extend the analysis to other situation-setting adverbs. Recall that Hoffman's [1996] topic algorithm (44) has the following condition: "when no anaphor is available in the previous utterance, choose

situation-setting adverb as the theme". This seems too strong. We also conjecture that utterance-initial modifiers are all theme, but, at this point, I am not aware of further backing in the literature.[7]

The contextual-assignment mechanism of utterance-initial modifiers are shown below. Note that the assignment of the *CL* status does not depend on the status of the argument.

		Modifier		Main clause
		Functor	Argument	
(62)	Example:	*Until*	*the 1980s,*	*tuberculosis....*
	Contextual-link status:		*CL*	
	Contextual-link status:		$\boxed{CL}$	

Unlike the case of the definite determiner, which is purely lexical, the above assignment is also structural in that the effect also depends on the position of the involved modifier relative to the main clause. We expect that a theory must be able to specify such structural specification in a systematic manner, which is not possible with partial parsing of Hahn [1995].

Indefinite Article

Next, let us consider the case of resetting a contextual-link status, i.e., assignment of non-contextual link to the phrase. The indefinite article, *a/an*, falls into this category. Negative also resets a contextual-link status (it does not specify a referent). The mechanism of assignment is shown below.

(63)		Indefinite article	Noun
	Example:	*a*	*door*
	Contextual-link status:	–	(*CL*) or *NL*
	Contextual-link status:		$\boxed{NL}$

Typically, the noun is a non-contextual link. If the noun is a contextual link, the indefinite article still assigns non-contextual link status to the NP. This can confuse the hearer because *some* door is already in the context and the speaker insists on a 'new' door. If the speaker's intention is to refer to a new door that is distinct from what is already in the context, another determiner, e.g., *another*, may be more suitable. But there is another possibility. Let us take a look at the following example from our experiment data:

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[7]Bonnie Webber [p.c., 1999] raised the following question. Not all utterance-initial modifiers behave in the same way. For example, *when* may well be a contextual-link assigner, *until* may actually not.

(64) *i.* Don't Miss Gastrointestinal Disorders in Athletes

    ii. Gastrointestinal (GI) problems are common among athletes.

    (three utterances omitted)

    vi. so an athlete may ignore symptoms and seek medical care only when they become severe enough to interfere with performance.

Here, the noun *athlete* in (*ii*) is discourse-old. A possible analysis is that the indefinite article is used for generic reference. At this point, I conjecture that indefinite with a contextual-link noun is generic and that it exceptionally assigns a contextual-link status to the NP. This point needs further investigation, and we will come back to the consequence of this conjecture in Chapter 7.

While both countable NP's with *a/an* and uncountable NP's with no article are considered indefinite (by lacking a definite determiner), there is a semantic distinction. The indefinite article, *a/an*, in general (conversationally) implies that there are no more than one [e.g., Hawkins, 1978, p. 179; Hawkins, 1991, p. 417]. This use of the indefinite article is thus often in contrast with other determiners, e.g., *some*, *many*, *all*. On the other hand, uncountable indefinites do not have this property. Possibly for this reason, we observe more problems with identifying contextual links for uncountable indefinites (see Chapter 7).

While the majority of indefinite NP's are non-contextual links, some case assigns a contextual-link status even when the associated noun is a non-contextual link. Let us examine the following examples:

(65) *a.* I met some students before class. *A student* came to see me after class as well. [Hawkins, 1991, (11), p. 418]

    b. I picked up that book I bought and *a page* fell out. [Prince, 1992, (19b)]

    c. Miss Murchison,' said Mr. Urquhart, with an expression of considerable annoyance, 'do you know that you have left out *a whole paragraph*.' [Gundel, 1996, (7), p. 143]

"*A student*" in (65*a*) must be considered EVOKED because the referent is already available in the discourse.[8] "*A page*" in (65*b*) and "*a whole paragraph*" in (65*c*) are INFERRABLE. We must consider these cases as contextually linked.

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[8] Contrary to a previous example (64), this instance of indefinite with a contextual link is not generic. But we will see a condition applicable to this case below.

thus, indefinite marking (at least in simple referential NPs) cannot in general separate EVOKED, INFERRABLE, and NEW. But a closer look at the involved nouns shows that there is something more to say. The first point is the lexical distinction between nouns like *page/paragraph*, and nouns like *student*. As observed by Prince [1992], 'page-type' nouns are associated with another entity, say, "*a book*". In other words, this type of noun is **two-place** (or *n*-place in general), unlike *student*. We can elaborate this point as follows. First, only two-place nouns are typically defined in terms of an *of* relation in dictionaries, e.g., "page (definition 1): one side *of a leaf of* something printed or written, as a book, manuscript, or letter" [Random House, 1993]. Second, two-place nouns cannot introduce a new referent without reference to the associated referent. We can see this effect in the following test: "OK, let's start. Here is #*a page/a book*." using *book* as an example of one-place noun. In this regard, two-place nouns are always INFERRABLE and never NEW, while one-place nouns may correspond to any of the three statuses. A preliminary corpus check on a two-place noun *uncle* shows 47 out of 48 instances in New York Times 1995 data from Linguistic Data Consortium (LDC) are associated with an explicitly introduced referent. The case without an associated referent seems to be metaphorical. A similar result has been observed for another two-place noun *leg*. This explains why body parts usually require the definite determiner *the* Quirk et al. [1985, p. 271] (see p. 66). It must be associated with the person it belongs. On the other hand, for a set of body parts, it is also common to use the indefinite article *a/an* to indicate that only one of them is under discussion (in many cases, it does not matter which one of them).

Since the distinction between the two types of nouns is specified in the lexicon and does not require further information, we can say, for two-place nouns, linguistic information is sufficient to invoke the necessary inference. Naturally, there may be cases where a noun is ambiguous between one-place and two-place.

In example (65a), the process to identify the referent of "*a student*", EVOKED, is a resolution process (i.e., identity check) and not an inference. If a one-place noun that is not NEW is always EVOKED and never INFERRABLE, we can still avoid the complexity involved in an inference process. In addition, the EVOKED status of "*a student*" is strongly affected by the use of the adverbial phrase "*as well*". If we drop "*as well*" in (65a), the interpretation of "*a student*" is likely to be NEW rather than EVOKED, or could even be a generic. Thus, the process that invokes resolution here seems to be in the domain of semantics and not world knowledge.

