Towards a Cognitive Linguistic Approach to Language Comprehension

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Declaration

I declare that this thesis has been composed by myself and that the work is my own.

Scott McGlashan

Abstract

This thesis develops a cognitive linguistic approach to language comprehension. The cognitive approach differs from traditional linguistic approaches in that linguistic description is seen as an integral part of the description of cognition, and that the object of description is the nature of conceptual structures, the processes which relate these conceptual structures, and the effect of context upon these processes. As a cognitive description within cognitive science, a computational approach is adopted: language comprehension is described in terms of two modules, a linguistic processing module and a discourse processing module. Within these modules, conceptual structures and processes are given a uniform characterization: structures are characterized as partial objects which are extended by processes into (potentially) less partial objects.

In the linguistic processing module, linguistic expressions are characterized as signs which combine as head and modifier. The conceptual structure in signs for lexical expressions is related to the conceptual structure in signs for phrasal expressions by means of two extensional processes: a specification process which unifies a modifier sign with part of the head sign; and a linking process which extends the head sign by unifying the specified part with its own conceptual structure. Thus combination yields a result sign with a linguistic conceptual structure for the phrase.

The discourse processing module characterizes the interpretation of linguistic conceptual structure by means of two extensional processes. The first process, anchoring, relates the linguistic conceptual structure to concepts in a model of the discourse by either unifying it with an existing concept, or creating a new concept. The second process, elaboration, extends concepts in the discourse model by means of background knowledge, or theories, which specify relations between and within concepts. This can result in the creation of concepts in the discourse model which are not directly referenced by linguistic expressions.

Finally, the cognitive linguistic approach maintains that the discourse context, in particular a portion of the discourse model, affects both discourse and linguistic processing. With discourse processing, this context can guide the anchoring of conceptual structures so that, for example, the contextually appropriate sense of ambiguous and polysemous expressions can be selected. The discourse context can also affect linguistic processing: a sufficiently specific context can result in the selection of the contextually appropriate sense of a lexical expression prior to combination and interpretation. Both these effects of context are motivated by empirical evidence, and the later effect supports the contention that there is an interaction between the linguistic processing and discourse processing modules during language comprehension.

Dedication

This thesis is dedicated to my mother, father and grandmother.

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Chapter 1

Introduction

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check by sticking your finger into the
compost, a lot of people don't like sticking their
finger into the compost i don't know if they expect
something to come out and bite them or
something, but that really is the very best water
meter you've got and it is already installed all
ready to use no batteries or anything ()
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The topic of this thesis is the description of language as illustrated in the quotation above[1]. Obviously, the description of language is a large topic to which many approaches can be adopted. Each approach has the ability to *highlight* and *hide* different aspects of language. For example, a sociological analysis of language emphasizes the role language plays in revealing the social relations between participants in the discourse. Literary analysis emphasizes the stylistic techniques which writers employ in order to achieve particular literary effects. Each of these approaches then emphasizes different aspect of language at the expense of other aspects.

In this thesis, a linguistic approach to language is adopted. The goal of this introductory chapter is to elucidate what is traditionally meant by a linguistic approach (section 1.1), where this approach seems to falter by hiding, rather than highlighting, fundamental aspects of language (section 1.2) and sketch some basic tenets on which an alternative approach might be based (section 1.3). This alternative approach characterizes language in terms of cognitive representations and processes, and emphasizes the role of 'context' in its interpretation. Section 1.4 provides an overview of how the approach is developed in this thesis.

1.1 The Linguistic Approach

The foundation of the modern linguistic approach to language can be attributed to Noam Chomsky (cf. Chomsky 1957; Chomsky 1965; Chomsky 1981). While other grammarians before him, most notably Boas, Sapir and Bloomfield, provided a basic framework which emphasizes linguistic structure — i.e. the treatment of language in terms of structures, or categories, which are manifest in language behaviour — and the subordination of meaning to structure, it was Chomsky who transformed their notions into the modern linguistic approach. Chomsky's approach is built upon three basic tenets of linguistic description: universality, creativity and systematicity.

Whereas traditional grammarians, such as Boas, suggested that each language had its own

[1] The extract is lines 137 to 142 in the transcription of *Gardener's Question Time* given in appendix A.

unique grammatical structure, Chomsky promoted the notion that linguistic structure was universal: all languages have the same underlying structure even although particular languages admitted properties which were not manifest in other languages. This notion had a profound impact upon the description of language: languages could, in principle, be described using the same categories and rules. Furthermore, in emphasizing the creativity of language, the object of description was not the structure of language independent of the language users, but the ability of speakers to produce, and listeners to understand, an indefinitely large number of utterances. The passage above illustrates one aspect of this creativity: our ability to understand a phrase such as *water meter* which, in the context of this discourse, refers to using fingers to test whether a plant needs watering. Finally, in emphasizing the systematicity in language, Chomsky highlighted the systematic basis of our linguistic abilities.

The result of emphasizing these aspects of language was the development of generative grammar in the late fifties and early sixties. In essence, generative grammar provided a formal description, couched in terms of putatively universal categories and rules, of our abilities to produce and understand language. In addition, it provided both a limit on what aspects of our language ability were to be described as well as a methodology for developing this description. In the first place, description was restricted to our abilities pertaining to the production and understanding of sentences: utterances larger than the sentence were excluded from linguistic description. Moreover, great emphasis was placed on our ability to produce and comprehend not just any sentence, but *grammatical* sentences as opposed to *ungrammatical* sentences:

> The fundamental aim in the linguistic analysis of a language L is to separate the *grammatical* sequences which are the sentence of L from the *ungrammatical* sequences which are not sentences of L and to study the structure of the grammatical sequences (Chomsky 1957: 13; original emphasis)

In other words, grammar was intended to provide a description of our ability to produce and comprehend grammatical sentences; ungrammatical sentences were to be excluded from the description. In Chomsky's terms, the grammar must generate, or enumerate, all and only the well-formed sentences in a language. If, however, the scope of grammar is to be fundamentally restricted on the basis of this distinction, it is essential that the basis for the distinction is made explicit.

Four potential bases for the distinction have been rejected by Chomsky. The first is intuition. While we may have an intuitive grasp of the distinction so that, for example, *the plants grow in the garden* is grammatical, or well-formed, and *in grow plants in garden the in* is ungrammatical, or ill-formed, that intuition is part of language, not independent of it, and so the grammar must give an account of it (cf. Miller 1962). The second is empirical: we cannot equate the set of grammatical sentences with the set of sentences actually produced and recorded as linguistic corpora. One reason for this concerns creativity (cf. Chomsky 1957: 15): the set of actual utterances is finite whereas the set of grammatical utterances is infinite since it includes sentences which we have not yet come across. Another concerns the distinction between competence and performance: competence concerns our ability to understand and produce sentences and performance the application of this ability ('ability in action'). Chomsky argues that many sentences which we actually produce will be ungrammatical on account of non-linguistic factors such as memory lapses, hesitations, interruptions, and so on. As a consequence of this, observation of actual linguistic behaviour must be 'idealized' so as to remove the 'extraneous' aspects of the phenomena responsible for ungrammaticality. In other words, grammaticality cannot be sourced in actual performance: it is part of competence.

The third potential basis is statistical approximation: i.e. that sentences are grammatical on the basis of the transitional probability of words occurring in a sequence. As Chomsky demonstrates, two words may have equal probability of occurrence in a given linguistic context on the basis of past experience; for example, *whale* and *of* may have zero probability in the context *I saw a fragile* ___, yet the sequence *I saw a fragile whale* is grammatical whereas *I saw* *a fragile of* is not.

A fourth potential basis for the distinction is semantics: grammatical sentences are 'meaningful' sentences. What differentiates this account from the others is that it is a distinction which is internal to the grammar. For part of the structuralist tradition has been to describe language in terms of different levels of structure (cf. Bach 1986 on the 'divide and conquer' strategy in linguistics). Traditionally, three levels have been recognized in grammar and each is associated with related, but independent, regularities in language:

phonology provides a description of the regularities which govern the combination of sounds;

syntax provides a description of the regularities which govern the combination of words;

semantics provides a description of the regularities which govern the combination of the meaning of words.

Chomsky claims that grammaticality is not defined at the levels of semantics. He makes this claim on the basis of the well-known examples in (1.1) and (1.2):

(1.1) Colorless green ideas sleep furiously

(1.2) *Furiously sleep ideas green colorless

Both examples, he claims, are "equally nonsensical, but any speaker of English will recognize that only the former is grammatical" (Chomsky 1957: 15).

If grammaticality is not to be defined in terms of actual occurrence, statistical regularity or semantics, then what is it to be defined in terms of? Chomsky's answer is that grammar itself defines grammaticality: the sequences a grammar *generates*, i.e. assigns a structural description to, are grammatical sentences independent of whether or not they have actually occurred, are semantically wellformed or statistically probable. This may seem anomalous given that semantics is part of grammar: surely, in order for a sentence to be grammatical, it needs to be assigned a wellformed semantic structure, just as it must be assigned wellformed syntactic and phonological structures. However, while semantics is part of the description assigned by grammar, these levels of description are independent levels of descriptions and are assigned different priorities. In particular, the syntactic level of description has priority in grammar: semantic and phonological structure are *interpretations of* syntactic structure. Thus, grammaticality is to be equated with syntactic wellformedness and semantic and phonological wellformedness are secondary considerations independent of grammaticality. This then allows for the possibility of a grammatical sequences being either semantically well-formed or illformed. What it forbids are grammatical sequences which are syntactically illformed.

1.2 Points Of Departure

The linguistic approach developed in this thesis diverges from the traditional approach in that linguistic description is seen as an integral part of the description of cognitive abilities, and the focus of the description is not grammaticality, but the nature of conceptual structure, the processes by which it is constructed and the effect of context on these processes.

One basic tenet of Chomsky's approach to the description of language is its independence from the description of other cognitive abilities. This independence is manifest in two ways. The first is a theoretical commitment to the study of language independent of its use in our everyday activity. For rather than attempt to describe language within the context of everyday activity, grammatical description is based upon a highly idealized notion of language. Language, however, is not an object in its own right: it is a tool which we use to communicate and its description should respect this (cf. Lewis 1960: 8). This should not be seen as a rejection of the modern linguistic tradition, but as a commitment to treating language description from a multi-disciplinary perspective rather than from a single perspective. As we shall see, viewing language in this way, highlights aspects of language which are amenable to a linguistic treatment but which have been ignored due to this traditionally insular perspective. Secondly, but closely related, are methodological considerations. Linguistics has developed a methodology which diverges from the methodology employed in other disciplines which study cognitive abilities. In psychology, for example, great emphasis is placed upon the use of experiments to both explore and validate hypotheses about cognitive descriptions. Likewise, in sociology, as demonstrated in conversation analysis, the preferred method of developing and validating hypotheses is through detailed observation and analysis of everyday language (cf. Levinson 1983; Atkinson and Heritage 1984; Wooffitt 1992). In linguistics, however, especially where the development of grammar is concerned, hypotheses are rarely subjected to detailed empirical validation, of either the experimental or observational variety. One consequence is that this makes it difficult to provide an account of how our linguistic abilities interact with both psychological and social abilities.

A second divergence from the traditional linguistic approach concerns the status of semantics. By focusing on grammaticality and equating it with syntactic well-formedness, semantics has not played a significant role in the development of grammar. The emphasis has been on the development of syntactic frameworks which are capable of assigning descriptions to an increasingly complex set of utterance types with the minimum of syntactic representations and rules. More recently, however, grammars have begun to develop more sophisticated approaches to semantics by importing theories from philosophy. These theories, such as those developed by Montague (1974), Kamp (1981), Barwise and Perry (1983) and Landman (1986), have subtly moved the emphasis of linguistic description away from grammaticality towards interpretability: i.e. the purpose of providing a linguistic description of utterances is not simply to determine their grammaticality, but to yield a semantic representation which can be assigned a semantic interpretation. In addition, since these models are typically discourse models, the emphasis is increasingly on what sentences, or parts of sentences, contribute to an evolving model of the discourse. With these semantics approaches, then, the emphasis is on semantic wellformedness conditions not just of sentences, but of sentences within a discourse. This takes grammar beyond the sentence.

These discourse-based approaches, however, are not generally well developed when it comes to characterizing the representation of lexical semantics (concepts associated with words) and the linguistic and discourse processes by which these representations are combined and related to our background knowledge and current knowledge about discourse. In part, this deficiency stems from a failure to adopt a cognitive approach to semantics: i.e. an approach which locates these representations and processes within a cognitive agent. This in turn leads to a failure to consider restrictions on representations and processes which we, as cognitive agents, are faced with, restrictions which experimental evidence from cognitive psychology can provide. For example, the construction of a semantic interpretation may be restricted by the discourse context in which it is embedded. Consider the extract in (1.3) (lines 74 to 83 in appendix A):