Therefore, for the above cases, we have certain linguistic cues that an indefinite expression is INFERRABLE. Although I do not claim that every indefinite INFERRABLE is linguistically marked, the above presentation shows that there still are some linguistic tools to pick up a number of indefinite INFERRABLES.

Projection of Contextual-link Status

We now turn to the discussion of projection of the contextual-link status. Included in this category are non-definite determiners, certain restrictive post-nominal modification, function words, argument-taking adverbs (not at the utterance-initial position), subordinators, and coordinators.

We have seen that definite determiners and indefinite articles *assign* contextual-link and non-contextual-link statuses, respectively. In between these two classes, other determiners are treated as projectors of contextual-link status. For example, the contextual-link status of a noun phrase "*many researchers*" depends on that of *researchers*, as shown below.

(66)   Determiner   Noun

         Example: *many*   *researchers*

         Contextual-link status: – X

         Contextual-link status: $\boxed{X}$

Here X is either a contextual link or a non-contextual link.

Restrictive post-nominal modifiers project the contextual-link status of the argument. For example, when *tuberculosis* is a contextual-link through discourse status, "*cases of tuberculosis*" is a contextual link due to the projection of the status from *of*-PP. For this reason, many such cases are attached with the definite determiner. The phrase "*cases of tuberculosis*" is not definite, but can be considered structurally-signaled INFERRABLE from "*of tuberculosis*".

The next case involves function words such as prepositions and auxiliary verbs. Our position is to consider them in the same class as non-definite determiners. For example, in a verb phrase "*function at a high level*", the preposition *at* projects the contextual-link status of "*a high level*". Similarly, for the case of "*is estimated*", the auxiliary *is* projects the contextual-link status of *estimated*. Assuming the same specification as non-definite determiners in (66), these function words project the contextual-link status of the argument: an NP for the case of preposition, and a main verb or another auxiliary verb for the case of auxiliary verb.

Yet another case of contextual-link projection involves coordinators. In this case, it is two-place (*n*-place in general case) rather than one-place as above. For example, the projection mechanism for a phrase "*proprioceptive training and proprioceptive rehabilitation*" is shown below.

(67)		Conjunct 1	Coordinator	Conjunct 2
	Example:	*proprioceptive training*	*and*	*proprioceptive rehabilitation*
	Contextual-link status:	*X*	–	*Y*

Contextual-link status:	Contextual link	if *both X* and *Y* are contextual links
	Non-contextual link	otherwise

This is slightly different from the previous cases of projection because coordination in general requires that the conjuncts are *like* categories.

There is possible support for this case. When multiple individuals are coordinated, e.g., "*John and Mary*", there may be 'collective' and 'distributive' readings [Landman, 1996, p. 425 (citing several earlier papers); Palmer, 1990 (for an implementation)]. The situation can be exemplified as follows (modified from Landman):

(68) *a*. John and Mary carried the piano upstairs. (collective)

　　 b. John and Mary signed the application. (distributive)

　　 c. John and Mary visited their friends. (ambiguous)

The point is the existence of collective reading suggests the availability of a contextual link covering both individuals. But, even for the distributive case, e.g., (*b*) above, it is in general possible to refer to both *John* and *Mary* collectively as *they*.

Nominal Pre-modifier

Nominal pre-modification can be very complex [Quirk et al., 1985 (for an analysis and examples)]. Here, we only consider two types of nominal pre-modifiers: adjective and noun (for noun-noun compound), which are most common in our experiment data. Between these, noun-noun compounds pose a great challenge because in general, either noun can be the head of the compound [e.g., Marcus, 1980; McDonald, 1981; Sparck Jones, 1983] and this may cause distinct interpretations about the relation between the two components.

Probably, the only currently available technique to analyze the structure of noun-noun compounds is to identify the semantic relation from lexical information as has been done in the above-mentioned literature. This could be done automatically to some extent [McDonald, 1981 (applying semantic network)], but other factors including pragmatic aspects may also affect this process [Sparck Jones, 1983]. Considering such difficulties and observing the experiment data, we take a position that the contextual-link status of the first noun is projected to the noun-noun compound. This assumption needs to be re-examined for other domains because this may well depend on the current domain.

Thus, the distinct cases of contextual-link projection are hypothesized as follows: (i) modification by a noun or a denominal adjective, and (ii) modification by a non-denominal adjective. Denominal adjectives, e.g., *medical*, are closely related to nouns and usually restricted to attributive (i.e., pre-nominal) positions [Quirk et al., 1985, p. 432].

The first case, noun or denominal adjective modification carries some nominal meaning. This type of modification projects its contextual-link status, as shown below.

(69)

	Noun/Denominal Adjective	Noun
Example:	*exercise*	*program*
Contextual-link status:	*X*	*CL* or *NL*
Contextual-link status:	$\boxed{X}$	

Here, "*exercise program*" may correspond to "*program for exercise*". The modification provides a cue for the inference process to make the noun INFERRABLE. Note that the above status may still be set/reset by a determiner.

On the other hand, modification by a regular adjective projects the contextual-link status from the noun as follows:

(70)

	Common Adjective	Noun
Example:	*active*	*woman*
Contextual-link status:	*CL* or *NL*	*X*
Contextual-link status:	$\boxed{X}$	

In this case, the adjective is an additional property for the referent. Here, "*active woman*" corresponds to "*woman is active*". Thus, the contextual-link status of the adjective does not affect the result status in the same way as the first case.

Possessive

Although possessive is usually considered definite, it does not seem as strong as a definite determiner in terms of contextual-link assignment. We assume a slightly complicated contextual-link projection for possessive NPs.

(71)

	Possessor	Possessive	Possessee
Example:	*a patient*	's	*capacity*
Contextual-link status:	X	–	–
Contextual-link status:	X		
Contextual-link status:	$\boxed{X}$		

In the above, the contextual-link status of the possessor is projected to the entire NP.