(1.3)
```
like to use things like green nicosheanna and
heally crison and other annual plants () and if you
cannot live without them, then i would suggest
that you make yourself a raised bed, perhaps
eighteen inches high which is a convenient height
you can sit on the edge of it and work from a
comfortable seated position () and grow them very
intensively, fill the bed with a very good quality
compost and grow the plants reasonably close
together, because they have got a deep root run in
good compost
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In (1.3), *bed* is not ambiguous: only the 'plant-sense' is appropriate in a gardening discourse. However, as an ambiguous expression, it has a number of potential senses, such as 'mattress-bed', 'plant-bed' and 'river-bed', which can appear in different contexts:

(1.4) John bought a new mattress for his futon bed.

(1.5) The diver collected clams from the bed of the Thames.

If these senses of *bed* are only apparent in different discourse contexts, then it is possible that the semantic representation is constructed by processes sensitive to context. The selection of different senses on the basis of context can then be seen as a restriction on discourse well-formedness.

The third divergence from the traditional approach concerns the independence of syntax and semantics. Traditionally, syntactic and semantic descriptions of sentences are viewed as systematically related but independent levels of description where grammatically was defined exclusively at the syntactic level. Increasingly, however, the priority of the syntactic level is diminishing: syntactic, semantic and phonological descriptions are seen as providing restrictions of equal standing on the linguistic well-formedness of sentences (cf. Fenstad et al. 1987: 15–17). We not only endorse this position, but extend it by claiming that discourse interpretation can affect the linguistic process which defines grammaticality. That is, linguistic well-formedness emerges from the satisfaction of syntax, semantic and phonological restrictions on word combination. Discourse processes likewise define discourse well-formedness through the satisfaction of restrictions on semantic interpretation. However, the semantic representation constructed by the latter processes can also restrict the representations constructed by the linguistic process. For example, the meaning of *bat* can vary with the contexts in (1.6) and (1.7):

(1.6) John was a keen naturalist. The bat he had been studying had unusually large ears.

(1.7) John was a keen sportsman. The bat he was using in the cricket match had an unusually large handle.

In (1.7) the discourse process can be seen as providing an interpretation of the first sentence which implicitly involves the concept of 'sports equipment'. If the linguistic process selects a lexical representation for *bat* not simply on the basis of phonological, syntactic and semantic restrictions — which would not lead to the selection of the appropriate sense — but also on the basis of discourse restrictions, and, given that only the 'game-bat' sense is compatible with 'sports equipment', then the contextually appropriate sense can be selected during the linguistic process.

1.3 Destinations

The destination of this thesis is a cognitive linguistic approach to language which characterizes comprehension in terms of the incremental construction of conceptual representations and their interpretation within a discourse model — i.e. a set of concepts, and relations between concepts, which have emerged during the discourse[2]. The conceptual representation itself is constructed by a linguistic process. This process combines linguistic representations, or *signs*, which have phonological, syntactic and semantic descriptions associated with lexical expressions. For example, the process combine the lexical representations for *pink* and *elephants* to produce a phonological, syntactic and conceptual representation for *pink elephants*. The interpretation of the conceptual representation is characterized by two discourse processes: *anchoring* and *elaboration*. Anchoring a conceptual representation involves its integration in the discourse model: the conceptual representation can either be identified with a compatible, existing concept; or

[2]Conceptual structure and semantic structure are thus treated as synonymous terms.

it can be added as a new concept. Once anchored, the concept is elaborated by background knowledge, or a *theory*. A theory specifies relations of a concept; for example, the theory for *elephants* specifies internal relations such that they necessarily have a trunk and are typically grey in colour, as well as external relations to other concepts such as location. When a conceptual representation is elaborated by a theory, these relations are then defined for the anchored representation. This results in either the confirmation of existing relations of the concept or the creation of new relations and concepts in the discourse model.

Furthermore, this approach treats the discourse model as a *context* which can affect both linguistic and discourse processes. The discourse model plays a role in determining the appropriate sense of ambiguous and polysemous expressions. In discourse processing, conceptual representations for these expressions may be disjunctive: they describe two or more incompatible concepts. Accordingly, they could be elaborated by theories appropriate to any of these concepts. However, the anchoring process will attempt to identify one of these concepts with a compatible concept in a portion of the discourse model. If there is such a concept, the other concepts in the conceptual representation are neither anchored nor elaborated. If there is no compatible concept, then two 'virtual' concepts are created. If no further conceptual representations are identified with one of these concepts by the end of the sentence, then the default sense is selected. The discourse model also acts as a context for sense selection in the linguistic process. For after a conceptual representation is anchored and elaborated in the discourse model, a portion of the discourse model is made available to the linguistic process. This 'discourse context' is then used to refine upcoming disjunctive signs. That is, if one semantic disjunct, but not the other, is compatible with a concept in the discourse context, then only this sense is retained in the sign. In this way, selection of contextually appropriate senses can occur at two points in comprehension: during linguistic combination so as to yield a less disjunctive sign[3]; and during the anchoring and elaboration of disjunctive conceptual representations.

1.4 Structure Of the Thesis

Chapter 2 addresses two general issues in the cognitive linguistic approach. The first of these is methodology: if language comprehension is to be characterized in terms of cognitive representations and processes, then how can we support or validate particular characterizations? A mixed approach is advocated: both observational and experimental evidence can be used to support a cognitive linguistic characterization. The second issue concerns the treatment of cognitive description as computational description of the cognitive agent. Three aspects are discussed: the level of computational description appropriate to a linguistic characterization; the existence of, and relationship between, modules; and the nature of symbols and rules within these modules. Our characterization is treated as a computational theory level description positing two modules, a linguistic processing module and a discourse processing module, which interact with each other: linguistic descriptions are passed from the linguistic processing module to the discourse processing module and a discourse context is passed in the opposite direction. An information-theoretic approach is adopted toward the symbols and rules in these modules: global invariance is characterized in terms of processes while local invariance is characterized in terms of constraints inside symbols; constraints, which when satisfied, yield further information about the symbol.

Chapter 3 addresses two empirical issues central to this approach. The first is the nature and structure of concepts. Two approaches to concepts, the classical approach and the prototype approach, are discussed with respect to categorization. It is argued while the prototype approach is capable of accounting for many empirical shortcomings of the classical approach, such as variation in the typicality (or centrality) of concepts, it is not able to account for the effects of context on this variation. The second issue concerns the relationship between linguistic and discourse processing. Empirical studies on the accessing of lexical representations are

[3] The result signs may still retain disjunctions since disjuncts may be nested.

taken to show not only that the contextually appropriate sense of ambiguous and polysemous expressions can be selected during discourse processing, but that discourse restrictions can lead to the selection of an appropriate sense within linguistic processing.

Chapter 4 develops the cognitive linguistic approach by discussing two approaches to semantic interpretation. In the correspondence approach, the distinction between semantic representation and interpretation is based upon an ontological distinction between representation and the world itself. The constructive approach rejects the ontological basis for this distinction and focuses instead on how cognitive agents construct conceptual structures. These structures are characterized as dynamic partial objects structured in terms of criterial necessity and symptomatic default relations, and extended on the basis of a dynamic discourse model and static background knowledge.

Chapter 5 describes the discourse processing module. Three levels in the processing of conceptual structures are identified: linguistic conceptual structures as constructed by the linguistic process; conceptual structures anchored in the discourse model; and conceptual structures elaborated through application of constraints defined by background knowledge or theories. The nature and structure of conceptual structures and theories are then characterized in terms of structured objects. The anchoring process is characterized as a extensional relation between a linguistic conceptual structure and a discourse model ordered in terms of accessibility. And the elaboration process as an extensional relation between concepts anchored in the model and theories. As a result of these processes, a linguistic conceptual structure may become a specific, stable and coherent concept in the model. However, this may not always arise initially: concept construction may involve sense correction. This arises when there is a conflict between properties of concepts, a conflict which is resolved through the 'defeat' of one of these concepts. These cognitive representations and processes are then used to account for sense selection and correction at the discourse processing level.

Chapter 6 discusses combination in the linguistic processing module. Two issues are identified. The first is that combination can be characterized in terms of the unification of linguistic categories, or signs. The second is that combination is an asymmetrical process: one sign in a combination has priority over the other sign. Two approaches to asymmetry are discussed and compared. The first approach characterizes the asymmetry in terms of the priority of functor signs over argument signs as in categorial grammar. The second characterizes asymmetry in terms of the priority of head signs over modifier signs as in dependency grammar. It is argued that the head-modifier distinction provides a more economical account of combination than the functor-argument distinction. We also introduce defeasibility phenomena where one sign 'defeats' semantic properties of the other sign.

Chapter 7 describes the linguistic processing module where combination is based upon the head-modifier distinction. Linguistic expressions are characterized as signs structured in terms of head and modifier properties. Combination is based upon two extensional processes: a specification process in which the modifier sign specifies part of the head sign; and a linking process in which substructures in the head sign are related by constraints defined in the head sign. It is then demonstrated how this approach, Unification Dependency Grammar, can account for sense selection and correction at the linguistic processing level through interaction with discourse processing module.

Chapter 8 concludes the thesis.

Chapter 2

Linguistic Descriptions as Cognitive Descriptions

2.1 Introduction

In this chapter we address two issues which arise with a cognitive approach to linguistic description.

The first concerns methodology: i.e. the methods we might employ to support, test or validate whether a linguistic description of behaviour is a characterization in terms of cognitive representations and processes. For while the traditional linguistic approach claims that it is a description of our cognitive abilities, the methods it employs, especially testing by example, contrasts with the methods employed by other disciplines, such as cognitive psychology, which also claim to offer cognitive descriptions.

The second issue concerns the manner in which cognition is to be described. In the traditional linguistic approach, the description of representations and the processes, are couched in terms of symbols and rules. This is not incompatible with contemporary cognitive science, where cognition is described in computational terms: i.e. both humans and computers are described as 'cognitive agents' capable of processing information. The processing within these agents can be described at a number of levels, levels which differ in their idealization of information processing. In addition, the description at each level is typically structured in terms of information processing modules consisting of representations and rules. Accordingly, we need to established the appropriate level of computational description for cognitive linguistic descriptions, its modularity and the nature of symbols and rules within the modules.

The chapter is structured as follows. Methodology is discussed in section 2.2 where a distinction between direct and indirect observation is made. Within indirect observation, the distinction between informal and experimental methods is discussed. Section 2.3 discusses cognitive linguistic description within the computational theory of mind. This encompasses a discussion of Marr's levels of description (section 2.3.1), modularity (section 2.3.2) and symbol processing (section 2.3.3). Section 2.4 concludes the chapter.

2.2 Methodology

If the cognitive linguistic approach is to be taken as a description of cognition, then we must be clear about the methods by which evidence is gathered both for the development and testing of cognitive descriptions. In cognitive science, development and testing of descriptions are based upon two observational methods. The first method, the *direct observation*, develops and tests cognitive description by direct observation of neural activity underlying human cognition. The second method, the *indirect observation*, constructs and validates cognitive descriptions on the basis of observation of the behaviour of human cognitive agents.

2.2.1 Direct Observation

Direct observation is used to construct and evaluate cognitive descriptions in neuroscience. Neuroscience constructs descriptions by directly monitoring, recording and analyzing neural activity (cf. Crick and Asanuma 1986). There are some obvious advantages and disadvantages with this method. One advantage is that it can furnish us with a very precise description, couched in terms of neural representations and processes, of sensory activity such as visual perception (cf. Marr 1982). A second advantage is that the techniques and terminology employed derives from the physical sciences, such as biology and chemistry, rather than the social sciences to which cognitive science has traditionally been allied. This can, and has, served to raise the 'scientific respectability' of cognitive science.

There are, however, a number of disadvantages in using this method for the cognitive description of linguistic behaviour.

One of these is that the descriptions are hardware-specific: cognition is constituted and delimited by the physical hardware which underpins human cognition. This leaves no room for the possibility that other types of devices, such as computers, *could* display linguistic behaviour to which we may attribute cognitive activity. Of course, some may see this as a proper restriction on what we wish to term 'cognitive agent': only carbon-based devices with neural hardware should be considered cognitive agents (cf. Searle 1984). However, at this early stage in the development of cognitive science, it seems wise to allow for the possibility that other devices, such as computers, could attain the status of cognitive agents (cf. Woolgar 1987).

The main disadvantage, however, is that this methods fails to provide a description of 'high-level' cognitive activity such as language understanding and production. This is not to deny that at some point in the future neuroscience might be able to furnish such a description of these cognitive activities, only that it does not currently do so. One may speculate that it will be a considerable time before such cognitive activities can be given neural descriptions. Furthermore, just as most cognitive scientists and linguists have rejected Bloomfield's pessimistic claim that a precise definition of the meaning of words requires a complete scientific description of the objects and processes in the world which they describe, so cognitive science has rejected the assumption that cognitive descriptions can only be constructed by observing the neural activity of human cognitive agents (cf. Lyons 1977a: 33)[1].

2.2.2 Indirect Observation

Within cognitive science, most cognitive descriptions are developed and tested by means of indirect observation. This method can be seen as complementary to direct observation. Rather than directly observe neuronal activity, descriptions are constructed by observing the behaviour of human cognitive agents. Given the gap between evidence obtained from observation of an

[1] Even those developing connectionist descriptions of cognition have rejected this (cf. Rumelhart and McClelland 1986). In addition, even though their descriptions are informed by neuroscience, the extent to which these descriptions are actually constrained by neurological evidence is open to question:

> As Jim Bower wrote: '...As a neurobiologist, however, I would assert that even a cursory look at the brain reveals a structure having very little in common with connectionist models.' (cf. Sloman 1991: 10)

agent's behaviour and the neural activity upon which it might be based, the resulting cognitive descriptions naturally differ both in specificity and scope from those arrived at by direct observation. In particular, cognitive descriptions are not committed to a one-to-one correspondence between representations and processes in the descriptions, and specific neural representations and processes. They merely claim that, at some level of description, neural activity can be appropriately described in this way. Such descriptions are *functional* cognitive descriptions since evidence derived from observed behaviour is only sufficiently specific to restrict the functions performed by a cognitive agent, not the hardware upon which it might be executed. Of course, the corollary of this lack of specificity is that high level cognitive abilities can be given a cognitive description, but low level ones cannot.

For the remainder of this thesis, it shall be assumed that cognitive descriptions will be developed and tested by evidence obtained using indirect observation. The cognitive linguistic approach, for example, is thus treated as a functional description of cognition whose evidence is derived from observation of linguistic behaviour. The neural activity taking place inside a cognitive agent is consequently irrelevant to the validity, or otherwise, of this type of description since the method cannot access what actually happens inside the agent's head. The neural basis of cognition in human agents is beyond its ken.

Having determined the evidential basis for cognitive linguistic descriptions, let us now turn to how these descriptions can be tested and evaluated.

In cognitive science, as with any other empirical discipline, hypotheses should be defeasible. That is, hypothesized cognitive descriptions should be couched in such a way that their validity can be empirically tested: the evidential conditions under which they are supported as well as these under which they are not supported should be stated, or if not, obvious to infer. This much is uncontroversial. What is controversial, however, is what counts as good evidence for cognitive linguistic descriptions. The controversy stems from the work practices of the disciplines forming cognitive science. Linguists, semanticians and philosophers tend to test descriptions against informal observation of behaviour. Cognitive psychologists, on the other hand, test their descriptions against observation of behaviour under experimental conditions. These work practices give rise to two senses of 'empirically testable': testing by informal observation and testing by experimental observation.

Informal Observation

With the first sense of empirically testable, descriptions are tested against observations of behaviour made in an informal setting. Typically, this involves determining what behaviour is predicted, or not predicted, by the description and consulting written texts to determine whether these predictions are valid.

Consider, for example, how linguistic descriptions of 'control' phenomena would be tested with this method. Suppose that the description involves the claim that the covert 'subject' of an embedded infinitival clause is co-referential with the object of the finite matrix clause. The prediction is then validated by constructed test sentences, such as those given in (2.1), using reflexive pronouns to determine the co-referential expression (co-reference is indicated by co-indexing):

(2.1) a. John told Peter^1 to shave himself^1
b. John asked Peter^1 to shave himself^1
c. John wanted Peter^1 to shave himself^1

The description would then be further tested by simply extending the set of test sentences. This might include varying the matrix verb, changing its mood and aspects as well as variations in the embedded clause. The prediction would not be valid if a test sentence can be constructed which counters the claim. With (2.2), the subject rather than the object is co-referential with the pronoun:

(2.2) John[1] promised Peter to shave himself[1]

In this way, claims which form part of cognitive descriptions are tested, and then revised, by informal observation.

This method of testing cognitive descriptions has some obvious advantages and disadvantages. One advantage is that it is based upon easily accessible data: data can either be found in existing texts or constructed. Another is that it permits descriptions to be developed and tested relatively quickly: a theory can be developed and, if necessary, data can be constructed to support it.

There are, however, a number of disadvantages. Firstly, gathering test data in this way is not systematic: the data can be sentences constructed by the linguists themselves or randomly selected sentences actually used by non-linguists. Secondly, test material tends to be *self contextualizing*: i.e. the context in which the sentence occurred is not provided and the reader is required to construct one for themselves. Thirdly, interpretation of test data is not independent of the observer's intuitions. Such a lack of independence would be justified on the basis that the principles the observer brings to bear in analyzing data are the same principles used to produce the behaviour in the first place. Even if the same person produces and analyses the test data, then there is an assumption that their account of their own behaviour can be equated with a description of the (cognitive) activity which produced it in the first place. Consequently, this method does not distinguish between descriptions of 'cognition-in-action' and 'cognition-in-account': i.e. between descriptions of the cognitive processes which gives rise to the behaviour and descriptions of accounts of the behaviour. Finally, informal observation is relatively blunt in that it tends to test sets of principles, or predictions, constituting a description rather than individual principles. On the available data, it can be shown that one description can account for more data than another, but it is difficult to know which of the individual principles is responsible. So unless descriptions differ with respect to a single principle, it is difficult to use data to test their accuracy.

Experimental Observation

The second sense of empirically testable is that descriptions are tested and validated by means of psychological experiments. In such experiments, behaviour is elicited from subjects by requesting them to perform a task, recording pre-determined aspects of their behaviour and then analyzing the results using standard qualitative and quantative methods.

Consider how claims about the relationship between covert subjects and matrix clause might be tested with this method (cf. Chomsky 1969; Chomsky 1982). Subjects are asked to read a text containing control expressions and select its co-referential antecedent from a list as soon as they have found it. The text itself can be systematically varied between and within subject groups so as to test whether, for example, the surrounding linguistic context, such as the matrix verb or the mood of the matrix clause, affects selection of an antecedent. The behaviour of subjects is then recorded in terms of experimental data concerning (correlations between) the type of control expression, type of matrix clause, accuracy and speed in selecting antecedent[2]. Analysis of this data may, for example, establish statistical correlations demonstrating that, for example, certain types of syntactic context facilitate the determination of the 'missing' subject in certain types of syntactic context since for these contexts the speed and/or accuracy is significantly higher than in the other types of context.

The experimental method has three advantages over the informal method.

[2] Where 'accuracy' can be determined prior to the experiment by a set of independent judges.

In the first place, there is a clear separation between the analysis of the data and its subsequent interpretation in terms of theories and intuitions. For data analysis is performed using a set of explicit, well known techniques whose application is, in principle, not subject to interference from the intuitions and theories of the experimenter. Of course, once data analysis has been completed, then the experimenter can interpret the results in terms of their intuitions and theories. The important point is that data analysis itself is independent of intuition and yields results which can be replicated by others as well as being subject to different interpretations. With the experimental method, cognitive science can be aligned with other scientific disciplines, such as physics and chemistry, which rely upon controlled experimentation and well-defined analytic methods to validate descriptions.

In the second place, the experimental method is capable of testing more precise claims than the informal method. The precision derives from two sources: the behaviour of subjects can be controlled and manipulated within the experimental laboratory; and differences in experimental conditions, such as task and context, can be treated as variables which, by means of data analysis, can be correlated and then interpreted so as to demonstrate the validity (or otherwise) of particular theoretical principles. Of course, in order for this to be possible, these principles must be distinctive – i.e. they must contrast with alternative principles, including the null hypothesis, in terms of their experimental correlates[3]. This allows the individual principles in a theory, as well as their interactions, to be controlled for and tested.

Furthermore, the experimental method is able to test descriptions at different levels of detail. One advantage of this is that differences between subject's accounts of their behaviour and their actual behaviour become manifest (cf. Evans 1980). For example, in a series of experiments conducted by Armstrong et al. (1983), the 'typicality' of concepts within superordinate concepts such as *fruit*, *vehicles* and *numbers*, was investigated. Two tasks were used to measure typicality: rating concepts along a typicality scale; and simply asking subjects about their typicality. They discovered a discrepancy between the ratings assigned by subjects and the accounts of their own behaviour. For example, subjects reported that all odd numbers were equally odd, yet behaved as if certain numbers were more odd than others — 3, 7 and 9 for example. Accordingly, the experimental method offers a way of assessing whether our reports of behaviour are accurate (in terms of independent experimental correlates) as well as cautioning us against the assumption that behaviour and accounts of that behaviour necessarily probe the same cognitive activity — they may be probing different aspects of the same activity or entirely different activities (cf. Johnson-Laird 1987).

Of course, the experimental method is not without its disadvantages. One of these is that behaviour is elicited from subjects in experimental situations rather than everyday situations. If there are dependencies between the elicited behaviour and the experimental context, then clearly the results of the experiments cannot be generalized to behaviour in everyday situations.

Methodological Reconciliation

Rather than simply accept one or other of these methods for developing and testing cognitive linguistic descriptions, both methods are employed in this thesis.

The informal method is primarily used to demonstrated the plausibility of, rather than test, claims of cognitive description. While little can be done to alleviate the lack of independence between data analysis and interpretation, the other problems, non-systematicity in collection and self-contextualizing data, can be alleviated through use of corpus material such as the transcription of an episode of *Gardener's Question Time* given in appendix A.

The experimental method, on the other hand, is used to test specific claims of the approach developed here. Four further points about this method should be borne in mind.

[3] Of course, descriptions which lack empirically contrastive principles, as many theoretical linguistic descriptions seem to, cannot be tested with the experimental method.

Firstly, in using experimental data, we are not committed to accounting for every effect observed in experiments. Experimental effects will be treated as clues about cognition, clues which can either validate a hypothesis, undermine it or not affect it. Experimental effects, then, will underdetermine description (cf. Carey 1982): they will provide us with clues as to the character of specific cognitive activities rather like a photograph of a building may tell us about that building — and we want a theory of buildings rather than a theory of photographs of buildings.

Secondly, corroborative experimental evidence will be admitted in the absence of direct evidence, although it will be significantly weaker evidence. Cognitive descriptions may differ in purpose — for example, accounting for semantic phenomena and visual perception — and it is assumed that they are founded upon the same set of principles unless there is evidence to the contrary. Obviously, corroborative evidence is not as reliable as direct evidence. For while experimentally tested descriptions are always susceptible to subsequent disconfirmation, principles established by analogy are doubly susceptible: by direct counter-evidence; and by disconfirmation of the analogous principle. For example, linguistic representations have been given a prototypical structure on the basis of Rosch's evidence for prototype structure of concepts (cf. Jackendoff 1983). Unfortunately, more recent work on concepts has undermined their prototypical structure, with the result that the corroborative evidence for this sort of structure for linguistic representations is no longer adequate (see section 3.2.2).

Finally, using the available experimental evidence is far from ideal, especially where the experimental context — situation, task and goals — is far from 'natural'. This problem has been recognized within cognitive psychology and this has led to the development of 'naturalistic' experiments, experiments which probe subject's behaviour in more natural contexts. For example, the 'maze' game experiments allow subject to engage in goal-directed activity whilst providing data on the use and resolution of referring expressions (cf. Garrod and Anderson 1987; Boyle 1990). Additionally, such experiments provide (more) 'natural' contexts for these resolution tasks in contradistinction to the 'self-contextualizing' tasks in other experiments.

2.3 Cognition as Computation

One of the foundational notions in cognitive science is the Computational Theory of Mind (CTM) (cf. Kolers and Smythe 1984: 291). The CTM postulates that cognition can be understood and described as a computation: i.e. cognitive descriptions can be couched in terms of computational information processing[4].

2.3.1 Levels of Description

Marr (1982) provides a basic descriptive framework in which to consider the relation between information processing behaviour and levels of description. In his framework, computation can be understood at three different, albeit related, descriptive levels: the computational theory level, the algorithmic level and the hardware implementation level.

The first level, the computational theory level, addresses questions such as the goal of the computation, why it is appropriate and the logic of the strategy by which it is carried out. The second level of description, the algorithmic level, addresses questions dealing with how the function is carried out, i.e. the algorithm for transformation, and representations of the input and the output. So in addition to dealing with *what* function is being computed it also deals with *how* the function is computed and how its inputs and outputs are represented. Indeed,

[4]That people can and do understand and reason about cognition in computational terms is supported by Lakoff and Johnson (1980: 27–28) who provide plentiful examples of computational metaphors; for example, *We're still trying to* **grind out** *the solution to this equation*, *My mind just isn't* **operating** *today* and *He* **broke down**.

this level of description attends to aspects of computation which are regarded as irrelevant at the first descriptive level including time and space issues. The third level, the hardware level, addresses how an algorithm, its inputs and outputs can be physically realized.

Two points about these descriptive levels need to be emphasized.

Firstly, at each level we must make a distinction between *theory* and *model*. A theory is a characterization of a phenomena given in words; a model is a characterization given in a formal language whose interpretation is highly constrained — a computer program or a logic. Furthermore, these levels describe the computation in an increasing less abstract way: i.e. each level imposes more and more restrictions on the computation. At the computational theory level, functional restrictions are imposed; at the algorithmic level, procedural restrictions are added; and at the hardware implementational level the description is further restricted by the nature of the hardware. Thus as we lower the degree of idealization we take on an increasing number of restrictions on the computational description of behaviour. Paralleling these levels of idealization in theory, we can built computational models which likewise take on board different sets of restrictions. Thus a model at the computational theory level need only compute the relevant function — how it does it, as well as the hardware on which it is computed, are irrelevant. But a model at the algorithmic level must not only compute the relevant function, but do so in a way consistent with certain limitations and errors (again hardware is irrelevant). Only at the hardware level does the model need to respect all restrictions.

The second point is that at each level of description, the theory provides an appropriate *interpretation* for the model. Models interpreted by theories appropriate to other descriptive levels will fail to provide the restrictions appropriate to the theory level. For example, if the model is appropriate to the hardware level of description, then it can also be described at the computational theory and algorithmic levels although such descriptions will necessarily underdetermine the properties of the model. That is, these descriptions will ignore hardware properties. If the model is at the computational theory level, then it can *only* be appropriately interpreted by a theory at that level: the manner in which the function is computed as well as the hardware it is being computed on are underdetermined by the computing theory level of description. Likewise if the model is of the algorithmic level, then it can appropriately be described at the algorithmic level. A description at the computing theory level will underdetermine properties of the model: it will ignore certain properties of the model intended as important. A description at hardware level will overdetermine the properties of the model: certain properties, hardware properties, will be considered relevant at this level of description although they were not intended to be relevant. Of course it is *possible* to give a description of any model at a higher or lower level of idealization than that for which it is intended but such descriptions are simply inappropriate: to give a description at a higher degree of idealization would miss out certain important constraints imposed on the model, while a description at a lower level would attribute constraints to the model which were not intended.

Having described the levels of computational description, their degrees of idealization and the relationship between theories and models, we now consider the level of description appropriate to a cognitive linguistic approach.

In the Chomskian approach, a fundamental distinction is made between two levels of description, differing in their degree of idealization, namely competence and performance. A competence description, or grammar, is about an (idealized) individual's knowledge of language whereas a performance description is about how this knowledge is put to work. These linguistic descriptions have been correlated with Marr's level 1 and level 2, respectively. A competence description is a declarative description of *what* function is computed, whereas a performance description is a procedural description of *how* the function is computed (cf. Steedman 1985: 359).

One effect of this distinction concerns their characteristic method of testing linguistic descriptions. Competence descriptions are tested by informal observation, while performance descriptions are tested by observation of linguistic behaviour under experimental conditions[5].

This approach to testing is based on the view, although not exclusive, that experimental evidence tests algorithmic descriptions of behaviour (cf. Broadbent 1985). That is, experimental evidence imposes empirical restrictions on cognitive descriptions which make explicit not only what function is being computed, but how the function is computed. Aspects of the description such as efficiency, time and space considerations as well as degradation of performance can, in principle, be tested through experimentation.

A traditional competence description of linguistic behaviour is a cognitive description at Marr's computational theory level and, as such, is tested by informal observation rather than experimental observation. In section 2.2.2, however, it was proposed that cognitive linguistic descriptions are tested by the informal method *and* the experimental method. The use of the experimental method to test competence descriptions can be justified by rejecting the assumption that Marr's levels of descriptions are autonomous. That is, rather than simply treat descriptions given at one level as wholly independent of descriptions given at another level, the descriptions can be seen as only partially independent. There are two reasons for adopting this position. Firstly, as we have seen, the restrictions applicable to one level are also applicable to lower levels; for example, the restrictions applicable to level 1 descriptions are also applicable to level 2 and 3 descriptions. Secondly, evidence relevant to a lower level is also relevant to a higher level given the lower level needs to respect restrictions imposed at the higher level. For example, if experimental evidence concerns claims made about the information relevant to the nature of some function, such as the combination of words, then this evidence bears just as much on a level 1 description as on lower level descriptions. Likewise, hardware evidence bearing upon how a function is computed is relevant to both level 2 and 3 descriptions (cf. Chater and Oaksford 1989). By rejecting the autonomy of levels, competence descriptions can be tested by both informal and experimental methods.

To deny autonomy between levels is not to deny differences between them. Competence and performance differ in *degree* of idealization. Performance descriptions offer detailed cognitive descriptions and this detail is apparent in how the function is computed as well as the nature of the input/output representations. Competence descriptions, on the other hand, offer descriptions which are less detailed in two senses. Firstly, they are descriptions which aim to describe a particular cognitive function, such as word combination, categorization, learning, memory and so on. Accordingly, they do not need to account for restrictions on a cognition function, only those appropriate to the computational theory level. They can, then, ignore experimental evidence which may bear upon the behaviour in question, but does not bear upon the aspect of behaviour they aim to describe. Competence descriptions can be seen as descriptions whose principles are contained within, or emerge from, performance descriptions (cf. Johnson-Laird 1986). Secondly, since competence descriptions are effectively restricted by experimental evidence, it follows that these descriptions may provide more details about the nature of function, as well as the nature of the representations, so long as they do not specify how the function is computed.

2.3.2 Modularity

Taking on board the computational theory of mind commits us to more than the notion that cognition can be described at three levels of computational description. It commits us to the notion that cognition has a functional architecture (cf. Pylylshyn 1984; Fodor and Pylyshyn 1988; Clark 1989). To say that cognition has a functional architecture is to say that there are some aspects of cognition which are *fixed*, i.e. are not subject to change through processing,

[5] Another way in which competence descriptions are validated is through modelling: hence the proliferation of parsers. While parsers are inherently procedural, they are not performance descriptions since they are interpreted as level 1 rather than level 2 models. This contrasts with other computational models, such as Hearsay, which are claimed as models of algorithmic theories (cf. Erman et al. 1980). Experimental evidence does bear upon the claims made in these models.

while other aspects are *variable*, i.e. aspects which can change through cognitive processing. In general, the functional architecture determines structure of cognition as well as interactions between its substructures; for example, the set of 'primitive' symbols and rules, the control structure determining rule application, and how memory is organized and accessed as well as the limitations on information transfer and so on (cf. Pylylshyn 1984: 92). Here we restrict attention to two facets of functional architecture which bear upon a level 1 description of linguistic behaviour: whether it is organized into modules and, if so, how they interact; and the nature and structure of symbols and rules within the description.

Before discussing these aspects of cognition, we must be clear about how we evaluate competing approaches. Given the emphasis placed upon informal and experimental testing of cognitive descriptions, it might be expected that competing approaches can be evaluated in this manner. However, as Pylylshyn (1984: 134) points out, functional architecture is cognitively impenetrable: neither informal nor experimental evidence can be used to test the validity of particular approaches. Having said this, different approaches can be evaluated in this way given that we are prepared to make some assumptions about the functional architecture and that the approaches which adopt these assumptions make different claims about how information is actually processed within the functional architecture. That is, while we cannot directly test the claims these approaches make about the macro-structure and micro-structure of cognition, we can test them, albeit indirectly, through the claims they make about information processing within the architecture.

With regard to modularity, three approaches will be discussed: strong modularity, non-modularity and weak modularity. In terms of Claxton's distinction between the associative approach and the integrative approach, strong modularity corresponds to the first and non-modularity to the second (cf. Claxton 1980: 199–205). Weak modularity, like strong modularity, claims that cognition has macro-structure, but differs from it in terms of the number of modules and the relations between them.

Strong Modularity

The strong modularity approach claims that in our description of behaviour it is appropriate to take as a working hypothesis that cognition has major structural divisions (cf. Fodor 1983). These divisions give rise to modularization in description: i.e. descriptions of particular cognitive functions is given in terms of information processing which takes place within, and between, independent modules. Each module has its own representation and processes. Modules are related by means of associations which defines their connectivity. Interaction between these modules derived directly from the von Neuman architecture: i.e. a digital serial computer with a single central processor operating over registers with typed data-structures. This characteristically resulted in serial, unidirectional interactions between modules: i.e. only one module could be active at any time and once a module has passed control over to the next module in the sequence, it cannot become active again within that cycle.

This approach characterizes language comprehension in the following way. Cognition is partitioned into a number of modules, each of which describe part of the comprehension process; for example, a phonology module, a syntax module, a semantics module, a context-independent semantic interpretation module and context-dependent semantic interpretation module. Each module contains representations and rules to carry out their part of the task; for example, the syntactic module consisted of syntactic representations and rules for their combination. The activation cycle is determined by uni-directional relations between modules so that an input utterance is first processed by the phonological module, its output given to the syntactic module and so on. The modular architecture underpinning this approach to language comprehension is illustrated in figure 2.1 (where the arrows indicate uni-directional relations). Allied with this approach to cognition is a method for interpreting psychological experiments. The purpose of conducting experiments was to accrue evidence for the structure and interaction of modules and

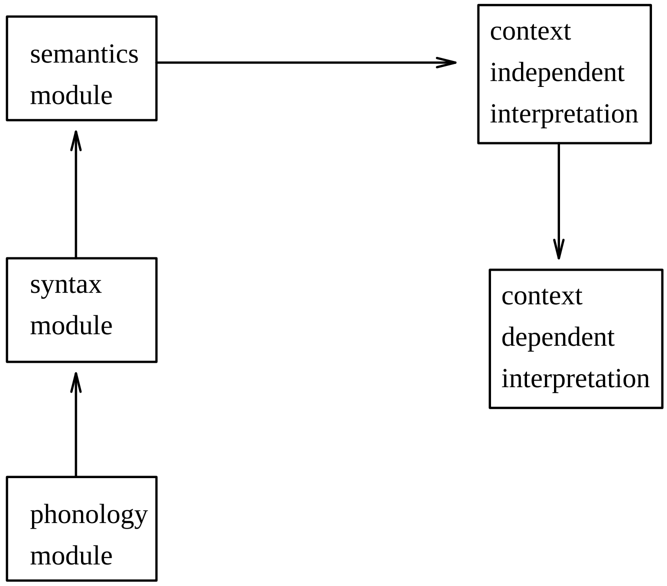

Figure 2.1: A strong modularity architecture for language comprehension

experimental results were interpreted in this light. Typically, neither the context of the task, the nature of the material used nor the goals of the task were seen as pertinent to interpretation. Claxton (1980: 6) gives a concise example of this type of methodology from Collins and Quillian (1969): they proposed that semantic memory is organized as a hierarchy of concepts, where only the features that distinguished each concept from its superordinate class were represented, and their predictions were confirmed by their experiments. More generally such an approach assumes that the different judgments elicited by experiments were due to different modules in cognition; for example, certain limitations, so called 'bottleneck' effects, on cognitive processing were due to the existence of a short-term memory which connects perceptual input with long-term memory. Accordingly, theories of linguistic processing couched in this framework attribute the difficulty of centre-embedding sentences to a capacity limitation in short term memory (cf. Kuno 1974; Frazier and Fodor 1978).

Non-Modularity

The foundational principle of the non-modular approach is that there are no major structural divisions in cognition. Distinctions characteristic of the modular approach, such as independent modules with their own representations and rules, are not countenanced. Instead cognition is described in terms of the interaction of a large number of 'means-specific' units: i.e. units sensitive to acquisitional history, context, content, modality and goals. These units can be described as both representational and processing units.

This approach is primarily informed by the connectionist models. These models, in turn, were inspired by neuroscience, where there is considerable evidence for specialized groups of neurons which responded to particular invariant properties of sensory input. In the computational models, these neurological constraints informed the functional descriptions of cognition.

With this approach, psychological experiments were seen not as offering general principles bearing upon cognitive organization, but rather as "ways of separating out and analysising more deeply the complex underlying processes" (cf. Baddley 1978 quoted in Claxton 1980: 230). This had repercussions for the interpretation of experiments. Instead of hypothesizing that different judgments would reveal aspects of *different* components of cognition, such as short term memory and long term memory, it was hypothesized that different judgments reveal different aspects of the *same* component. Accordingly, experimental evidence concerning, say, verbal recall was taken to reveal properties of specific items rather than general structural principles. Finally such an approach regarded limitations, such as bottleneck effects, as deriving from specific conflicts rather than inherent capacity limitations. As Touretzsky and Hinton (1986: 31) say of language interpretation:

> Because the working memory for each item is distributed over many units, thresholds, or weights, there will be interference if more than a few items are stored at once, and the interference will be greater as the items become more similar.