Pronoun

Pronouns must be subclassified into the following three types:[9]

(72) *a.* Definite: contextual link, e.g., *these*

   b. Indefinite: non-contextual link, e.g., *anyone*

   c. Argument-taking: project the contextual-link status of the argument, e.g., "*many of X*"

The first case sets a contextual-link status, and the second case resets one. The third case is the same as a non-definite determiner.

Summary

As we have seen so far, linguistic marking of contextual link is rich and complex in English. In addition to linguistic marking, contextual-link status can be identified through discourse status and domain-specific knowledge. Thus, it is also possible that the contextual-link status of an discourse-old element may be projected through a complex linguistic structure guided by linguistic marking.

Before proceeding, let us make a remark on where contextual-link assignment/projection is found. Contextual-link assignment/projection is generally associated with linguistic structure where

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[9]A pronoun has complex properties including the cases of discourse deixes [Webber, 1991] and the fact that a single pronoun can refer to different types of referents [Webber, 1983]. But for the purpose of analyzing contextual-link status, these kinds of subtlety do not seem critical.

extraction is not possible, e.g., NP and adverbial phrase. In these phrase types, a theme-rheme partition cannot occur because such a partition cannot be the semantic composition that results in a proposition.

On the other hand, between a verb and its arguments or between a clausal modifier and the modified clause, a contextual-link can give rise to a theme with the complement, a rheme. Thus, in general, assignment and projection of contextual-link status is not observed for these types of combinations. The resulting phrase may thus involve a mixture of contextual-link statuses. We discuss a systematic way to deal with such a case using 'structured meaning' at the end of this chapter.

3.3.2 Special Constructions

This section analyzes various constructions in English and investigates whether the construction marks information structure and/or a contextual-link status.

Topicalization, Left Dislocation, and Focus Movement

Prince [1984] discusses the pragmatic functions of topicalization and left dislocation. For example, an unmarked sentence form "*John saw Mary yesterday*" corresponds to the following two examples [Prince, 1984, (2), p. 213]:

(73) *a*. Mary John saw yesterday. (topicalization)

   b. Mary, John saw her yesterday. (left dislocation)

Topicalization involves a 'gap' in the main clause, but left dislocation does not. Prince's analysis goes as follows. For topicalization (TOP), the topicalize/dislocated NP must be referential and either evoked or in a salient set relation to an evoked referent (special case of inferrable). It also signals a 'narrow' rheme within the main clause corresponding to a pitch accent. Dislocation can be classified into two subcases. The first case (LD-1) is similar to topicalization except that the 'narrow' rheme requirement does not apply. For the second case (LD-2), none of these requirements is observed. But the dislocated NP must be a rheme (Prince's 'focus').

Prince [1984, p. 220] argues that one function of TOP is to set up an open proposition in contrast to the rheme (her 'focus'). The information structure may look like the following:

(74)　[This dream]　[I've had　*t*　[maybe three, four times]]

　　　　　　　Theme　　　　　　　*Rheme*

The above analysis also depends on whether the interpretation for "*this dream I've had*" can be considered a contextual link or not. This seems to be the case because in (19) on p. 218 [Prince, 1984], the preceding utterance includes "*I have a recurring dream in which...*".

But the unmarked order can be associated with the same (even more straightforward) information structure: "[I've had this dream]$_{Theme}$ [maybe three, four times]$_{Rheme}$". Then, the TOP counterpart may be used to *contrast* "*this dream*" with some other dream and still keeps the original information structure (contrastive topic as in Büring [1997b]). On the other hand, if the gap is at the end of the utterance, the unmarked form has a discontiguous information structure, but the topicalized form has a binomial *Theme* − *Rheme* partition as follows.

(75)　*a.*　[Felix]$_{Theme}$ [**praised**]$_{Rheme}$ [Donald]$_{Theme}$. (unmarked)

　　　b.　[Donald, Felix]$_{Theme}$ [**praised**]$_{Rheme}$. (topicalized)

In addition, specification of a theme requires that the theme in the above be a contextual link.

Prince [1984, fn c. on p. 214] also analyzes 'focus movement', which is structurally identical to topicalization (at least superficially) but with distinct *Rheme* − *Theme* pattern as follows:

(76)　[**A bite**]　[he wouldn't eat *t*]

　　　Rheme　　　*Theme*

As the example shows, the moved NP can (but does not need to) be a BRAND-NEW referent. There is no assignment of contextual-link status by focus movement. Thus, this construction only marks information-structure.

If we consolidate the preposing phenomenon common to topicalization and focus movement, the construction *either* (i) retains the original information structure (topicalization from in the middle), (ii) sets up *Theme* − *Rheme* information structure (topicalization from the rightmost position), or (iii) sets up *Rheme* − *Theme* information structure (focus movement). It is a weak condition in that the construction does not determine an information structure, but it licenses a set of information-structure patterns. Since this is a structural condition, it must be specified in the grammar and interfaced to the information-structure unit, not possible in Hahn's [1995] partial-parsing approach.

Left dislocation is structurally different from topicalization/focus movement due to the absence of the gap. LD-1 is like topicalization. But the function of LD-2 seems less certain. One possibility is that it shares the weak information-structure condition of the combination of topicalization and focus movement. That is, all of these may be a weak information-structure marker.

Finally, let us return to the hypothesis (30). Topicalization, focus movement, and left dislocation are basically all root phenomena and cannot be embedded. Thus, we can say, these constructions are partially and weakly information-structure marking. We will be comparing this situation with cleft in English shortly and with long-distance fronting in Japanese in Chapter 5.

Cleft and Pseudocleft

The traditional view about cleft (*it*-cleft) is that utterance (77*a*) below presupposes (77*b*) [Delin, 1995, p. 98, citing earlier work].

(77) *a*. It was **John** who left. (cleft)

    b. Somebody left. (presupposition)

But Prince [1978, p. 898] points out that a large number of cases (called informative-presupposition *it*-cleft) do not fit into this pattern. The following is an example from Delin [1995, (7), p. 104].

(78) *i*. Joe Wright you mean

    ii. Yes yes

    iii. I thought it was Joe Wright who'd walked in at **first**

The information structure for the clefted part appears as follows (*a*), cf. (*b*) for (77a).[10]

(79) *a*. it was [Joe Wright]$_{Theme}$ [who'd walked in at **first**]$_{Rheme}$

    b. It was [**John**]$_{Rheme}$ [who left]$_{Theme}$.