Weak Modularity

One advantage of both the strong modularity and non-modularity approaches is that their descriptions have obvious computational models. Unsurprisingly, their corresponding models tend to be good at accounting for phenomena highlighted by their own approach, but not so good with phenomena highlighted by the other approach. Models of the strong modularity approach are proficient in capturing 'non-interactive' aspects of behaviour, such as list processing, just as models of the non-modular approach excel with 'interactive' aspects, such as context-sensitivity and 'content-addressability' (cf. McClelland et al. 1986). On the other hand, strong modularity models reveal their weaknesses with 'interactive' phenomena such as context-sensitivity in semantic interpretation, whereas non-modularity models reveal theirs in phenomena such as high level structure and 'on the fly' rules (cf. Hadley 1990).

The disadvantage of these approaches is that the main difference between them — whether or not cognition can be described in terms of modules — cannot be empirically tested. For whether the distinction is countenanced depends more on modelling than experimental considerations. As Kolers and Smythe (1984) point out, computational descriptions influenced by modelling considerations run the risk of attributing to the functional architecture of cognition accidental properties, properties which are not necessitated by independent evidence, but are (solely) dependent upon considerations of how the description can be computationally modelled. It is for this reason that we have emphasized so heavily the distinction between description and model.

In this thesis, however, we shall assume a modular approach to cognition. There are two reasons for this. The first is that this approach is well understood and extensively used for the description of high level cognitive functions, such as language comprehension and production, compared with the non-modular approach. The second is that models based upon the non-modular approach are increasing moving toward a modular approach in order to describe these high level functions: i.e. many connectionist approaches now organize units into modules (cf. Waltz and Pollack 1985; Miikkulainen and Dyer 1989). Although we have accepted the modular approach for pragmatic reasons, the relationship between modules in the strong modularity approach is rejected on the grounds that modules are unable to *interact* since there is only a uni-directional relationship between modules. Accordingly, modules in the strong modularity approach can only pass information up to the next module in the hierarchy: they cannot receive information from a module higher in the hierarchy.

Although we shall provide empirical evidence to support weak modularity in section 3.3, the difference between strong and weak modularity can be illustrated with interpretation of *bat* in (2.3):

(2.3) John was a keen naturalist. The bat he had been studying had unusually large ears.

Here interpretation seems straightforward: only the 'animal-bat' sense is appropriate in a nature discourse. If we assume language comprehension requires two modules — a linguistic processing module which combines linguistic symbols and a discourse processing module which interprets them within a discourse model — and these modules are related by bi-directional relations, then not only can the linguistic processing module pass a linguistic description of expressions to the discourse processing module, but the discourse processing module can pass part of the discourse model to the linguistic processing module. The interaction between these modules is illustrated in figure 2.2. In the case of (2.3), the discourse model can pass, as part of the

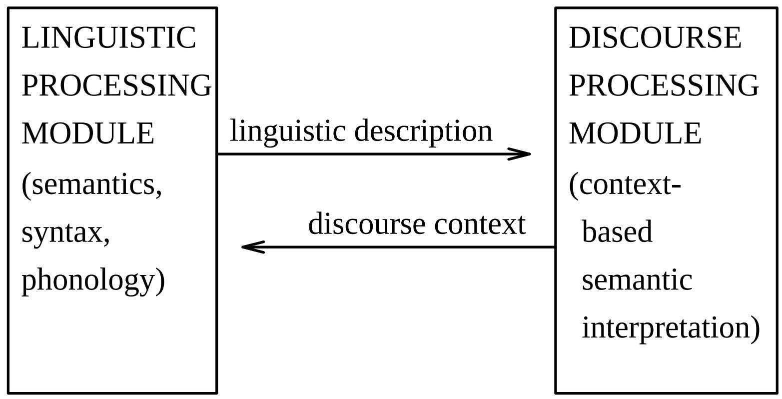

Figure 2.2: A weak modularity architecture for language comprehension

discourse context, a representation of the 'animal-bat' sense to the linguistic processing module and this representation can constrain selection of the sense of *bat*. With weak modularity, the selection of a contextually appropriate sense can take place during linguistic processing.

With strong modularity, however, this account is not possible since interaction between modules is not permitted: the sense of *bat* could only be selected *after* linguistic processing was completed (i.e. after syntactic and semantic representations have been constructed). The semantics module, for example, would have to independently propose interpretations for *bat* and the context-dependent semantic interpretation module would then dispose amongst them (cf. Crain and Steedman 1985). The discourse context is only able to impose restrictions on the sense of expressions after they have been linguistically processed. Furthermore, such an approach runs the risk of a combinatorial explosion: if different senses are associated with different syntactic categories and semantic interpretation only takes place at the end of the utterance, then multiple syntactic structures may need to be constructed.

2.3.3 Symbol Processing

Let us now turn our attention to the third aspect of functional architecture, symbol processing. Symbol processing characterizes information processing in terms of symbols, representing information, which are transformed or manipulated by rules in a manner that is independent of, yet systematically appropriate to, their semantic denotation (cf. Fodor and Pylyshyn 1988; Clark 1989: 12). Cognition, when viewed as information processing, is predominantly described using symbols and rules:

> Language, commonsense reasoning and conscious problem solving can all be described at this level in terms of structures, composed of symbols, that are manipulated by formal rules. (Touretsky 1987: 1)

Even within the connectionist approach to computation, cognition is seen as symbol processing. Of the three schools of connectionism, only the eliminative school denies the validity of symbolic descriptions of cognitive behaviour and claims that the appropriate level of description is sub-symbolic (cf. Pinker and Prince 1987; Touretsky 1987; Smolensky 1988). The remaining schools, the implementational school, which claim that connectionist architectures are mere implementations of the classical symbol processing, and the revisionist school, which claim that connectionist architectures might lead to fundamental changes in our understanding of symbol processing, still maintain a commitment to symbolic cognitive description.

In Fodor and Pylyshyn's interpretation, cognition is characterized in terms of a "language of thought" with the following properties (cf. Fodor 1975; Fodor and Pylyshyn 1988: 12–13):

1. Mental representations have a combinatorial *syntax* and *semantics* in which there is a distinction between structurally atomic and structurally molecular representations; the structurally molecular representations have syntactic constituents that are themselves either structurally molecular or structurally atomic; and the semantic content of a molecular representation is a function of the semantic contents of its syntactic parts.
2. The formality condition: mental processes are (only) sensitive to the structural properties of representations.

Behaviour is described in term of symbol processing where both the symbols and rules are syntactic units which admit a semantic interpretation[6]. This distinction between the syntax and semantics of symbol processing is manifest in that the processes which process symbols are solely determined by the syntactic structure of the symbols: i.e. their labels and structure. The semantic interpretation of symbols, or rules, play no role in the characterization of cognitive processes. Their semantics merely functions as independent validation of the consistency and completeness of the system. Furthermore, the relationship between the syntax and semantics of the system is transparent: semantic properties parallel, or follow from, the syntactic properties. If the symbol has the property of being labelled as syntactically complex, then it is also semantically complex.

This interpretation of symbol processing is intimately related to Fodor's stance on modularity described in section 2.3.2. Processing in each module is characterized in terms of symbols transformed by rules. Since these modules are independent, yet systematically related, it follows that the symbols and rules in these modules are also independent yet systematically related. Symbols and rules in each module thus form distinct vocabularies which need to be explicitly related. These relations are expressed in mapping rules which map between structures of different modules.

Their interpretation of symbol processing can be illustrated by considering the comprehension of *happy women* within the architecture shown in figure 2.1. Given that the processing in the phonological module exports a phonological representation of *happy women* to the syntactic module, this representation needs to be mapped into symbols appropriate to this module. We assume the following symbols and rules in the syntactic module:

(2.4) symbols: ADJ N NP
rules: NP $\rightarrow$ ADJ + N

where '$\rightarrow$' is interpreted as a constituency relation. The mapping rules would then map *happy* onto the symbol ADJ and *women* onto the symbol N. The rules would then be applied resulting in the complex symbol NP related by constituency to the atomic symbols ADJ and N. This structure is then mapped by rules into the semantic module where the following symbols and rules are assumed:

[6] 'Syntax' and 'semantics' here should not be confused with syntax and semantics in linguistics. 'Syntax' simply refers to the structure of the symbol system, whether that structure is syntactic, semantic or phonological. 'Semantics' refers to the interpretation of the system.

(2.5) symbols: PROP OBJ COBJ
rules: COBJ $\rightarrow$ PROP(OBJ)

The mapping rules map ADJ to PROP, N to OBJ and NP to COBJ and the semantic rule establishes the semantic constituency relation between these semantic symbols. The result symbols are then given a semantic interpretation. In the context-independent module, these symbols are mapped onto a set of female individuals with the property 'happy' and context-independent inference rules would apply yielding additional properties such as their relationship to men, their ability to have children and so forth. Only at this point, would *happy women* be give an interpretation within the context. If the context were as follows:

(2.6) The nuns love living in the abbey. These happy women grow their own vegetables and make their own clothes.

then the object for *happy women* could be identified with the object for *the nuns* in the discourse model and domain-specific inferences would then add further properties such as their commitment to celibacy. In this way, the interpretation of *happy women* requires symbols in each module and rules which map between them.

The approach to symbol processing we advocate for a cognitive linguistic approach to language comprehension differs from Fodor and Pylyshyn's in two respects: semantic interpretation is context-dependent; and symbol and rules within modules are characterized in an explicitly information-theoretic manner.

In the first place, language comprehension processes can be affected by context where 'context' includes domain-specific knowledge, perceptual knowledge, discourse knowledge and goals of the cognitive agent. Experimental evidence suggests that inferential processes are not only affected by domain-independent semantic information but also domain-specific information. For example, in the 'four card problem' it has been shown that when abstract concepts are replaced with concepts from familiar domains, inferential abilities are noticeably improved (cf. Wason 1977; Oaksford 1988). Likewise, it has been demonstrated that limitations on young children's reasoning abilities can be affected by the content of the particular tasks, contra the Piagetian position (cf. Donaldson 1978). Other evidence demonstrates that semantic processing can also be affected by the perceptual context. In Gestalt terms, the interpretation of the 'figure' symbol is affected by the interpretation of the 'ground' symbols so that, for example, a grey blob on a black background appears much lighter than the same blob on a white background (cf. Wertheimer 1938). An analogous phenomena has been observed in semantic interpretation. For example, the processes which determine the semantic symbol appropriate for a linguistic expression can be affected by the linguistic context in which the word occurs. In particular, it can affect which semantic properties are accessible. In (2.7), the interpretation of *skunk* is affected by the context in such a way that the property *smell* is more accessible than other properties:

(2.7) The skunk stunk up the entire neighbourhood.

Changing the current context can cause this property to become less accessible than other properties. Evidence of this type has lead to the claim that the semantic representation of a word can be divided into *context-independent* properties and *context-dependent* properties, where the latter only become accessible when the appropriate supporting context is present (cf. Barsalou 1982). Finally semantic processing can also be affected by the goals of the cognitive agent. Semantic categorization is one of these processes[7]. If we accept that concepts form hierarchies, with general concepts at the top and more specific concept underneath them, then the categories in which concepts are placed can vary with the goal of categorization (cf. Kintsch

[7] Categorization is discussed more fully in section 3.2.

1972). For example, while *dog* can be part of a category with *mammal* and *animal*, it can also be part of a category *pet* and *animal*. Which categorization of *dog* is appropriate will differ depending on whether we are interested in a biological or pet classification. If we are interested in the latter then *turtle* will be classified with *dog*; if the goal was the former classification, then *turtle* would not be classified with *dog* (cf. Goodman 1972).

This evidence supports an approach where various sorts of 'context' play a role in language comprehension. What it does not do, however, is distinguish between an approach in which contextual interpretation occurs after non-contextual interpretation versus an approach in which interpretation is systematically based upon context. Crucially, there is a difference between these approaches. In the former approach, the interpretation of ambiguous and polysemous expressions would require all possible senses to be initially accessed and only later would the contextually appropriate sense be selected. In the latter approach, since interpretation takes account of context, only contextually appropriate senses would be considered; contextually inappropriate senses would not. By adopting the later approach as part of the cognitive linguistic approach, we claim that context, specifically discourse context, can restrict semantic interpretation in an immediate rather than delayed manner. In terms of the architecture given in figure 2.2, the claim is that discourse processing can immediately provide a contextually appropriate interpretation of linguistic expressions. This, of course, complements the interaction between the discourse processing and linguistic processing modules: in some cases, the discourse context can immediately restrict semantic interpretation in the discourse processing module; and in other cases, it can immediately restrict the linguistic representations combined in the linguistic processing module.

The second difference with Fodor and Pylyshyn's approach to symbol processing is that we explicitly adopt an information-theoretic approach. Two general approaches to information processing can be distinguished. In the first, the quantitive approach, information is characterized in terms of the number of formal choices or options available in a given state of a computational device and information processing involves a potential reduction, but not an increase, in the number of choices (cf. Shannon and Weaver 1949). In the second, the qualitative approach, information is characterized as the 'content' available in a given state of processing and information processing involves transformations of this content.

Information-theoretic approaches extend the qualitative approach in a number of ways (cf. Gibson 1979; Dretske 1981; Barwise and Perry 1983; Dretske 1985; Devlin 1991). Information is seen as emerging from the satisfaction of constraints: information does not exist a priori, but only after constraints have been satisfied. Constraints are relations between properties. These relations can be conditional or unconditional. Constraints expressing conditional relations are composed of licensing properties and contingent properties: contingent properties are licensed, or justified, by the licensing properties. When constraints have been satisfied, information emerges and this licenses behaviour: the behaviour exhibited by an information processing agent is determined by information which arises from the satisfaction of constraints. Constraints, prior to satisfaction, can be seen as potentially informative and, when satisfied, as actually informative. Once constraints are satisfied, or become informative, they specify information about a situation, such as a visual scene or a discourse situation. Finally, constraints provide information which remains invariant, or persists, under transformation. Recurrent behaviour then is accounted for by persistent information which emerges from the satisfaction of constraints.

This approach can be illustrated with the example of our recurrent behaviour at traffic lights[8]. Consider the situation when we are at a set of traffic lights; if the lights are red, we stop; and if they are green, we drive on. Clearly there is a recurrent relation between the colour of traffic lights and whether we stop or not and this relation persists over time. What behaviour we perform, stopping or driving on, depends upon the information arising from these constraints: if the lights are at green, then this information licenses us to drive on; and if they

[8] I am indebted to Michael Oaksford for the example.

are at red, then this information licenses us to stop. Of course the conditions under which a constraint is satisfied, and thus information licensing behaviour emerges, is far more complex than simply the colour of the traffic lights: it also involves whether we are driving a car, on a 'real' road, and so on (i.e. what we have simply called the situation).

The information-theoretic approach embodied in the cognitive linguistic approach differs from these approaches in its cognitive basis. For the approach adopted by Gibson (1979), as well as by Barwise and Perry (1983), treats constraints as restrictions which hold between situations in the real world. When we, as cognitive agents, are attuned to these constraints, they yield information about the situations in the real world. An alternative is to treat constraints as cognitive relations: they are restrictions between a cognitive agent's interpretations of, or beliefs about, situations independent of whether these relations hold in the real world. The motivation behind this cognitive interpretation will become clear in chapter 4 where the relationship between semantic representation and interpretation is discussed in more detail.

In the cognitive linguistic approach, rules specify globally invariant relationships between symbols within a module: i.e. relationships which hold under any, and every, circumstance. Local invariances are expressed as constraints within symbols.

Constraints specify relations between properties of the symbols. When a constraint is satisfied, the symbol becomes more informative and this affects how the symbol can interact with other symbols. For example, linguistic symbols are structured representations composed of three components — phonological, syntactic and semantic (conceptual) components — and constraints which express relations both within and between these components. During combination, the constraints in symbols guide the combination process by specifying the relationships between syntactic and semantic arguments. With a verb like *kissed* in *Fred kissed his wife*, its linguistic symbol contains constraints which specify that the semantics of its subject is to be identified with the value of the 'agent' role in its semantics, just as the semantics of its object is identified with the value the 'theme' role. Furthermore, constraints play a key role in the discourse processing module. In this module, the important symbols are background knowledge, or theories, about concepts. Constraints associated with these symbols specify semantic relations both within and between concepts. When a linguistic symbol is imported into the discourse module, its conceptual representation is integrated with the current discourse model and a discourse symbol is sought. The constraints in this discourse symbol are then applied to this concept: if they are satisfied, then the concept may be extended with new properties as well as relations with other concepts in the discourse model. For example, the concept 'kiss' may be extended by constraints which specify temporal and causal relations between the concepts which occupy the 'agent' and 'theme' roles.

Since local invariance is specified by constraints in symbols, only three general rules, or principles, are required. The first principle, combination, specifies how symbols in the linguistic processing module combine: i.e. how the symbols for linguistic expressions are combined into a (more informative) symbol for their concatenation. The second and third principle operate in the discourse processing module. The second principle, anchoring, describes how conceptual representations in linguistic symbols are integrated in the current discourse model so as to yield a more informative representation of the discourse. This may involve either the creation of new concepts in the model or the extension of old ones. The third principle, elaboration, describes how concepts in the discourse model are extended on the basis of discourse symbols, or theories. Crucially, this involves the satisfaction of constraints in theories; these constraints can create relations with concepts contained in the discourse model.

2.4 Conclusion

In this chapter we have addressed two issues pertinent to a cognitive linguistic approach to language comprehension: methodology and the status of cognitive descriptions as computational descriptions. With methodology, we rejected an approach to cognition based upon direct observation of neural activity, but advocated a hybrid approach where both informal and experimental observation provide complementary perspectives. Embracing the computational theory of mind, the cognitive linguistic approach was characterized as a level 1 computational description with two modules, a linguistic processing module and a discourse processing modules. The relationship between these modules was seen as bi-directional: the linguistic processing module exports a linguistic description of expressions to the discourse model and the later module exports a portion of the discourse model to the former module. The notion of symbol processing in these modules was given an information-theoretic characterization: rules express global invariances while constraints within symbols express local invariance. Furthermore, the approach make two claims about the effects of context on language comprehension. Firstly, it was claimed that semantic interpretation in the discourse module can be affected by the discourse context so that contextually inappropriate senses of ambiguous and polysemous expressions are not integrated and elaborated as concepts in the discourse model. Secondly, it was claimed that the discourse context can affect linguistic symbols in the linguistic processing module such that contextually inappropriate senses of ambiguous and polysemous expressions can be discarded prior to combination. Before we develop this approach further we need to provide empirical evidence which supports these contextual effects on conceptual representations.

Chapter 3

Concepts in Categorization and Lexical Access

3.1 Introduction

In chapter 2 we developed the notion of linguistic description as a description of the cognitive representations and processes which underlie a cognitive agent's linguistic behaviour. In particular, these descriptions are to be supported and validated through informal and experimental evidence pertaining to human cognitive agents; and the descriptions are seen as Marr's level 1 computational descriptions with language comprehension characterized in terms of two modules, a linguistic processing module and a discourse processing module, whose symbols contain constraints specifying local invariance and whose rules describe global invariance in comprehension.

Central to this cognitive linguistic approach to language comprehension are conceptual structures, the processes by which they are constructed and the effects of context on these processes. In particular, three levels of conceptual structure can be established: *lexical conceptual structure* associated with lexical expressions; *linguistic conceptual structure* which arises from the combination of lexical conceptual structures in the linguistic processing module; and *discourse conceptual structure* which arises from interpretation of linguistic conceptual structures within the discourse processing module. In order to provide a precise characterization of these conceptual structures, we need empirical evidence about their general nature and structure: this puts us in a position to make more precise the distinction between linguistic and discourse conceptual structures as well as the relation between them. To achieve this goal, we shall discuss two approaches to conceptual structure, or more general concepts, which have been adopted in cognitive psychology to account for categorization.

Furthermore, our approach makes two claims about the effects of context on the construction of conceptual structure. The first is that context can affect the construction of discourse conceptual structure. In particular, discourse context can affect selection of the senses of ambiguous and polysemous expressions. If we assume that these expressions are associated with lexical conceptual structure which specify multiple senses, and these multiple senses are retained in the linguistic conceptual structure when they combine with other expressions, then context affects the process by which they are related to discourse conceptual structures such that only those senses appropriate to the discourse context are retained — inappropriate senses are discarded. The second claim is that discourse context can also affect the construction of linguistic conceptual structure from lexical conceptual structure. With ambiguous and polysemous expressions, senses appropriate to the discourse context are retained in the linguistic conceptual structure whereas inappropriate ones are discarded. Thus discourse context can be seen as imposing restrictions which determine which senses are appropriate and which inappropriate: in some cases, it restricts discourse processes which construct discourse conceptual structure from linguistic conceptual structure; and in others, it restricts the linguistic process which constructs linguistic structure from lexical conceptual structure. These claims will be supported not only by categorization evidence, but also by lexical access evidence.

The chapter is organized as follows. Categorization is discussed in section 3.2. In section 3.2.1 and section 3.2.2 respectively, empirical evidence is adduced to show that the characterizations of concepts offered by the classical and prototype approaches are problematic, especially with respect to context effects on categorization. In section 3.3, we turn our attention to context effects on lexical access and consider two points of view: a view which claims that all senses of lexical expressions are available for linguistic processing independent of context; and a view which claims that context can restrict the senses available for linguistic processing. Section 3.4 concludes the chapter.

3.2 Categorization

At its simplest, categorization concerns the ability to judge 'category' relations between concepts: i.e. to decide whether one concept is an instance, or *exemplar*, of another concept. Our discussion of categorization is restricted in three ways. Firstly, we shall focus on lexical concept categorization: i.e. our ability to judge relations between concepts which can be represented by single linguistic expressions (cf. Murphy 1988). Secondly, the research on categorization has primarily focused on concepts which describe entities, such as *fruit* and *furniture*, rather than events, states and actions (cf. Medin and Smith 1984: 122)[1]. While this allows us to build up an accurate picture of entity concepts, it does run the risk that the characterization will not generalize to other types of concepts. We shall assume, however, that the characterization of entity concept will generalize unless there is specific evidence to the contrary (cf. the use of corroborative evidence in section 2.2.2). Finally, for reasons of space, only decompositional featural approaches are discussed: i.e. approaches where concepts are structured in terms of features and relations. Accordingly, we shall not discuss non-decompositional approaches such as the extensional approach where concepts are treated as unanalyzed units structured by meaning postulates (cf. Kintsch 1974; Fodor et al. 1975; Fodor 1977; Fodor et al. 1980). Nor shall we discuss non-featural accounts such as the dimensional probabilistic approach and the holistic probabilistic approach (cf. Rosch et al. 1976b; Smith and Medin 1981: 130–142).

3.2.1 The Classical Approach

The classical approach, CA, has its roots in the Aristotelian notion that the meaning of words are definitions (cf. Johnson-Laird 1983; Medin and Smith 1984). This approach can be seen as a cognitive version of the correspondence approach to meaning (see section 4.2): concepts are treated as cognitive representations which refer to sets, or categories, of objects in the world (cf. Murphy and Medin 1985: 290). Underpinning the relationship between concepts and categories is an ontological commitment: conceptualization 'cuts the world at its joints', so that conceptualization reflects the categorial structure of the world. This influential approach to concepts, although criticized by a few (cf. Cassirer 1923; Wittgenstein 1953), remained the standard approach until recently, when not only were several empirical weaknesses exposed, but, perhaps more importantly, a rival approach, the prototype approach, was developed. Although there were some subsequent attempts to revive the classical approach within cognitive psychology, such as the hybrid conceptual core approach and the backup approach, these sharply delimited its scope (cf. Miller and Johnson-Laird 1976).

In the CA, concepts are summary representations in the sense that they provide a short

[1] Concepts and their features are indicated in the text as *concept*.

unitary description of all its subordinate concepts. For example, the concept *fruit* would be represented by a single description which covers all its subordinate concepts, such as *apples*, *pears* and *lemons*, rather than as a multiple description which covers each of these subconcepts[2]. These summary representations are composed of a set of necessary features which are sufficient to refer to all and only its corresponding objects in the world. That is, they are definitional descriptions where each feature necessarily holds of each and every subordinate concept and the set of features is sufficient to delimit reference to the corresponding category of objects in the world. For example, *bachelor* can be defined in terms of the necessary features *unmarried*, *male* and *adult* (cf. Katz 1972). Thus, there cannot be a *bachelor* who is not *unmarried*, *male* and *adult* and any object in the world of which these features hold is, by definition, a *bachelor*. Finally, the superordinate-subordinate distinction is characterized in terms of a subset relation between concepts which gives rise to different levels of conceptualization. For example, in figure 3.1, there are two levels of categorization: the first level contains the concept *furniture*; and the second, the concepts *table* and *chair*. These levels emerge from subset relation

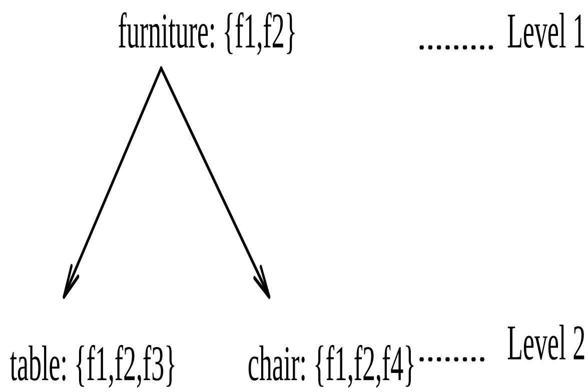

Figure 3.1: The organization of concepts in the Classical Approach

between the concepts: the concept *furniture* is the superordinate concept and the concepts *table* and *chair* are subordinate concepts since the subordinate concepts contain as part of their definitions, the set of necessary features, $\{f1, f2, f3\}$, which define the superordinate concept. The definition of these subordinate concepts also contains other features not defined by *furniture*, features which differentiate subordinate concepts from each other; for example, *table* contains the feature $f3$ and *chair* the feature $f4$.

Strengths of the Classical Approach

Two strengths of CA are its representational elegance and determinacy in categorization. The CA is elegant in that concepts are compact summary representations comprising a set of features capable of picking out (identifying) all and only the objects in the corresponding category. This strength arises in part because there is no distinction between the concept itself and the conditions under which it correctly applies: i.e. the features which are necessary and sufficient for the definition of the concept are also the conditions which correctly identify the corresponding category of objects in the world.

The CA also confers certainty in categorization since a conceptual description will only apply when its definition is satisfied. This certainty is also evident in inference since if we know that an object is in a category corresponding to a given concept, then we necessarily know what

[2] This later approach is adopted by the exemplar prototype approach described in section 3.2.2.

features it will have. For example, if I know that *John* is a *bachelor* then, since the features of this concept are necessary features, I know with maximum certainty that *John* is *male*, *unmarried* and an *adult*. As we will see in section 4.3.2, this certainty is bought at a price and the price is rigidity: if, for whatever reason, we come across an object which lacks one of the alleged defining features, then we are thrown into complete uncertainty as to the status of the concept.

Weaknesses of the Classical Approach

There are five weaknesses of the CA with respect to categorization: variation in the centrality of concepts; the use of characteristic features; the existence of unclear cases; the lack of overt definitions; and a nesting problem.

The first weakness is that it fails to predict that concepts differ in 'centrality'. In the CA, categorization is symmetrical in the sense that all subordinate concepts have equal status as members, or exemplars, of a concept. However, there is evidence which suggests categorization is not symmetrical: some concepts are more central to the superordinate concept than other concepts (member centrality); and some conceptual levels are more central than others (level centrality).

Member centrality is manifest in categorization as *typicality effects*: the more central a concept, the more 'typical' it is of the superordinate concept. For example, the concept *bird* includes subordinate concepts such as *eagle*, *dove*, *parrot* and so on. These concepts may differ in categorization tasks such that *eagle*, for example, systematically manifests more typicality effects than the other concepts. There is considerable experimental evidence for typicality effects (cf. Rips et al. 1973; Rosch 1973; Rosch 1974; Rosch 1975; Rosch 1978):

Goodness of Exemplar Rating Members, exemplars, of the same concept systematically differ with respect to typicality or representativeness (cf. Rips et al. 1973; Rosch 1973). When subjects were asked to rate how good an example of the concept various members are, it was found that there were differences in goodness of exemplar (GOE) ratings which were systematic across subjects (cf. Rosch 1973; Mervis et al. 1976). For example, when *robin*, *chicken*, *duck* and *goose* are rated for their GOE as the concept *bird*, *robin* has a significantly higher GOE rating than *chicken*, *duck* or *goose* (3.00 v. 2.00 — Rips et al. 1973).

Reaction Time Members of a concept differ with respect to reaction time (RT) for verification (cf. Roth and Shoben 1983). Subjects were given a sentence of the form *An [example] is a [concept]*, where *[example]* was a subordinate concept of *[concept]*, and were asked to decide if the sentence was true. The results show that subconcepts differed in RT; for example, *A robin is a bird* took less time to verify than than *A chicken is a bird* and *A goose is a bird*.

Error Rates Members of a concept differ with respect to error rates in verification. Again, the members judged more central by other measures have a lower error rate than members judged less central or peripheral.

Production of Exemplars Members systematically differ with respect to the order in which they are produced (verbally or graphically): central members tend to be produced before non-central ones (cf. Mervis et al. 1976).

Similarity Central subordinate concepts tend to be less similar to peripheral subordinate concepts of a concept than vice versa. For example, when American subjects judged *United States* to be a very good example of the concept *country*, they also rated *Mexico* as more similar to the *United States* than the *United States* is to *Mexico* (cf. Rosch 1975; Tversky and Gati 1978).

Generalization Central members tend to allow generalization of new information to other, more peripheral members than vice versa (cf. Rips 1975). For example, if people are told that *robins* have a contagious disease, then they are more likely to believe that the disease spreads from *robins* to *ducks* on an island than from *ducks* to *robins* when told that *ducks* have the disease.

Acquisition Members of a category systematically differ in acquisition such that central member tend to be learnt before peripheral members. This has been demonstrated in both semantic and perceptual categorization tasks (cf. Rosch 1973; Mervis 1980).

These typicality effects support the hypothesis that subordinate concepts may differ in centrality. Furthermore, since the subordinate concept(s) which tend to manifest centrality within one task also tend to manifest centrality in other tasks, these concepts are central to the superordinate concept in the sense that they systematically manifest priority across different tasks. It is important to note that centrality is merely based upon a tendency to manifest typicality effects in a given task — central concepts do not *necessarily* manifest these effects.

Empirical evidence also supports level centrality as manifest in 'basic-level' effects. Observation of these effects can be traced to Roger Brown (cf. Brown 1958; Brown 1965). He observed that while an object, such as *dime*, can be categorized at many levels within a conceptual hierarchy, one level was central or basic. He argued for the existence of such a level on the grounds that it was the level of distinctive actions[3], the level first acquired by children and used to name things, and the level where names are shortest and used most frequently.

More specific observations were made by Berlin with respect to levels of natural kind categorization made by Tzeltal speakers of Mexico (cf. Berlin et al. 1974). The basic level of categorization was manifest in simple naming task: when natives were asked to name plants and animals around them, they tended to name them at the 'middle' level of categorization, genus, rather than at the superordinate (less specific) life form level, or at the subordinate (more specific) species level. For example, particular trees tended to be named as *oak* rather than *tree* or *white oak*. These observations of the centrality of the middle level were reinforced by experimental studies (cf. Rosch et al. 1976a; Mervis and Crisafi 1982; Murphy and Smith 1982). For example, with the hierarchy *fruit*, *pear* and *conference pear*, the middle-level, *pear*, has priority with respect to speed of categorization and ease of learning. Other experimental manifestations of level centrality parallel those discussed for member centrality.

The second weakness is that the CA does not predict that non-necessary, or characteristic, features play a role in categorization since concepts only contain features which necessarily hold of all its subordinate concepts. Rosch and colleagues conducted a series of experiments in which they attempted to specify the determinants of member centrality (cf. Rosch and Mervis 1975; Rosch et al. 1976b; Mervis and Rosch 1981). In one experiment subjects were asked to list features of subordinate concepts of natural kind concepts such as *bird*, *furniture*, and *fruit*. The features listed for these concepts included non-necessary features; for example, the feature *made of wood* was listed for the subordinate concept *chair*, but it is not necessarily the case that all chairs are made of wood. In fact, they demonstrated that there was a correlation between the frequency with which features of a particular subordinate concept were listed and its centrality in a superordinate as manifest in its GOE rating, speed of verification, and so on. This correlation, 'family resemblance', stated that in superordinate concepts, the centrality of a subordinate concept increases with the number of features it shares with other subordinate concepts, and decreases with the number it shares with the subordinate concepts of other superordinate concepts. For example, the subordinate concept *chair* has a high family resemblance measure while the subordinate *lamp* has a low measure, and this correlates with their respective centrality in the superordinate concept *furniture*.

[3] Objects categorized at this level correlate with distinctive non-linguistic actions whereas other levels of categorization lack such distinctive actions. For example, *dimes* are associated with distinctive actions such as exchangeable for cigarettes, milk, two nickels and so on; other levels of categorization, such as *money* (superordinate level) and *1952 dime* (subordinate) are not.

The use of non-necessary features in categorization is well attested by other researchers. Hampton, for example, had one group of subjects list features of concepts like *fruit* and then rate the degree to which their subordinate concepts had these features (cf. Hampton 1979). These ratings were then used to predict the time taken by another group of subjects to categorize the subordinate concepts. Again, these features were non-necessary and the number of features shared by the concept and its subordinate concepts provided a good indication of the centrality of the subordinate concepts. Further evidence of the use of non-necessary features comes from experiments which use similarity judgments rather than attribute listing (cf. Rips et al. 1973; Shoben 1976). In such experiments subjects are given two concepts to rate for similarity; for example, *bird-eagle* (superordinate and subordinate concepts) and *robin-eagle* (subordinate concepts). The ratings are then used to construct a multi-dimensional similarity space where distance between concepts correlates with their similarity (or dissimilarity). It was found that the dimensions seem to reflect non-necessary features, such as *ferocity*, and that the distance between a concept and its subordinate concepts correlates highly with categorization time.

These results are not only problematic for the CA in showing that non-necessary features play a role in categorization, but also problematic in that variation in the centrality of subordinate concepts seems to correlate with (non-necessary) feature similarity to the superordinate concept. However, it should be pointed out that the attribute listing methodology has been questioned (cf. Tversky and Hemmenway 1984; Tversky 1977). In particular, it has been argued that discourse and situational factors may affect attribute listing (cf. Tversky and Hemmenway 1984). When subjects list attributes, they may only mention those which make explicit relevant contrasts between subordinate concepts rather than necessary features[4]; for example, *two-legged* may be listed as a feature of *bird* but not of *chicken* or *duck* because it does not distinguish between these concepts, whereas *flies*, listed for *robin*, distinguishes it from other subordinate concepts such as *chicken* and *penguin*. Additionally, they may list features which are relevant by virtue of being salient in the situations in which the concept is encountered; for example, although *edible* can be seen as a feature of *food*, *animals*, *money*, *wood* and so on, the feature is only directly relevant to the situations in which *food* is typically used. Even with this qualification, however, it seems difficult to deny that concepts consist of more than necessary features and that non-necessary features play a role in categorization. This has been acknowledged in one extension of the CA, where concepts are partitioned into a definitional core with necessary features and an identification procedure with non-necessary features (cf. Medin and Smith 1984; Miller and Johnson-Laird 1976).

A third weakness of the CA concerns the existence of unclear cases of categorization. Since concepts are definitions and subordinate concepts contain the definitional features of their superordinate concept, the CA predicts determinacy in categorization. However, their categorization can be uncertain. For example, since subjects did not consistently categorize *tomatoes* as *fruit* nor *boxing gloves* as *clothes*, it is argued that categorization can be indeterminate (cf. Cohen and Murphy 1984; McCloskey and Glucksberg 1978).

Indeterminacy in categorization seems a priori problematic if categorization is based upon comparison between definitional concepts. However, the CA can adopt various lines of retreat. One of these derives from Putnam's 'division of linguistic labour' whereby some cognitive agents have non-definitional concepts, but others, experts in the linguistic community, have definitional concepts (cf. Putnam 1973). For example, my concept of *gold* may be incomplete as a definition, such as *a yellow precious metal*, since it is not sufficient to pick out all and only the 'gold' objects in the world, whereas an expert's definition is sufficient and yields a determinate categorization of objects. The main drawback of this solution, as we shall see, is that even expert's concepts are not necessarily CA definitions. Another retreat is to assume that the same expression can be associated with more one than concept. It has been argued that natural kind expressions are associated with two definitional concepts, a technical one and a common one (cf. Holyoak and Glass 1975). So, for example, the difficulty in categorizing *tomato* as a *fruit* may stem from the expression being associated with two definitions, one

[4] They invoke Grice's principle of relevance (cf. Grice 1975).

satisfying the technical definition of *fruit* (by virtue of having seeds) and another satisfying the common definition of *vegetable* (by virtue of its role in meals).

The fourth weakness of the CA is that the definitional nature of concepts is not manifestion in categorization. In experiments where subjects listed attributes for concepts such as *furniture* and its subordinate concepts *chair*, *table* and so on, the results show that no features listed for one of these subordinate concepts were also listed for other subordinate concepts; i.e. no necessary features of *furniture* was listed for its subordinate concepts (cf. Rosch and Mervis 1975). Furthermore, observational evidence supports the claim that concepts are not necessarily definitions. Wittgenstein argued that concepts like *game* and *number* lack definitions since they do not to share a set of necessary features with their subordinate concepts:

> Look for example at board-games, with their multifarious relationships. Now pass to card-games; here you many find correspondences with the first group, but many common features drop out and others appear. When we pass next to ball-games, much that is common is retained, but much is lost. — Are they all 'amusing'? Compare chess with noughts and crosses. Or is there always winning and losing, or competition between players? Think of patience ...And we can go through the many, many other groups of games in the same way; can see how similarities crop up and disappear. (Wittgenstein 1953: 66)

The claim then is that there is no set of features common to all *games* sufficient for the correct identification of the corresponding objects in the world. Of course, there are some features, such as 'being an event', which are common to all *games*, but no set of these are sufficient to pick out instances of 'games' in the world (cf. Carey 1982: 386).

Closely related to Wittgenstein's argument against definitions is one by Austin (1961). He questioned the traditional notion that concepts associated with the same expression, i.e. senses of an expression, are simply subordinate concepts of the same superordinate concept. Consider the three senses of the adjective *healthy* in *healthy body*, *healthy complexion* and *healthy exercise*:

> There is what we may call a *primary nuclear sense* of 'healthy': the sense in which 'healthy' is used of a healthy body: I call this *nuclear* because it is 'contained as a part' in the other two senses which may be set out as 'productive of healthy bodies' and 'resulting from a healthy body'. (Austin 1961:71 quoted in Lakoff 1987:18)

The relation between these senses, or concepts, is not simply based upon sharing features which are sufficient to delimit a superordinate concept. Rather the concepts associated with the expression seem to be ordered in terms of centrality with *healthy qua a body* as the central concept. The others are related to this concept by virtue of a metonomy relation: i.e. *healthy qua exercise* produces *healthy bodies* and *healthy qua complexion* is the result of *healthy bodies* (cf. Lakoff 1987: 19).

Such experimental and observation evidence provides prime facie counter-evidence to the CA's claim that concepts are definitions. One response to this evidence is to claim that only a subset of concepts, such as scientific concepts, have definitions. These concepts have been taken as providing the best support for the claim that concepts can have definitions and these definitions are sufficient to identify pre-existing categories in the world; for example, biological concepts have been given definitions by biologists and these concepts correspond to 'real' biological categories in the world. If this was the case, then biological concepts would provide evidence that at least a subset of concepts have definitions. However, it is neither the case that biological concepts reflect pre-existing categories in the world nor that their concepts are CA definitions (cf. Lakoff 1987: 185–195).

If biologists' concepts did correspond to pre-existing categories of animals in world, then we would expect there to be unanimous agreement as to these categories. This, however, is not the case. There are at least three contrastive classifications: the phenetic, cladistic and evolutionist classifications. For example, two species of *zebra*, *Grevey's zebra* and *mountain zebra*, are categorized differently according to these classifications: by the phenetic criteria, basically overall current similarity, they both belong to a single category, but by the cladistic criteria, roughly shared (historically) derived character, they belong to different categories. Both classifications are useful in biology: one reveals groupings based upon current similarity while the other takes a more historically oriented approach. This multiplicity of classifications is hard to reconcile with the notion that biological concepts correspond to pre-existing category in the world. Rather it demonstrates that biologists are capable of developing diverse classifications depending upon what satisfies their current goals. As a result, it seems problematic to bestow upon their categorization any metaphysical significance. If this is the case with expert's concepts, then the ontological commitment which underpins the CA seems flawed. Furthermore, biological concepts are not obviously CA definitions. As Lakoff (1987) points out, the biological species concept of the evolutionist position, fails to meet the criteria for classical definitions. For example, species do not have homogeneous internal structures where members share a set of necessary and sufficient features; definitions are polythetic. Thus it is difficult to reconcile CA definitions with biological definitions and, by analogy, other supposedly 'well-defined' conceptual domains.

A more successful response to this evidence is to maintain that concepts are definitions, but admit that categorization evidence, as manifest in attribute listing for example, simply does not reveal the necessary features (cf. Smith and Medin 1981: 30). In particular, definitions can be seen as 'hidden' parts of concepts, parts which do play a role in cognitive processes such as categorization, comprehension and production, but parts which are not easy to verbalize. That certain aspects of concepts are 'hidden' in this sense is not particularly controversial nor implausible. For example, Johnson-Laird (1987) makes a distinction between verbal definitions and ineffable (truth) conditions: i.e. between meaning acquired from verbal definition or use in verbal expressions and meaning acquired from direct acquaintance with the referents of the expression (cf. Johnson-Laird 1987: 205–206).

The final weakness of the CA concerns concept nesting: the definitions of superordinate concepts are nested inside subordinate concepts (cf. Smith and Medin 1981: 46–49). If concept similarity is based on common and distinctive features, a concept should be more similar to its immediate superordinate concept than to a distant superordinate concept (cf. Tversky 1977). Conversely, if categorization speed is dependent upon the number of features to be compared, then it should be quicker to categorize the concept as a distant superordinate than an immediate one.

Experimental studies, however, confound definitional concept nesting. In one study, a subordinate concept was given to subjects and they were asked to list its superordinates. Given that the frequency with which a superordinate is produced is a measure of the similarity, the CA predicts that immediate superordinates will be produced more frequently than distant superordinates. The results show that no superordinate was more likely than any other; for example, given *rose*, *flower* was not more frequently produced than *plant* (cf. Loftus and Scheff 1971). In more recent studies, a concept and one of its superordinates were directly rated for similarity (cf. Rips et al. 1973; Smith et al. 1974; Roth and Shoben 1983). The results showed a tendency for concepts to be rated as more similar to immediate than distant superordinates. There were significant exceptions to this tendency; for example, *duck* and *chicken* were rated more similar to *animal* than *bird*. The CA, while predicting the tendency, fails to account for the exceptions. In a third set of studies, categorization times were investigated with respect to concept nesting. Although some early studies found that categorizations were fastest for immediate superordinates (cf. Collins and Quillian 1969), others found no significant result (cf. Smith et al. 1974), a recent study found results parallelling those of the similarity rating experiments (cf. Roth and Shoben 1983). That is, there was a tendency for categorization to be fastest with immediate rather than distant superordinate concepts, but there were notable exceptions; for example, it took longer to categorize *duck* as a *bird* than *duck* as an *animal*.

While these results confound the CA's predictions about nesting, the exceptions themselves are interesting in that they reveal an interaction between level and member centrality. Given that the basic level is the immediate superordinate, similarity between concepts at this level and concepts at a superordinate level is determined not only by the common and distinctive features, but also by the centrality of the superordinate concept in the basic level concept such that peripheral subordinate concepts, such as *duck*, are judged significantly less related to the basic level concept than central subordinate concepts, such as *robin*, but more related to distant superordinate concepts such as *animal*. Clearly, if an approach to concepts is to account for this type of categorization evidence then, unlike the CA, it must at least recognize level and member centrality.

In sum, categorization reveals a number of weaknesses in the classical approach's characterization of concepts. Having said this, it is possible to envisage an approach which is based upon some tenets of this approach. A number of changes would be required though. In the first place, the approach would need to countenance the role of typicality in conceptual representations: subordinate concepts can vary in the extent to which they are typical of their superordinate concept; conceptual levels would also need to vary in typicality; non-necessary, or typical, features would need to be introduced into the characterization of concepts. As we have just observed, the interaction between member and level typicality could then account for nesting. As for indeterminacy in categorization, this could be accounted for if we accepted that the same linguistic expression may be associated with more than one concept, and these concepts were not necessarily subordinate concepts of the same superordinate concept. In addition, we would also need to accept that the relationship between concepts and categories in the world is not transparent; biological concepts, for example, do not necessarily correspond to pre-existing categories in the world. Finally, the evidence for necessary features is not well supported empirically: even if we accept that these features are 'hidden' by, for example, the attribute listing methodology, then an alternative source of support is required for these features.

3.2.2 The Prototype Approach

The prototype approach (PA) offers a radically different characterization of concept compared with the classical approach. For rather than extend the classical approach to meet the empirical shortcomings discussed in section 3.2.1, the characterization of concepts was directly based upon empirical data, especially data which highlighted a correlation between the typicality relations between concepts and conceptual levels, and characteristic (or typical) features of concepts (cf. Lakoff 1987: 136–7). In particular, the PA rejects the characterization of concepts as sets of necessary features. Instead it characterizes concepts in terms of a set of characteristic features, the *prototype*, which stands a minimum distance from other subordinate concepts, or exemplars, of the concept, and a maximum distance from the exemplars of contrastive concepts. Membership of the concept is determined by a similarity metric (with a threshold) which measures the degree of similarity between a potential exemplar and the concept prototype. Within the PA there are two views: the probabilistic view and the exemplar view.

The Probabilistic View The probabilistic view, like the CA, holds that concepts are summary representations: i.e. the prototype constitutes a homogeneous representation of the concept. Its homogeneity has two consequences for the prototype: it is an abstract representation; and it always plays a role in categorization. Furthermore, the prototype is structured probabilistically: i.e. it consists of a set of characteristic features which vary in their probability of occurring in exemplars of the concept. A simple probabilistic representation for *apple* is given in figure 3.2 (cf. Smith and Osherson 1984). In figure 3.2 the weights on the features *colour*, *shape* and *texture* represent their diagnosticity (or salience in categorization) and the weights on the (mutually exclusive) values, such as *red*, *white* and *yellow*, represent the likelihood of an exemplar having a feature with this value. The prototype for *apple* is constructed from this representation by selecting the features and values with the highest weight: i.e. the prototypical *apple* is *red*, *round* and *smooth*. Membership of the concept is based on a metric which

3	colour	red	8
		white	1
		yellow	1
		...	
		...	
1	shape	round	9
		oval	3
		...	
		...	
2	texture	smooth	9
		rough	1
		...	
		...	

Figure 3.2: A probabilistic representation of the concept *apple*

determines whether the target concept possesses some criterial sum of the weighted features of this prototype. For example, while a *red apple* or *brown apple* will be exemplars by virtue of meeting the similarity threshold, a *lemon* will not since it fails to be sufficiently close to the prototype in terms of *shape* (*oval*), *texture* (*rough*) and *colour* (*yellow*).

The Exemplar View The exemplar view differs from the probabilistic view in not treating concepts as summary representations. The prototype is a set of one or more specific exemplars of the concept. With the representation of the concept *apple* shown in figure 3.3, the prototype consists of the specific exemplars *granny smith* and *golden delicious* apples. In this representation, the prototypes *granny smith* and *golden delicious* apples are specializations of *apple* and each prototype is given a featural description (cf. Smith and Medin 1981: 145). Membership of a concept is decided on the basis of (unweighted) featural similarity with the prototypes. Since the prototype consists of multiple descriptions, the exemplar view permits membership decision to be made in various ways: for example, all prototype exemplars could be retrieved and the target concept is a member if it is sufficiently similar to one of these; or, making use of the homogeneity of structure, only one of these exemplars may be retrieved and compared with the target concept.

	apple	
Exemplar 1 granny-smith	Exemplar 2 golden-delicious	other instances (not exemplars)
shape: round texture: smooth colour: brown	shape: round texture: smooth colour: green	

Figure 3.3: An exemplar representation of the concept *apple*

The substantive difference between these PA views is not the abstractness nor multiplicity of prototypes, but explicitness of disjunction.

In both views the prototype can actually vary in abstractness. The probabilistic view does not exclude a concrete prototype and the exemplar view permits abstract prototypes. For example, the Medin and Schaffer (1978) context model and the Cohen and Murphy (1984) model are versions of the exemplar view which incorporate summary information in the prototype. Furthermore, empirical evidence suggested that prototypes may vary in abstractness. For example, in Rosch's work on colour categories she found that focal colours were best exemplars, or prototypes, even though there were no names for them in the language (cf. Rosch 1973). Other work has shown that more specific exemplars may also be used in categorization. For example, it has been demonstrated that when subjects were asked to estimate the frequency of certain types of events, their estimates were based upon recruitment of a few specific exemplars of each event type (cf. Kahneman and Tversky 1973; Kahneman and Miller 1986). Other studies have furnished evidence by demonstrating that the negative categorizations, i.e. deciding that a target concept is not a member of a given concept, is based upon the retrieval of particular counterexamples. For example, the speed in deciding that *all birds are eagles* is false may be attributed to the retrieval of the counterexample *robins* (cf. Holyoak and Glass 1975). And if specific exemplars are used in negative categorizations, it is plausible that they are used in other sorts of categorizations.

Another insubstantial difference is the multiplicity of prototypes. Categorization data certainly supports their multiplicity. In many cases more than one exemplar attains relatively high GOE rating; for example, *carrot* and *peas* have ratings of 1.5 and 1.7 respectively as exemplars of *vegetable* (cf. Armstrong et al. 1983: 276). Furthermore, it is difficult to imagine there being a single prototype for concepts such as *animal* or *furniture* (cf. Smith and Medin 1981: 147). While this seems to confound the probabilistic view, it is plausible that more than one prototype can be abstracted from the representation by varying the diagnosticity of features.

The important difference between these views concerns disjunction (cf. Smith 1978). The probabilistic view involves implicit disjunction, while the exemplar view involves explicit disjunction. This is illustrated schematically in figure 3.4 (cf. Smith and Medin 1981: 167). The

Concept	Instance 1	Instance 2
w_1F_1	F_1	F_3
w_2F_2	F_2	F_4
w_3F_3	F_5	F_5
w_4F_4		
w_5F_5		

Concept		Instance 1	Instance 2
Exemplar 1	Exemplar 2		
F_1	F_3	F_1	F_3
F_2	F_4	F_2	F_4
F_5	F_5	F_5	F_5

Figure 3.4: Implicit and explicit disjunction in prototype concepts

significance of this difference will become apparent when we consider how the PA accounts for the apparent lack of definitions.

Strengths of the Prototype Approach

Unsurprisingly, the strengths of the PA are that it accounts for the empirical data on categorization which is problematic for the CA.

The first strength is that it predicts that exemplars, or subordinate concepts, vary in centrality. The central exemplar(s) is represented as the prototype and categorization is based upon sufficient similarity with the prototype. Since the prototype is represented in terms of features, these features are the (proto)typical features of the concept: they tend to be shared by many (but not necessarily all) exemplars of concept and constitute the basis for the determination of categorization (cf. Rosch and Mervis 1975). The similarity metric varies slightly depending upon which PA view we consider. With the probabilistic view, for example, the metric is based upon weighted features: a target concept is more similar to a concept depending on similarity as measured by weighted shared features. Thus *robin* would share more salient features with *bird* than *chicken*; whereas *bird* and *robin* share *feathered*, *winged*, *flies* and *sings*, *bird* and *chicken* lack the last two features (alternatively, these features are not so highly weighted in *chicken* as they are in *bird*). Now consider two manifestations of centrality: typicality ratings and speed of categorization. With typicality ratings, *robin* will be judged more representative of *bird* than *chicken* since it has a higher 'family resemblance' score than *chicken*; likewise, *robin* will be quicker to categorize as a *bird* than *chicken* since the similarity metric will attain the threshold for *bird* more quickly than for *chicken*.

The second strength is that it accounts for level centrality: i.e. experimental evidence which supports the centrality of the 'basic level'. One account is based upon cue validity (cf. Rosch and Mervis 1975; Rosch 1978). Cue validity can be seen as an alternative similarity metric for the probabilistic view. Rather than base similarity on shared features, the family resemblance metric is based upon distinctive shared features: i.e. features common to the concept which are not possessed by contrastive concepts (cf. Medin et al. 1987: 244). For example, while *animate* is a common feature for *bird*, it is not distinctive in that it is shared with contrastive concepts such as *dog*, *cat*, *elephant* and so on (cf. *flies* and *winged*). Cue validity is the conditional probability that a exemplar is a member of a particular concept given some feature as a cue (cf. Smith and Medin 1981: 79):

> The cue validity of a particular feature f, vis-a-vis a particular target concept x, is such that it increases with the probability that f occurs with exemplars of f and decreases with the probability that f occurs with exemplars that contrast with x.

For example, *animate* would have a low cue validity for *bird*, whereas *feathered* would have a high cue validity.

Category cue validity can be defined as the sum of all individual cue validities of the features associated with a concept and, it is argued, concepts at the basic level have the highest category cue validity. For example, in the taxonomy with *furniture*, *chair* and *kitchen chair*, *chair*, as the concept on the basic level, should have the highest category cue validity. The cue validity for the subordinate concept *kitchen chair* will be low because most of its features will be shared with other contrastive concepts and only a few features, such as *found-in-kitchens*, would be distinctive to the concept. Likewise, *furniture* will have a low category cue validity since it has few or no common features (cf. Rosch and Mervis 1975). The basic level category *chair*, however, will have a high category cue validity since its exemplars share many distinctive features.

The third strength of the PA is its ability to account for nesting phenomena. Given that similarity is measured in terms of family resemblance, the PA predicts that while *robin* is judged more similar to *bird*, *chicken* is judged more similar to *animal*. For *robin* has more shared features, and fewer distinctive feature, with *bird* than *animal*, whereas the reverse holds for *chicken*. Likewise *robin* will be categorized as a *bird* faster than it will categorized as an *animal* since it shares more features with *bird* and thus will reach its membership threshold fastest. The opposite holds for *chicken*: it will be categorized faster as an *animal* than as a *bird* since it shares more features with *animal*. The different views within the PA may account for this in slightly different ways; for example, the probabilistic view will measure similarity in terms of the weighted sum; and the exemplar view can account for this phenomena even more transparently by including in the prototype of *bird* the exemplar *robin* but not *chicken* and including the exemplar *chicken* but not *robin* in the prototype of *animal* (cf. Smith and Medin 1981: 151). Thus the PA accounts for the interaction between member and level centrality: central exemplars of a basic level concept are more closely related to the immediate superordinate than distant superordinates, whereas the reverse holds for peripheral exemplars.

Its fourth strength is its account of unclear cases. Unclear cases of membership can arise from two sources in the PA: the target concept can have a family resemblance score which is close to, but does not exceed, the threshold; and its family resemblance score can be close to, or perhaps exceed, the threshold of more than one concept. For example, *boxing glove* may have a family resemblance score which is close to, but does not exceed, the membership threshold for *clothing*; and *tomato* may have a score which exceeds the membership thresholds for both *fruit* and *vegetable*. As expected, the probabilistic and exemplar views account for this in slightly different ways. With the former, the membership threshold is a weighted featural sum. With the later, the threshold is featural sum based upon (family resemblance) similarity with prototype exemplars: thus, membership becomes unclear when the target concept is not sufficiently similar to a (number of) prototype exemplars of a particular concept and/or the prototype exemplars of more than one concept.

As for the use of non-necessary features, their use is intrinsic to the PA: categorization is not based upon necessary features. In fact, with the probabilistic view the issue of necessity does not arise since features are only probabilistically related to the concept. However, given that features with a high conditional probability are analogous to necessary features, this view assumes that features with a low conditional probability play an important role in categorization. For example, low weighted features *flies* and *sings* play a crucial role in accounting for the GOE ratings of *robin* and *chicken* as exemplars of *bird*. In the exemplar view, where the issue of necessity may arise, non-necessary features play a role in categorization since categorization is based upon a comparison with prototype exemplars and its features may not necessarily hold of other exemplars of the concept, including other prototype exemplars. For example, if *robin* is a prototype exemplar for *bird*, then one of its features, *red-breasted*, will play a role in categorization without it necessarily being a feature of all exemplars of the concept *bird*.

The apparent lack of definition is also unsurprising in light of the PA. Apart from the issue of whether necessary features are involved in the concept representations, the use of a membership threshold based on family resemblance allows featural sufficiency to vary: i.e. the set of features which are sufficient to delimit a concept is not invariant. Thus one exemplar can be a member of a concept on the basis of sharing the distinctive feature f^1, f^2 and f^3 with the concept prototype, but another exemplar can be a member on the basis of sharing the features f^1, f^4, and f^5. In both cases then, these exemplars will exceed the membership threshold for the concept but not on the basis of the same feature set. Again each view interprets this in a slightly different way. With the probabilistic view, membership is determined on the basis of a weighted sum of features and different combinations of features will attain the same sum. For example, while both *chair* and *rug* match enough features of *furniture* to gain membership, they do so on the basis of slightly different feature sets as shown in figure 3.5 (cf. Smith and Medin 1981: 68). With the exemplar view, variation in featural sufficiency is even more transparent: since membership is determined on the basis of similarity to a prototype exemplar, and since these exemplars can consist of different feature sets, two concepts can be exemplars of the same concept on the basis of sharing different sets of features.

This variation highlights the importance of disjunctive conceptual structure in PA. With the implicit disjunction in the probabilistic view, membership cannot be entirely heterogeneous since it is determined by comparison with a single implicit prototype and so there will be at

Chair (specific)	Rug (specific)	Furniture
F_1 (physical object)	F_1	1.0 F_1
F_2 (non-living)	F_2	1.0 F_2
F_3 (decorative)	F_3	0.9 F_3
F_4 (rigid)	F_7 (covers floor)	0.8 F_4
F_5 (has seat)	F_8 (can lie on it)	0.5 F_5
F_6 (has legs)		0.7 F_6
		0.4 F_7
		0.6 F_8

Figure 3.5: Membership based on different features

least some degree of featural overlap (cf. Smith and Medin 1981: 68). However with the explicit disjunction in the exemplar view, membership can, in principle, be entirely heterogeneous: since membership is determined by comparison with one of a number of prototype exemplars, and each of these exemplars can be associated with non-overlapping feature sets, different members of the category need not have any features in common. So while both PA views can be seen to account for the lack of definitions for membership in terms of variation in the sufficient set of features, they differ as to how much variation is permitted.

Weaknesses of the Prototype Approach

The major weakness of the PA is that its account of concept centrality is not adequate. In both the probabilistic and exemplar views, the prototype is fixed for the concept and manifestations of centrality only vary depending on the family resemblance between a target concept and the prototype. However, empirical data suggests that centrality is not fixed but variable, and this variation is systematically related to aspects of context such as goals, perspectives, category labels and discourse context.

Variation in centrality is manifest in goal-derived concepts (cf. Barsalou 1983; Barsalou and Sewell 1984). These are concepts which are constructed for some immediate goal; for example, things to take from one's home during a fire, what to get for a birthday present, foods not to eat on a diet and so on. His categorization experiments with these concepts yield four pertinent results. First, knowing the goal that relates the target exemplars facilitated subjects' decisions as whether they were exemplars of the concept or not; not knowing the goal made the decision correspondingly more difficult. For example, knowing that the goal is *things to take from one's home during a fire* helps determine that *children*, *jewelry*, *photographs* and *camera* are exemplars of the concept. Secondly, exemplars vary in centrality; for example, *chocolate* is a better exemplar of *food not to eat on a diet* than *bread*. Thirdly, variation in centrality is not predicted by the family resemblance similarity metric since the exemplars have a low family resemblance scores. Fourthly, variation in centrality can be predicted, and so possibly determined by, the degree to which each exemplar satisfies the relevant goal — for example how high a value they have on a relevant dimension, such as *calorific value* for *food* and *worth* for *things to take out during fire* — as well as how frequently they have been used as past instances of the concept, for example how familiar a particular food is as an exemplar of *diet foods*. Furthermore, Barsalou has also suggested that our goals may also play a role in the determinant of centrality in categories other than goal-derived concepts. Variation in centrality may be (partially) based upon the degree to which exemplars satisfy our goals or ideals in interacting with the object rather than family resemblance; with *fruit*, for example, how much we like the taste of it. Thus the PA prediction that family resemblance systematically predicts centrality is confounded in the case of goal-derived concepts and perhaps even more generally — the purpose of the categorization can partially determine concept centrality.

Barsalou also demonstrates that another aspect of context — perspectives — play a role in determining centrality (cf. Barsalou 1985; Barsalou and Sewell 1985; Barsalou 1986). Whereas previous categorization experiments made no mention of the cultural perspective from which GOE was to be rated — the context was 'null' with respect to cultural perspective — Barsalou conducted a series of experiments in which subjects were explicitly asked to rate exemplars of taxonomic and goal-derived concepts from various cultural perspectives such as Americans, French, Chinese, hippies and housewives. The results showed that conceptual centrality systematically varied with perspective. This confounds the PA prediction that centrality is transparently and invariantly determined by family resemblance.

Barsalou (1985) further demonstrates that context, this time in the form of a name for the concept, affects centrality. The main task for subjects was to rate fictional characters as to their suitability for a given occupation. Prior to this, subjects were divided into two groups: the first group was told that the characters were either PE teachers, who jogged with varying degrees of regularity, or current affairs teachers, who read newspapers with varying degrees of frequency; and the second group was told that the joggers and readers were simply known as Q and Z programmers. Analysis of the GOE rating showed that determination of centrality was affected by whether the names for the two groups of characters related the activities to their jobs: when they were related, as with current affairs teachers who read newspapers, centrality was principally determined by the degree to which the character participated in the activity; when they were not related, as with Z programmers who read newspapers, centrality was determined by family resemblance. Again, the PA does not predict that centrality can vary as a function of context.

Similar findings have been reported with respect to linguistic context (cf. Roth and Shoben 1983). Linguistic context came in the form of sentences presented to subjects before their reading time for a target sentence was measured. Consider, for example, the context sentences in (3.1) to (3.3) and the target sentence in (3.4):

(3.1) Mary watched the bird all day.

(3.2) Mary saw the bird swimming.

(3.3) Mary looked at the bird on the telephone wire.

(3.4) Mary was very fond of ducks.

The results show that exemplars judged central to the concept only had faster RTs than peripheral exemplars following neutral context sentences, such as (3.1) above. The RT for peripheral exemplars was significantly affected by biasing contexts: with contexts such as (3.2), which is biased towards the *duck* exemplar interpretation (the bird is able to swim), the RT was faster than with the neutral context; but with contexts such as (3.3), which is biased against the *duck* interpretation (the bird is able to fly in order to be on the telephone wire), the RT was slower than with the neutral context. These results support the claim that centrality is determined by family resemblance in null contexts, but by semantic relations between concepts in biasing contexts: if the target concept satisfies restrictions imposed on the superordinate concept (*bird*), then categorization is facilitated as with *duck* in (3.2); if the target concept does not satisfy the restrictions, as with *duck* in (3.3), categorization is disfacilitated and an increased RT results.

The facilitatory effect of semantic relations between a concept in the context and the target concept is also manifest in tasks such as artificial concept construction and concept learning (cf. Wattenmaker et al. 1986; Medin et al. 1987). For example, this claim is supported in the learning of concepts which differ in their separability. In the PA concepts are separable on the basis of feature summing: i.e. concepts are linearly separable through a (weighted) additive combination of features. This yields the prediction that linearly separable concepts are easier to learn than non-linearly separable concepts. To test this prediction, Medin and Schwanenflugel

(1981) conducted a series of experiments with varying concept sizes and materials, but failed to find evidence to support it. However, other researchers found that the explicit presentation of a theme which related features of concepts did facilitate the acquisition of linearly separable concepts (cf. Wattenmaker et al. 1986). For example, in one experiment, the central features of the target concept were relevant and appropriate features if subjects were looking for a *substitute hammer*. With subjects who were introduced to the notion of *substitute hammer*, linearly separable concepts were easier to learn than non-linearly separable concepts. Furthermore, when linking themes were introduced for non-linearly separable concepts, they were easier to learn than linearly separable concepts. Thus the presentation of a theme which relates concepts facilitated their learning.

The second weakness of the PA approach concerns its account of level centrality. Here there are two problems: the cue validity account is flawed; and, like exemplar centrality, level centrality can systematically vary with contexts which make explicit semantic relations between a concept in the context and the target concept.

In the PA, the basic level is that level which maximizes the number of common and distinctive features. With the probabilistic view, this is measured in terms of category cue validity: concepts on the basic level have the largest sum of cue validities for their features. The problem with this account, however, is that it consistently identifies the superordinate level within a taxonomy as the central level (cf. Murphy 1982; Medin and Smith 1984; Murphy and Medin 1985). For any feature which cues membership in one category will always cue membership in a superordinate concept. Thus cue validity for superordinate concepts will always be equal to or greater than that for allegedly basic level concepts. For example, while the feature *winged* will be good cue for the concept *bird*, it will also be a cue for the concept *animal*. As Murphy (1982) points out, this problem can be circumvented by not directly connecting features of basic level concepts to superordinate concepts: features of basic level concepts would only act as cues for these concepts, not superordinate concepts.

Another alternative is that the central level is determined by a function which combines cue validity with category (inference) validity (cf. Jones 1983; Murphy and Medin 1985). Category validity is the opposite of cue validity in that the central level is the one whose categories maximize inferences (cf. Medin 1983). In particular, inference validity is the conditional probability that, given a concept, we can infer that it has a particular feature. Category inference validity is the sum of such inference validities for a concept. For example, given the concept *duck*, we might infer with a high degree of probability that it has the features *feathers*, *winged*, *swims*, and so on. However, category inference validity systematically identifies the most subordinate level in a taxonomy as the central level since, as the most specific, it permit most inferences. For example, my pet duck, *Nora Barnacle*, will not only have the inferences associated with *animal*, *bird* and *duck*, but will also permit specific inferences concerning the exact colour of its *feathers*, where it lives, what it eats, and so on.

There are two alternatives accounts of level centrality. The first concerns correlated features (cf. Rosch et al. 1976a; Rosch 1978; Mervis and Rosch 1981). With basic level concepts, such as natural kind concept, it has been argued that there is a tendency not only for certain groups of features to co-occur, but also to co-vary. For example, not only do the features *wings*, *feathers* and *beaks* co-occur in the concept *birds* (cf. other animals), but there are correlations between these features so that, for example, the larger the *wing span* of *birds*, the greater the probability that they live by the sea and eat fish[5]. Malt and Smith (1983) provide evidence that basic level concepts have correlated features and that they play a role in categorization. Medin and Shoben (1988) show that naming one feature affects correlated features in adjective-noun combinations; for example, *spoons* are typically *small*, but *wooden spoons* are typically *large*. Thus the basic level could be characterized as that level whose concepts have a greater number of correlations between features than concepts at superordinate or subordinate levels. The problem, however, is that, like category validity, the most specific concepts will have the

[5] Though there are exceptions such as *golden eagles*.

most correlated features. For example, with my pet duck, there will be additional specific correlations between *colour* and *size*, *location*, *ownership* and so on. This is corroborated by Murphy and Medin who argue that correlated features can be the basis for inferences which go beyond the given (cf. Murphy and Medin 1985: 293); for example, on seeing a round object in a gymnasium, we might predict that it can bounce (correlations between *shape* and *location* of the object and our characteristic interaction). Clearly, the more specific the concept, i.e. lower in a taxonomy, the more correlated features and thus more inferences beyond the given.

The second alternative, although closely related to the correlated features account, appears to avoid this problem. The central level is characterized as the most abstract level at which exemplars of a concept have approximately the same parts (cf. Medin and Smith 1984; Tversky and Hemmenway 1984). As Lakoff points out, this account of level centrality is closely allied to Gestalt perception, the perception of overall part-whole configuration, although it clearly goes beyond perception (cf. Lakoff 1987: 47). The basic level has priority over other levels of categorization in that concepts at this level have more features concerned with parts. There are two reasons why parts are salient: parts correlated with functions — for example *feathers* on *birds* are correlated with their capacity to *fly*; and we interact with objects in terms of their parts — for example, we see the *shape* of *birds*. Markman and Callahan (1983) corroborate the salience of parts in so far as they provide experimental evidence to show that collection concepts based upon part-whole relations, for example a *family* is a collection concept with parts for *father*, *mother* and *children*, are easier for children to understand than concepts based upon the subset relation. Furthermore, this account can be seen as closely related to the correlated feature account since the basis for partitioning whole concepts into parts may well be the clustering of correlated features: i.e. parts can be interpreted as clusters of correlated features.

This part-whole account, however, is inadequate since it is unclear how it is to be applied. For rather than concepts at different levels in a taxonomy either having or not having a part-whole structure, categories at all levels may have a part-whole structure and these structures may differ in specificity. Different, compatible concepts then may share the same part-whole structure, but categories at lower levels may have more specific parts. For example, the concept for a particular subordinate concept of *car*, such as a *Renault 1400TS*, has more specific part-whole structure(s) than *car*: a *car* may have the part *spare tyre* whose location on the *car* is not specified, whereas on the concept for a *Renault 1400TS* the location of the *spare tyre* is specified as directly above the engine. Furthermore, the superordinate concept *vehicle* may consist of parts such as *physical shape* and *mode of propulsion*, and these parts are correspondingly more specific in exemplars such as *cars*. Thus if levels of categorization differ in terms of the number and specificity of part-whole structures, it is difficult to see what level is the 'most abstract level with approximately the same parts'.

The second problem for the PA's account of level centrality is that context affects the centrality of conceptual levels. Like exemplar centrality, experiments alleged to furnish evidence for a cue validity account were conducted with a null or neutral context. For example, with natural kind terms, where the basic level is *bird* rather than *robin* or *animal*, the experiments tend to be simple listing features, word pairs and so on. However, when experiments also use biasing contexts, level centrality seems to be affected by context.

Level centrality seems to vary with cultural perspective and degree of expertise (cf. Rosch et al. 1976a; Dougherty 1978). For example, the basic level of categorization of plants and trees can vary depending upon whether the subjects come from urban, industrialized cultures or agricultural non-industrialized cultures. While the life form level, *tree*, are basic for American subjects, the genus level, *oak* and *teak*, are basic for Tzeltal speakers. This suggests that the basic level may be partially determined by the importance of the conceptual domain within a culture: the more important the domain to a culture's activities, the more differentiated the concepts and so the lower the basic level in the taxonomy[6]. Furthermore, within a given

[6]Murphy and Medin (1985: 305) provide convincing evidence that membership of concepts is similarly

culture, there will be groups to whom particular conceptual domains are important and their basic level will be correspondingly lower in the taxonomy than other members of the culture; for example, train spotters will have a more differentiated concept of *trains*, such that specific types of train will be more central than the generic level. This is closely related to Putnam's notion of the division of linguistic labour: i.e. for a given domain, there may be experts and novices where the experts, since their concepts are more differentiated, have a central level of categorization which is lower on the taxonomy than the basic level of the novices (or even beyond their taxonomy).

In the second place, observational evidence suggests that level centrality can be determined by situational context. Consider exophoric reference where a expression refers to an object in the extra-linguistic situation (cf. Sanford and Garrod 1981: 119). Such expressions need to be sufficiently specific to differentiate the intended referent from other potential referents, yet only as specific as is relevant to the aim or theme of the discourse. Consequently, the central level of conceptual description in a taxonomy will not be fixed, but vary in accordance with referential requirements imposed by the discourse context. In null contexts, i.e. contexts which impose no specific referential requirement, the appropriate conceptual expression will be at the basic level; for example, if there is only one *bird*, a *robin*, in the garden, then *look at the bird in the garden* is appropriate. In other contexts, the central level may be more specific or less specific. In a situation where there are three *birds* — a *robin*, a *thrush* and an *eagle* — and we wish to identify the *robin*, then a subordinate level description is appropriate: *look at the robin in the garden*. A superordinate level description may be appropriate when the goal is to highlight a property of the superordinate concept rather than a property of the 'basic' level; for example, *look at the silly animal in the garden* would be appropriate if the 'silliness' was not specific to *birds* or *robins*.

Observational evidence also suggest that discourse context can impose restrictions on the appropriate conceptual level of description. Consider the following examples:

(3.5) John bought a vehicle yesterday. It was a ___.

(3.6) John bought a car yesterday. It was a ___.

(3.7) John bought a BMW yesterday. It was a ___.

In each, the context sentence introduces a concept, a type of vehicle, and the target sentence further describes the concept. With a semantic restriction such that subsequent descriptions of a concept add new information, then we would expect the appropriate level of description to be more specific than mentioned in the context sentence rather than simple at the basic level, *car*. With (3.5), the semantic constraint and the basic level coincide and we would expect a *car* as a frequent response. With (3.6), we would expect a concept at more specific level of description, such as *BMW*. Finally, with (3.7), we would predict that the appropriate level was still more specific; for example, *series five BMW*. In this way, experimental and observational evidence suggests that level centrality is not fixed but can vary as a consequence of context (culture, expertise, situational, linguistic) imposing specific semantic requirements.

In sum, while the prototype approach to concepts provides an account of categorization data problematic for the classical approach, its own weaknesses are exposed when experiments include non-null contexts. In particular, while the correlation between characteristic features of a concept and its centrality with respect to a superordinate concept may hold in null contexts, concept centrality in non-null contexts seems to arise from semantic relations between the context itself and the concept. As we have just observed, context can have an analogous effect on level centrality in non-null contexts. Furthermore, while it would be possible to take either the classical or prototype approach as the basis for our approach to concepts, we will modify the classical approach along the lines suggested at the end of section 3.2.1. For while the

affected. The Karam of New Guinea do not categorize cassowary as a bird on account of their antithesis of forest and cultivation.

prototype may be a "conventional grammatical fiction" (Rosch 1978: 40) useful for accounting for the some of the minutiae of experiments, and could be extended to make centrality more context-sensitive, the classical approach, as we shall see, is easier to incorporate into cognitive linguistic approach to language comprehension.

3.3 Lexical Access

In this section, we consider lexical access as evidence to support our claim that context can affect lexical conceptual structure as well as discourse conceptual structure. Many experimental studies have shown that context does affect conceptual structure. The data used in these studies tends to fall into two groups: ambiguous expressions, such as *bank*, whose lexical representation contains two different lexical concepts — one for the 'financial institution' sense and another for the 'river' sense; and polysemous expressions such as *eat*, whose lexical representation contain a lexical concept — the generic sense — together with subordinate concepts corresponding to specific senses appropriate to what is being eaten (cf. Weinreich 1966). Hodgkin (1977) demonstrated that local linguistic context, in the form of a verb's selection restrictions, may select between the senses of unambiguous nouns; for example, *butcher* was responded to faster when the verb imposed an animacy restriction as with *the milk pleased the butcher* than when the verb lacked an animacy restriction as with *the milk soaked the butcher*. Anderson and Ortony (1975) show that nouns such as *container* can have specific senses imposed by context; for example, with *the container held the apples*, *basket* proved to be a better recall cue than *container*. Garnham (1979) demonstrates a similar effects for verbs; *fried* is a better recall cue than *cooked* for *the housewife cooked the chips* (but not for *the housewife cooked the peas*). Potter and Faulconer (1979) demonstrate that with *house* in the context of a preceding adjective like *burning*, an atypical picture of house burning was responded to faster than the typical picture of house. Finally, Tabossi and Johnson-Laird (1980) demonstrated that context can require expressions to contribute concepts with specific properties; for example, when the question *Is a diamond brilliant?* is followed by *The mirror dispersed the light from the diamond* subjects responded faster than when it was followed by *The goldsmith cut the glass with the diamond* where the context highlights its hardness rather than reflectivity.

This data has been taken to demonstrate that context does affect the conceptual structure. What is not addressed by these experiments is *when* context affects it: i.e. given that context imposes semantic restrictions on the upcoming lexical expressions in a sentence, when do these restrictions affect conceptual structure? In particular, does discourse context select the appropriate sense of ambiguous and polysemous expressions before or after linguistic processing? If they apply before linguistic processing, then it is reasonable to expect sense selection to take place during the retrieval of lexical representations. If, on the other hand, sense selection on the basis of discourse context takes place after linguistic processing, then all senses, including contextually inappropriate ones, will be available even if we are not conscious of their availability (cf. Holley-Wilcox and Blank 1980). The first view is adopted by the context-dependent selective access view (CDSA) which claims that context can have an immediate effect on lexical access: only contextually appropriate senses of a linguistic expression are accessed (cf. Glucksberg et al. 1986; Tabossi 1988a). The second view is adopted in the context-independent multiple access view (CIMA) which claims that all senses of a lexical expression are initially accessed and then, and only then, can context select the relevant sense (cf. Swinney 1979; Onifer and Swinney 1981; Prather and Swinney 1988). The contrast between these views can be illustrated with an ambiguous expression such as *bank*:

(3.8) The robber held up the cashier at the bank.

(3.9) The fisherman sat on the bank hoping for a catch.

The CIMA claims that in both the contexts in (3.8) and (3.9), lexical access results in two lexical concepts being accessed[7]. Once both sense have been accessed, context can then play a role in selecting an appropriate sense: the institution sense is appropriate in (3.8) while the river sense is appropriate in (3.9). With the CDSA, only the appropriate sense for each context will be accessed; in (3.8), for example, the river bank sense will not be accessed at all.

There is a third view which incorporates aspects of both the CIMA and CDSA views. In this view, access is also determined on the basis of the relative frequency of senses (cf. Onifer and Swinney 1981; Simpson 1981). The most frequent sense is accessed independent of context unless the context is highly inappropriate. Less frequent, or subordinate, senses are only accessed in clearly appropriate contexts. Consequently, given the senses of *bank* are ordered such that the institutional sense is more frequent than the river sense, in a sentential context like *John walked to the bank*, where either sense may be appropriate, only the institutional sense is accessed since this context is not 'clearly appropriate' to the river bank sense. Likewise only the institution sense is accessed in (3.8), whereas in (3.9) only the river bank sense is accessed: the context is highly inappropriate to the institutional sense. This view of lexical access bears comparison with the prototype approach discussed in section 3.2.2.

In order to evaluate these views we need data which bears upon the relationship between lexical access, context and sense ordering (or centrality). The data will cover access of both ambiguous and polysemous expressions since, on the grounds of descriptive economy, the same process is involved in both (cf. Tabossi 1988a: 158; Lytinen 1988).

3.3.1 Semantic Priming

Semantic priming concerns the facilitatory effects related words, such as *doctor* and *nurse*, can have on comprehension tasks (cf. Neely 1977). For example, when subjects are asked to make a lexical decision, i.e. decide whether an expression is a word, the decision is quicker in the context of a related word. For example, lexical decisions are quicker with the related pair *doctor-nurse* than with the unrelated pair *doctor-bread* (cf. Meyer and Schvaneldt 1971).