Thus, the cleft construction does not assign rheme or theme status on the clefted NP. The only possibility is that it separates theme and rheme.

Collins [1991, p. 111] presents data (Table 3.1) regarding the distribution of referential and contrastive status on the components of cleft sentences (based on a modern British English corpus). This shows that the construction does not assign contextual-link status either.

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[10]The information-structure analysis for the element "*it was*" is ignored here because it is not critical for the current purpose.

	Clefted element	Complement	%
Unmarked	NEW/Contrastive	EVOKED/INFERRABLE	36.0
Marked	EVOKED/INFERRABLE	NEW/Contrastive	34.6
	NEW/Contrastive	NEW/Contrastive	29.4

Table 3.1: Corpus Analysis of Clefting [Collins 1991]

In addition, the cleft construction can be embedded, as shown in the following example [Delin, 1995, (24a), p. 111]:

(80) If it was John that ate **beans**, Bill will be disappointed.

Thus, following the hypothesis (30) that linguistic marking of information structure is matrix-level, it is not inherently an information-structure marker.

In summary, the cleft construction seems to serve various functions, including information structure (indirectly), contextual link, and contrastiveness, in a rather heterogeneous way. Thus, we could not reliably identify the involved information structure simply from the form. This contrasts with the case of topicalization/focus movement/left dislocation.

Let us now turn to the pseudocleft construction. Although pseudocleft has been once considered interchangeable with *it*-cleft as shown below, Prince [1978, (1), p. 883] argues that they are quite different.

(81) *a*. What John lost was his keys. (pseudocleft)

   b. It was his keys that John lost. (*it*-cleft)

Structurally, the pseudocleft construction simply includes a 'free relative' (also 'headless' relative) at the subject position [Higgins, 1979, p. 1].[11]

Empirically, Collins [1991, p. 133] shows data (modern written British English) that the free relative of pseudoclefts are either EVOKED (64.6%) or INFERRABLE (35.4%). Note that his definition of 'free relative' includes the form such as "*the thing that...*", "*the place where...*", and "*all that...*". Collins [1991, p. 145] also shows that in 'reverse pseudoclefts', i.e., of the form "*that's what...*", the free relative is not new.[12] Then, the free relative part of a pseudocleft must be a contextual link.

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[11]The definition of free relative varies. We may generally consider any *wh*-word without the head noun as free relative, e.g., *what*, *where*, *when*, *why*, *how*.

[12]He states that this type of utterance adds little information. But this point needs to be explored further.

In summary, the free relative involved in a pseudocleft marks a contextual-link status. As a free relative can appear basically in any NP slot, it works much like a definite determiner. As in the case of definite determiners, free relatives can indirectly mark a theme through the main hypothesis (48). This is quite distinct from the case of cleft in agreement with Prince's [1978] argument.

VP Preposing and Inversion

Ward [1990, p. 760, citing his 1985 thesis] argues that VP preposing "marks the entity represented by the preposed constituent as being anaphorically related to other discourse entities via a salient (partially ordered) set relation" and makes the complement as rheme ('focus').[13] The following is an example of VP preposing from Ward [1990, (1), p. 742].

(82) At the end of the term I took my first schools; it was necessary to pass, if I was to stay at Oxford, and pass I did, after a week... (the preposed VP is underlined)

He also states that the anaphoric relation is *explicit*. This suggests that VP preposing sets $Theme - Rheme$ information structure.

Birner [1994, p. 251] argues that the preposed element of inversion (see below from Birner [1994, (1a), p. 233]) is either discourse-old or INFERRABLE (counting 99.77% of 1290 utterances), corresponding to our contextual link.

(83) Labor savings are achieved because the crew is put to better use than cleaning belts manually; also eliminated is the expense of buying costly chemicals. (the inverted elements are underlined)

In addition, for NPs, the preposed elements are 90% out of 1485 tokens definite, while 51% of the postposed tokens are definite. This again suggests the $Theme - Rheme$ pattern.

Let us now turn to an observation that neither VP preposing nor inversion seem to be embedded. Thus, both VP preposing and inversion can be considered information-structure marking, following the hypothesis (30) that linguistic marking of information structure is matrix level. Neither VP preposing nor Inversion is very common in expository texts, but we do have one instance of inversion in our experiment data.

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[13]A more recent survey is found in Birner and Ward [1999].

Heavy NP Shift

The situation with heavy NP shift (see an example below) seems less clear than previous cases.

(84) *a.* Max put all the boxes of home furnishings in his car. (canonical order)

      b. Max put in his car all the boxes of home furnishings. (shifted form; Zubizarreta [1998, (145), p. 148])

Hawkins [1994] argues that the primary factor is constituent weight. On the other hand, Arnold et al. [1997] argues that the construction is conditioned by both referential status (newness) and grammatical complexity. It seems inconclusive to determine the status of heavy NP shift as either a marker of information-structure or contextual-link.

Since and Because

While both *since* and *because* can be used for a subordinate reason clause, their pragmatic function appears different. I personally have never paid close attention to any distinction until recently. I also observed that a Dutch linguist used *since* and *because* interchangeably in her examples. When I asked her about her intuition, she told me that they are the same.

Now, the observation is as follows. In response to a *why* question, only *because* clause, but not *since* clause, can be used [Lambrecht, 1994, p. 69]. Quirk et al. [1985, p. 1071] also observes that only *because* clauses can be placed in various 'focus'-related positions such as clefted position, focus of negation, and association with *only*. In addition, Moser and Moore [1995, p. 133] present a corpus-based analysis showing that 22 out of 23 occurrences of *since* precede the main clause while 13 out of 13 occurrences of *because* follow the main clause. These observations indicate that *since* cannot be a rheme, but do not restrict the status of *because*. This suggests that *since* is a theme marker.

There is a potential problem with the above analysis. Our hypothesis about information-structure marking (30) on p. 37 predicts that *since* (as a theme marker) cannot appear in embedded environments. But the following examples show the contrary.

(85) *a.* We know the story unfolds in the not-too-distant future <u>because</u> <u>since</u> there's no land to grow tobacco, they must have salvaged their cigarettes from somewhere. (New York Times 07-28-95 from LDC NYT95 at position 45048430)

> *b.* This is the point we are seeking, <u>for</u> <u>since</u> the lengths of the subintervals tend to zero, the point *P* is also near the sequence *Q* of endpoints from the set *B*. (from a textbook on Topology)

An alternative view is that *since* is a contextual-link marker. This can explain why *since* can be a theme at the matrix level, but cannot explain why it cannot be a rheme. The situation is analogous to the case of definite expression. A definite expression at the matrix level can be a theme, but it can also be a rheme depending on the statuses of the other elements of the utterance.

At the moment, we consider the examples (85) exceptional, retain the idea that *since* as a theme marker. Further investigation is called for.
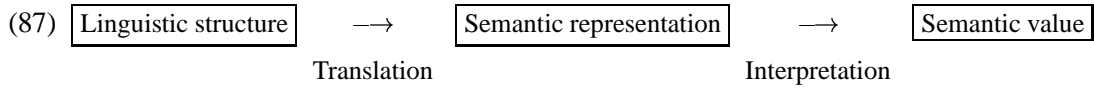
Summary

The special constructions in English are complex with respect to their pragmatic functions. The above analysis to identify marking for information structure and contextual link can provide fresh insight into this situation.

3.4   Grammatical Components

In the previous section, we have observed that lexical and structural information is crucial for identifying contextual links. To access these properties, we take a grammatical approach. In this section, we develop our grammar to capture the other major component of the main hypothesis (48), i.e., 'semantic composition'. In the first subsection, we define the notion of semantic composition along the line of Montague [1974]. This approach allows us to relate a semantic structure tightly with a surface syntactic structure. The second subsection is a partial solution to the problem with binomial information structure. By choosing an appropriate grammar formalism, we can analyze so-called 'non-traditional' constituents without loosing the precision of Montague's idea.

3.4.1 Syntax-Semantics Interface

Our starting point is the tradition of Montague [1974], also discussed in more recent textbooks [Chierchia and McConnell-Ginet, 1990; Gamut, 1991]. The semantic process can then be represented as follows (slightly modified from Gamut [1991, p. 149]):[14]

(87) | Linguistic structure | $\longrightarrow$ | Semantic representation | $\longrightarrow$ | Semantic value |
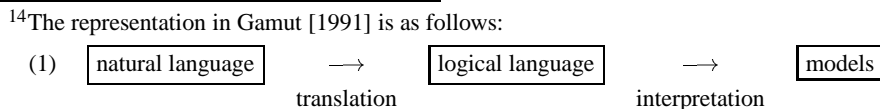   Translation   Interpretation

While it is possible to directly interpret linguistic structure (bypassing semantic representation), we opt for the above two-step approach for expository and practical reasons. For much of the discussion about formalization, we use semantic representation rather than semantic value (full interpretation).[15] In addition, our implementation solely deals with semantic representations for practicality. One additional note is that in the above figure, 'linguistic structure' is a result of parsing a linguistic expression (a string of tokens with no structure).

For semantic representation, we use the following notations:

(88)   *a*. Variable: upper case, e.g., *X*

      b. Constant: lower case

           Individual: e.g., *a*

           Property: e.g., *f* or $\lambda X.\lambda Y.f(X)(Y)$ (in a lambda notation)

      c. Functor-argument structure: e.g., $f(a)(b)$ where the argument *b* is least oblique [16]

      d. Modification structure: e.g., $a//b$ where *a* is modified by *b*

In many cases, a predicate may also specify an event argument. In this thesis, we consistently omit such an argument although we discuss some issues related to event.

Next, the process of translation and interpretation is represented as follows [Gamut, 1991, p. 160]:

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[14]The representation in Gamut [1991] is as follows:

(1) | natural language | $\longrightarrow$ | logical language | $\longrightarrow$ | models |
                  translation   interpretation

[15]Semantic representation is also called logical form (LF).

[16]In this notation, "*Felix praised Donald*" is translated into $praise'(donald')(felix')$. The other argument ordering $praise'(felix')(donald')$ with the subject and object appearing according to the surface order is probably more common. The reason for the present choice of notation is that the basic operation of functional application closely corresponds to 'concatenation' or 'juxtaposition'. In addition, there is another advantage in relation to binding phenomenon discussed in Steedman [1996].

(89) *a.* Translation: $x \longmapsto x'$ (some upper-to-lower case conversion may be involved)

    b. Interpretation: $[\![\varphi]\!]_{M,g} = \langle \text{semantic value} \rangle$

        Note: M and g are the model and the assignment of variables.

For example, the translation of [*Felix praised*] [*Donald*] is shown as follows:

(90) *a. Felix praised* $\longmapsto \lambda X.praise'(X)(felix')$

    b. Donald $\longmapsto donald'$

This in turn can be interpreted in a model M_1 with an arbitrary assignment g_2 as follows:[17]

(91) *a.* $[\![\lambda X.praise'(X)(felix')]\!]_{M_1,g_2} = \mathsf{property}_{123}$

    b. $[\![donald']\!]_{M_1,g_2} = \mathsf{individual}_{456}$

The next step of combining elements is **semantic composition**. At the level of semantic representation, semantic composition is a relation applied to two input representations and one result representation. We consider the following two cases for semantic composition:

(92) *a.* Functional application for a functor M and an argument N: MN or $[M](N)$

        β-reduction: e.g., $\left[\lambda X.f(X)\right](a) \longrightarrow_\beta f(a)$

        Note: The distinct sets of parentheses in the form "$[M](N)$" is used as a visual cue of functional application.

    b. Functional composition: $\left[\lambda X.f(X)\right] \circ \left[\lambda Y.g(Y)\right] = \lambda Y.f\left(g(Y)\right)$

Continuing with the earlier case, the semantic composition of "$\lambda X.praise'(X)(felix')$" and "$donald'$" can be achieved by functional application with the result "$\left[\lambda X.praise'(X)(felix')\right](donald')$". After application of β-reduction, we obtain "$praise'(donald')(felix')$". Its interpretation is "$[\![praise'(donald')(felix')]\!]_{M_1,g_2} = \mathsf{true}$" (in a certain model M_1).