Semantic priming has been used with the lexical decision task to probe whether the contextually appropriate sense of ambiguous expressions is accessed. Schvaneldt et al. (1976) demonstrated that a 'priming' context containing a related member of a pair can have this effect with ambiguous expressions such as *bank*. While *bank* alone (the neutral context) facilitated lexical decisions on both the targets *money* and *river*, when *bank* was preceded (and primed) by a word such as *save*, then only the contextually-relevant target, *money*, was facilitated.

This finding has been interpreted as evidence for the CDSA and counterevidence to the CIMA: although both senses are activated in a neutral context, only the relevant sense is activated in a context which primes the sense; otherwise we would expect both targets to be facilitated. The problem with this interpretation, however, is that the decisions occurred around 500ms after the onset of the ambiguous expressions, but CIMA claims that both activation and selection take place within 200ms (cf. Seidenberg et al. 1982; Glucksberg et al. 1986). Consequently, within 500ms all senses could be accessed and the relevant sense selected and the irrelevant suppressed by a post-access decision. While this data from semantic priming provides further evidence for the selection of contextually appropriate senses, it does not discriminate between the CIMA and the CDSA.

3.3.2 Cross-Modal Priming

Experiments within the cross-modal semantic priming paradigm provide a more convincing source of evidence (cf. Swinney 1979; Swinney et al. 1979; Onifer and Swinney 1981). Subjects

[7] It is not relevant to this view whether these senses are represented as different lexical entries or different parts of the same one.

perform a visual lexical decision task while listening to a sentential context which either primed one of the sense of an ambiguous expression or was a control. Importantly, the visual target for the lexical decision task is presented precisely on the offset of the ambiguous expression. Swinney argues that by presenting the visual target simultaneously with the end of the ambiguous item, the lexical decision on the target clearly reflects the effects of priming on the semantic activation of the ambiguous expression.

Swinney (1979) used this technique to demonstrate that context did not affect lexical access and thus provided evidence for the CIMA approach. Sentences were auditorily presented and these were either controls or primed one of the sense of ambiguous expressions such as *bug*; for example,

(3.10) The man was surprised when he found several spiders, roaches, and other bugs in the corner of his room.

primes the insect sense rather than the microphone sense of *bug*. At the offset of this expression, subjects performed a lexical decision task on visual targets such as *ant* or *spy*. The results showed that *bug* facilitated lexical decision on these targets independently of whether it was related to the contextually primed sense: i.e. lexical decisions for where *bug* was primed for the insect sense and the target was *spy* and where *bug* in the microphone sense with *ant* as target were faster than the control context with either *spy* or *bug* as target. Furthermore, when the visual targets were presented three syllables from the auditory prime, only those targets related to the contextually primed sense were facilitated. This contrast between the immediate effect and delayed effect of context was taken as evidence for the CIMA and as counterevidence for the CDSA. Moreover, Onifer and Swinney (1981) found similar results for ambiguous expressions whose senses, unlike those of *bug*, differed in frequency. For example, *ring* has a dominant sense, the jewellery sense, and a subordinate sense, the noise sense, yet in priming contexts such as:

(3.11) The housewife literally lit up as the plumber extracted her lost wedding ring from the sink trap.

(3.12) The office walls were so thin that they could hear the ring of their neighbor's phone whenever a call came in.

ring facilitated lexical decisions on targets independent of context. This evidence was taken as support for claiming that lexical access is independent of both context and the frequency of senses.

Other experimental results, however, seem to confound these results. Using a 120ms inter stimulus interval (ISI), Simpson (1981) found frequency and context effects: in neutral context, visual targets related to the frequent sense of ambiguous expressions were facilitated, whereas those related to the infrequent sense were not. For example, with *bank* as the context, the target *money* (related to the dominant financial institution sense) was facilitated but not *river*. Furthermore, in highly constrained priming contexts, targets related to the contextually primed sense were facilitated, independent of the frequency of these senses. For example, with the context in (3.13):

(3.13) The vampire was disguised as a count.

the target *duke*, related to the subordinate nobility sense, was facilitated whereas *number*, related to the dominant enumeration sense, was not. Similarly, in (3.14):

(3.14) My dog wasn't included in the final count.

only the target *number* was facilitated. These result provide evidence for an approach where lexical access is dependent upon the centrality of senses in neutral contexts, but upon semantic relatedness in highly constraining contexts.

Onifer and Swinney claim, however, that these results are also consistent with the CIMA on account of the 120ms ISI (cf. Onifer and Swinney 1981): their results where obtained with a zero ISI in the immediate condition and this delay, they claim, might be long enough to select by frequency and context the appropriate senses and thereby suppress accessed, but inappropriate, senses.

Other results are not quite so easy to accommodate to the CIMA. Seidenberg et al. (1982) used a word naming task rather than a lexical decision task where there was no delay between the ambiguous auditory word prime and the visual target. They found good evidence for selective access albeit only when the context contained a word semantically related to one sense of the ambiguous expression. For example, the context sentence in (3.15):

(3.15) Although the farmer bought the straw ...

facilitated naming with the target *hay* but not *sip* since *farmer* is closely related to the 'crop' sense of *straw* (cf. *Although Joe bought the straw* ... where there was no evidence for selective facilitation). Since this result cannot be dismissed on the grounds of a delayed ISI or the effects of post-access decision processes, it constitutes prime facie counter-evidence to the CIMA. It would appear that while some contexts may not affect lexical access, the contextually relevant sense is immediately accessed in highly constraining contexts. However, such a view does not explain the discrepancy between Swinney's and Seidenberg's experiments: i.e. the former consistently obtains multiple access, yet the later obtains selective access in biasing contexts.

Two explanations have been suggested (cf. Seidenberg et al. 1982). The first is methodological: backward priming in the cross-model priming paradigm has created the effect of multiple access (cf. Glucksberg et al. 1986). The second is that selective access is only apparent in contexts which impose specific constraints on the sense of ambiguous primes: the contexts in Swinney's experiments are not sufficiently constraining to yield selective access (cf. Tabossi et al. 1987; Tabossi 1988a; Tabossi 1988b). While both explanations attempt to support the CDSA, only the later is capable of sustaining support.

3.3.3 Backward Priming

Backward priming in the cross-modal priming paradigm concerns the effect the visual target word has on an auditory ambiguous prime. Glucksberg et al. (1986) assume that the form of an auditory word is not processed immediately, but stored in 'echoic' memory and processed at the same time as the visual word. For example, an auditory ambiguous prime like *cast* is stored in echoic memory and processed simultaneously with a visual word like *actress*. Accessing the senses of *cast* takes place against two contexts: the first context provided by prior auditory sentential context; and the second provided by the 'subsequent' visual word. Glucksberg et al. argue that this later context can facilitate the lexical access of inappropriate senses of the ambiguous prime word. A sentential context for *cast*, such as *the nurse adjusted the cast on the patient's leg*, facilitates the medical sense of *cast*. However, given that *cast* is retained in echoic memory and processed simultaneously with an inappropriate visual target such as *actress*, presented at the offset of the ambiguous prime *cast*, the relationship between the visual target and the inappropriate sense of the ambiguous prime (the theatre sense) is detected and this causes the inappropriate sense to be accessed as well. This in turn makes lexical decisions on inappropriate target words faster than those of (unrelated) control target words.

Backward priming effects have been independently observed within the visually presented lexical decision tasks (cf. Koriat 1981; Kiger and Glass 1983). The claim of Gluckeberg et al. is that the same effect is also manifest in cross-modal lexical decision tasks of Swinney (1979) and Onifer and Swinney (1981) and that multiple access of ambiguous words may be an artifact of backward priming. In biasing sentential contexts, the appropriate sense is selected on the basis of this context. However, the visually presented word provides a second context which allows inappropriate senses to be accessed and thus gives an effect of multiple access. In order to determine whether backward priming is the source of multiple access, Glucksberg et al. constructed a variant of the cross-modal lexical decision paradigm intended to prevent backward priming. This paradigm used interference rather than facilitation as an measure of lexical access. In particular, their experiments used the auditory material of Onifer and Swinney (1981) but with non-words as the visual targets. The rationale for using non-words was that, as non-lexical items, they lacked relations with lexical items and hence could not serve as contextual cues for ambiguous words: non-words could not (backward) prime the ambiguous words. The non-word targets were misspelt variants of words semantically related to the ambiguous word as well as controls. For example, in experiments with the ambiguous word *state*, there were four visual targets: *condry*, a misspelling of the *country* related to the (dominant) country sense of *state*; *conbishun*, a misspelling of *condition*, related to the (subordinate) condition sense of *state*; and control targets *droncy*, a scrambled version of *condry*, and *chubison*. The rationale for using these targets concerned the time taken to make a lexical decision on non-words: a non-word, such as *condry*, which is more similar to a word (*country*), take longer to judge than an obvious non-word like *droncy*. Crucially, sentential context could interfere with this lexical decision task: the context may select the sense of an ambiguous word, *state*, semantically related to a word *country* and accessing this sense makes it more difficult to decide that *condry* is a non-word due to its similarity with *country*. According to Glucksberg et al., a sentential context such as:

(3.16) Even though the outside of the car appeared new, the motor was actually in a very bad state and the mechanic said it would probably need a complete overhaul to work again.

should interfere with the lexical decision on a non-word visual target on account of similarity with words semantically related to the appropriate sense. The results showed that contexts which make appropriate the dominant sense of an ambiguous prime, the related non-word took longer than the control yielding an interference effect of 60 msecs; and in inappropriate contexts, an interference effect of 15 msecs. The pattern of interference for targets related to subordinate senses was similar: in appropriate contexts, the effect was 49 msecs; and in appropriate contexts 5 msecs. Glucksberg et al. take these results as evidence that the multiple access of ambiguous words in appropriate contexts is an artifact of backward priming since experiments precluding backward priming yield evidence for selective access.

While there is no doubt as to the experimental sophistication of the Glucksberg et al. approach, there are problems with their interpretation of the results. The evidence for backward priming between auditorially and visually presented words has been questioned by Prather and Swinney (1988). They conducted cross-modal variants of Kiger and Glass's visual modality experiments and found no evidence of priming or interference. Moreover, they also questioned the assumption that non-words such as *condry* and *conbishun* cannot facilitate the processing of related senses of ambiguous words. Glucksberg et al. describe a pilot study which found no facilitatory effects of non-words targets of ambiguous primes; for example, *fisch* did not affect the lexical decision time on an ambiguous word like *scale*. However, when the Glucksberg et al. material was used in a priming experiment where both the prime and non-word targets were presented visually, facilitation effects were found: a non-word 'related' to the sense of an ambiguous prime facilitated lexical decisions relative to control non-words. This suggests that non-words can facilitate the processing of 'related' words and this in turn undermines the claim of Glucksberg et al. that their results, unlike those of Onifer and Swinney (1981), are not susceptible to backward priming effects.

This conclusion is reinforced by experiments conducted by Tanenhaus et al. (1988). They conducted a series of non-word decision experiments using the ambiguous primes and non-word targets used by Glucksberg et al. together with unambiguous primes and more word-like control targets. They interpreted the results as demonstrating that non-word interference effects were strategic: non-word interference is only manifest when more than 50% of trials contained prime words related to the non-word target. They further suggest an alternative explanation of why Glucksberg et al. only observed non-word interference when targets were related to the contextually appropriate sense of the ambiguous prime:

> The nonword interference task, as used by Glucksberg and colleagues, is sensitive only to contextual integration. Thus, the context effects obtained by Glucksberg et al. reflect the fact that only the contextually appropriate sense of an ambiguous word is integrated with the preceding context, whereas the inappropriate sense is rapidly discarded. (Tanenhaus et al. 1988: 322)

While undermining the interpretation of Glucksberg et al., neither Prather and Swinney nor Tanenhaus et al. directly challenge the claim that multiple access is an artifact of backward priming. There are, however, two problems with this claim.

The first is that there is conflicting evidence about the occurrence of backward priming in cross-modal experiments and thereby for the claim that backward priming is a source of multiple access in this paradigm. Peterson and Simpson (1987) found backward priming of auditory primes by visual targets after both 0 msec and 200 msecs delays in lexical decision tasks. Using the same primes and targets in contexts similar to those of Onifer and Swinney (1981), no backward priming effect was obtained in contexts biasing the prime word. Although their primes were not ambiguous, multiple access without backward priming might have been observed in these contexts. On the other hand, Van Petten and Kutas (1987), argue for a backward priming explanation of multiple access patterns obtained through measuring event-related brain potentials of target words following sentential contexts with ambiguous words. With a 200 msecs delay, an unrelated and inappropriately related target showed a larger reading than the appropriately related target. Approximately 300 msecs later, however, the reading for the inappropriately related target began to converge with that for the appropriately related target.

The second problem is that there is evidence of multiple access in paradigms which are not susceptible to backward priming. For example, Whitney et al. (1985) used Stroop interference rather than RT to measure the semantic activation of unambiguous nouns in contexts which biased either a prominent property, a non-prominent property or were control contexts:

(3.17) The boy skinned his trout.

(3.18) The boy dropped his trout.

(3.19) The boy skinned his knee.

These contexts were followed by visual target, such as *scales* and *slimy*, describing these properties of the noun. Each of these visual targets were presented in coloured ink and the subjects' task was to name the colour of the ink. After a 0 msec delay, targets describing either low or high prominence properties interfered with the naming task significantly more after biasing contexts than the control context. After 300 and 600 msec delays, however, this pattern was only observed with high dominance properties: low dominance properties significantly interfered with the task only after the appropriate biasing context. Whitney et al. interpret this pattern as supporting multiple access: initially all noun information is accessed independent of context and only subsequently does context impose restrictions by discarding non-dominant or contextually inappropriate properties of the noun.

In sum, the claim that multiple access is an artifact of backward priming is not well supported by experimental studies. Not only is there considerable doubt concerning the premise of Glucksberg et al. experiments — non-words cannot facilitate processing of related senses of ambiguous words — but other experiments suggest that multiple access may occur without backward priming. This can be taken as an indication that further experimental studies are required to demonstrate the occurrence of backward priming, as well as the correlation between backward priming and multiple access.

3.3.4 Contextual Constraints

The second explanation for the discrepancy concerns the relationship between the priming word and its context. Selective lexical access arises when the context imposes semantic restrictions which are sufficiently specific to discriminate between the different senses of the priming word. When context is not sufficiently specific, multiple access arises: all senses are compatible with the context's semantic restrictions and hence are accessed. Consequently, the conflict between the multiple access effects obtained by Swinney (1979), Onifer and Swinney (1981) and Whitney et al. (1985) and the selective access effects obtained by Seidenberg et al. (1982) arises from the relationship between the context and the priming words; many contexts for ambiguous primes in the former experiments "do not contain words highly related to the ambiguous words" (cf. Seidenberg et al. 1982: 528).

Patrizia Tabossi, the main proponent of this approach, argues that these contexts in these experiments act like neutral contexts with respect to lexical access. Consider again the contexts in (3.11) and (3.12) used in Onifer and Swinney (1981). The context does not disambiguate *ring* by imposing specific semantic restrictions: it does not make salient specific properties of the jewellery sense of *ring*, such as its round shape or its high value (cf. Tabossi 1988a: 158). Likewise, contexts used by Swinney (1979) and Whitney et al. (1985) fail to disambiguate through the imposition of specific semantic restrictions. With (3.10), the context does not make relevant specific properties of the animal sense of *bug*, such as its animacy, which differentiate it from the microphone sense. And although some of the context used by Whitney et al., such as (3.17) and (3.18), do impose such restrictions, many do not; for example, *The man used the oak* was intended to make relevant the low dominance property *lumber* of *oak*, the context itself does not highlight this property (cf. *The man chopped up the oak*). Since many of the contexts in these experiments failed to make relevant the specific property of the prime word, the prime word was accessed as if in a neutral context and multiple access effects were obtained.

If the nature of the context does have this effect on lexical access, then experiments which systematically vary the semantic restrictions imposed by context should obtain selective access effects when these restrictions are sufficient to discriminate between senses of the priming word and multiple access effects otherwise. Experimental studies on recognition of unambiguous words used to complete sentences have clearly distinguished between the constraining effects of different sentential contexts (cf. Schwanenflugel and Shoben 1985; Schwanenflugel and LaCount 1988). Contexts were divided into high and low constraint contexts as illustrated in (3.20) and (3.21) respectively:

(3.20) The landlord was faced with a strike by the ___.

(3.21) She cleaned the dirt from her ___.

where high constraint sentences imposes a strong semantic restrictions on the upcoming word and low constraint sentences only imposes weak semantic restrictions. The upcoming words were of three types: expected words such as *tenants* and *shoes*; related words such as *residents* and *sandals*; and unrelated words such as *builders* and *floor*. The results of these experiments showed that high constraint sentences have a narrow range of facilitation since only expected completion were facilitated. Low constraint sentences have a wider scope of facilitation: both expected completions and completions related to the expected completion were systematically facilitated. Unrelated completions, however, were never facilitated by high or low constraint sentences.

Tabossi uses a similar technique to obtain selective access effects for both unambiguous and ambiguous words. Using a cross modal lexical decision task, she investigated the effect of different contexts on the unambiguous words such as *butter*[8] (cf. Tabossi 1988a). In one experiment a visual target, such as *fat*, was presented at the offset of the unambiguous word in three contexts:

(3.22) In order to follow her diet, the woman eliminated the use of butter.

(3.23) Before paying, the man checked the price of butter.

(3.24) In order to soften it, the woman heated the piece of butter.

The context in (3.22) imposes a specific semantic restriction on the sense of *butter*, a restriction which is appropriate to the visual target *fat* (butter is fattening). The second context in (3.23) imposes no specific restrictions on the sense of *butter*, while the third context in (3.24) imposes a specific restriction which is inappropriate to the target *butter* (butter is malleable). According to the multiple access view, where each of these senses is accessed independent of context, the lexical decision task will not be affected by the nature of these contexts for *butter*. According to the view that selective access is dependent upon the facilitatory effects of context on *butter*, the results should differ. In particular, lexical decisions in positively constraining contexts like (3.22) should be faster than in unconstraining, or neutral, contexts like (3.23). Lexical decisions in negatively constraining contexts, such as (3.24), however, should be slower than in a neutral context on account of interference between the sense facilitated by the context and that required by a visual target like *fat*. The results of her experiments matched these predictions and she concludes that:

> Lexical access may be affected by prior sentential context, provided that it imposes constraints upon the semantic information to be retrieved in an incoming word. (Tabossi 1988a: 159)

This conclusion is further supported by experiments using ambiguous words (cf. Tabossi et al. 1987). This time, the sentential contexts imposed semantic constraints on ambiguous words by priming characteristic properties of either its dominant or subordinate sense:

(3.25) The violent hurricane did not damage the ships which were in the port, one of the best equipped along the coast.

(3.26) Deceived by the identical colour, the host took a bottle of barolo, instead of one of port, and offered it to his guests.

In (3.25), the dominant meaning of *port* is facilitated through the context imposing the characteristic property that the port is safe, whereas in (3.26) the subordinate meaning is primed through the property that the port is red. These sentences were followed by either visual targets, such as *safe* and *red*, which related to one of these senses or were a control such as *short*. The results showed that in (3.25), which biased the dominant meaning, *safe* was responded to faster than *red* or *short*. However, in contexts which biased the subordinate meaning, both *safe* and *red* were responded to faster than the control *short*. These results support not only the effects of context upon lexical access, but also dominance effects. While context and dominance constraints converge in contexts biasing the dominant meaning so that only the dominant sense need be accessed, both senses are accessed in contexts which bias the subordinate sense since context and dominance effects diverge.

Accounting for the lack of selective access effects in some experiments on the basis of the nature of the sentential context has been further reinforced by experiments which demonstrate that the discrepancy is not due to different relationships between the visual targets and the

[8] The experiments were actually conducted in Italian, but Tabossi's examples are given in English.

priming word (cf. Tabossi 1988b). For whereas Tabossi used targets which described a characteristic aspect of the sense (e.g. *red*, *safe*), Onifer and Swinney (1981) used targets which were associates or synonyms of the priming word (e.g. with *ring* the targets were *finger* and *bell*). Consequently, the discrepancy could be due not to differences in context, but different intra-lexical relations between prime and target words. Tabossi investigated this by varying the primes and targets. Using targets which are associates of the prime, such as *sea* and *liqueur* for the prime *port*, in a context such as:

(3.27) The man had to be at the port at five o'clock for a very important meeting.

which was biased towards the dominant sense but did not prime it, no selective access effects were observed: lexical decisions with *sea* and *liqueur* were faster than control *hand*. Likewise, using the same biasing, but non-constraining context, but with targets describing characteristic aspects of the prime's senses, no selective effect was observed: lexical decisions on *red*, *safe* were faster than the control *hand*. Finally, when associate primes were presented after constraining contexts such as (3.25), selective access was obtained: decisions on *sea* were faster than those on *liqueur* or *hand*.

In sum, the results of these experiments reinforce the results of Seidenberg et al. (1982) and support a view of lexical access in which both context and dominance play a role in selecting the appropriate sense of expression. This view also provides an explanation of the discrepancy with results, such as those of Swinney and Onifer (1981), which failed to find these selective effects. Furthermore, these results provide empirical support for our claim that discourse context can affect lexical as well as linguistic conceptual structure: in cases where the discourse context is sufficiently specific, the contextually appropriate sense can be selected from lexical conceptual structure; and in cases where it is not sufficiently specific, the contextually appropriate sense is selected from linguistic structure.

3.4 Conclusion

In this chapter we have discussed empirical evidence which provides an insight into the nature and structure of conceptual descriptions in categorization and lexical access processes. This evidence supports our claim that discourse context can affect lexical as well as linguistic conceptual structure. In the case of expressions with multiple senses described in their lexical conceptual structure, a context which is sufficiently specific to discriminate between these senses can lead to the selection of the contextually appropriate sense, and the discarding of inappropriate senses prior to integration with a model of discourse (cf. Johnson-Laird 1987). Contexts which lack this degree of specificity can still play a role in sense selection but only at a later stage in the processing of conceptual structure. As a result, this supports our claim that there is an interaction between the linguistic processing and discourse processing modules: the discourse processing module must provide the linguistic processing module with a discourse context which then provides contextual restrictions on lexical conceptual structure.

As for the nature of conceptual structures themselves, lexical access as well as categorization emphasizes the importance of centrality and typicality. For not only do concepts contain characteristic or typical features, but concepts, and levels of concepts, are also related by typicality. However, the prototype approach's account of the ordering of concepts and levels of concepts in terms of typical features of concepts, is insufficient since the accessibility of concepts is also sensitive to context. One way of dealing with this is to treat concept centrality as a 'default' ordering which, unless overridden by a sufficiently specific context, such as contextual information about the culture perspective, goals or current discourse model, determines the accessibility of concepts. Such a treatment is compatible with organizing concepts in terms of the subset relations as we observed in the classical approach. In other words, concepts can be internally and externally organized by necessary relations, such as the subset relation between concepts, and typicality relations, such as the typicality relation between a concept and one of its features. However, if we are to develop this approach further, then two issues must be addressed. The first is the nature of the relation between levels of conceptual structure. For example, an expression like *fruit* in *John ate the fruit* has a lexical conceptual structure which is related to a linguistic conceptual structure in the linguistic processing module and then to a discourse conceptual structure in the discourse processing module. What then is the nature of the relationship between each of these conceptual levels? The second issue concerns the necessity and typicality relations themselves. For while the empirical evidence in this chapter provides evidence for typicality relations, it does not provide evidence for necessary relations. What motivation is there for necessary relations? Once we have addressed these issues in chapter 4, we can provide a characterization of conceptual structures in the discourse processing module in chapter 5.

Chapter 4

Approaches to Semantic Interpretation

4.1 Introduction

In chapter 3 we discussed empirical evidence which supported not only the need for typicality relations in conceptual structure, but evidence which supported our claims about the effects of context on conceptual structure. In terms of the cognitive linguistic approach to language comprehension outlined in chapter 2, discourse context can restrict lexical conceptual structures as well as linguistic conceptual structures: the discourse processing module exports a discourse context to the linguistic processing module which can lead to the selection of the contextually appropriate sense in lexical conceptual structures; and, within the discourse module, the discourse context can lead to the selection of the contextually appropriate sense in the linguistic conceptual structure. In this chapter we shall develop this approach by addressing two related issues.

The first issue concerns the relationship between levels of conceptual structure. In particular, we shall focus on the relationship between linguistic conceptual structure and discourse conceptual structure — as we shall see in chapters 6 and 7, the relationship which holds between these levels also holds between lexical and linguistic structures, thus giving a uniform relationship between levels of conceptual structures. From the formal semantics point of view, the relationship between these levels is one of interpretation within a model: the linguistic conceptual structure is a semantic representation for linguistic expressions and the discourse conceptual structure is an interpretation of this representation within a model of the world, or more specifically, a model of the discourse. Two principles of the formal semantic approach are of particular interest: semantic representations and interpretation are seen as independent levels of structure which are systematically related by a *correspondence* relation; and many, but not all, formal approaches subscribe to a realist theory of meaning, which makes a number of claims about the relationship between meaning and the world. The cognitive linguistic approach primarily differs from the formal semantic approach with respect to these principles: the realist theory is rejected; and semantic representations and interpretations are treated as levels of conceptual structure related by *extension* — discourse conceptual structure is an extension of linguistic conceptual structure.

The second issue concerns the nature and structure of these conceptual representations. With an extensional relationship between linguistic and conceptual structure, conceptual structures are treated as partial objects: i.e. semantic representations which are incomplete and which can become more complete through the addition of new properties and relations. Linguistic conceptual representations are extended into discourse conceptual representations within the discourse processing module and this leads to them (potentially) becoming less partial representations. Furthermore, as we suggested in chapter 3, these conceptual representations are structured in terms of typicality and necessity relations. These relations are motivated in terms of a criterial approach where criterial necessity relations are characterized as weaker necessity relations than deductive necessity relations.

The chapter is structured as follows. In section 4.2 we describe the correspondence approach to semantic interpretation and briefly discuss the problems which arise from its realist foundations. In section 4.3 we develop the cognitive linguistic approach by discussing five key aspects: semantic interpretation, or meaning, is bound to the information state of cognitive agents; this information state changes over time; in language comprehension, the information state can be characterized as a cognitive agent's dynamic discourse model; linguistic conceptual representations are characterized as dynamic partial objects which are extended in discourse conceptual representations within the cognitive agent's discourse model; and conceptual representations are structured in terms of criterial necessity and typicality relations. Section 4.4 concludes the chapter.

4.2 Interpretation as Correspondence

The correspondence approach to semantic interpretation is founded upon two principles: a model-theoretic approach to interpretation; and a truth-conditional approach to interpretation (cf. Dowty et al. 1981).

The model-theoretic approach characterizes interpretation using the resources of mathematical logic such as set theory. A distinction is made between domains: the logical form, or semantic representation, associated with expressions in natural or formal languages; and a model which specifies the semantic value, or interpretation, of the representation. These domains are ontologically independent: structure of semantic representations is defined in terms of predicates, constants, variables and operators, such as conjunction and (logical) implication; and structures in the model are defined in terms of a set of objects and relations. These ontologies do not overlap: structures in these domains are defined in different formal languages. While these domains are independent, they are also systematically related by *correspondence*. The systematic correspondences between structures in these domains are specified by a recursive interpretation function. Interpretation is thus compositional: the interpretation of a whole structure is a function of the interpretation of its parts (cf. Frege 1976). Furthermore, the meaning of the part in the logical form language is the conditions under which it corresponds to an object in the model. Depending upon the state of the model these conditions may, or may not, be satisfied within the model.

The truth-conditional approach imposes further conditions upon the model-theoretic approach (model theory itself is neutral). In particular, the conditions under which a structure in logical form corresponds to a structure in the model are treated as truth conditions and the model itself is treated as an instance of the world. The interpretation of natural language expressions is thus based upon semantic representations which specify conditions under which there is a true correspondence between expressions and (a model of) the world:

> To know the meaning of a (declarative) sentence is to know what the world would have to be like for the sentence to be true. (Dowty et al. 1981: 4)

The semantic representation of a sentence, then, is the set of necessary and sufficient conditions under which it truly corresponds to relations between objects in the model of the world. Its semantic interpretation can either be true or false: i.e. either these conditions are satisfied in the model or they are not. Consider, for example, the representation and interpretation of *Bush welcomed Gorbachev* illustrated in figure 4.1. Its semantic representation is characterized

semantic representation: $w(b, g)$
semantic interpretation:

$$
\begin{array}{ll}
|w|(|b|,|g|) & \\
|b| = & Bush \\
|g| = & Gorbachev \\
|w| = & << Bush, Gorbachev >> \\
M = & < A, F > \\
A = & < Bush, Gorbachev, Yeltsin > \\
f_w a = & \begin{cases} 1 & \text{if a} \in \text{A} \\ 0 & \text{otherwise} \end{cases}
\end{array}
$$

Figure 4.1: Model-theoretic interpretation of *Bush welcomed Gorbachev*

as the structure $w(b, g)$: i.e. a two-place predicate w whose first argument is the constant b and whose second argument is the constant g. The conditions on the interpretation of this structure are as follows: the interpretation of b, i.e. $|b|$, must correspond to the object *Bush*, just as the interpretation of g must correspond to *Gorbachev*, and the interpretation of w must correspond to a relation between objects, where the relation is characterized a set of paired objects $<< Bush, Gorbachev >>$. Consequently, the interpretation of the sentence *Bush welcomed Gorbachev* is true with respect to the model M if and only if these conditions are satisfied in the model: i.e. if the representation can be compositionally related by interpretation function F, here $f_w a$, to the set of objects in the model A.

The correspondence approach originates with Tarski's extensional definition of truth which states that a sentence S is true in model M under assignment g (cf. Tarski 1944). As formal semantics developed, however, richer definitions have emerged which provide more structure within the model and correspondingly finer distinctions in the truth conditions. For example, approaches where truth is evaluated against a 'world' which is one of the 'possible' worlds within the model, arose from the introduction of modality: i.e. a sentence S is true at world W in model M under assignment g (cf. Kripke 1965; Montague 1974). With other definitions, truth is also evaluated against a subset of possible worlds accessible from the world W in which the sentence is uttered (cf. Veltman 1983; Stalnaker 1984; Veltman 1985):

> A sentence S is true at world W in model M under assignment g given some contextual (information) structure I.

where I is a subset of worlds constituting the 'background' information available at the world W. Other more recent definitions, such as those offered within Discourse Representation Theory (DRT), have taken into account the discourse context of the sentence (cf. Kamp 1981; Heim 1982; Heim 1983; Groenendijk and Stokhof 1989):

> A piece of discourse D is true in a model M under a proper embedding of (the representation of) D into M.

And finally, the definitions offered by Situation Semantics take both the structure and partiality of objects into account (cf. Barwise and Perry 1983; Israel 1983; Fenstad et al. 1987).

One advantage of the correspondence approach is its clarity: the analyses of semantic phenomena it offers are couched in terms of a framework where semantic representations, semantic interpretations, and the relationship between them are clearly defined (cf. Dowty et al. 1981). Another advantage is that it can give an account of what language is good for. Language can be used to communicate about the world and thus guide our behaviour within it (cf. 'language success' in Putnam 1978). Given that the systematic correspondence between semantic representations of linguistic expressions and objects and relations in a model of the world are satisfied, information about the world can be communicated and this information can guide the behaviour of cognitive agents. If one agent utters the sentence *there is a dangerous dog in the next room*, for example, then another agent could interpret this with respect to their model of the world and this information could lead to her running away or making sure the door is securely closed.

The correspondence approach, however, is problematic for a cognitive linguistics approach in that it is not a cognitive approach to semantic interpretation: i.e. neither semantic representations nor their interpretation in a model of the world have anything to do with cognitive representations. This raises the question of whether the correspondence approach *could* be part of cognitive approach to language comprehension (cf. Partee 1978). In particular, are the semantic representations associated with linguistic expressions, and their interpretation in a model of the world, available to us as cognitive agents? If they are not, then the utility of model-theoretic approach is that of a meta-constraint upon formal semantic description rather than part of cognitive agent's interpretative competence: satisfaction within a model does not reflect our judgment as to whether or not a description associated with a sentence is true, but whether the description of that judgment is formally correct (cf. Putnam 1988).

In the first place, semantic representations, or intensions, in the correspondence approach are not available to us in the sense of grasping the content of an expression:

> The model-theoretic intension of a word has in principle *nothing whatsoever* to do with what goes on inside a person's head when he uses that word. (Dowty 1979: 375; original emphasis)

Furthermore, even if they were cognitive representations, they would be beyond the capacities of individual cognitive agents. For they describe the outer limits on meaning of expressions rather than the actual meaning available to a particular agent. Consider, for example, the treatment of natural kind terms such as *lion* and *gold*. The intension of *gold* specifies not what a listener grasps during comprehension or production, but rather all the relevant connections between a word and its semantic interpretation:

> How to recognize its extensions, all semantic entailments and true empirical facts involving the word. (Dowty 1979: 385).

With natural kind terms such 'connections', it is assumed, are only known to a few experts within the linguistic community: the majority of language users do not have access to these semantic representations, they do not know the conditions under which this expression is true or false. As a result, it seems difficult to treat these semantic representations as conceptual representation in the cognitive linguistic approach.

In the second place, given that interpretation is determined within a model of the world, it seems possible that this model is available to cognitive agents. Such a model, however, is not available to us in the sense of 'grasping' the content of a sentence (cf. Dowty et al. 1981; Kamp 1981; Rott 1990):

> Such a model is not in any sense a representation, mental or otherwise, of the content of the sentence.

Another way in which this model could be available to cognitive agents is as a 'mental' model of the world: i.e. the model in the correspondence approach is our model of the world. Satisfaction within the mental model would then mirror the judgment as to whether a certain state of affairs holds in the world. The problem, however, is that many instances of the correspondence approach adopt a realist approach to the relationship between meaning and the world. For example, Landman (1985: 35) treats Situation Semantics as a realist theory of meaning:

> The most striking difference between the semantic theory embodied in Jon Barwise and John Perry's *Situations and Attitudes* and most variants of intensional semantics is the strict realism it supports.

Realism is a philosophical doctrine founded upon the following principles:

Bivalence all descriptions of the world are either true or false.

Logical Independence the truth (or falsity) of a description obtains independently of any individual.

Metaphysical Independence the world is determinately constituted independent of any experience we may have of it.

However, if we were to adopt a realist approach towards the relationship between meaning and the world, then we would face a number of problems.

In the first place, the principle of bivalence has been questioned on the grounds that there are situations in which cognitive agents can be unsure as to whether a description of the world is true or false. For example, while we may be sure that London is the capital of England, we may be unsure whether the statement *Edinburgh is more beautiful than London* is true or not. A second problem concerns logical independence: i.e. truth is absolute and not relative to the information or evidence of a cognitive agent. For example, the comparison between Edinburgh and London is true or false independent of the evidence which any cognitive agent can be adduced. No matter how much evidence, say in the form of surveys, is provided to show that the description is 'true', the truth or falsity of the statement is unaffected. The third problem is that realism claims the structure of the world obtains independently of our perceptions of it. The world, apparently, comes to us with structure, i.e. objects and relations, over which we have no control. However, some semanticians have denied that we can directly refer to any objects in this world (cf. Landman 1986): we do not actually know which real world objects and relations our language refers to since we do not interact with the world directly — it is always mediated through our experience. Furthermore, it is arguable that our experience of the world and the world itself cannot be separated:

> It can be misleading ... to speak of direct physical experience as though there were some core of immediate experience which we then 'interpret' in terms of our conceptual system. (Lakoff and Johnson 1980: 57)

Rather our experience of the world is "a product of the kind of being we are and the way we interact with our physical and cultural environments" (Lakoff and Johnson 1980: 119). Since part of this interpretation is cultural, it would be appropriate to say "we experience our 'world' in such a way that our culture is already present in the very experience itself" (Lakoff and Johnson 1980: 57). Given these considerations, it seems that the world realism speaks of is not the world available to cognitive agents. We only have access to an interpretation of the world — the real world, whose existence is not denied, is always beyond our ken.

4.3 Interpretation as Extension

If the correspondence approach to interpretation is rejected as inappropriate to a cognitive linguistic approach to language comprehension, then how is the relation between the semantic representation of a linguistic expression and its interpretation characterized? The relationship can be characterized in terms of an extensional relationship: a semantic interpretation is an *extension* of a semantic representation. Crucial to this approach is that semantic representations and interpretations share the same ontology: they are structures composed of elements drawn from the same vocabulary, rather than different vocabularies. Extension itself is characterized in terms of the relationship between partial objects: a semantic representation is a partial object which can become less partial through interpretation. Before we provide a more formal characterization of the extension of partial objects in section 4.3.1, we need to address the issue of how this approach to interpretation differs from the correspondence approach.

The most obvious difference is that this approach is cognitive. Semantic representations and interpretations are cognitive structures:

- meaning is first and foremost that which is grasped by a cognitive agent who comprehends or produces an utterance.
- interpretation of an utterance is determined within a cognitive agent's model of the world.

While this does not preclude a truth-conditional approach to interpretation, the truth of interpretation is not directly germane to a cognitive linguistic approach. Furthermore, although interpretation takes place within a 'model of the world', the approach is not model-theoretic: the focus is on the conceptual representations, processes and the effects on context rather than providing a model theory for their interpretation. This model of the world differs from models in the correspondence approach in three ways: the model specifies information available to the cognitive agent; the model is dynamic in that this information changes over time; and the model specifies information available in a discourse.

Many model-theoretic approaches have now adopted the epistemic rather than logical notion of interpretation (cf. Landman 1986; Morreau 1990; Veltman 1990). What is foundational to these approaches is the centrality of the information state in the process of interpretation: the information state provides evidence upon which a cognitive agent can determine whether or not an utterance is true or false. Such approaches, however, are not committed to the cognitive reality of the information state (cf. Rott 1990). In Veltman's approach, for example, the information state is treated a set of possible worlds compatible with all an epistemic cognitive agent 'knows' or what they accept as true. In the cognitive linguistic approach, we are committed to the cognitive reality of the information state: it describes part of the world against which a individual cognitive agent interprets linguistic expressions.