At the level of semantic value, the semantic composition of (91*a*) and (91*b*) is obtained by applying the set membership "$\mathsf{individual}_{456} \in \mathsf{property}_{123}$" where $\mathsf{property}_{123}$ is a set of individuals. This should yield the same truth value as the above. The process of semantic interpretation shown above can be associated with surface syntactic structure, as shown in Fig. 3.1.

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[17]A model is roughly a specification about how symbols are interpreted in the world. An assignment is a mapping from a free variable to a referent. In the shown example, there is no free variable, thus the assignment is irrelevant. For more detail, see the above-mentioned textbooks.

$$\text{``Felix praised Donald''} : praise'(donald')(felix')$$

$$\text{``Felix praised''}: \lambda X.praise'(X)(felix') \qquad \text{``Donald''} : donald'$$

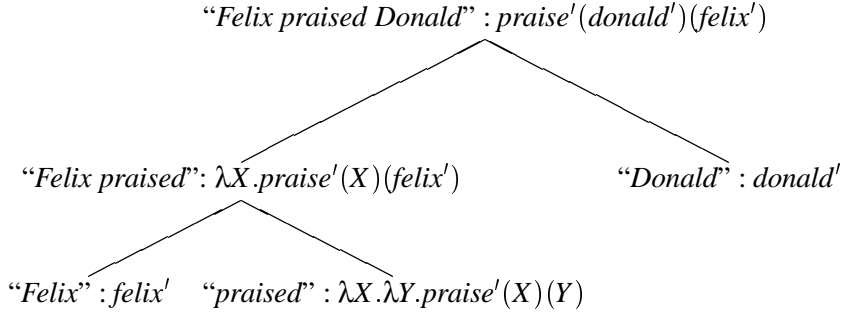$$\text{``Felix''} : felix' \quad \text{``praised''} : \lambda X.\lambda Y.praise'(X)(Y)$$

Figure 3.1: Syntax and Semantics along Linguistic Structure

In Subsection 3.2.2, we have discussed the notion of context and discourse status. With the semantics assumed here, we define the **context** as a set of semantic values, corresponding to various semantic types. Then, a semantic value is **discourse-old** if the identical one is already in the context. Note that distinct linguistic expressions or even distinct semantic representations may be interpreted into a single semantic value. For example, the following situation is possible:

(93) *a.* $[\![felix']\!]_{M_1,g_2} = \mathsf{individual}_{456}$

    b. $[\![dr.\_katz']\!]_{M_1,g_2} = \mathsf{individual}_{456}$

As long as we analyze discourse status at the level of semantic value, reference can be correctly resolved even for a case like this (reference resolution is not our focus, though).

Let us now see how the main hypothesis (48) can be applied to identify information structure. Suppose that a question "*Who did Felix praise?*" has already introduced a representation "$\lambda X.praise'(X)(felix')$" into the context. The last semantic composition of the response "*Felix praised Donald*" is "$\left[\lambda X.praise'(X)(felix')\right](donald')$".[18] The component "$\lambda X.praise'(X)(felix')$" is discourse-old, and thus a contextual link. Then, the main hypothesis (48) can be applied to identify the theme, "$\lambda X.praise'(X)(felix')$", and the rheme "*donald'*".[19]

3.4.2 Flexible Constituency

Any grammar compatible with this type of semantics may be a candidate as a grammar formalism of choice. But there are a few other issues. Earlier in Subsection 3.2.2, we have considered semantic representations of various types as a source of interpretation (i.e., to obtain discourse

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[18]This is not the only derivation, but we will come back to this point later.

[19]Prideaux [1979] had an idea of deriving information structure from surface structure via semantics.

referent). But most traditional grammars do not recognize a linguistic unit, i.e., a constituent, of the type "*Felix praised*", i.e., non-traditional constituent. Another problem is discontiguous information structure of the pattern such as "*Theme – Rheme – Theme*". A solution to the latter problem is possible by extending the notion of semantic representation and semantic composition, and is discussed in the next section. A solution to the former problem is possible by adopting an appropriate grammar formalism such as Combinatory Categorial Grammar (CCG) [Ades and Steedman, 1982; Steedman, 1991a].

CCG is motivated for syntactic reasons as well, with respect to coordination, extraction, and phonological structure in English [Dowty, 1988; Steedman, 1991a]. In this section, we will briefly describe some ideas about CCG and about how such non-traditional constituents can be recognized. The detailed discussion of CCG is given in Chapter 4, and some practical points in Chapter 6.

In CCG, each linguistic expression is associated with a 'category'. A category is a pair of 'syntactic types', e.g., *NP* and *S*, and the corresponding 'semantic representation', e.g., *john'* and *clever'* (*john'*). Surface structure is derived through the combination of categories, i.e., both syntactic type and semantic representation. Such a combinatory process involves two types (in the current work): 'functional application' and 'functional composition'. Roughly speaking, use of functional application alone results in a system closely corresponding to context-free grammar. But, with functional composition, we have more flexibility in the way categories are combined. Now, let us represent functional composition as $f \circ g$, as in mathematics. Then, combination of $f \circ g$ and a is equivalent to combination of f and $g(a)$, i.e., "$[f \circ g](a) = [f](g(a))$". Thus, if subject-verb-object sequence can be represented as "$f - g - a$" sequence, both bracketing "$f - [g - a]$" and "$[f - g] - a$" are possible. For the earlier example, $[f - g]$ corresponds to "*Felix praised*". Now, the standard technique to analyze a NP as a function f in the Montague tradition is 'type raising'. For example, the individual type a can be type raised to $\lambda P.P(a)$, a function that takes a property as an argument. Type raising was originally motivated for coordination of an individual and quantified NPs, e.g., "*John and most students*". The associativity observed here is the source of flexibility in CCG (and other categorial grammars).

By adopting CCG, we can recognize surface constituency more flexibly than traditionally considered. This can provide a theoretical background for relating surface structure and semantic interpretation. In an earlier section, we have reviewed several cases of information-structure marking

in terms of linguistic structure. The framework allows us to describe such relations in a straight-forward manner. In addition, if we process information structure in close connection to semantic representation, the framework allows parallel processing of surface structure, semantic interpretation, and information-structure processing.