The implication of the cognitive notion of information state is that meaning and interpretation are 'mind-bound': i.e. the information state describing objects and relations in the world differs in structure and content between each and every individual. For example, my representation of *Edinburgh* may differ in structure and content from your representation; I may have a more detailed, perhaps contradictory, information about the geographic layout of the city compared with yours. Such a position has been resisted within formal semantics since Frege's criticisms of psychologism and idealism (cf. Frege 1976). Formal semantic frameworks which have adopted the epistemic position consequently treat information states, and the objects and relations which populate them, as more abstract representations. One position, the intersubjectivist position, treats information states as information about the world which is shared by cognitive agents. In one version of this, information states are private to cognitive agents, but they are assumed to be related by a counterpart relation; for example, we have our own private representations for *Edinburgh*, but assume there is a corresponding representation in the information states of other cognitive agents (cf. Zeevat 1985). Another version of this position again holds that our information states are private, but that there is a structural isomorphism between our private representations and another abstract, non-private structure (cf. Landman 1986: 107–108). In particular, our private representations of *Edinburgh* are subjective *tokens* of the same intersubjective *type* of representation. With the intersubjective position, meaning is neither in the world nor in cognitive agents, but is shared by different cognitive agents in the sense that there is a underlying common pattern in their information states.

The problem with the intersubjective position is that by assuming a common thread in our information states it leaves no room for mis-understanding between cognitive agents. Although our private representations of *Edinburgh* may differ in detail, they still contain a core of shared information. Such an assumption, however, becomes problematic in cases where cognitive agents interpret utterances in fundamentally different ways. Consider the following example of 'repair' taken from Cawsey (1991) (cf. Levinson 1983):

(4.1) A: I think John's got his oral tomorrow.
B: Oh, is he going down to Cambridge?
A: No, I mean John Smith.

In (4.1), the representations associated with *John* differ in the information states of A and B: B's representation is of an individual called *John* who did his PhD at Cambridge, whereas A's representation is of another individual with the same name who did not do his PhD at Cambridge. Until this misunderstanding is repaired in the third turn, their information states are incompatible — their information states contain different representations for *John*. Thus A and B are talking about different individuals[1]. If this is the case, then it seems difficult to maintain that information states are 'shared' in the intersubjective sense.

We maintain that information states are private and mind-bound as are representations and relations within them. Adopting this position, of course, raises the problem of how we know about the information states of other cognitive agents: if my information state and your information state are private to us, then how can I know what you mean? The answer is that while our information states are private, we use language to express these states and other cognitive agents interpret these expressions against their own information states. For example, the first turn of A in (4.1) will be interpreted against the information state of B so that a structure representing *John's got his oral tomorrow* is created. This structure may then by augmented by inferences which provide a full name for *John*, say *John Brown*, and a location for the oral examination, say *Cambridge*. When B expresses part of this information state to A in the second turn of the dialogue, A attempts to interpret the question against her own information state. However, A's information state has a structure where it is *John Smith* who has the oral and the location is, say *Edinburgh* not *Cambridge*. Since this interpretation is inconsistent with her information state, A attempts to repair it by clarifying which *John* is being discussed. In this way, their interpretations can be incompatible with the current information state of the other cognitive agent, although they not aware that they are incompatible until the difference is made public. This does not imply that we assume other cognitive agents have the same information states as ourselves: only that the difference is irrelevant until we have reason to think there is such a difference (cf. Garrod and Anderson 1987). This notion of epistemic information state, although irreducibly mentalist, recognizes that representations and relations in our information state must be expressed, must be made public, in order to communicate meaning.

Another difference with traditional model-theoretic approaches is that information states are dynamic rather than static. The correspondence approach is static in the sense that the representation of an utterance is related to fixed and eternal structures, namely the objects and relations in the model. Accordingly, interpretation can be seen as validation: a representation is truthful if and only if it can be validated against the model (cf. Putnam 1988). There is no sense it which interpretation changes the model. With a dynamic information state, on the other hand, interpretation can result in a change to the information state. In the dialogue in (4.1), B's information state may not contain a structure corresponding to *I think John's got his oral tomorrow.*. Once B has interpreted the utterance against her current information state, the

[1]Simon Garrod (p.c.) also observed this phenomena when subjects were discussing individuals at parties which they thought the other subjects had attended (they had not).

structure is added to, or integrated with, this information state to yield a new information state with this structure. In this way, a cognitive agent's information state can *change* over time. This dynamic notion of meaning and interpretation has been developed in semantic frameworks such as DRT and update semantics, as the following quote from Veltman illustrates:

> You know the meaning of a sentence when you know the *change* it brings about in the information state of anyone who wants to incorporate the piece of news conveyed by it. (Veltman 1990: 28–29)

Such a notion derives, in part, from computer science where the interpretation of a program can be given in terms of operations over machine states. Where they differ is that the notion of dynamic semantics is declarative rather than procedural: the change an utterance brings about in the information state is described in terms of relations between two information states, the current information state and the new information state, rather than in terms of an ordered set of operations (cf. Wedekind 1990).

Finally, interpretation in the cognitive linguistic approach takes place with an information state for a discourse rather than simply a sentence: the information state can be seen as a cognitive model of the discourse. Traditional model-theoretic approaches, such as Montague's, were based upon interpretation of isolated sentences. Each part of a sentence was assigned a representation which was recursively composed into a representation for the whole sentence. The sentence was then assigned an interpretation within the model. No account was taken of how the interpretation of the current sentence was affected by the interpretation of preceding sentences. However, with the advent of dynamic approaches such as DRT and update semantics, the context of interpretation moved beyond the sentence: a sentence was interpreted within a current information state which included the interpretation of preceding sentences. One of the advantages of such a move is that formal semantics could provide formal descriptions of not just sub-sentential anaphora but also super-sentential anaphora of the sort illustrated in (4.2):

(4.2) George bought a car. He drives it to work.

The DRT representation of (4.2) is given in figure 4.2. In DRT, anaphors, such as the pronouns

g c	
g = George	
bought(**g**, **c**)	
car(**c**)	S1
drive(**g**, **c**)	S2

Figure 4.2: A DRT representation of *George bought a car. He drives it to work.*

he and *it* are interpreted relative to the dynamic discourse context. The discourse context is represented as discourse representations structures (DRSs) which are incrementally constructed according to the linear ordering of the corresponding sentences[2]. Each DRS consists of two components: a set of discourse referents; and a set of conditions upon the discourse referents. In figure 4.2, the top box contains the discourse referents and the lower box their conditions. The referent of each noun phrase in (4.2) are represented as a discourse referent in figure 4.2 (given in bold typeface): **g** is the discourse referent referring to an individual called *George*;

[2] Construction is non-monotonic in DRT. Other dynamic approaches, such as dynamic predicate logic have adopted a monotonic approaches to construction (cf. Groenendijk and Stokhof 1989). We return to the issue of monotonicity in section 5.7.

and **c** is a member of the set of *cars*. The first three conditions are established with the first sentence; the last one with the second sentence. The reason why there are only two discourse referents, but four noun phrases, is that anaphoric noun phrases access discourse referents given in preceding DRSs. In other words, rather than interpret the second sentence in isolation from the first part of the discourse, it is interpreted in the context of the first, thereby allowing the anaphoric relations to be (implicitly) represented.

Where the cognitive linguistic approach differs from DRT is in the representation of content. If we take the DRS conditions as descriptions of the content of the associated expressions, something which Kamp does not do, then it should be apparent that they only provide a coarse-grain description of the semantics of the corresponding utterance. They do not, for example, specify the nature of the semantic relations between 'buyer' and 'bought' in the verb *bought* let alone any conditions upon the nature of the objects which can be so related. There is, for example, no condition upon 'buyer' that it is sentient; in DRT cabbages are capable of buying cars! This is not to deny that DRT could not be augmented to include these conditions, only that it does not currently do so[3]. Other formal frameworks, such as Situation Semantics, are quite capable of specifying such conditions. Specifying such conditions is necessary for the cognitive linguistic approach on two grounds. Firstly, it is these conditions which differentiate conceptual representations. Secondly, if the construction of conceptual structure can, as we have claimed, be affected by context, including the discourse context, then such distinctions must be explicit so that the context can play a role in determining which sense is appropriate with the current discourse context.

In sum, the cognitive linguistic approach to interpretation differs from traditional formal semantic approaches in that interpretation takes place against an information state which is available to a cognitive agent and which changes through the integration of detailed descriptions of objects and relations linguistically referenced in the discourse. We shall term this information state a *discourse model*. Furthermore, linguistic conceptual structures and discourse conceptual structures are characterized in terms of the *same* basic elements and relations. What differentiates them is that discourse conceptual structures are integrated into the discourse model — linguistic conceptual structures are not part of this model. Finally, the relationship between these levels of conceptual structure is characterized in terms of the extension of partial structures: a linguistic conceptual structure is a partial structure which is extended into a partial discourse structure through interpretation against a discourse model.

4.3.1 Extending Conceptual Structures

Conceptual structures are characterized as partial objects which are related through extension: a lexical conceptual structure is extended into a linguistic conceptual structure which, in turn, is extended into a discourse conceptual structure. This idea of relating structures through extension arises from treating conceptual structures as partial structures. In recent years there has been a growing interest with partiality in semantics (cf. Barwise and Perry 1983; Benthem 1985; Landman 1986). There are two parts to this development: an ontological shift from total to partial objects in the model; and a linguistic shift from total to partial interpretations of representations. Here we focus on partial objects, their ordering in terms of subsumption and their extension through unification.

The distinction between partial and total objects concerns the 'specificity' of objects. Total objects are objects which are totally specific relative to the ontology of the system; partial objects are underspecified objects. More formally, an object O is a *total* object if for every property p defined within the ontology, then either $p(O)$ or $\neg p(O)$. In other words, a total object is an object whose properties are all specified. A partial object, on the other hand, is an object whose properties are underspecified: i.e. only some properties of the object are specified.

[3] Recent, unpublished work by Kamp has adopted this approach (cf. Kamp and Partee 1989).

Unlike total objects, partial objects can be ordered in terms of specificity: i.e. one object can be more specific than some other object. For example, given a set of (compatible) properties $\{p^1, p^2, p^3\}$ and a set of objects $\{O^1, O^2\}$ where O^1 is defined as the set of properties $\{p^1, p^2\}$ and O^2 is defined as the set $\{p^1, p^2, p^3\}$, then O^2 is 'less partial than' O^1 because the set of properties which defined O^1 is a subset of the properties which define O^2. Conversely, O^2 is 'more partial than' O^1. We shall use the notion of *subsumption* to refer to partial ordering between object:

> O^A subsumes O^B, notated as $O^A \sqsubseteq O^B$, iff O^A is at least as specific as, if not more specific than, O^B: i.e. the set of properties defining O^A is identical to the set of properties defining O^B or they are a subset of the properties defining O^B.

Objects which can be ordered by subsumption, can also be *extended* into another (partial) object by means of unification:

> O^A unifies with O^B, notated as $O^A \sqcup O^B$, iff the result of unification is the least informative object subsumed by O^A and O^B: i.e. two objects can unify if they have compatible properties and all their properties — no more, no less — are properties of the object which results from their unification.

For example, if there is an object O^3 with the properties $\{p^4, p^5\}$, O^3 could unify with O^2 if the properties of O^2 and O^3 were compatible and the object which results from their unification had the properties $\{p^1, p^2, p^3, p^4, p^5\}$.

There are two different notions of extension, however, depending upon whether the partial objects are treated as static or dynamic partial objects. Fred Landman nicely illustrates this difference with an analogy between extension and watching movies:

> A movie is a dynamic entity which gains its sense by the things happening in it. We can stop the movie at certain points, freeze the action at a certain scene; that can even help us understand the movie better. But taking a classical view on the movie, is taking an *external* view on it, regard it as an ordered set of distinct images. Doing that might serve some purposes, but we cannot understand the *meaning* of the movie in that way, because its meaning lies in the action, in the things that are happening in it. It is impossible to understand a movie, if while watching it, you seriously regard it as a long sequence of distinct pictures. It is only by ignoring that aspect of the movie, by stepping in it, that is, by taking an *internal* view, that we can make sense of it. (Landman 1986: 125)

In particular, the extension of static objects is the *replacement* of two partial objects by another, distinct object: static extension gives rise to a distinct object. With dynamic objects, on the other hand, extension is the *growth* of two partial objects into one and the same partial object: dynamic extension results in the same object.

This distinction emerges from different notions of identity. The extension of static objects is based upon a notion of identity where objects are distinguishable from all other objects: they are only identical with themselves. Extension then involves the replacement of objects with another object, which *cannot be identical to the original objects*. Extension of dynamic objects, however, is based upon an alternative notion of identity, namely the Identity of Indiscernables (cf. Landman 1986: 34):

> Identity of Indiscernables
> P and Q are *identical* if they are indiscernable with respect to incompatibility.

Incompatibility is defined as follows:

Incompatibility

Two facts are *incompatible* if one carries information that the world is organized in a different way from what it is according to the other.

In other words, objects can only be identical if they do not have incompatible properties. Furthermore, identity is based upon discernibility: i.e. whether two objects can be distinguished on the basis of an information state. Discernibility and (weak) indiscernibility are defined below (cf. Landman 1986: 126):

Discernability

d_1 is *discernable from* d_2 *on the basis of* information state **s** iff there is a property P such that:
either $P(d_1) \in \mathbf{s}$ while $P(d_2)$ is incompatible with some fact $f \in \mathbf{s}$ or or $P(d_2) \in \mathbf{s}$ while $P(d_1)$ is incompatible with some fact $f \in \mathbf{s}$.

Indiscernability

d_1 and d_2 are *indiscernable on the basis of s* iff they are not discernable on the basis of **s**.

Two partial objects can grow into one and the same object if they are not discernable on the basis of incompatible properties in the information state. Dynamic partial objects can be (successively) extended, but will remain the same object so long as they are not extended into an object incompatible with the object at previous stages of extension.

Conceptual structures are characterized as dynamic partial objects in the cognitive linguistic approach. Conceptual structures are defined for some, but not all, properties in the ontology and, as partial objects, can be ordered in terms of subsumption. Furthermore, conceptual structures can be extended through unification with other partial objects. In the case of a linguistic conceptual structure, it is unified with a structure in the current discourse model so as to yield a discourse conceptual structure for the linguistic expression. Since these structures are dynamic partial objects, different linguistic expressions can reference the same discourse conceptual structure in the discourse model: i.e. different linguistic conceptual structures can be extended into the same discourse conceptual structure in a cognitive agent's discourse model.

4.3.2 Necessary and Typical Properties

So far in this chapter we have developed the cognitive linguistic approach by characterizing conceptual structures as dynamic, partial objects which can be ordered in terms of subsumption and extended through unification. The relationship between linguistic conceptual structures and discourse conceptual structures is characterized in terms of the extension of linguistic conceptual structures into discourse conceptual structures within the discourse model of the cognitive agent. In chapter 3, we discussed the classical approach to concepts and suggested that the classical approach can be augmented with typicality relations: conceptual levels, subordinate concepts of a superordinate concept, and properties of concepts can be related by typicality relations. Furthermore, conceptual levels, concepts and properties are also related by necessity relations. For example, subordinate concepts are related by a necessary subset, or subsumption, relation to their superordinate concepts: subordinate concepts such as *chair* and *table* must be at least, if not more, specific concepts than the superordinate concept *furniture*. In addition, the properties of these concepts are related by necessity and typicality relations; for example, *table* has the necessary property of being supported by legs and the typical property of being made of wood.

These relations, however, do not seem to hold independent of background knowledge which we bring to bear in interpreting linguistic expressions: there seems to be a dependence between necessary and typical properties defined for conceptual structures and the background knowledge which we use in interpreting them within a discourse model. With *chair*, for example, the necessary property of being supported by legs depends upon a particular theory of *chairs*: our theory of *chairs* defines certain necessary and typical properties of the concept *chairs*. Crucially, if this background knowledge changes, then so does the concept of *chair*. For example, although a *chair* is typically made of wood, this is not a property of *metal chair*: the background knowledge that chairs are typically made of wood is 'overridden' by the asserting that they are made of metal and its conceptual structure in the discourse model has the 'material' property *metal* rather than *wood* to reflect this. We shall further develop the notion of theories and their role in interpretation in chapter 5 and focus in this section on motivating necessary and typicality relations in terms of criterial and symptomic evidence relations, respectively.

The term 'criterion' derives from Wittgenstein's later philosophical writing (cf. Wittgenstein 1953). Wittgenstein himself rarely made it entirely clear what he meant by criterion (there is no 'a criterion may be defined as ...') since he saw his remarks as 'a number of sketches of landscapes ... where ... the same or almost the same points were being approached afresh from different directions, and new sketches were made' (Wittgenstein 1953: pvii). In the main, the interpretation offered here is heavily reliant on Lycan's interpretation of the role of criterion in descriptive language use (cf. Lycan 1971).

Commentators have differed over how to interpret the form of a criterion: some have seen it as an object, others as a relation. With a criterion as an object, one object is a criterion for another object, where 'object' ranges over linguistic expressions, the use of such expressions, properties, entities and events. This may be expressed as 'x is a criterion for y, where x and y range over such objects' (cf. Lycan 1971: 109). With a criterion as a relation, one object stands in a criterial relationship with another object. This may be expressed as 'x has a criterial relation with y' (cf. McGinn 1980; Baker 1977; Baker and Hacker 1984; Grayling 1985). It would appear, however, that there is no substantial difference between these two interpretations. For when Wittgenstein talks about a criterion as an object it is clear that a criterion is always a criterion *for* something and this implies that such an object must always hold a relationship with something else — hence we can talk about the relation itself as the criterial relation.

The equivalence of these interpretations is reinforced by each having the same function in the theory of descriptive language use. For criteria fulfill two roles: they are a privileged type of evidence; and this evidence can used to justify a claim, or interpretation, made by a cognitive agent (cf. Wittgenstein 1953; Wellman 1967; Lycan 1971). Here we focus on the types of evidence relations since this provides us with motivation for necessity and typicality relations in conceptual structure.

The evidential status of criterion can be simply described as follows: to say x is a criterion for y is 'to say at least that, whenever I know that x is instantiated (that something of the type x occurs or obtains), I am to that extent warranted in supposing that y is instantiated as well' (cf. Lycan 1971: 109). However, the same general statement could be made of two other evidence relations, namely deductive and inductive evidence relations. These relations differ with respect to the *situations*, or parts of situations, in which the relation holds. When x is in a deductive relation with y, then if x is present in any situation, so too must y. Conversely, if y is not present in some situation, then x cannot be present either. Thus there is no situation, apart from the absurd situation, in which one is not present without the other. This relation is closely related to two inference rules, modus ponens and modus tollens. With modus ponens, or affirming the antecedent, a relation R is deductive iff y is present in all situations in which x is present:

$$\frac{\text{modus ponens}}{\forall x \forall y (R(x,y) \wedge x \rightarrow y)}$$

With modus tollens, or denying the consequent, R is deductive iff x is absent in all situations in which y is absent:

modus tollens

$$\forall x \forall y (R(x,y) \wedge \neg x \rightarrow \neg y)$$

Accordingly, with the deductive evidential relation, the status of x as evidence for y is maximumly certain since no matter what the situation, if x exists, then so must y. The inductive evidence relation, on the other hand, involves not necessity but possibility: if x is present, then y may be present. Conversely, if y is absent, then x may be absent. Thus y does not necessarily accompany x in every situation and x does not logically entail y: in some situations x may be present, yet y absent.

The criterial evidence relation has a status intermediate between deductive necessity and inductive necessity relations: it is a stronger type of evidence relation than the inductive relation, but a weaker type than the deductive relation. Criterial relations attain this intermediate status because criterial necessity is intimately related to the situation; in particular, a cognitive agent's background knowledge about part of the situation. Consequently, the certainty of a criterial necessity relation is related to this background knowledge. This contrasts with the deductive evidence relation where *no matter what the situation*, x is evidence for y: deductive necessity gives us certain evidence independent of our knowledge about the situation. With inductive evidence, of course, there can be no certainty at all: *no matter what the situation*, if x is present, y may, or may not, be present.

Five properties of the criterial relations underpin their intermediate status: context-dependence, normativeness, convention, public observability and multiplicity. Of these, the first three directly support its difference with deductive and inductive evidence relations.

Firstly, criterial relations are context-dependent: x is only good evidence for y in certain contexts (cf. Wittgenstein 1953: 584). Consequently, the relation between a concept and a necessary property only holds when we have the appropriate background knowledge about a situation. Deductive relations, however, are context-independent: the necessity relation holds across all situations so that x is always and everywhere good evidence for y. Inductive relations are also context-independent, although the relation is simply one of possibility rather than necessity.

Secondly, criterial relations are normative: x is good evidence for y in some situation unless evidence has been produced to the contrary. As Chihara and Fodor put it:

> x is a criterion for y in situations of type s if the very meaning or definition of y justify the claim that one can recognize, see detect or determine the applicability of y on the basis of x in a normal situation of type s. (Chihara and Fodor 1967: 181–182)

In 'normal' cases then, x is good evidence for y. However, there may be 'bizarre' cases, where specific counterevidence has been adduced, and the relation no longer holds. In other words, the status of x as evidence for y is revisable in ('bizarre') circumstances which reveal alternative background knowledge about a situation and this knowledge does not support the necessity relation between x and y. Contrast this with the deductive evidence relation where the status of x as evidence for y is not revisable. When counterevidence is adduced to a deductive evidence relation in a deductive system, all axioms are undermined: maximum doubt is the twin of maximum certainty.

An example of pain behaviour illustrates normative nature of criterial relations as well as their revisibility. Suppose that you are walking along Princes' Street in Edinburgh on a Saturday afternoon. You see someone, Albert, exhibiting pain behaviour; for example, he is rolling on the ground, emitting agonized shrieks, holding his left leg and shouting 'Oh the pain, the pain!'. On the criterial approach, the pain behaviour is criterial evidence for an observer claiming that Albert is in pain: the observer's background knowledge about the situation supports a necessary relation between pain behaviour and the claim that the person displaying the pain is in pain. This is the normal case. But suppose someone, a Sceptic perhaps, denies Albert is in pain. For this denial to be accepted, and so the relation between pain behaviour and someone being in pain revised, he would have to provide evidence that the case was bizarre: i.e. that the background knowledge which the observer used in interpreting the situation is inappropriate for this circumstance. For example, the observer's background knowledge may be inappropriate because this event takes place during the Edinburgh Fringe Festival and Albert is an actor advertising a play. This would be a bizarre case: new background knowledge about the situation has been revealed, knowledge which no longer supports the status of pain behaviour as evidence for Albert being in pain.

The example also illustrates how we, as cognitive agents, are not omniscient: not all background knowledge about a situation is available to us when we interpret situations. We judge the status of Albert's pain behaviour as evidence of pain on the basis of the actual background knowledge which we bring to bear in interpreting the situation. In normal cases, this background knowledge and the situation are not incompatible: i.e. the background situation does not support properties of the situation which are incompatible with the actual situation. In bizarre cases, on the other hand, further information about the situation — that Albert is an actor advertising a play — is not compatible with our current background knowledge and so the evidential status of pain behaviour must be revised in light of this new information. Thus we may be forced, through incompatibility, to revise our background knowledge about situations as further information emerges.

Thirdly, criterial relations are conventional: that x is necessarily good evidence for y is *determined by convention*. In particular, criterial necessity relations are defined within our background knowledge about situations and this knowledge is part of our social or cultural knowledge (cf. Wittgenstein 1953). This knowledge determines what information counts as necessarily good evidence for us to make a claim: we have learnt within our culture to call x good evidence for y in certain contexts. Deductive evidence relations, however, are not determined by conventional knowledge but by logical necessity.

The fourth property of criterial relations is that they are publicly observable: i.e. given that x and y are in criterial relation for one cognitive agent, then this relation must be available to other agents so that its evidential status can be inspected and corroborated. Wittgenstein adopts this position on criteria as a curative to what he sees as the 'illness' of adopting mental pictures or private sensations as criteria. To take private sensations, for example, as criteria is fallacious since the sensations of one individual are not available to other cognitive agents and thus others cannot check them.

Wellman, however, argues that Wittgenstein is wrong about our ultimate criteria being publicly observable (cf. Wellman 1967: 165-168). While accepting the need for criterial relations to be observable, he argues that only private sensations can be observed. He bases this claim upon, for example, differences in agent's powers of discrimination (e.g. colour blindness and loss of discrimination in taste with age) and private experiences, such as dreams and hallucinations. The problem with Wellman argument is that criteria are no longer open to corroboration: an agent's own sensations, or memory, cannot corroborate the evidential status of criteria since they themselves are the basis for asserting the relations and as such do not offer an independent check on the appropriacy of the criteria.

Further, since we have already rejected the notion that cognitive agents have access to the world independent of their interpretation of it, criteria must be corroborated in some other way. Rather we hold that criteria are publicly observable in the sense that we *express* in language our interpretation of, or information about, situations and these can be corroborated by other people. This makes corroboration of criteria only intersubjective rather than subjective — as in the case of private sensations, or objective — as in the case of the real world. It is intersubjective because, although corroboration comes from another cognitive agent, that agent is constrained to make an interpretation on the basis of the 'same' background knowledge (cf. Lakoff and Johnson 1980). In this way then, the evidential status of criteria can be corroborated by another individual applying the same background knowledge in interpretation. The case of

Albert in Princes' street illustrates the point. If I were to say that Albert's pain behaviour was good evidence for claiming that he is in pain, then my claim could be corroborated by another individual applying background knowledge which supported a necessary relation between pain behaviour and the pain itself. This other individual could corroborate my claim or deny it by, for example, arguing that Albert's behaviour did not constitute pain behaviour or that I had made a misinterpretation of the situation since I did not have the background knowledge that Albert is only an actor faking pain.

The fifth and final property of criterial relations is multiplicity: there may be several different xs in a criterial relation with any one y. y may be present on the basis of the presence of different xs. Which criterion is relevant will depend on background knowledge about the situation: x^1 may be good evidence for y in one situation, but x^2 in another. In contrast, while deductive relations may be multiple too, they cannot be dependent upon background knowledge about the situation: a deductive relation must hold across all situations and so cannot be evidence in one situation, but not evidence in another. Furthermore, the relationship between these different criterial relations give rise to a 'family resemblance' effect. Wittgenstein illustrates this with the notion of a game:

> Games form a *family* the members of which have family likenesses. Some of them have the same nose, others have the same eyebrows and others again have the same way of walking; and these likenesses overlap. (Wittgenstein 1953: 17)

Thus difference criteria may be appropriate in different situations but there must be a sufficient degree of similarity between the different criteria for the same claim; if there is not a sufficient degree of similarity, then the different criteria cannot be good evidence for the same claim.

Thus the criterial evidence relation differs from both deductive evidence relations and inductive evidence relations in terms of context-dependence, normativeness, convention, public observability and multiplicity. Necessary relations in conceptual structures are based upon criterial evidence relations where these relations are supported by conventional, publicly observable background knowledge which we use in interpreting a situation. The sort of certainty which criterial necessary relations in background knowledge confer on interpretation has the advantage that it is neither absolute, as with deductive relations, nor simply probable, as with inductive relations. For with criterial necessity, we draw a boundary around the information about a situation and *assume* that further information will be compatible with our current interpretation; 'doubting has come to an end' (cf. Wittgenstein 1953: 180). However, when information comes to light which is incompatible with our current interpretation, then our interpretation is revised by changing the background knowledge which leads to this interpretation.

Finally, typicality relations, like criterial relations, in conceptual structure are also supported by background knowledge about a situation. Typicality relations are symptomatic evidence relations which provide contingently, as opposed to necessarily, good evidence for a claim. Since criterial evidence is necessarily good evidence for y, this leads to the certainty of y in terms of the background information about the situation; symptomatic evidence, on the other hand, is contingently good evidence for y in terms of this background information and so only leads to an increased probability of y. These relations also differ in directness: while criteria provide direct evidence, symptoms only provide indirect evidence. This leads to two ways in which a claim can be justified, as the following quote illustrates:

> To the question "How do you know that so-and-so is the case?", we sometimes answer by giving *'criteria'* and sometimes by giving *'symptoms'*. If medical science calls angina an inflammation caused by a particular bacillus, and we ask in a particular case "why do you say this man has got angina?" then the answer "I have found the bacillus so-and-so in his blood" gives us the criterion, or what we may call the defining criterion of angina. If on the other hand the answer was, "his throat is inflamed", then this might give us a symptom of angina. ... Then to say "A man

> has angina if this bacillus is found in him" is a tautology or it is a loose way of stating the definition of "angina". But to say, "A man has angina whenever he has an inflamed throat" is to make a hypothesis. (Wittgenstein 1953: 24–25)

If background knowledge about a situation supports typicality as well as necessary relations, then this suggests another way in which interpretation can be revised. Background knowledge may support a typical relation between a concept and a property; for example, that *actors* typically fake behaviour. This relation is supported by the situation unless there is evidence to the contrary. In some situations, this evidence may be adduced; for example, although Albert is an actor he really is in pain since he has just been mugged by 'casuals' (football hooligans). As a result, our interpretation of the situation needs to be revised in light of information which undermines a typicality relation supported by the background situation.

4.4 Conclusion

In this chapter we have developed the cognitive linguistic approach to language comprehension by discussing the nature of the relation between conceptual structures and motivating necessary and typicality relations within these structures. We rejected the characterization of the relation between linguistic conceptual structures, or semantic representation, and discourse conceptual structures, or semantic interpretation, as a correspondence between independent levels of structure partly on the grounds that the approach is positively non-cognitive and partly because of problems with realism to which some of these approaches subscribe. Instead, we developed an approach where the relationship is characterized in terms of the extension of dynamic, partial structures. In interpretation, linguistic conceptual structure is extended into a discourse conceptual structure which then becomes part of a dynamic model of discourse available to cognitive agents. Furthermore, we motivated necessary and typical relations within conceptual structures on the basis of criterial necessity and symptomic evidence relations. The interpretation of linguistic expressions involves background knowledge and this knowledge supports necessary and typical relations within and between conceptual structures. One important aspect of this criterial motivation is that interpretations are revisable: our interpretation of linguistic expressions needs to be revised in light of further information incompatible with current background knowledge. Consequently, the description of the discourse processing module must provide an account of cases where linguistic interpretation is revised. As we shall see, this description is based upon two aspects of interpretation highlighted in this chapter: linguistic conceptual descriptions are extended into discourse conceptual structures in a discourse model; and interpretation makes use of background knowledge which supports the necessary and typical relations in conceptual structure.

Chapter 5

Discourse Processes

5.1 Introduction

In this chapter we describe how a cognitive linguistic approach to language comprehension characterizes semantic interpretation. According to the modular architecture discussed in section 2.3.2, our account of language comprehension is divided between two modules. The linguistic processing module constructs a linguistic structure for a phrasal expression from lexical structures associated with lexical expressions. The conceptual part of the linguistic structure, i.e. the linguistic conceptual structure, is then interpreted in the discourse processing module so as to yield a discourse conceptual structure. As we discussed in section 4.3, the relationship between linguistic and discourse conceptual structure is characterized in terms of extension: the linguistic conceptual structure is extended into a discourse conceptual structure in the cognitive agent's discourse model. Furthermore, in motivating necessary and typicality relations in terms of criterial necessity and symptomatic evidence relations, we claimed that these relations are supported by background knowledge, or theories, about the situation described by the linguistic expressions. In the cognitive linguistic approach, two processes are defined in the discourse processing module: an *anchoring* process which extends the linguistic conceptual structure into a conceptual structure within the discourse model; and an *elaboration* process which extends the conceptual structure in the discourse model through application of *constraints* defined by a theory. That is, theories are defined for constraints, as discussed in section 2.3.3, and these describe necessary and typicality relations between properties of concepts. Consequently, the cognitive linguistic approach characterizes the interpretation of linguistic expressions in two phases: a phase in which linguistic conceptual structures become *anchored* conceptual structures; and a phase where these structures become *elaborated* conceptual structures. As we shall see, not all cases of anchoring and elaboration involve a straightforward monotonic extension of concepts: in some cases, there is a conflict between the properties of the same concept in the discourse model.

This characterization of interpretation supports the relationship between conceptual structure and discourse context for which we provided empirical evidence in chapter 3. In particular, the current discourse model is used to guide the anchoring process: linguistic conceptual structures with multiple senses, or concepts, are interpreted so that only contextually appropriate concepts are anchored and elaborated in the discourse model. In addition, a portion of the discourse model, a *discourse context*, is exported to the linguistic processing module: this context, as we shall see in chapter 7, is used to guide the combination process such that the relevant senses of ambiguous and polysemous expressions can be selected immediately. In this way, the approach can support both delayed and immediate sense selection.

The chapter is structured as follows. In section 5.2 we discuss a number of key features of the approach, including its incrementality, its unitary ontology and the consequences of an extensional relationship between conceptual structures. In section 5.3, we describe the common ontology underlying conceptual structures and theories. We then describe the conceptual structure and discourse process in detail: in section 5.4 we describe the nature and structure of linguistic conceptual structures; in section 5.5 the anchoring of linguistic conceptual structures in the current discourse model; and in section 5.6 the elaboration of anchored descriptions through application of theory constraints. The two type of extension, growth and correction, which emerge from this approach are discussed in section 5.7 and a partial account of sense correction is offered. In section 5.8, we exemplify this approach with cases of discourse level sense selection. Section 5.9 concludes the chapter.

5.2 Discourse Interpretation

In the cognitive linguistic approach, conceptual structures are related by extension: linguistic conceptual structures are an extension of lexical conceptual structures; anchored conceptual structures are an extension of linguistic conceptual structures; and elaborated conceptual structures are an extension of anchored conceptual structures. Since these conceptual structures are related by extension, they share the same ontology: all levels of conceptual structures are described in terms of the same set of properties and relations. These conceptual properties and relations are defined by background knowledge, or theories, about concepts: i.e. lexical, linguistic, anchored and elaborated conceptual structures are all composed of properties and relations defined by theories about concepts. These properties and relations of concepts are described in section 5.3. This approach to semantic structures thus differs from approaches, such as the correspondence approach described in section 4.2, which characterize semantic representations and semantic interpretations in terms of disjoint sets of properties and relations. Likewise, it differs from approaches, such as traditional psychological approaches to concepts, where there is an ontological distinction between concepts and background knowledge (cf. Miller 1978). Rather conceptual structures and theories differ in the roles they play in language comprehension. While lexical and linguistic conceptual structures are directly associated with linguistic representations of lexical and phrasal expressions, theories are not: they provide constraints on conceptual structures in the discourse model. For once a conceptual structure has been anchored in the discourse model, a theory for it is sought: the theory is defined for constraints which may not only confirm properties of the anchored concepts, but also add new properties and relations. These relations may relate the concept to other new concepts, which require anchoring in the discourse model, as well as concepts which are already anchored.

The extension of conceptual structures takes place incrementally rather than in a batch. With a 'batched' approach, linguistic conceptual structures are only exported to the discourse processing module at the end of a clause or sentence (cf. Crain and Steedman 1985). For example, with a sentence like *These happy people grow their own vegetables*, the linguistic process would combine conceptual structures for each lexical expression into a linguistic conceptual structure for the whole utterance and then, and only then, this structure is exported. This approach tends to be adopted in frameworks based upon the correspondence approach to interpretation, such as Unification Categorial Grammar (see section 6.3)[1]. With an 'incremental' approach, the linguistic conceptual structures are interpreted as the linguistic structures are combined: i.e. the linguistic structure for each word or phrase is exported to the discourse processing model and this linguistic conceptual structure is anchored and elaborated in the discourse model. If the order of combination follows the order of words, then the conceptual representation of *these happy people* is anchored and elaborated prior to its combination with *grow*. The interpretation of subsequent expressions such as *grow* can then be affected by concepts in the discourse model arising from the interpretation of expressions earlier in the sentence. In this way, interpretation of an expression in a sentence can not only be affected

[1] The correspondence approach itself is not committed to batch interpretation: the principle of compositionality ensures that every word and phrase *can* be assigned an interpretation in the model (see section 4.2).

by concepts in the discourse model contributed by previous sentences, but also by concepts contributed within the current sentence.

Incremental extension can have three effects on conceptual structures: conceptual structures in the discourse model can be more specific, coherent and stable than linguistic conceptual structures.

Increased specificity arises from the nature of extension: a linguistic conceptual structure subsumes a discourse conceptual structure. While the discourse conceptual structure must contain the properties given in the linguistic conceptual structure, new properties and relations can be added through anchoring and elaboration in the discourse model. Consider, for example, the interpretation of the two instances of *ticket* in (5.1):

(5.1) John bought a ticket to Paris. The ticket was blue.

The first sentence gives rise to a discourse model with a concept for *bought* related by an 'agent' relation to the concept for *John* and by a 'theme' relation to a concept for *a ticket to Paris* where the concept for *ticket* is related by a 'goal' relation to the concept for *Paris*. Once anchored, the conceptual structure is elaborated by theories for each of these concepts. The concept for *ticket* may be elaborated by a theory which creates additional concepts and relations. These relations underpin both the internal coherence of the concept as well as its external coherence. These relations include necessary, typical or co-variation relations between concepts (cf. section 3.2.2). In particular, a 'journey' theory of *ticket* may create a 'journey' concept which consists of two concepts: an 'arrive' concept, itself consisting of relations to concepts for 'theme' (who is arriving on the journey), 'place' (where they are arriving) and 'time' (when they are arriving); and a similarly structured 'depart' concept. Furthermore, the theory may establish relations between these concepts so that, for example, the 'goal' concept instantiated by the concept for *Paris* is necessarily identified with the concept in the 'place' role within the 'arrive' concept of the 'journey' concept — i.e. *Paris* is the arrival location in a journey. In this way, the concept for *ticket* has become more specific through elaboration. In the second place, a concept can become more specific through anchoring to a concept already elaborated in the discourse model. If, for example, the linguistic concept for *ticket* in the second sentence is anchored to the elaborated concept for *ticket* referenced in the first sentence, then the concept will be extended through the addition of properties and relations already defined for 'ticket': i.e. it will consist of a 'journey' concept, itself consisting of a 'depart' and 'arrive' concepts, and so on.

Secondly, the extension of linguistic concepts can also give rise to increased coherence, in particular increased discourse coherence. Discourse coherence concerns how discourse holds together in a meaningful or sensical way: i.e. how the phrases and sentences form a meaningful whole rather than simply a collection of isolated individual parts (cf. Kintsch and vanDijk 1978; vanDijk and Kintsch 1983; Myers et al. 1986: 6–8). One prominent approach to discourse coherence is that it is determined by relations between sentences: i.e. parts of the sentential representations are related and these relations give rise to coherent discourse. For example, in the Kintsch and vanDijk (1978) model, propositional information is abstracted from the incoming text and connected to previous propositional information in order to form a coherent discourse representation. One of the simplest ways in which propositions are linked is via explicit repetition of a noun phrase as with (5.1): the first proposition, with *bought* as the predicate, is linked to the second proposition, with *is blue* as the predicate, through repetition of *ticket*. However in the cognitive linguistic approach, we adopt a more general approach to discourse coherence: coherence can be established not only by expressions which are anchored to *explicit* concepts in the discourse model, but also *implicit* concepts (cf. Sanford and Garrod 1981). The distinction between explicit and implicit concepts arises from the contrast between linguistic conceptual structures and their corresponding theories: explicit concepts are concepts in linguistic concept structure — i.e. they are *referenced* by linguistic expressions — while implicit concepts are concepts introduced by theories. For example, in (5.1), the elaborated concept of *ticket* is related to an implicit 'colour' concept: the theory defines a 'colour' role with a 'colour' concept whose specific colour is not defined. When *blue* in the second sentence is interpreted, it is anchored to this implicit concept in the discourse model, and elaboration by its theory provides a specific value for the 'colour' property of the 'ticket' concept. Thus not only is conceptual structure for the second sentence linked to the conceptual structure for the first via the explicit concept 'ticket', it is also linked by the implicit concept 'colour'.

Finally, the extension of a linguistic conceptual structure into a discourse conceptual structure may give rise to increased stability in the discourse model. For the lexical conceptual structures for polysemous and ambiguous expressions can consist of multiple concepts which vary in their relatedness (cf. Lakoff 1987). For example *mother* is polysemous: it has specific senses, such as those expressed in *biological mother*, *nurture mother* and *genetic mother*, and these senses can be characterized as a lexical conceptual structure with a concept representing the generic sense of *mother* and subordinate concepts representing its specific senses. With an ambiguous expression like *bat*, however, its lexical conceptual structure consists of two unrelated concepts for its 'animal-bat' and 'game-bat' senses: no generic sense subsumes these senses in the lexical conceptual structure[2].

These lexical conceptual structures may be preserved in the linguistic conceptual structure for a phrasal expression. For example, the linguistic representation for *bat* in *I bought a bat* will retain the concepts for both its 'animal-bat' and 'game-bat' senses if linguistic combination does not select between them (see section 7.2.2). When this linguistic conceptual structure is interpreted, each of these concepts could be anchored and elaborated in the discourse model. For example, an anchored concept will be created for the 'game-bat' sense and a theory associated with this concept may create properties which relate it to concepts in the discourse, such as the implicit concept 'game' and the explicit concept 'buy'. Such an interpretation, however, would be unstable since the same expression references two alternative, *virtual* extensions of the same linguistic conceptual structure. Such instability can be resolved by only anchoring and elaborating the most typical sense or maintaining the instability until further information which resolves the instability turns up, as with (5.2):

(5.2) I bought a bat. It is called Harry and eats mice.

where the second sentence will lead to the 'game-bat' extension being discarded and the 'animal-bat' extension being maintained as the contextually appropriate extension of *bat*. In some circumstances, interpretation can be immediately stable: only one of a set of alternative concepts is anchored and elaborated in the discourse model. This immediate increase in stability arises from one, but not the other, concept in the linguistic conceptual structure being anchored to an existing concept in the discourse model. For example, the first sentence in (5.3):

(5.3) I was in the pet shop yesterday. I bought a bat.

acts as a context for the interpretation of *bat*. In particular, interpretation of *pet shop* creates an implicit concept 'animal' and, given 'animal-bat' but not 'game-bat' is subsumed by this concept, the 'animal-bat' concept is anchored to this implicit concept. In this way, interpretation where an anchored concept in the discourse model is related to one, but not the other, sense of polysemous and ambiguous expressions can result in the selection of the contextually appropriate senses and thereby confer stability upon the linguistic conceptual structure of the expression.

From this brief discussion of the nature of interpretation and its effects on linguistic conceptual structure, it should be apparent that interpretation is characterized in terms of three

[2] The lexical concept for each of these senses can, of course, subsume more specific senses, as in *cricket bat* and *guana bat*. Thus the lexical conceptual structure for ambiguous expressions can included subsumed conceptual structures, as with polysemous expressions.

types of conceptual structure and two extensional phases. In the first phase, linguistic conceptual structures are extended into anchored conceptual structures in the discourse model by an anchoring process. In the second phase, anchored conceptual structures are extended into elaborated conceptual structures in the discourse model by an elaboration process which makes use of constraints in theories. As we will demonstrate in section 5.8, this approach to interpretation can account for cases where the contextually appropriate sense is selected after linguistic combination: i.e. where the linguistic conceptual structure for a lexical expression contains multiple concepts and one of these concepts is selected for anchoring and elaboration on account of its relationship with a concept in the current discourse model. Obviously, it cannot account for cases where sense selection occurs within the linguistic processing module since we have not yet described this module (see chapter 7). However, if the linguistic process is going to be capable of selecting a contextually appropriate sense, rather than simply a linguistically appropriate sense, then the linguistic processing module requires a *discourse context*: i.e. a set of concepts anchored and elaborated in the discourse model which can restrict the lexical access such that only contextually appropriate sense are contained in the linguistic conceptual structure. Consequently, while the linguistic processing module incrementally exports a linguistic structure to the discourse processing module, the discourse processing module incrementally exports to the linguistic processing module a discourse context. The interaction between linguistic and discourse processing, as well as the phrases in the extension of conceptual structures, is illustrated in figure 5.1.

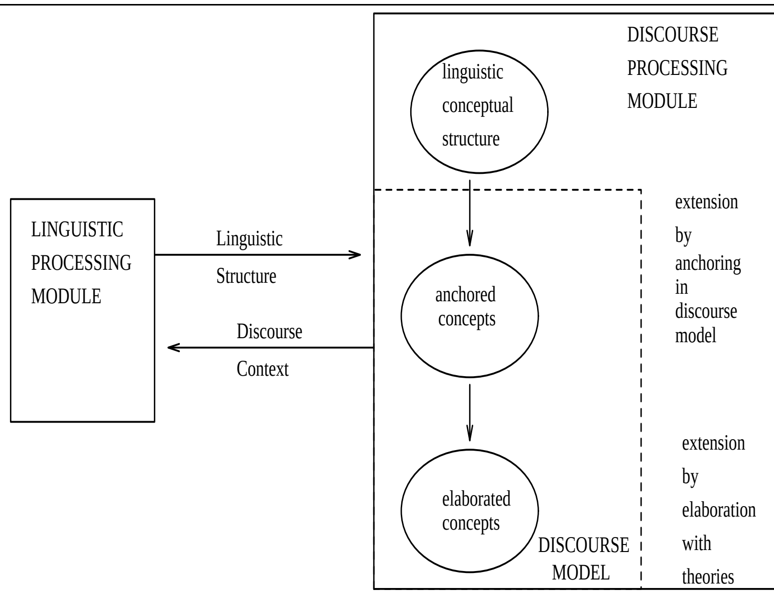

Figure 5.1: Interaction between the linguistic and discourse processing modules together with phases in conceptual extension

5.3 Basic Ontology

In this section, we describe the ontology shared by concepts and theories: i.e. they are constructed from the same, as opposed to disjoint, sets of properties. As we shall see in more detail in section 5.6, concepts differ from theories in that concepts do not contain constraints, only the result of applying constraints and conversely, theories only specify constraints, not the result of applying the constraints. We shall also see how different stages in the extension of conceptual structure differ.

As discussed in chapter 4, concepts are characterized as partial objects: i.e. objects which may be underspecified with respect to the properties defined in the ontology of the system. Concepts are thus composed of one or more properties. These properties are represented in terms of attribute values pairs: i.e. each property has an attribute label and a value (cf. Shieber 1986; Pollard and Sag 1987; Johnson 1988; Wedekind 1990). Values may be atomic or complex: an atomic value is a constant or variable; and a complex value consists of one or more attribute value pairs.

The simplest approach to characterizing concepts is to treat each one as an independent set of attribute value pairs. The disadvantages of this approach is that it fails to express the relationships between different concepts and it fails to capture generalizations about the properties of these concepts. For example, as we observed in section 3.2.1, concepts can be related by a subset relation and the properties defined for a superordinate concept, such as *furniture*, are also defined for subordinate concepts, such as *chair* and *table*. One method of providing generalizations about concepts is to characterize them as templates or types (cf. Shieber 1986). Such an approach is derived from sorted logics and strong data typing in programming language theory. In the simplest approach, concepts can be characterized as atomic types (cf. Smolka 1988). A set of atomic concept types are defined as well as a partial ordering over these types, i.e. a subsumption hierarchy with a top type and types which are subsumed by the top type. Figure 5.2 shows part of an ontological hierarchy where, for example, the type SENTIENT is subsumed by the type ANIMATE: i.e. SENTIENT is a more specific type of concept than ANIMATE[3]. The problem with characterizing concepts as atomic types, however,

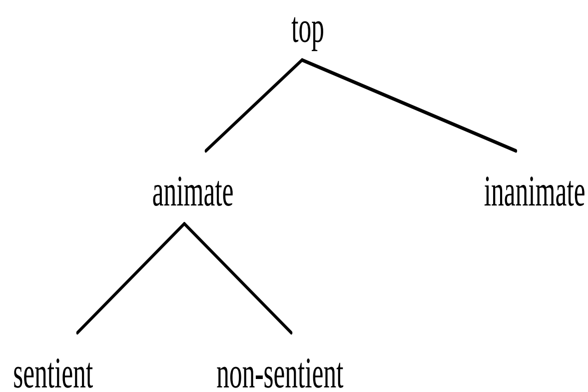

Figure 5.2: A simple atomic type hierarchy

is that they are unable to express relationships between types of concepts and properties: i.e. that the type of a concept is related to its properties. Accordingly, concepts are characterized as complex types (cf. Smolka 1989). The definition of a complex type involves the declaration of the relation between types as well as between types and their properties. For example, with complex types, not only can we state that the concept SENTIENT is a subtype of the concept ANIMATE, but that it is also defined for the property cognitive. Finally, concepts are characterized as closed types (cf. Smolka 1988): i.e. a concept is only defined for properties in its definition — other properties are undefined for the type. Whereas generalizations expressed with open type definitions have the force of existential quantification, the generalizations in closed type declarations have the force of universal quantification (cf. Moens et al. 1989).

[3] The type of a concept is given in SMALL CAPITALS while its properties, including attribute (or role) labels and atomic values, are given in sans serif.

Concepts in the cognitive linguistic approach are defined in (5.4) where '$\wedge$' indicates conjunction of properties and '*' indicates that the label is an abbreviation for a set of properties:

(5.4) concept = id $\wedge$ type $\wedge$ mode properties* $\wedge$ core properties* $\wedge$ constraints

That is, a concept is defined as the conjunction of id, type, and constraints properties together with a set of mode and core properties. We now consider each of these in turn.

5.3.1 Id

The first property, id, specifies an index for the concept. The value of this property can be a variable or a constant. Concepts which are not yet anchored in the discourse model have a variable value for this property[4]. For example, a linguistic structure may describe a concept of the type SENTIENT and its value for id will be a variable. However, when this concept is anchored in the discourse model, the value of id is given a constant value such as sentient1. Properties can then be assigned to this anchored concept through elaboration by an appropriate theory. In this way, concepts with constant values for their id property are *pegs*: they indicate a place holder upon which properties of an concept are predicated in the discourse model (cf. Landman 1986: 124). Concepts without a constant value for id cannot be distinguished from any compatible concept in the discourse model; when the id of a concept is instantiated, the concept is distinguishable from all other concepts in the discourse model. In addition, when a concept in linguistic conceptual structure is assigned the same constant value for id as specified for a concept already anchored in the discourse model, these concepts are identical: they have been dynamically extended into one and the same partial concept[5].

5.3.2 Type

The type property identifies the location of the concept within an inheritance hierarchy. A representative portion of an inheritance hierarchy is given in figure 5.3. Types are ordered in terms of subsumption such that more general types of concept subsume more specific types and, conversely, types which are subsumed by more general types inherit properties from them. Apart from the root of the hierarchy, which defines *mode* properties, each type is defined for either atomic or complex *core* properties: atomic properties are characterized with a value attribute; and complex properties are characterized with one or more role attributes, where each role expresses a relation between the concept itself and another concept in the hierarchy. In the hierarchy shown in figure 5.3, the root type TOP is defined for two mode properties, polarity and definite. The TOP type subsumes four general types of concept which in turn inherit these mode properties: EVENT, ENTITY, PROPERTY and PRE-PROPERTY. The type EVENT, for example, is defined for a core property (or role) theme. This property is inherited by the type RUN which is also defined for the roles source and goal. Likewise, ENTITY is defined for the role colour and this property is inherited by subsumed concept types such as ELEPHANT.

The four types subsumed by TOP deserve a special mention since they constitute the major ontological divisions in the hierarchy. EVENT is distinguished from ENTITY on the basis of dependence and spatio-temporal stability. For EVENT concepts require ENTITY concepts to fulfill their roles; for example, a LIKE event requires an ENTITY to fulfill the agent role and another for the theme role. Although ENTITY concepts may have roles, they are not dependent upon them. In addition, ENTITY concepts are time-stable since they maintain their identity

[4] Properties with variables as their values can be omitted from the concept unless the variable is shared with another concept. For example, in *John wants to buy a bat*, the concept for *John* and the concept in the agent role of *buy* are co-referential and so share the same variable value.

[5] They are partial concepts since another concept later in the discourse may also be anchored with the same id and add further properties.

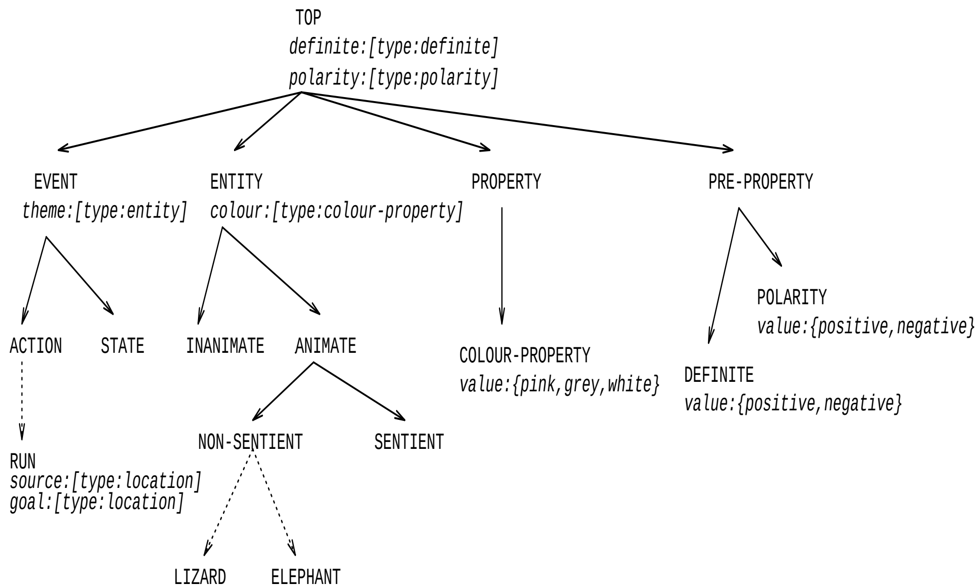

Figure 5.3: A portion of an ontological hierarchy

over time and spatially-stable since they occupy a (contiguous) region of space (cf. Givón 1979). EVENT concepts, on the other hand, lack these properties since they can change over time and are not space-occupying.

PROPERTY concepts fulfill core property roles in ENTITY or EVENT concepts. For the later concepts provide what Bartsch (1987) terms 'thematic dimensions': thematic dimensions are ways in which an ENTITY or EVENT can be specified. An ENTITY, for example, can be specified by its location in space and time (spatial and temporal dimensions). But it can also be specified by its location on thematic dimensions; for example, *John* can be specified from the perspective of his health or wealth as in *John is a very wealthy man*. Specifying an ENTITY by different thematic dimensions singles out its relevant properties.

Pre-properties, on the other hand, fulfill mode property roles on PROPERTY, ENTITY or EVENT concepts. Pre-properties provide a specification of a property which needs to be evaluated during interpretation. For example, in *a very drunk man*, the noun *man* is associated with a concept of the type SENTIENT. This concept has a role drunk which takes a concept of the type PROPERTY as its value; say DRUNK-PROPERTY. The adverb *very* specifies a mode property on the DRUNK-PROPERTY and the value of this property is partly determined by the mode specification.

5.3.3 Mode Properties

The motivation for the distinction between mode and core properties is due to the process of anchoring concepts in the discourse model. Whereas core properties form part of the anchored concepts, mode properties merely guide the process: they are used to determine which peg is appropriate for anchoring a concept, but pegs themselves do not contain mode properties.

Mode properties are concepts of the type PRE-PROPERTY. In the hierarchy shown in figure 5.3, two mode properties are defined for TOP and, by inheritance, for every type in the hierarchy. The polarity pre-property describes the polarity of a concept. For example, *no* is associated with a concept of the type POLARITY with the value negative. The definite pre-property indicates whether a concept is linguistically marked as anchorable to an existing peg in the discourse model. For example, *the* is a concept of the type DEFINITE with a value positive and indicates that there should be a peg for it in the discourse model (cf. *a*)[6]. When concepts with polarity and definite roles are anchored in the information state, the values of these roles guide the process. For example, a concept with negative polarity, such as contained in the conceptual structure for *no plants*, guides anchoring so that the concept is not anchored with concepts of the type PLANT as would normally be the case.

5.3.4 Core Properties

Core properties are properties of a concept which persist when the concept is anchored in the discourse model. The value of property is a complex value: the property label describes a relationship between the concept itself and some other concept of the type ENTITY, EVENT or PROPERTY. For example, RUN is defined for three properties (or roles): theme whose value is a concept of the type ENTITY; and goal and source whose values are concepts of the type LOCATION[7]. A concept such as this describes the concept of *run* in a sentence such as *John runs from London to Brighton* as illustrated below:

(5.5)

$$\begin{bmatrix} \mathit{type} : \mathit{run} \\ \mathit{theme} : \begin{bmatrix} \mathit{type} : \mathit{sentient} \\ \mathit{name} : \begin{bmatrix} \mathit{type} : \mathit{name} \\ \mathit{firstname} : \begin{bmatrix} \mathit{type} : \mathit{firstname} \\ \mathit{value} : \mathit{john} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \mathit{source} : \begin{bmatrix} \mathit{type} : \mathit{city} \\ \mathit{value} : \mathit{london} \end{bmatrix} \\ \mathit{goal} : \begin{bmatrix} \mathit{type} : \mathit{city} \\ \mathit{value} : \mathit{brighton} \end{bmatrix} \end{bmatrix}$$

where *John* has specialized the value for the theme role as SENTIENT with a name property which related to a FIRSTNAME concept with the value john, while *London* and *Brighton* have specialized the LOCATION types of the source and goal roles as CITY and provided a value for each concept.

5.3.5 Constraints

The final attribute of a concept is constraints: i.e. a set of constraints on a concept. Constraints make explicit the relation between a concept and its properties. The relations between concepts and properties are criterial relations: i.e. criterial necessity and symptomatic typicality (see section 4.3.2). This differentiates the approach from feature-based approaches which either lack typicality, such as the classical approach (see section 3.2.1), or characterize necessity as a deductive evidence relation. Furthermore, the use of criterial relations also differentiates our approach from non-decompositional approaches, where concepts are atomic, i.e. unstructured, but are related by 'extrinsic' relations such as meaning postulates (cf. Dowty 1979; Dowty

[6] Unfortunately, natural language is not this systematic: indefinite NPs can reference concepts already in the discourse model, just as definite NPs may fail to reference a concept in the discourse model (cf. Sanford and Garrod 1981; van derSandt 1988).

[7] These properties are (loosely) based upon thematic roles in grammar and thus can be seen as linguistically relevant properties of concepts (cf. Anderson 1971; Anderson 1977; Fillmore 1987; Starosta 1988; Anderson 1989). They can be interpreted as follows: agent roles specify the source of an action; theme the entity which is in a state or affected by an action; goal the destination of a theme in a 'moving' event; and source the source of a theme in a 'moving' event.

et al. 1981). For while intrinsic approaches with deductively related properties and extrinsic approaches with meaning postulates are formally equivalent, the equivalence disappears with intrinsic approaches with criterial relations (cf. Jackendoff 1983; Franks et al. 1988).

Constraints is a complex property defined as follows:

(5.6)
$$
\begin{aligned}
\text{constraints} &= \text{set-of(constraint)}\\
\text{constraint} &= \text{name} \wedge \text{type} \wedge \text{condition} \wedge \text{arg}^*\\
\text{name} &= \text{equality} \vee \text{inequality} \vee \text{vequality}\\
&\quad \vee \text{co-variation} \vee \text{causality}\\
\text{type} &= \text{necessary} \vee \text{default}\\
\text{condition} &= \text{path} \vee \text{constraint}\\
\text{arg} &= \text{path} \vee \text{constraint}
\end{aligned}
$$

With constraints, sub-structures within a concept are explicitly related. The name of the constraint specifies the relation between the arguments in the constraint. Relations include equality, inequality, vequality (value equality), co-variation and so on. For example, a vequality constraint specifies the value of a path argument. The type of constraints indicates whether the relation is necessary or a default; while default relations may hold, necessary relations must hold for the concept to be well-formed. Conditions indicate that the relation is conditional; necessary constraints must hold if the condition is satisfied; default relations may hold if the condition is satisfied. Using such constraints, the relationship between the sub-structures can be made explicit as the following example demonstrates:

(5.7)
$$
\begin{bmatrix}
\textit{type} : \textit{wash} \\
\textit{agent} : \begin{bmatrix} \textit{type} : \textit{animate} \end{bmatrix} \\
\textit{theme} : \begin{bmatrix} \textit{type} : \textit{entity} \end{bmatrix} \\
\textit{constraints} : \left\langle \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{necessary} \\ \textit{path} : \text{<agent type>} \\ \textit{value} : \textit{animate} \end{bmatrix} \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{necessary} \\ \textit{path} : \text{<theme type>} \\ \textit{value} : \textit{entity} \end{bmatrix} \right\rangle
\end{bmatrix}
$$

where the first constraint specifies that the path <agent type> necessarily has the value animate and the second constraint that the path <theme type> necessarily has the value entity. In this way, constraints can be seen as well-formedness conditions on concepts: they specify which properties a concept must have as well as what properties it might have. As we shall see, lexical and linguistic concepts do not contain constraints: only theories of concepts contain constraints. Consequently, when a concept in linguistic conceptual structure is elaborated, its properties are checked by applying the constraints in the theory of the concept.

Constraints do not just confirm structure in a concept: they can also create structure. For example, a concept in linguistic structure can be underspecified with respect to the core property colour. A necessary constraint on the concept may then create the path < colour type colour−property> and a default constraint specify a default value for this concept:

(5.8)

$$\left\langle \begin{array}{l} \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} : <\text{colour type}> \\ \mathit{value} : \mathit{colour\text{-}property} \end{bmatrix} \\ \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{default} \\ \mathit{path} : <\text{colour value}> \\ \mathit{value} : \mathit{grey} \end{bmatrix} \end{array} \right\rangle$$

Constraints can thus be defined for a concept so that its elaboration by a theory in the discourse model gives rise to the creation of new properties which express relations with concepts. For example, the concept in (5.9) is part of the linguistic conceptual structure for *bed* and partly describes the 'plant-bed' sense. The constraints in (5.10) can be applied to (5.9) resulting in the elaborated concept in (5.11).

(5.9)

$$\begin{bmatrix} \mathit{type} : \mathit{plant\text{-}bed} \end{bmatrix}$$

(5.10)

$$\begin{bmatrix} \mathit{type} : \mathit{plant\text{-}bed} & \\ \mathit{constraints} : & \left\langle \begin{array}{l} \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} : <\text{material type}> \\ \mathit{value} : \mathit{material} \end{bmatrix} \\ \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} : <\text{material value}> \\ \mathit{value} : \mathit{soil} \end{bmatrix} \\ \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{default} \\ \mathit{path} : <\text{location type}> \\ \mathit{value} : \mathit{garden} \end{bmatrix} \end{array} \right\rangle \end{bmatrix}$$

(5.11)

$$\begin{bmatrix} \mathit{type} : \mathit{plant\text{-}bed} \\ \mathit{material} : \begin{bmatrix} \mathit{type} : \mathit{material} \\ \mathit{value} : \mathit{soil} \end{bmatrix} \\ \mathit{location} : \begin{bmatrix} \mathit{type} : \mathit{garden} \end{bmatrix} \end{bmatrix}$$

When the constraints in (5.10) are applied to the concept in (5.9), the concept is elaborated through the addition of the roles material and location. The first and second constraints creates the role material and assigns its concept the type MATERIAL and the value soil. The third constraint, a default constraint, creates the role location and assigns its concept the type GARDEN. Constraints on a concept can thus be seen as inference rules which elaborate underspecified concepts in linguistic conceptual structure. In the case of (5.9), these constraints infer that if there is a plant bed, then it must be made of soil and it may be located in a garden.

5.4 Linguistic Conceptual Structure

The linguistic conceptual structure is the semantic part of the linguistic structure exported by the linguistic processing module. As we shall see in chapters 6 and 7, lexical and linguistic structures are characterized as structured objects, namely signs, which have semantic, syntactic and phonological properties, as well as constraints which explicitly relate substructures within signs. Combination of expressions is characterized in terms of the extension of signs to produce a result sign for the phrasal expression. Thus a linguistic conceptual structure is the value of the semantics property in a result sign.

Linguistic conceptual structures are composed of concepts as defined in section 5.3. In the simplest case, the linguistic conceptual structure for an expression is a single concept: i.e. the expression always specifies the same sense. However, in the cognitive linguistic approach, the relationship between concepts and linguistic conceptual structure can be more complex due to the tension between conceptual flexibility and specificity (cf. Dunbar and Myers 1988; Murphy 1988; Myers et al. 1989). What underpins this approach are the two assumptions about word meaning (cf. Lyons 1977b; Ross 1981):

1. The meaning of any words can consist of more than one sense; the majority of words have a large number of interrelated senses.
2. The meaning of a word varies systematically with context.

These assumptions directly oppose the assumption that most words have a single sense and that where there is more than one sense, there are only a few, unrelated senses. The later assumption underpins Lexical Atomism (cf. Lycan 1988). The linguistic theories of Davidson, Hintikka and Montague are founded upon lexical atomism. In particular, Lexical Atomism assumes a limited role for flexibility, especially ambiguity, in natural language:

> Lexical ambiguity in a natural language is neatly limited. Of course a word may have more than one sense, but the several senses it has may be crisply captured in a short, discrete list and treated by linguistic conceptual as brutally homonymous or equivocal (otherwise its separate uses could not have been learned in so short a time by speakers). (cf. Lycan 1988: 107)

We, on the other hand, claim that flexibility is fundamental to natural language: many words are ambiguous and/or polysemous in that they can specify more than one specific sense and which sense they will specify depends upon the context in which they occur[8]. Consider, for example, the different senses of *charged* in (5.12) to (5.17) respectively (taken from Lycan 1988: 111):

(5.12) Chatterton charged the gun.
(5.13) Chatterton charged the jury.
(5.14) Chatterton charged her with murder.
(5.15) Chatterton charged him with responsibility.
(5.16) Chatterton charged the chap too much.
(5.17) Chatterton charged the battery.

In these examples, *charged* specifies a range of sense varying from the 'swearing in' sense in (5.13), through the financial sense in (5.16) to the electrical energy sense in (5.17). However, in each example which specific sense is appropriate seems unproblematic.

This tension between flexibility and specificity has directed us towards treating the senses of many expressions as conceptual structures which contain more than one concept. Each of these concepts specifies linguistically relevant properties of concepts: i.e. properties of the concept described in section 5.3 which, like traditional selectional restrictions, restrict the

[8] See chapter 3, especially sections 3.2.2 and 3.3, for experimental evidence.

combinatorial potential of the expression (cf. Katz and Fodor 1963). In particular, each concept must be specified for its type; may be specified for mode properties such as definite and polarity, as well as core properties, such the thematic roles agent and theme which determine the valency of verbs like *wash*; but is never specified for constraints. Furthermore, these concepts in a linguistic structure are ordered in terms of subsumption and disjunction. Consider for example, the conceptual structure associated with *bed*. In (5.9), one of its senses, the 'plant-sense', is represented. However, *bed* is both polysemous and ambiguous: there are, for example, more specific sense compatible 'plant-bed' senses, such as 'flower-bed' and 'vegetable-bed', as well as other, incompatible senses such as 'mattress-bed' and 'river-bed'. These sense can be ordered in term of subsumption and incompatibility as figure 5.4 illustrates. The conceptual

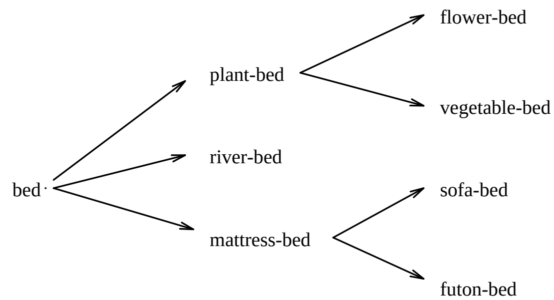

Figure 5.4: Senses of *bed* ordered in terms of subsumption and incompatibility

structure for *bed* can be characterized in terms of disjunction of incompatible concepts and the conjunction of compatible ones. If, however, disjunctive normal form is used to represent incompatible concepts, then there may be redundancy since the shared properties will need to be represented separately in each sense (cf. Bouma 1990). This redundancy can be avoided by 'general' disjunction where a disjunctive structure is optimized so as to partition it into a definite or stable part, containing only unconditional conjunctions, and an indefinite or unstable part containing a set of disjunctions (cf. Kasper 1987; Wedekind 1990). For example, the structure in (5.18) can be optimized as (5.19) with σ as the definite part shared between each disjunction:

(5.18) $(\theta \wedge \sigma) \vee (\lambda \wedge \sigma) \vee (\chi \wedge \sigma)$

(5.19) $\sigma \wedge (\theta \vee \lambda \vee \chi)$

In this way, shared properties of concepts can be represented as a stable part shared by each disjunct in the conceptual structure.

By ordering concepts in linguistic conceptual structure in terms of subsumption and disjunction, *bed* can be associated with the conceptual structure in (5.20):

(5.20)

$$\left\{ \begin{array}{l} \left[\ \mathit{type} : \mathit{mattress\text{-}bed}\ \right] \\ \left[\begin{array}{l} \mathit{type} : \mathit{plant\text{-}bed} \\ \left\{ \begin{array}{l} \left[\ \mathit{type} : \mathit{vegetable\text{-}bed}\ \right] \\ \left[\ \mathit{type} : \mathit{flower\text{-}bed}\ \right] \end{array} \right\} \end{array} \right] \end{array} \right\}$$

This conceptual structure consists of a top-level disjunction where each disjunct specifies a general concept: the first disjunct contains a concept of the type MATTRESS-BED; and the second, a concept of the type PLANT-BED. Nested within the second disjunct is a further disjunction specifying two specific sense subsumed by the PLANT-BED concept: the first disjunct specifies a VEGETABLE-BED concept; and the second specifies a FLOWER-BED concept. Each of these disjunctions can be specified for typicality as suggested in chapter 3; for example, MATTRESS-BED may be the dominant sense and within the subordinate sense PLANT-BED, VEGETABLE-BED may be more typical than FLOWER-BED. As we shall see in section 7.2, these typicality relations can be defined by constraints on signs.

Characterizing lexical conceptual structure in this manner supports the notion that flexibility is an inherent part of language comprehension. For extending conceptual structures of this sort can result in any embedded concept being selected for anchoring and elaboration in the discourse model. The point at which a specific concept is selected can, of course, vary. In some cases, the discourse context will provide sufficient restrictions on the upcoming concept to select a concept in the lexical conceptual structures. In other cases, the conceptual structure of a combining expression can constrain the appropriate sense; for example, with *charged* in (5.12) to (5.17), the conceptual structure for the object NPs plays a crucial role in selecting the appropriate sense. In still other cases, the linguistic conceptual structure will retain the disjunctions specified in lexical conceptual structure of the combining expressions. When this occurs, the current discourse model plays the major role in selecting the appropriate sense. For example, with *bed* in (5.21):

(5.21) The kids were playing in the house. Peter fell onto his bed and giggled.

the MATTRESS-BED concept is appropriate since the interpretation of *house* results in the creation of an implicit concept (BEDROOM) which contains another implicit concept of the type MATTRESS-BED in the discourse context and only the concept MATTRESS-BED in the structure for *bed* can be anchored to this concept. In this way, flexibility in conceptual structure is natural since cognitive agents are also provided with the means of selecting the appropriate sense. Of course, there will still be cases where even the discourse model will be unable to select between competing senses. If neither of the top-level disjuncts are selected, then ambiguity arises; if one of these is selected, but lower disjuncts cannot be selected, then a generic sense arises.

5.5 Anchored Concepts

The first phase of interpretation in the discourse processing module involves the *anchoring* of concepts in the linguistic conceptual structure. The purpose of the anchoring is to integrate the concept into the current discourse model. This can occur in one of two ways. One way is through unification of the concept with a *peg*, i.e. a concept already anchored in the discourse model with a constant value for its id property. Consider the discourse given in (5.22) to (5.25):

(5.22) John and Mary traveled into London yesterday.

(5.23) They went into a travel agents.

(5.24) John bought a ticket to Paris.

(5.25) The ticket was blue.

In (5.25), the linguistic conceptual structure for *The ticket* may consist of a single concept of the type TICKET. This concept can be unified with the concept for *a ticket to Paris* which is already anchored and elaborated at this point in the discourse. Thus (5.26) unifies with (5.27) to yield the concept in (5.28):

(5.26)

$$\left[\ type : ticket\ \right]$$

(5.27)

$$\begin{bmatrix} id : ticket1 \\ type : ticket \\ goal : \begin{bmatrix} id : city2 \\ type : city \\ value : paris \end{bmatrix} \\ journey : \begin{bmatrix} id : journey1 \\ type : journey \\ arrive : \begin{bmatrix} id : arrive1 \\ type : arrive \\ place : \begin{bmatrix} id : city2 \\ type : city \\ value : paris \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

(5.28)

$$\begin{bmatrix} id : ticket1 \\ type : ticket \\ goal : \begin{bmatrix} id : city2 \\ type : city \\ value : paris \end{bmatrix} \\ journey : \begin{bmatrix} id : journey1 \\ type : journey \\ arrive : \begin{bmatrix} id : arrive1 \\ type : arrive \\ place : \begin{bmatrix} id : city2 \\ type : city \\ value : paris \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

If there is no compatible peg in the discourse model for the concept to unify with, then a new peg is created: the id of the concept is assigned a constant value and the concept is added to the discourse model. For example, at the point of interpreting (5.22), given in (5.29), there is no compatible peg in the current discourse model for the concept associated with *London*[9]:

(5.29)

$$\begin{bmatrix} id : go1 \\ type : go \\ theme : \begin{bmatrix} id : sentient1 \\ type : sentient \\ \left\langle \begin{matrix} \begin{bmatrix} id : sentient2 \\ type : sentient \\ name : \begin{bmatrix} id : name1 \\ type : name \\ firstname : \begin{bmatrix} id : firstname1 \\ type : firstname \\ value : john \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \begin{bmatrix} id : sentient3 \\ type : sentient \\ name : \begin{bmatrix} id : name2 \\ type : name \\ firstname : \begin{bmatrix} id : firstname2 \\ type : firstname \\ value : mary \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{matrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

[9] In (5.29), the conjunction *John and Mary* is treated as a concept with a set value.

Consequently, a new peg, city1, is created and the concept for *London* is anchored to this peg in accordance with the linguistic conceptual structure for *went*:

(5.30)

$$\begin{bmatrix} id : go1 \\ type : go \\ theme : \begin{bmatrix} id : sentient1 \\ type : sentient \\ \left\langle \begin{array}{l} \begin{bmatrix} id : sentient2 \\ type : sentient \\ name : \begin{bmatrix} id : name1 \\ type : name \\ firstname : \begin{bmatrix} id : firstname1 \\ type : firstname \\ value : john \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \begin{bmatrix} id : sentient3 \\ type : sentient \\ name : \begin{bmatrix} id : name2 \\ type : name \\ firstname : \begin{bmatrix} id : firstname2 \\ type : firstname \\ value : mary \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{array} \right\rangle \end{bmatrix} \\ goal : \begin{bmatrix} id : city1 \\ type : city \\ value : london \end{bmatrix} \end{bmatrix}$$

Anchoring thus involves an extension of the concept: minimumly, the id of the concept is given a constant value; and, if the concept is unified with an existing peg, then properties of the peg and concept are shared since they are both one and the same dynamic partial concept. Further, as a consequence of anchoring a concept, the discourse model is extended either through the addition of a new peg or through the extension of an existing peg.

So far, the only restriction on anchoring is that the concept must be compatible with the peg: i.e. only compatible concepts can unify. However, this is not adequate. For, as we noted in section 5.3.3, the mode properties of a concept provide further restrictions on anchoring. This is apparent with concepts referenced by pronouns such *she*, *they*, *it* or *themselves*. For example, if the discourse in (5.22) to (5.25) were extended with (5.31):

(5.31) The travel agents congratulated themselves on the sale.

then, in principle, the reflexive pronoun *themselves* could be anchored to either the peg for *John and Mary*, i.e. sentient1, or the peg for *The travel agents*, travel-agent1, since both are specified for sets of entities. However, the concept for *themselves* is specified for the mode property pronominal as shown in (5.32):

(5.32)

$$\begin{bmatrix} type : sentient \\ pronominal : \begin{bmatrix} type : pronominal \\ value : reflexive \end{bmatrix} \end{bmatrix}$$

and the anchoring process is guided by this mode property such that the concept must be anchored to an existing, compatible peg and this peg must be contained within the anchored conceptual structure referenced by the current sentence. Of course, not all concepts provide such specific restrictions on anchoring. For example, if (5.25) were replace by (5.33):

(5.33) It was blue.

then the concept for *It*, i.e. a concept of the type ENTITY, could be anchored to any anchored concepts in the discourse model with a compatible type; e.g. city1, company1 (for *a travel agents* in (5.23)), ticket1 and city2. If the anchoring were simply based upon recency, i.e. anchor to the most recent peg added to the discourse model, then *It* would be incorrectly anchored to the peg city2 (cf. Zernik and Brown 1988).

In the cognitive linguistic approach, anchoring is restricted by structuring the discourse model in terms of *domains* and requiring pegs to remain consistent through the discourse. The notion of structuring a discourse model in terms of domains derives from research which investigated the relation between an anaphoric expression, such as a pronoun, in a sentence and its antecedent within the discourse (cf. Grosz 1977; Sidner 1979; Grosz 1981; Grosz et al. 1983; Dale 1990). For example, with the generation of anaphoric expressions in the EPICURE generation system, the discourse model is organized into three domains: a local focus domain which contains linguistic information about the current and previous utterances; a global focus domain which contains conceptual information, but not lexical and syntactic information, about the remainder of the discourse; and a discourse center, within the local focus domain, which contains the focus of attention in the discourse (cf. Dale 1990: 243–251). These domains are ordered in terms of *accessibility*: i.e. how accessible the concepts within these domains are for pronominalization. In particular, the discourse focus domain is more accessible than other parts of the local focus domain, and the local focus domain is more accessible than the global domain. Pronominalization is then determined on the basis of whether the antecedent is located in an accessible domain; for example, if the antecedent is the discourse centre, then the concept can be pronominalized as with *drain the carrots and rinse them* (cf. Dale 1990: 244).

We adopt a similar, although simpler, approach to accessibility. The discourse model is structured into four domains, ordered with respect to accessibility as illustrated in figure 5.5[10]. The 'top' domain of the discourse model contains two domains: a global domain and a local

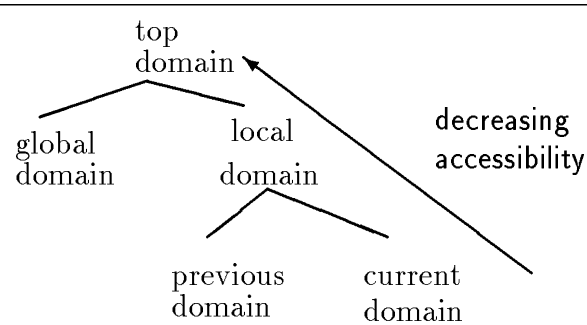

Figure 5.5: Domains in the discourse model ordered with respect to accessibility

domain. The local domain in turn contains two domains: a current utterance domain, which contains conceptual structure created during the interpretation of the current sentence[11]; and a previous utterance domain containing the conceptual structure for the previous sentence. The global domain contains conceptual structures created from the interpretation of sentences other than current and previous sentences. The structure of the discourse model arising from the interpretation of the discourse in (5.22) to (5.25) is illustrated in figure 5.6 where conceptual

[10]These domains can be further structured in terms of rhetorical relations between conceptual structures, such as cause-consequence, condition-consequence and argument-claim, where the appropriate set of relations may vary with the type of discourse (cf. Mann and Thompson 1988; Caenepeel 1991).

[11]Utterances, of course, may not be sentences; for example, an appropriate answer to the question *Where do you want to fly?* is *Paris*.

structures are given a schematic graph-theoretic representation[12]. Anchoring a concept in the

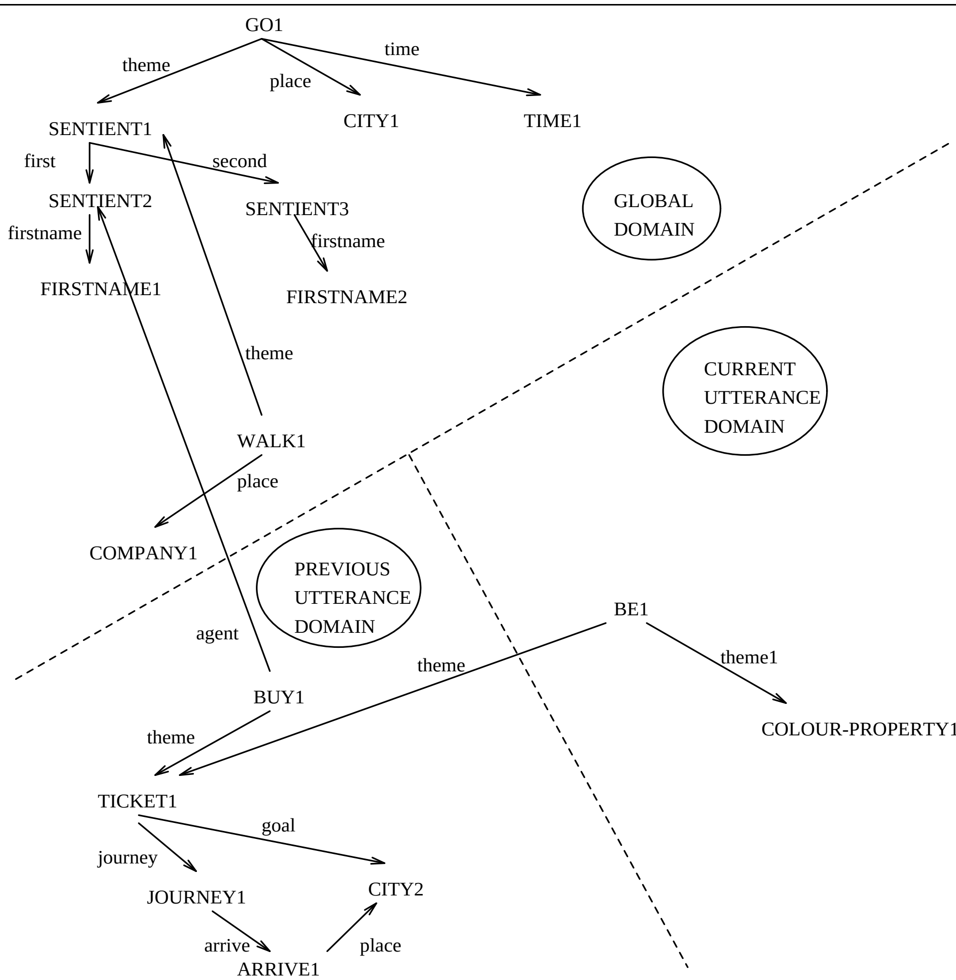

Figure 5.6: A discourse model structured in terms of accessible domains

current domain involves finding the most accessible peg where pegs in the current domain are more accessible than those in the previous domain, and these in turn are more accessible than pegs in the global domain. Of course, since anchoring can relate pegs in different domains, a peg established in a less accessible domain can become more accessible as the discourse progresses through anchoring; for example, sentient2 (the peg for *John* in (5.22)) is more accessible than other pegs in the global domain since the same peg is used to anchor the concept *John* in (5.24). However, even this restriction is insufficient. For if (5.25) is replaced by (5.33), then the concept for *It* could be anchored to any compatible peg in the previous utterance domain: i.e. ticket1 or city1. Until the rest of the sentence is interpreted, *It* could be anchored to either ticket1 or city1. When *was blue* is interpreted, *It* can only be anchored to ticket1. For the elaboration of the BE concept involves application of a necessary constraint which equates the value of theme1 with the value of some property of theme. That is, the ENTITY concept for *It* is augmented with a colour property with the value blue. Given that the concept TICKET but not the concept CITY is defined for a colour property, this concept can only be anchored to ticket1. Consequently, we are faced with choice as to how the concept for *It* is anchored before *was blue*

[12]This representation is equivalent to the attribute value representation (cf. Shieber 1986). However, many substructures have been omitted from the graph representations for clarity.

is interpreted. One solution is to arbitrarily anchor it to a compatible peg, such as city1, and revise the discourse model when the incompatibility arises. An alternative solution is to create a new peg for *It*, wait until the end of the current utterance domain and then attempt to find a compatible peg in the preceding domain. Whatever solution is adopted, the notions of revising a discourse model and delaying a choice until the end of the current utterance domain are also pertinent to concept elaboration.

Before we consider elaboration, a further restriction on accessibility is necessary. This restriction concerns the accessibility of explicit and implicit concepts within the same domain: i.e. concepts which are directly referenced by a linguistic expression and concepts created by the elaboration of explicit concepts. Consider the following examples taken from Sanford and Garrod (1981):

(5.34) Mary put the baby's clothes on.

(5.35) Mary dressed the baby.

In (5.34), there are three ENTITY concepts corresponding to *Mary*, *baby* and *clothes*. In (5.35), there are also three concepts: two concepts corresponding to *Mary* and *baby*; and a third, implicit concept of the type CLOTHES which has been created in the discourse model. Sanford and Garrod (1981: 104) argue that the CLOTHES concept is created as soon as *dressed* is interpreted on account of a minimal RT difference when these sentences are followed by (5.36):

(5.36) The clothes were made of pink wool.

The implication here is that the implicit concept is accessible when *the clothes* is being anchored and, since they are compatible, the new concept is anchored to implicit concept.

Implicit concepts, however, are not always so accessible. When (5.36) was replaced by (5.37):

(5.37) They were made of pink wool.

there was a significant difference in RT suggesting that implicit concepts are not accessible to concepts referenced by pronominal expressions. Furthermore, implicit concepts contained within implicit concepts are less accessible than those contained within concepts referenced in the discourse. For when (5.35) was followed by (5.38) and (5.39):

(5.38) The clothes were made of pink wool.

(5.39) The material was made of pink wool.

there was a significant difference in RT. If we consider the concept in (5.40):

(5.40)

$$\begin{bmatrix} id : clothes1 \\ type : clothes \\ material : \begin{bmatrix} id : material1 \\ type : material \end{bmatrix} \end{bmatrix}$$

material1 is less accessible than clothes1 since the latter is embedded within an concept which is not referenced in discourse.

The final restriction on anchoring concerns cases where the linguistic conceptual structure consists of more than one concept, as with the conceptual structure of *bat* with ANIMAL-BAT and GAME-BAT concepts. This structure is anchored so that if one of the concepts, but not the other, can be anchored to a peg in the discourse model, then other concepts are discarded — they are neither anchored nor elaborated in the discourse model. For example, when *bat* occurs in a biasing context such as (5.3) given here as (5.41):

(5.41) I was in the pet shop yesterday. I bought a bat.

there is an accessible peg for the ANIMAL-BAT concept but not the GAME-BAT concept. This peg arises from the elaboration of the concept of *pet-shop* which creates an implicit concept of the type ANIMAL as shown in (5.42):

(5.42)

$$\begin{bmatrix} id : pet\text{-}shop1 \\ type : pet\text{-}shop \\ animal : \begin{bmatrix} id : animal1 \\ type : animal \end{bmatrix} \end{bmatrix}$$

Consequently, the concept ANIMAL-BAT can be anchored to ANIMAL1 since the type ANIMAL subsumes the type ANIMAL-BAT. Only this sense of *bat* is anchored and elaborated in the discourse model — no new peg is created for the GAME-BAT sense. However, *bat* can occur in contexts such as (5.2):

(5.43) I bought a bat. It is called Harry and eats mice.

where, when *bat* is interpreted, there are no (compatible) pegs in the discourse model upon which one of its concepts can be anchored. Consequently, we are faced with the same choices as when a concept could be anchored to more than one peg. This time we could create a 'virtual' peg for each concept, as illustrated in figure 5.7 where there are two incompatible values for the theme relation, and wait until the end of the current utterance domain to see if either of these pegs is used to anchor incoming concepts and, if neither do, then only the concept corresponding to the typical sense is actually added to the discourse model. If we adopted

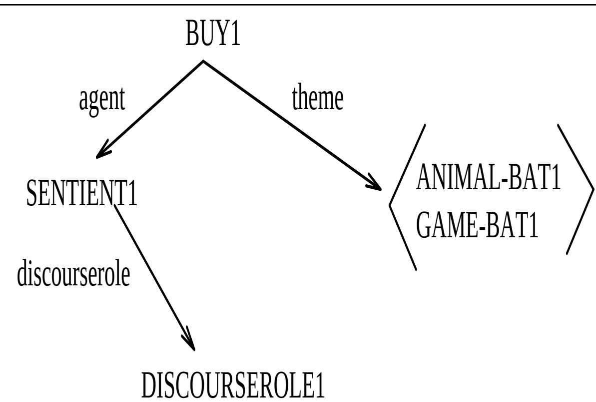

Figure 5.7: A concept related to two 'virtual' pegs for *bat*