3.5 Discontiguous Information Structure

In the previous section, we have seen that Combinatory Categorial Grammar (CCG) is a solution to non-traditional constituency. But we also have observed another problem for binomial information structure, i.e., discontiguous information structure. This problem has not yet received full attention, except for Krifka [1992] and Steedman [1999, Section 5.5]. This section presents a solution to this problem based on their insight and techniques, focusing on the concept underlying the solution. A more formal presentation will be covered in Section 4.3.

Motivation

We have adopted a binomial information structure to model the informational contrast between theme and rheme. But, as discussed in Subsection 2.3.4, other types of partitions have been pro-posed as well. One (but not the only) motivation for such a move is to account for discontiguous information structure such as in the form of "$Theme - Rheme - Theme$", as can be seen in the following example [Steedman, 1999, (35)]:

(94) *Q*: I know which team Mary **expects** to **lose**. But which one does she **want** to **win**?

   A: [Mary **wants**]$_{Theme}$ [**Ipswich**]$_{Rheme}$ [to **win**]$_{Theme}$.

   The following is a still more complicated example with the pattern of "$Theme - Rheme - Theme - Rheme$" [p.c., Mark Steedman, 1998].

(95) *Q*: I know what team Fred wants to win the Cup, but which team does Alice want to lose which contest?

   A: [Alice wants]$_{Theme}$ [**Australia**]$_{Rheme}$ [to lose]$_{Theme}$ [the **Ashes**]$_{Rheme}$.[20]

   Although CCG can accept constituents more flexibly than traditional grammars do, discontigu-ous information structures do not correspond to constituents recognized even by CCG.

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[20]With or without L+H* on the themes.

Analysis

By observing the examples (94, 95), we might consider a possibility that the discontiguity is a result of syntactic restrictions on realization of information structure. That is, in English, the word order is basically fixed and the information structure is separated due to that factor. If this is the case, we should be able to analyze and predict occurrences of discontiguous information structure simply through syntax. But this is not the case.

Let us consider an example in Japanese (grammatical labels: TOPic, ACCusative, NoMinaLizer, COPula, and Question).

(96) *Q*: Ken-wa   nani-o   tabeta-no?
       Ken-TOP   what-ACC   ate-Q
       "What did Ken eat?"

       A: [Ken-wa]$_{Theme}$ [**banana**-o]$_{Rheme}$ [tabeta]$_{Theme}$.
          Ken-TOP   banana-ACC   ate
          "Ken ate a banana."[21]

The strict verb-final property is one thing that causes the discontiguous information structure. But that is not the only factor. Either of the following responses may be uttered in place as well.

(97) *a.* [**Banana**-o]$_{Rheme}$ [Ken-wa   tabeta]$_{Theme}$.
       banana-ACC   Ken-TOP   ate
       "It was a banana that Ken ate."

       b. [Ken-ga   tabeta-no-wa]$_{Theme}$ [**banana**-da]$_{Rheme}$
          Ken-NOM   ate-NML-TOP   banana-COP
          "What Ken ate was a banana."

Note that the above two are grammatically more marked forms than the SOV in (96*A*) and that there are forms of questions that correspond to these marked forms. But, in any case, the form of question does not seem to restrict the form of response.

Thus, we cannot say that discontiguous information structure is a result of syntactic constraints. We need to accept that there are various factors that cause discontiguous information structure. For whatever reasons, once a particular construction is chosen, information structure must be realized even if discontiguity results.

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[21]Depending on the situation, the definite article *the* may also be applicable.

Even for the discontiguous case, there are a few properties that stay as in the contiguous case. First, the surface syntax does not violate the grammaticality. Second, discontiguous theme (rheme) elements can be combined into a single theme (rheme) semantic unit, and then the theme and the rheme can compose and derive the proposition corresponding to the utterance. For example, consider the utterance (95*A*) repeated below.

(98) [Alice wants]$_{Theme}$ [**Australia**]$_{Rheme}$ [to lose]$_{Theme}$ [the **Ashes**]$_{Rheme}$.

Each theme/rheme component may be semantically represented as follows:

(99) *a.* "Alice wants": $\lambda X.\lambda Y.want'(X)(Y)(alice')$

    b. "Australia": $australia' = \lambda P.P(australia')$

       Note: The right-hand side is a 'type-raised' semantic representation of the individual.

    c. "to lose": $\lambda X.lose'(X)(pro)$

    d. "the Ashes": $ashes' = \lambda P.P(ashes')$

Here, the treatment of control structure has been simplified [Steedman, 1996, for more detail]. The semantic representations for the combined theme and rheme are as follows:

(100) *a.* $Theme: [\lambda X.\lambda Y.want'(X)(Y)(alice')](\lambda X.lose'(X)(pro))$

      $= \lambda X.\lambda Y.want'(X)(lose'(Y)(pro))(alice')$

    b. $Rheme: [\lambda P.P(ashes')] \circ [\lambda P.P(australia')] = \lambda P.P(australia')(ashes')$

      Informally, this corresponds to a pair of (ordered) individuals that would satisfy a certain property.

The proposition can now be derived as follows:

(101) *Proposition*: $[\lambda P.P(australia')(ashes')](\lambda X.\lambda Y.want'(X)(lose'(Y)(pro))(alice')) =$

    $[\lambda X.\lambda Y.want'(X)(lose'(Y)(pro))(alice')](australia')(ashes') =$

    $want'(australia')(lose'(ashes')(pro))(alice')$

The correct semantic analysis of discontiguous information structure and thus must correspond to the *usual* semantic analysis of utterance.

Therefore, while semantic derivation of discontiguous information structure does not directly correspond to the surface derivation, it must be semantically in concordance with the surface derivation. We propose an analysis of discontiguous information structure, which can be used to account for the semantic derivation we have just seen above.

Structured Meaning Approach: Introduction

In order to allow the discontiguous patterns, we need to accept an additional degree of freedom in linguistic analysis. For this purpose, we adopt the 'structured meaning' approach [von Stechow, 1991; Krifka, 1992] (both cite earlier work of Klein and von Stechow and that of Jacobs).

The point of the structured-meaning analysis is as follows. The traditional semantic representation as a value corresponding to a constituent is not sufficient to analyze the correct 'focus' projection, i.e., the focus scope. We use the term 'focus' here following the literature (but it really is our 'contrast'). This problem can be solved if, as a semantic representation, we associate with a constituent a 'structure', rather than a value. For a sentence "John only introduced Bill to Sue.", the following three distinct focus scopes are possible [e.g., von Stechow, 1991] (the index is used to indicate the association).

(102) *a*. John only$_1$ introduced **Bill**$_1$ to Sue.

     b. John only$_1$ introduced Bill to **Sue**$_1$.

     c. John only$_1$ introduced [**Bill** to **Sue**]$_1$.

Purely syntactic approaches [e.g., Chomsky, 1971; Culicover and Rochemont, 1983] assume that a focus feature $[+F]$ on a phrase is projected from a pitch accent at a specific position, e.g., rightmost head of the phrase. But these approaches would assign the same syntactic structures for the above cases. Thus, the above distinction cannot be accounted for.

Structured meaning is proposed to solve this problem by deriving structured semantic representation to capture the underlying contrast between 'background' and 'focus' (their terminology). Combined with a semantic analysis such as Rooth [1996], this approach can provide correct semantics for the examples in (102). The standard representation used in the literature for structured meaning is $\langle Background, Focus \rangle$. The structured meanings corresponding to the verb phrases in (102) are shown as follows:

(103) *a*. John only$_1$ introduced **Bill**$_1$ to Sue.

$$\left\langle \lambda X.\lambda Z.introduce'\,(X)\,(sue')\,(Z)\,, bill' \right\rangle$$

     b. John only$_1$ introduced Bill to **Sue**$_1$.

$$\left\langle \lambda Y.\lambda Z.introduce'\,(bill')\,(Y)\,(Z)\,, sue' \right\rangle$$

     c. John only$_1$ introduced [**Bill** to **Sue**]$_1$.

Analysis 1: $\left\langle \lambda X.\lambda Y.\lambda Z.introduce'\left(X\right)\left(Y\right)\left(Z\right),bill',sue'\right\rangle$ (multiple foci as a list [von Stechow, 1991, p. 43])

Analysis 2: $\left\langle \lambda X.\lambda Y.\lambda Z.introduce'\left(X\right)\left(Y\right)\left(Z\right),bill' \bullet sue'\right\rangle$ (multiple foci as a product [Krifka, 1992, p. 21])

In order to justify the structured-meaning approach, let us discuss a few more applications. Structured meaning is also used for an analysis of propositional attitude [Cresswell, 1985]. The point is that the argument of propositional-attitude verbs, e.g., *think*, is not a semantic representation as a value but its structure. Another application is to an analysis of thematic role [Chierchia, 1989]. He shows that this move can provide an appropriate analysis of control structure.

But there is a limitation with the previous work. The general case of semantic composition is not discussed in von Stechow [1991]. Krifka [1992] defines four cases of functional application of two structured meanings, depending on how the two components of structured meanings are applied. But his analysis is also too limited for our purposes. The only case of composing two structured meanings results in a 'product' ($bill' \bullet sue'$), as can be seen in (103). We need a more general approach that is applicable to an arbitrary semantic type. Since CCG involves both functional application and functional composition as a means of semantic composition, we also need to consider both of these.

Since the 'structured meaning' approach is occasionally compared with the 'alternative semantics' approach [Rooth, 1985], it seems beneficial to briefly discuss their relation. Structured meaning is one way of semantic representation and alternative semantics is one way of interpreting semantic representations. Researchers who focus on structured meaning assume certain semantic interpretations [Krifka, 1992, p. 21]. Those who focus on Alternative Semantics assume certain syntactic mechanisms to deliver a desirable semantic representation [Rooth, 1996]. Therefore, it is rather pointless to compare both approaches in terms of expressibility, and argues that structured meaning is more expressive than Alternative Semantics as in von Stechow [1991, p. 73]. He seems to consider alternative semantics too simplistically. Partee [1999] also emphasizes the difference that structured meaning and Alternative Semantics are a 'grammaticalized' and a 'non-grammaticalized' approach. But these approaches must be syntactic and semantic sides of a single coin.

Application to the Current Theory

In the current work, we adopt structured meaning for the contrast between a contextual link and a non-contextual link. The intuition behind this move is that for each constituent, the semantic representation may keep such a contrast rather than reducing it to a simple semantic value, unlike assignment/projection of contextual-link status (Subsection 3.3.1). This enables us to 'carry' a binomial internal structure of constituents to the next level of semantic composition. The use of contextual-link status is feasible because it can be identified in terms of discourse status, linguistic form, and domain-specific knowledge.

The structured meaning approach adopted in this section allows us to analyze discontiguous information structure within a binomial model of information structure. This is important for several reasons. First, we can analyze realistic linguistic data with a simple model of information structure. Second, by avoiding multiple partitions of information structure, we can focus on a small number of properties that characterize information structure more precisely. By integrating with a Montague-style analysis, congruent relations between syntax, semantics, and information structure are possible. It facilitates the connection between linguistic marking of information structure and contextual link to the grammatical components of phonology, syntax, and semantics. The relation to processing can be improved as well by allowing parallel processing of contextual link and information structure along parsing. Potentially, it can also provide semantic representations for Alternative Semantics analysis. In the next chapter, we will also discuss formalization of the proposed approach and an application to an analysis of 'gapping'.

3.6 Summary

In the theory of information structure developed in this chapter, we emphasize the following two points. Themes are necessarily 'contextually-linked' and a proposition is a 'semantic composition' of a theme and a rheme. The notion of contextual link is further characterized by discourse status, domain-specific knowledge, and linguistic marking. We also observe that a number of linguistic analyses provide support for contextual-link marking.

Semantic composition is captured within a framework of CCG, which can recognize surface constituents corresponding to units of information structure. We also address another potential

problem for binomial partition and propose a solution using structured meaning. The chapter argues that the proposed theory can be used for analyzing information structure in texts and is thus a key to the Identification Problem.

We have left two main components of the theory for the following two chapters, i.e., formalization within CCG and analysis of linguistic marking of information structure in Japanese. Once these are explored, we can proceed to implementation and evaluation of the theory.