this approach, and GAME-BAT is the typical sense, then the discourse model will need to be revised since the GAME-BAT concept is not compatible with the extension which arises from interpretation of *eats mice* (EAT requires an ANIMATE concept for the theme role). The same situation would result if we adopted the alternative approach of anchoring the typical sense at the point when *bat* is interpreted. The former approach, of course, has the advantage that if the sense is selected within the current utterance domain, then no revision is required:

(5.44) I bought a bat which eats mice.

As we shall see, this approach is adopted towards the application of default constraints during elaboration.

We can now define a simple anchoring principle:

> <u>Principle Of Anchoring</u>
> For each concept C in a linguistic conceptual structure *anchor* C to a peg P in the discourse model M if:
>
> 1. P is the most accessible concept in M;
> 2. C unifies with P to give P';
> 3. P' remains consistent throughout the discourse.
>
> If there no such P, then create a peg for C in M with a constant value for its id property.

This principle depends upon the following Accessibility Principle:

> <u>Principle of Accessibility</u>
> A peg P is the most *accessible* concept for a concept C in a discourse model M iff:
>
> 1. Anchoring does not violates restrictions associated with the mode properties of C;
> 2. P is contained in a domain in which no other concept is more accessible: i.e. an explicit concept is more accessible than an implicit concept; and an implicit concept contained in an explicit concept is more accessible than an implicit concept contained in an implicit concept;
> 3. There is no other P' such that P' is contained in a more accessible domain for C: i.e. the current utterance domain is more accessible than the previous utterance domain; and the previous utterance domain is more accessible then global domain.

5.6 Elaborated Concepts

Concepts anchored in the discourse model are *elaborated* by *theories*. Theories are background knowledge about a situation, or part of a situation. The motivation for theories derives from the distinction within cognitive psychology between concepts and theories (cf. Miller and Johnson-Laird 1976; Fillmore 1982; Murphy and Medin 1985; Lakoff 1987):

> Representations of concepts are best thought of as theoretical knowledge or, at least, as embedded in knowledge that embodies a theory about the world. (Murphy and Medin 1985: 298)

This approach is neither reductionist nor circular. Concepts are not simply reduced to theories, or vice versa, but can be seen as different parts of the same knowledge structure relevant to different cognitive goals:

> Concepts and theories must live in harmony in the same mental space: they therefore constrain each other both in content and representational format. (Murphy and Medin 1985: 313).

The part of this structure included in linguistic (or lexical) conceptual structure contains information pertinent to linguistic combination; and the part included in theories contain information for motivating and defining the internal structure of concepts. In particular, theories underlie the organization of the concepts, such as the hierarchy in figure 5.3, the assignment of necessary and default properties to individual concepts as well as relations, including explanatory and causal relations, between concepts. For example, Cohen and Murphy (1984) argue that our interpretation of compound concepts such as *engine repair* require knowledge about the use of vehicles, their parts and functions, as well as what can go wrong with them. Accordingly,

> The interpretation of a compound concept may be thought of as a hypothesis generated by background theories. (Murphy and Medin 1985: 306)

In this way, concepts and theories share the same ontology, although different parts of this ontology are relevant to structures and theories. This contrasts with the use of theories in the 'naive semantics' approach where concepts are reduced to theories (cf. Dahlgren et al. 1989).

Theories have three important characteristics. Firstly, the theories are *commonsense* beliefs about the world, not scientific, 'objectively' true knowledge about the world. As Murphy and Medin put it, a theory is

> Any of a host of mental "explanations" rather than a complete scientific account. (Murphy and Medin 1985: 290).

Secondly, theories are part of our social knowledge about the world: commonsense theories are established within a society and members of the society (implicitly) accept these theories by using them to produce and comprehend language. This, as well as their status as commonsense beliefs, aligns a theory-based approach with the criterial and symptomic evidence relations discussed in section 4.3.2. Thirdly, theories underlie the specificity and coherence of concepts in the discourse model. In particular, a theory specifies necessary and typical (or 'default') relations between a concept and its properties, as well as relations between these properties. For example, the 'genetic mother' theory underlying some uses of the expression *mother* may specify necessary relations between the concept 'mother' and properties such as being female, and the existence of a child and a father, as well as typical properties such as her age. This theory may also specify necessary and typical relations between the properties themselves; for example, the mother may be married to the father and the mother and father may have caused the birth of the child by sexual intercourse. These relations between a concept and its properties can function in two ways. Firstly, if a concept is not already specified for these properties, then elaboration with a theory may result in the addition of new properties — the concept may be extended by a theory. Secondly, while concepts may be specified for properties, the concept itself does not specify whether these are necessary or typical properties of the concept. Consequently, a theory underlies the coherence of a concept by confirming the properties specified in a concept and motivating their existence in terms of necessary and typicality relations with the concept itself.

In the cognitive linguistic approach, theories are characterized in terms of the conceptual structures discussed in section 5.3. In particular, theories are defined for a type and constraints. Thus theories share a type property with concepts and this property is pivotal in determining which theory is used to elaborate concepts. In the simplest case, a theory with an identical value for type is used. For example, the concept describing the 'plant-bed' sense of *bed* given in (5.9) can be elaborated by the theory in (5.10) since they have an identical type value, namely PLANT-BED. However, a concept can be elaborated by any theory whose value for type is subsumed by the value of type in the concept. Thus a PLANT-BED concept can be elaborated by a VEGETABLE-BED theory or a FLOWER-BED theory (see section 5.8 for an example of this). Once a theory has been selected, the concept is elaborated by the theory through application of its constraints: i.e. the constraints define necessary and typical relations with properties for the concept. In some cases, these properties will already be specified for the concept: elaboration simply confirms the well-formedness of the concept. For example, the anchored MOTHER concept for *female mother* specifies the value female for the gender property and this property is confirmed by one of the necessary 'gender' constraints defined for the GENETIC-MOTHER theory. In other cases, these properties are not yet specified for the concept and application of the constraint results in the addition of new properties. For example, elaboration of the concept associated with *my mother* by the GENETIC-MOTHER theory involves the application of a constraint which creates the property gender and assigns it the necessary value female. Not all constraints are necessary constraints; for example, a necessary constraint might create the property father whose value is a SENTIENT concept with a gender property whose value is male, and a default constraint can then create a marry property and assign both the core of MOTHER and the value of father to roles within it. Likewise, the PLANT-BED concept of *bed* in (5.9) can be elaborated by the theory in (5.10) so as to yield the extended concept in (5.11). That is, it extends the PLANT-BED concept by adding a (necessary) property location with the (necessary) value soil and a location property with the (default) value garden.

The application of default constraints, however, are problematic in a similar way to the anchoring of the default senses in ambiguous and polysemous expressions discussed in section 5.5. With a necessary constraint, application of the constraint creates a property which, so long as the concept retains its identity, should hold of the concept throughout the discourse. The same, however, is not true of default constraints: if a default constraint applies to a concept, so specifying a typical value for a property, then later in the discourse another compatible concept may be anchored to this concept and assign the same property a necessary value. Consider the following example:

(5.45) John bought an elephant which was pink.

When the concept associated with *elephant* is anchored and elaborated in the discourse model, a typicality constraint can apply, creating a colour property with the value grey, the typical colour of elephants:

(5.46)

$$\begin{bmatrix} id : elephant1 \\ type : elephant \\ colour : \begin{bmatrix} id : colour\text{-}property1 \\ type : colour\text{-}property \\ value : grey \end{bmatrix} \end{bmatrix}$$

However, when the concept corresponding to *pink* is anchored to the peg colour-property1, it specifies the value as pink, a value which is confirmed by a necessary constraint of the PINK theory. Here then we have a conflict between a value assigned by a default constraint in one theory and a value assigned by a necessary constraint in another theory. This conflict can be avoided by defining a *domain* for default constraint application: i.e. default constraints are only applied at the closure of the domain. In particular, default constraints are only applied at the closure of the current utterance domain. Thus the default value grey is not assigned when *elephant* is anchored and, since the colour property is assigned the value pink by the end of the sentence, the default constraint will not apply.

Even with this modification, however, not all elaborations of concepts will involve the confirmation or addition of properties. For example, in

(5.47) John bought an elephant. The elephant was pink.

the default value for colour will be assigned by the ELEPHANT theory when the current utterance domain is closed. However, when the second utterance is interpreted, the concept for *elephant* will be anchored to elephant1 and interpretation of *was pink* will attempt, and fail, to apply a necessary constraint assigning the value pink. This results in a a conflict between the necessary and typical values for the colour property of *elephant*. As we shall see in section 5.7, this conflict underlies conceptual extensions which involve information correction rather than information growth[13].

We can now define a principle of elaboration:

> <u>Principle Of Elaboration</u>
> For each anchored concept C in the discourse model *elaborate* C with respect to a theory T, where the type of T is subsumed by the type of C, by applying the necessary constraints defined for T immediately and applying default constraints at the closure of the current utterance domain.

Of course, this principle of elaboration is too general: not only will constraints create implicit concepts within explicit concepts, and then implicit concepts within these, but the process will keep on applying, creating more and more implicit concepts in the discourse model. This seems counter-intuitive: interpretation involves the construction of shallow rather than deep conceptual structures in the discourse model:

> Subjects automatically infer only enough information to connect together the concepts explicitly stated in the text, and only connect together those concepts in relatively local proximity in the text. (cf. McKoon and Ratcliff 1988: 343).

Consequently, we shall restrict elaboration to explicit concepts and implicit concepts within them.

5.7 Growth and Correction

In the anchoring and elaboration of concepts, two types of the extension have been encountered (as suggested by the discussion of criterial and symptomic evidence relations in section 4.3.2): information 'growth', the normal case, where the extension of concept is monotonic; and information 'correction', the bizarre case, where extension is non-monotonic (cf. Landman 1986; Rott 1990).

With information growth the extension of the discourse model M is monotonic where monotonicity is defined as follows (where $\models$ is a 'supports' relation):

(5.48) $M^{new} \sqsubseteq M^{old}$ iff $\forall\sigma(M^{new} \models \sigma \rightarrow M^{old} \models \sigma)$

Growth is thus an extension where all information (σ) supported by the resultant state of the discourse model (M^{new}) is supported by the previous state of the discourse model (M^{old}). The growth of the discourse model may come about through the addition of necessary and typical properties and relations to anchored concepts or through the introduction of new concepts.

Information correction, on the other hand, involves not the addition of information but its revision: some information is lost or changed in the discourse model. Information correction

[13] Whereas the problem with (5.45) is exclusive to the dynamic incremental approach to interpretation, the second example (5.47) is also a problem for 'batch' approaches where the domain of interpretation is the sentence.

arises from a conflict between properties either when one concept is being anchored to an existing concept in the discourse model or when a concept is elaborated through the application of constraints defined by a theory. Two types of conflict can be identified: conflict between properties assigned by necessary and default constraints; and conflict between properties assigned by necessary constraints.

Examples (5.45) and (5.47) are conflicts of the first type since the conflict arises between properties assigned by a necessary constraint of one theory and a default constraint of another. This type of conflict need not arise within the same sentence or even within successive sentences in a discourse: it can arise from the interpretation of expression in sentences which are not adjacent. Consider the following sentences where (5.49) and (5.50) may be followed by (5.51) or (5.52) (cf. Sanford and Garrod 1981: 10):

(5.49) John was on his way to school.

(5.50) He was terribly worried about the maths lesson.

(5.51) He thought he might not be able to control the class again today.

(5.52) It was not a normal part of a janitor's duties.

Sanford and Garrod found that when people were asked about *John* after reading (5.49) and (5.50), most said he was a schoolboy. However, when (5.51) or (5.52) was read, people found the continuations surprising; *John* is actually a teacher or janitor. Experiments based upon similar material demonstrated that when a concept like that referenced by *John* is compatible with interpretations made in later sentences, there is a distinct advantage in terms of RT over those where incompatible interpretations are made.

This finding can be accounted for in the cognitive linguistic approach by *school* referencing a concept which is elaborated by a theory whose constraints construct pupil, teacher and janitor roles. The concepts in each of these roles are related by inequality relations (whoever is a teacher is not a pupil and so on), so only one of these concepts can be anchored to the concept for *John*. A default constraint, applied at the closure of (5.49), then allows the concept in the pupil role to be anchored to the concept for *John*. This concept is then monotonically extended by the concepts in (5.50). With (5.51) and (5.52), however, there is a conflict between the properties of this anchored concept and properties of the concept in the linguistic conceptual structures for these sentences: while their linguistic structure requires the concept to be anchored to either the anchored concepts in the teacher role or the janitor role, the concepts in these roles are incompatible with the concept referenced by *John* on account of the inequality constraint. At this point, the discourse model must be revised in order to maintain consistency: information supplied by the default anchoring to the concept in the pupil role is retracted and the concept for *John* (including information accrued in (5.50)) is now anchored to the concept in either the teacher or janitor roles. Thus, information correction can come about through the retraction of properties assigned by default constraints when they conflict with properties assigned by necessary constraints: necessary constraints have priority over default constraints.

A second type of information correction arises with conflicts between properties assigned by necessary constraints. Such conflicts can be caused by conceptual structures which, according to linguistic restrictions, must be unified, but are incompatible with respect to properties assigned by necessary constraints. For example, in *stone soldiers* there is a conflict between necessary constraints which assign values to the material role: a theory constraint associated with *stone* assigns it the value stone, while a theory constraint associated with *soldiers* assigns it the value flesh. In this case, the conflict is resolved in favour of *stone*: *stone soldiers* are made of stone. The result of this correction, however, is not simply a revision of the discourse model: a new sense of *soldiers* has been created.

This ability to revise information and create new word senses can be seen as an integral part of linguistic creativity. That is, linguistic creativity involves not only the monotonic extension of concepts in linguistic conceptual structures, but the creation of new conceptual structures which reflect new sense of expressions. The tension between these aspects of creativity can be characterized in term of the interaction between linguistic inertia and linguistic force:

Linguistic Inertia Two tokens of the same word have the same meaning until something differentiates them.

Linguistic Force Words resist combining unacceptably in the linguistic environment, until forced to ...grammatical strings will not go together unacceptably ...if there is any step-wise adaption of word meanings (compared to their occurrences in the corpus) which would result in an acceptable utterance and is not prevented by the environment. And those step-wise adaptions are ...specific kinds of differentiation. (Ross 1981 quoted in Lycan 1988: 110)

Linguistic force, then, can lead to the construction of new linguistic structures through differentiation, or branching, within existing linguistic structures. However, this does not account for why, in the case of *stone soldiers*, the 'step-wise adaption' is performed on *soldiers* rather than *stone*: i.e. why the necessary constraint associated with the later has priority over the former. We shall pursue this point when we discuss linguistic information correction, or defeasibility, in sections 6.6 and 7.4.

5.8 Discourse Sense Selection

In this section, we illustrate the cognitive linguistic approach to interpretation through the analysis of sense selection which takes place in discourse rather than linguistic processing; i.e. 'delayed' sense selection according to section 3.3. Again, we shall use a highly schematic graph-theoretic notation for the representation of concepts in the discourse model.

Discourse sense selection covers examples in which the contextually appropriate sense of ambiguous or polysemous expressions is selected when the expression is anchored and elaborated in the discourse model. Consider the following examples:

(5.53) The accountant decorated her new house. Then she bought a bed.

(5.54) The accountant went into the garden. She walked over a bed planted with vegetables.

Examples (5.53) and (5.54) concern the selection of senses in the ambiguous noun *bed*: in (5.53), the dominant sense, 'mattress bed', is selected when the linguistic conceptual structure of *bed* is anchored in the discourse model; and in (5.54), the subordinate sense is selected at this point. In neither case is the discourse context exported to the linguistic processing module sufficient to constrain sense selection at the linguistic level (see section 7.3).

Interpretation of the first sentence of (5.53) results in the discourse model in figure 5.8. The discourse model in figure 5.8 constitutes the previous utterance domain for the interpretation of the second sentence. There are three explicit concepts in this domain: DECORATE1 which has two roles, agent and theme; ACCOUNTANT1 which fulfills the agent role; and HOUSE1 which fulfills the theme role. Each of these concepts can be elaborated with constraints defined in their respective theories. In figure 5.8, we have shown the elaboration of HOUSE1. Its theory is given in (5.55):

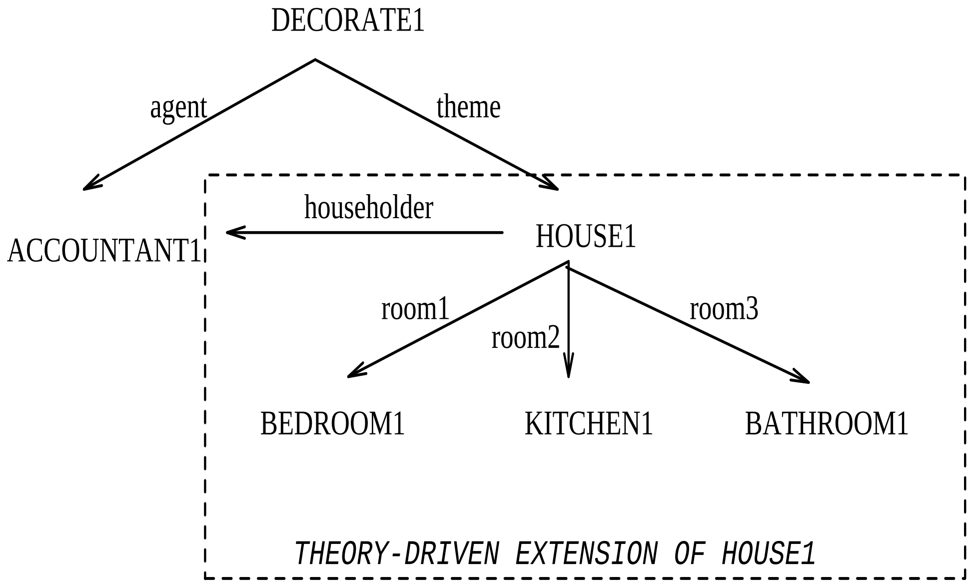

Figure 5.8: Discourse model for *The accountant decorated her new house*

(5.55)

$$\begin{bmatrix} type : house \\ \\ constraints : \left\langle \begin{bmatrix} name : vequality \\ type : necessary \\ path : \langle \text{householder type} \rangle \\ value : sentient \end{bmatrix} \begin{bmatrix} name : vequality \\ type : necessary \\ path : \langle \text{room1 type} \rangle \\ value : bedroom \end{bmatrix} \begin{bmatrix} name : vequality \\ type : necessary \\ path : \langle \text{room2 type} \rangle \\ value : kitchen \end{bmatrix} \begin{bmatrix} name : vequality \\ type : necessary \\ path : \langle \text{room3 type} \rangle \\ value : bathroom \end{bmatrix} \right\rangle \end{bmatrix}$$

(5.55) contains constraints which define four roles, three of which are concepts subsumed by the type ROOM as shown in figure 5.9[14]. The elaboration of HOUSE1 results in the creation of three implicit concepts: BEDROOM1, KITCHEN1, BATHROOM1 and SENTIENT1. As figure 5.9 shows, the first three can be elaborated so as to create embedded implicit concepts; for example, BEDROOM1 can be elaborated to created a concept BED1 in the role bed. As for the fourth, SENTIENT1, it has been anchored to ACCOUNTANT1 since the later is compatible and accessible in the discourse model.

[14] We could use a role rooms with a set value to indicate this: i.e. its value is a set of concepts with a 'spanning' type (ROOM) and with the three roles given above. This treatment would be comparable to the treatment of conjunction in (5.29).

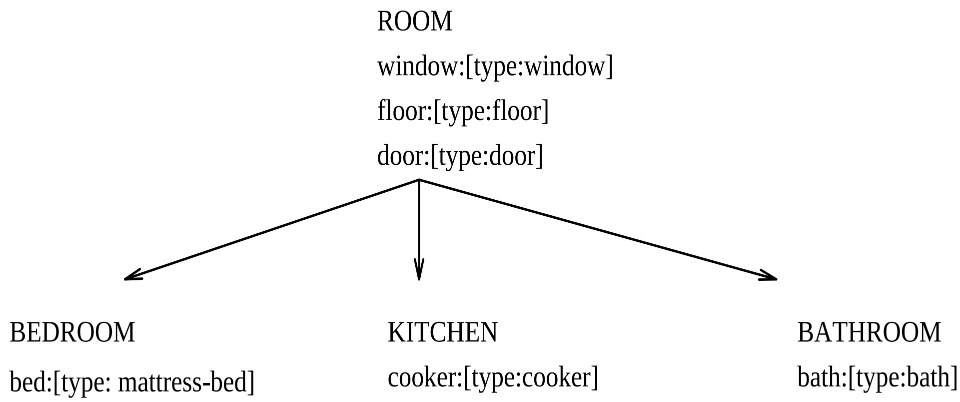

Figure 5.9: Part of the ENTITY hierarchy with ROOM

Let us now step through crucial points in the interpretation of the second sentence, *Then she bought a bed*. During the anchoring of *Then she bought*, the concept for *she* in the agent role of BUY1 is anchored to the concept in the agent role of DECORATE1. The linguistic concept structure for *bed* in this context is given in (5.20) and reproduced here as (5.56):

(5.56)

$$\left\{ \begin{array}{l} \left[\; type : mattress\text{-}bed \; \right] \\ \left[\begin{array}{l} type : plant\text{-}bed \\ \left\{ \begin{array}{l} \left[\; type : vegetable\text{-}bed \; \right] \\ \left[\; type : flower\text{-}bed \; \right] \end{array} \right\} \end{array} \right] \end{array} \right\}$$

where the top level disjunction describes the two generic senses of *bed* and the second disjunct contains disjunctive concepts for two more specific senses; we shall discuss them in relation to (5.54).

The theories for MATTRESS-BED and PLANT-BED are given in (5.57) and (5.58) respectively:

(5.57)

$$\left[\begin{array}{l} type : mattress\text{-}bed \\ constraints : \left\langle \begin{array}{l} \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : \langle \text{material type} \rangle \\ value : spring \end{array} \right] \\ \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : \langle \text{location type} \rangle \\ value : bedroom \end{array} \right] \\ \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : \langle \text{contents type} \rangle \\ value : sentient \end{array} \right] \end{array} \right\rangle \end{array} \right]$$

(5.58)

$$\left[\begin{array}{ll} type : plant\text{-}bed & \\ constraints : & \left\langle \begin{array}{l} \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : \text{<material type>} \\ value : soil \end{array}\right] \\ \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : \text{<location type>} \\ value : garden \end{array}\right] \\ \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : \text{<contents type>} \\ value : plant \end{array}\right] \end{array} \right\rangle \end{array}\right]$$

With the linguistic structure in (5.56), the concept in the location role of BUY is either of the type MATTRESS-BED or PLANT-BED. Rather than simply create two 'virtual' extensions, the discourse model can be used to select between the senses. In this state, the mattress-bed sense is selected: the location of MATTRESS-BED, i.e. a concept of the type BEDROOM, can be anchored to the implicit concept BEDROOM1 and the implicit concept within BEDROOM1, namely MATTRESS-BED in the bed role can be the anchor point for the MATTRESS-BED concept referenced by *bed*. The resultant discourse model is shown in figure 5.10. In this way, the

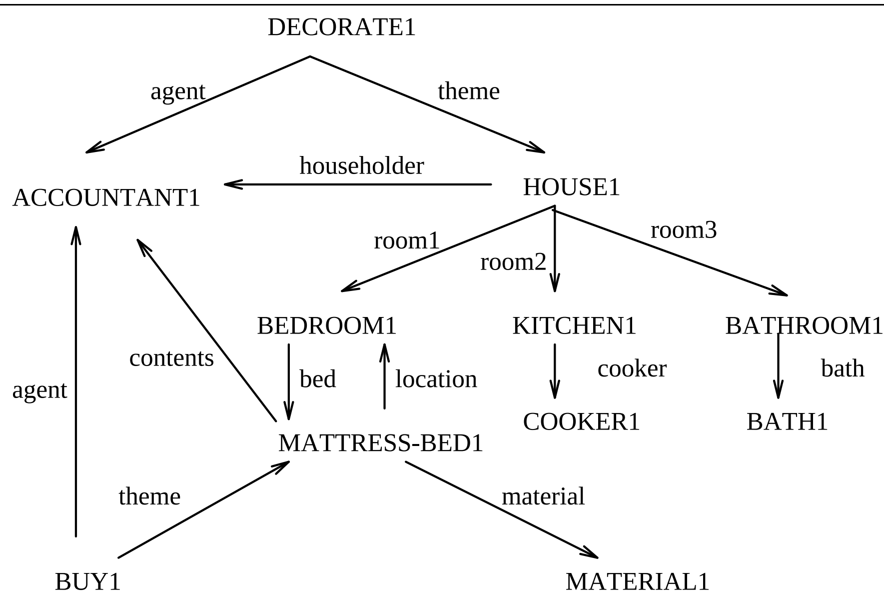

Figure 5.10: Discourse model after *Then she bought a bed.*

contextually appropriate sense of *bed* is selected and anchored in the discourse model.

Interpretation of the polysemous noun in (5.54) follows a similar pattern. The linguistic concept structure for *garden* is elaborated by the theory in (5.59):

(5.59)

$$\begin{bmatrix} \mathit{type} : \mathit{garden} & \\ \mathit{constraints} : & \left\langle \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{typical} \\ \mathit{path} :<\text{region1 type}> \\ \mathit{value} : \mathit{flower\text{-}bed} \end{bmatrix} \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{typical} \\ \mathit{path} :<\text{region2 type}> \\ \mathit{value} : \mathit{vegetable\text{-}bed} \end{bmatrix} \right\rangle \end{bmatrix}$$

which defines gardens as typically having two regions, flower bed and a vegetable bed. The discourse model which results from interpretation of the first sentence is given in figure 5.11.

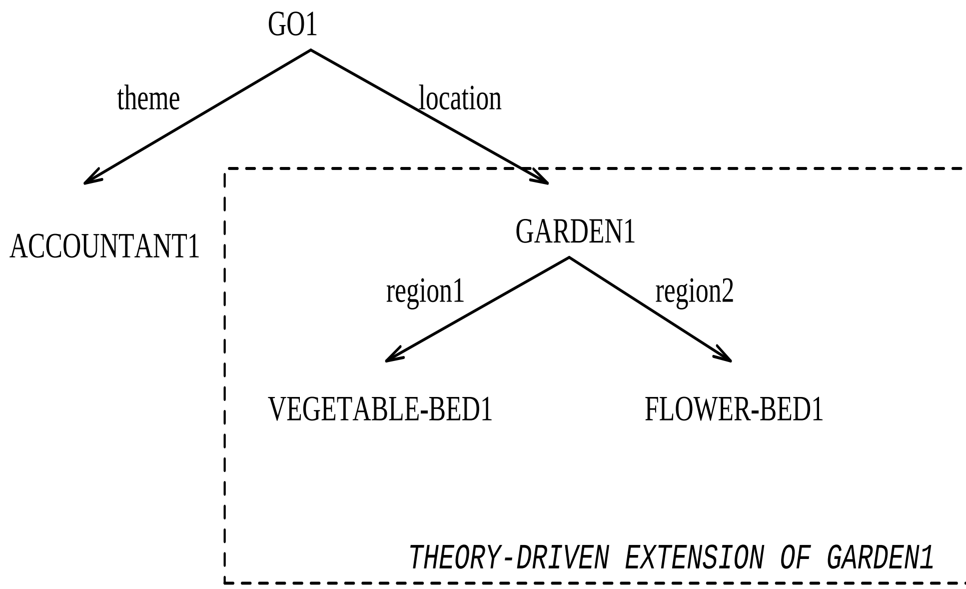

Figure 5.11: Discourse model after *The accountant went into the garden.*

The interpretation of the second sentence *She walked over to the bed planted with vegetables* is similar to the interpretation of the second sentence in (5.53) up to the point *bed* is encountered: i.e. *she* can be anchored to ACCOUNTANT1 at the linguistic level. When *bed* is encountered, its linguistic structure is as given in (5.56). The disjunctive structures contained within the plant-bed sense can be elaborated by the theories in (5.60) and (5.61):

(5.60)

$$\begin{bmatrix} \mathit{type} : \mathit{vegetable\text{-}bed} & \\ \mathit{constraints} : & \begin{bmatrix} \left\langle \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} :<\text{contents type}> \\ \mathit{value} : \mathit{vegetable} \end{bmatrix} \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} :<\text{location type}> \\ \mathit{value} : \mathit{garden} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

(5.61)

$$\begin{bmatrix} \mathit{type} : \mathit{flower\text{-}bed} \\ \mathit{constraints} : \begin{bmatrix} \left\langle \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} : \text{<contents type>} \\ \mathit{value} : \mathit{flower} \end{bmatrix} \begin{bmatrix} \mathit{name} : \mathit{vequality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path} : \text{<location type>} \\ \mathit{value} : \mathit{garden} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

where (5.60) defines vegetable bed as containing vegetables and being located in a garden; and (5.61) defines flower beds as containing flowers and also being located in a garden. Since the linguistic structure for *bed* is disjunctive, the discourse model is consulted so as to try to select a contextually appropriate sense. While the typical top-level disjunct, MATTRESS-BED, cannot be anchored in this context, there are two possible pegs for PLANT-BED: VEGETABLE-BED1 and FLOWER-BED1 are both compatible and accessible. However, this disjunct can be further expanded into VEGETABLE-BED and FLOWER-BED and both of these can be also be anchored to these concepts. If the typicality constraint specified for (5.56) were to apply now, the default sense VEGETABLE-BED would be selected, FLOWER-BED discarded and VEGETABLE-BED anchored to VEGETABLE-BED1[15]. However, as we suggested in section 5.6, default constraints do not apply until the end of the current utterance domain. Consequently, the linguistic structure is only refined to PLANT-BED and the rest of the sentence is interpreted.

The rest of the sentence, *planted with vegetables*, is a complex modifier of *bed* as shown in (5.62):

(5.62)

$$\begin{bmatrix} \mathit{id} : A \\ \mathit{type} : \mathit{plant\text{-}bed} \\ \mathit{desc} : \begin{bmatrix} \mathit{type} : \mathit{plant\text{-}event} \\ \mathit{location} : \begin{bmatrix} \mathit{id} : A \end{bmatrix} \\ \mathit{theme} : \begin{bmatrix} \mathit{type} : \mathit{vegetable} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

There are two important points to note about this linguistic structure. Firstly, the desc role: the value of this role is a modification which does not bind any specific role of the root type PLANT-BED (cf. *red* in *red apple* binds to the colour role of APPLE). Secondly, the root type must be identified with some concept contained within the desc concept; in this case, the value of location as indicated by shared variable A. When such structures are anchored, they are transformed so that the root type of the desc role, here PLANT-EVENT becomes the root type for the whole structure: i.e. (5.62) is transformed into (5.63):

(5.63)

$$\begin{bmatrix} \mathit{type} : \mathit{plant\text{-}event} \\ \mathit{location} : \begin{bmatrix} \mathit{id} : A \end{bmatrix} \\ \mathit{theme} : \begin{bmatrix} \mathit{type} : \mathit{vegetable} \end{bmatrix} \end{bmatrix}$$

In this case, PLANT-BED is specialized as VEGETABLE-BED since PLANT-EVENT is defined for the following constraint:

[15] Typicality relations between the senses of polysemous and ambiguous expressions are defined in the constraints of the sign for *bed* (see section 7.2.1).

(5.64)

$$\begin{bmatrix} name : equality \\ type : necessary \\ path1 : \text{<theme>} \\ path2 : \text{<location contents>} \end{bmatrix}$$

where the constraint gives the role contents in PLANT-BED1 a concept of the type VEGETABLE and this allows PLANT-BED1 to be specialized as an concept of the type VEGETABLE-BED. After this local interpretation, these concepts can be anchored in the rest of the discourse model. This time, PLANT-BED1 is anchored to VEGETABLE-BED1 as the resultant discourse model for (5.54) in figure 5.12 illustrates.

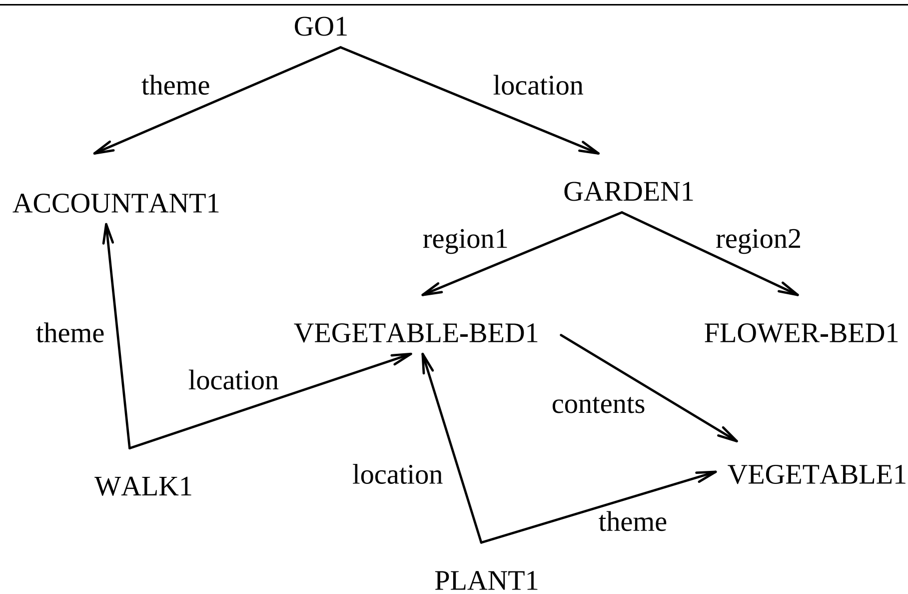

Figure 5.12: Discourse model after *She walked across the bed planted with vegetables*

5.9 Conclusion

In this chapter we have described the cognitive linguistic approach to semantic interpretation. Interpretation was characterized as involving three levels of conceptual structure related by two extensional processes, anchoring and elaboration. Each of these levels of conceptual structure, as well as theories, share the same ontology: they are constructed from the same set of basic elements. The linguistic conceptual structure is a linguistically relevant description associated with an expression; expressions with multiple senses are characterized as disjunctive conceptual structures. The concepts in this conceptual structure are added to the discourse model by an anchoring process which attempts to find compatible existing concepts in the current discourse model: if such a concept is found, then the two concepts are unified; and if not, a new anchored concept, or peg, is created in the discourse model. The concepts in the discourse model are then elaborated by theories which describe necessary and typical relations between a concept and its properties. As a result, anchored concepts are extended into elaborated concepts. This approach to interpretation countenances two sorts of extension in the discourse model: in the normal circumstances, concepts are monotonically extended; and in bizarre circumstances, their extension is non-monotonic — the interpretation concepts may be revised. However, we suggested that many cases of non-monotonic extension can be avoided through judicious anchoring and elaboration. Finally, we demonstrated in detail how this approach accounts for sense selection at the discourse level.

This approach to language comprehension, however, has not yet characterized the relationship between lexical and linguistic conceptual structures. Such characterization is needed in order to account for how sense selection in the linguistic processing module can be restricted by the discourse context. Furthermore, we noted that in some cases of non-monotonic extension, we were unable to account for why a necessary property of one concept has priority over a necessary property of another concept. Consequently, we shall now consider the nature of linguistic combination, as characterized in grammars, so as to address these issues.

Chapter 6

Principles of Linguistic Combination

6.1 Introduction

In chapter 2, we presented the architecture of the cognitive linguistic approach to language comprehension. Two modules were posited: a linguistic processing module which combines representations for lexical expressions to yield a linguistic structure, including a conceptual structure, for the phrase; and a discourse processing module which interprets this conceptual structure in the discourse model of a cognitive agent. Chapter 3 provided evidence for the interaction between these modules: the discourse processing module exports a *discourse context* which restricts the sense of ambiguous and polysemous expressions combined in the linguistic processing model. In chapters 4 and 5, we characterized the nature of conceptual structures and the processes by which they are interpreted in the discourse processing module. This approach was shown to account for cases where the sense selection occurs at the discourse level. In this and the next chapter, we focus on the linguistic processing module: in particular, the characterization of linguistic structures, the process by which they combine and how a discourse context allows us to account for sense selection at the linguistic level.

Two issues in linguistic combination are addressed in this chapter.

The first issue concerns the nature of the relationship between lexical and linguistic structures. In chapters 4 and 5, the relationship between linguistic conceptual structure and discourse conceptual structure was characterized in terms of the extension of partial concepts: the anchoring process extended concepts in the linguistic conceptual structure into anchored concepts in the discourse model; and the elaboration process extended anchored concepts through application of constraints defined for theories. A uniform relationship between levels of conceptual structures can be maintained if the relationship between linguistic structures associated with lexical expressions and the linguistics structure associated with their concatenation as a phrase is also characterized as an extensional relationship. For example, the lexical structure for *pink* and the lexical structure for *elephants* can be extended into a linguistic structure for the phrase *pink elephants*: i.e. the linguistic structure for the phrase is compatible with, and at least as specific as, the linguistic structures for the lexical expressions. Since this extensional relationship between linguistic structure is maintained in grammars where combination is based upon the unification of linguistic structures, the linguistic processing module will be characterized as a unification grammar.

The second issue concerns the fact that combination involves more than the unification of linguistic structures. For combination is asymmetrical: one linguistic structure in a binary combination has priority over the other structure with respect to combination. This priority is manifest in the syntactic type of phrasal expressions; for example, *pink* is an adjective and *elephants* is a noun, yet the syntactic type of *pink elephants* is a noun not an adjective. Consequently, we shall consider the basis for this asymmetry. Two approaches will be discussed. In one approach, adopted in categorial grammars such as Unification Categorial Grammar, priority is based upon the functor argument distinction: linguistic structures combine as functor and argument, and the functor has priority over the argument. In another approach, adopted in dependency grammars, priority is based upon the head modifier distinction: linguistic structures combine as head and modifier, and the head has priority over the modifier. As we shall see not only is the head modifier distinction superior with respect to serialization, category constancy and motivation, but when linguistic sense correction, or defeasibility, is considered, correction systematically correlates with this distinction.

The chapter is structured as follows. In section 6.2 we describe some properties of unification grammar. In section 6.3, we describe in detail one unification grammar, Unification Categorial Grammar, where priority in combination is based upon the functor argument distinction. In section 6.4, we introduce an alternative basis for asymmetry in combination — the head modifier distinction. In section 6.4.1 we discuss some of the potentially distinctive properties of heads which might motivate this distinction, and in section 6.4.2 characterize their priority in terms of their semantic type. In section 6.5 the functor argument and the head modifier distinctions are compared and it is argued that the head modifier distinction is superior on the grounds of descriptive economy. Finally, in section 6.6, we introduce evidence, defeasibility evidence, which not only reinforces the claim made in section 5.7 that the extension of conceptual structures may involve sense correction, but also supports the head modifier distinction: while heads have priority with respect to combination, modifiers have priority with respect to correction. Section 6.7 concludes the chapter.

6.2 Unification Grammar

A unification grammar is a grammar which represents the information associated with linguistic expressions in terms of partial feature structures and combines these structures through unification. Examples of unification grammars include Functional Unification Grammar (cf. Kay 1979), Definite Clause Grammar (cf. Pereira and Warren 1980), Lexical Functional Grammar (cf. Bresnan and Kaplan 1982), Generalized Phrase Structure Grammar (cf. Gazdar et al. 1985), Head-driven Phrase Structure Grammar (cf. Pollard 1985; Pollard and Sag 1987) and Unification Categorial Grammar (cf. Calder et al. 1987; Zeevat et al. 1987; Zeevat 1988; Andry et al. forthcoming).

In unification grammars, feature structures are characterized as sets of properties or attribute value pairs[1]. Since we have already discussed these structures in chapters 4 and 5, we shall simply illustrate their use in unification grammar to account for subject verb agreement in the phrase *deer run*.

Let us assume that there are substructures within the subject *deer* and the verb *run* given in (6.1) and (6.2) respectively:

(6.1)

$$[\ subject : [\ agr : [\ person : third\ ]\ ]\ ]$$

(6.2)

$$[\ verb : [\ agr : [\ number : plural\ ]\ ]\ ]$$

[1] Attribute value pairs are also known as label-value pairs, feature-value pairs and parameter-value pairs.

Let us further assume that the rule of agreement is represented by the template in (6.3)[2].

(6.3)

$$\begin{bmatrix} verb : \begin{bmatrix} agr : X \end{bmatrix} \\ subject : \begin{bmatrix} agr : X \end{bmatrix} \end{bmatrix}$$

This template imposes an equality relation between the value of the agreement properties of subjects and verbs through the use of the shared variable X: i.e. the value of **agr** in subjects and verbs must be identical. The unification process attempts to induce a resultant structure by recursively substituting the substructures mentioned in the template with their unifications. The structure in (6.3) can be successfully unified with that in (6.1) and the structure in (6.4) is induced:

(6.4)

$$\begin{bmatrix} verb : \begin{bmatrix} agr : \begin{bmatrix} person : third \end{bmatrix} \end{bmatrix} \\ subject : \begin{bmatrix} agr : \begin{bmatrix} person : third \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

where the substructure $[person : third]$ is shared between the **agr** properties of **subject** and **verb** on account of the shared variable X in (6.3).

Unification of (6.2) with (6.4) induces (6.5):

(6.5)

$$\begin{bmatrix} verb : \begin{bmatrix} agr : \begin{bmatrix} person : third \\ number : plural \end{bmatrix} \end{bmatrix} \\ subject : \begin{bmatrix} agr : \begin{bmatrix} person : third \\ number : plural \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

where the value of the verb's **agr** property is further specified with pair $[number : plural]$ and, via the shared variable in the template, this pair is shared with the subject's **agr** property. Thus unification of (6.1) and (6.2) with (6.3) required two substitutions, one for <verb agr person> and one for <subject agr number>, and through the shared variable their values are shared with <subject agr person> and <verb agr number> respectively. Furthermore, since unification is commutative, these substitutions also take place with the subject and verb structures inducing the following structures respectively:

(6.6)

$$\begin{bmatrix} subject : \begin{bmatrix} agr : \begin{bmatrix} person : third \\ number : plural \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

(6.7)

$$\begin{bmatrix} verb : \begin{bmatrix} agr : \begin{bmatrix} person : third \\ number : plural \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The result of unifying structures then makes more determinate the linguistic structures associated with lexical expressions: unifying the structures associated with *deer* and *run* via the template in (6.3) results in a structure for a third person plural expression.

This example illustrates two central properties of the unification process: monotonicity and order-independent. It is monotonic since the information in the input structures is always

[2] An equivalent way of representing this rule is by the path equation <verb agr> == <subj agr>.

preserved in the resultant structure. Unification can never lose or change information in the input structures; nor can it add information not present in at least one of these structures. The resultant structure in (6.5) accordingly contains all and only the information in the input structures, (6.1), (6.2) and (6.3). Furthermore unification is order-independent: the result of a series of unifications is independent of the actual order of these unifications. This property is intimately connected with monotonicity: since unification can only add, not change or lose, information in the initial structures, the order in which they are unified will not affect the resultant structure. In the above example, (6.2) could have been unified with (6.3) and then (6.1) with the result of the first unification and (6.5) would still have resulted.

Representing the information associated with lexical expressions with feature structures and combining them through a unification process has three important consequences for unification grammar.

Firstly, unification grammars are declarative since there is a straightforward, systematic correlation between the unification process and the application of identity constraints: unification involves the simultaneous satisfaction of identity equations. The unification process is closely related to set-theoretic union: the union of two sets is simply the addition of all their members; and a series of unions is independent of the order in which sets are added together. As a consequence when combination rules are based solely upon unification, the grammar is monotonic and order-independent. So although the unification process can be specified as an algorithm, the properties of monotonicity and order-independence ensure that how the process is computed does not affect what the result will be, given the same inputs[3]. The chief advantage of such grammars is that the structures associated with lexical expressions can be treated as axioms in a logic and combination rules as rules of inference. Treating grammar as logic gives grammarians access to some powerful tools for analyzing grammars, including their semantics.

Not all unification grammars are monotonic and order-independent, however. For combination in unification grammar can be characterized in terms of processes other than unification and these can be nonmonotonic and/or order-dependent. When such processes are allowed in the grammar, the systematic correlations with identity statements is lost. For example, the unification process will fail when its input structures are incompatible. However, incompatibility can be resolved by another process in the grammar which allows the values of one structure to have priority over those of the other structure. For example, an 'overwriting' process is used in PATR-II to resolve lexical conflicts:

> Overwriting is a noncommutative operation akin to destructive unification except that, in the case of unification "clashes", one of the operands (say, the rightmost) is given precedence. Thus, unlike unification, overwriting never fails. (cf. Shieber 1986: 60).

Combination then is non-monotonic and order-dependent: some information has been lost in the course of combining the structures; and the overwriting process is ordered after the unification process. In sum unification simply favours, as opposed to requires, grammar to be monotonic and order-independent.

Secondly, unification favours lexicalist grammars: i.e. grammars in which the burden of combinatorial information is associated with the structures in the lexicon rather than associated with combination rules. As a result, although lexical structures are highly complex, the combination rules are simple and few in number. Unification grammars tend to be lexicalist grammars for two reasons. Firstly, such structures provide a means of representing large quantities of complex information. Secondly, since unification is monotonic, it prohibits many traditional rules which lose or change information specified in lexical structures. Note that this again is only a tendency: if rules are monotonic then derivational grammars are still monotonic (cf. Anderson and Durand 1986; Kalman 1988).

[3] Accordingly, unification allows a free choice of processing strategy and control structure in computational models of the grammar (cf. Karttunen 1986).

Thirdly, unification favours surface-based grammars: i.e. grammars which derive representations for phrases and sentences without mediating levels of structure. This contrasts with derivational grammars, such as Aspects, which are not surface-based grammars since combination is characterized through the derivation of a surface structure from an underlying level of representation, deep structure, by transformational rules which create further mediating levels of structure (cf. Chomsky 1965). Unification grammars tend to be surface-based because combination can be characterized in terms of a combination principle which incorporates more than one process. For example, the combination principle in Unification Categorial Grammar, Functional Application, incorporates the processes of instantiation and stripping. With the application of a rule based upon a single principle, there can be no mediating levels of representation.

6.3 Unification Categorial Grammar

Unification Categorial Grammar (UCG) is a unification grammar whose combinatorial principle is based upon the functor argument distinction in categorial grammar (cf. Ajdukiewicz 1935; Montague 1974; Vennemann and Harlow 1977; Flynn 1982). A categorial grammar is defined in terms of a set of linguistic categories and a category-based combination principle. The set of permissible categories is defined recursively starting with the basic categories, NP and S[4].

1. NP and S are categories.
2. If A and B are categories, then $A|B$ is a category.
3. Nothing else is a category.

The combination principle is functional application:

> Functional Application (FA)
> If X is an expression of category $A|B$ and Y is an expression of category B, then the concatenation XY is an expression of the category A.

An argument then is a simple category B. A functor is a complex category, $A|B$, composed of three parts: '|' which denotes a function, the 'take' category B denoting the input to the function and the 'make' category A denoting the output of the function. In this way, functors denote functions over, or relations between, 'take' and 'make' categories. A particular categorial grammar arises when a list of lexical expressions are associated with one, or more, categories. The set of expressions such a grammar generates is simply the closure of the list of lexical expressions under functional application (cf. Zeevat 1988: 203).

In categorial grammar there is strict isomorphism between the syntactic and semantic components: for each syntactic category there is a corresponding semantic category and for each syntactic rule a corresponding semantic rule[5]. Accordingly, the basic syntactic categories S and NP correspond to propositions and individuals respectively, complex categories, $A|B$, to a function from semantic objects of type B to semantic objects of type A and functional application to application of the meaning of $A|B$ to the meaning of B, resulting in a meaning of type A.

The central insights of categorial grammar then are that semantic and syntactic categories are either basic or complex and categories combine as functors and arguments. Whereas basic categories are defined intrinsically, complex categories are defined extrinsically: i.e. purely in terms of the functional relation between two other categories, categories which themselves may

[4] Directionality in combination is ignored: '|' covers both forward and backward functional application in categorial grammar.

[5] Categorial grammar embodies the rule-to-rule hypothesis (cf. Dowty et al. 1981; Steedman 1986).

be basic or complex. For example, both syntactic categories, S|NP and S|(S|NP), are complex categories: the former is defined as a function from the basic category NP to the basic category S and the later as a function from (S|NP) — itself a function from NP to S — to the category S. Such categories combine asymmetrically as functor and argument: a functor is a category of type $A|B$ which takes, or consumes, a category of type B and makes, or yields, a category of the type A; and an argument is a category of type B[6].

UCG extends categorial grammar by characterizing linguistic representations as feature structures and functional application as, in part, a unification process. In particular, grammatical representations are characterized as *signs* (cf. Pollard 1985; Pollard and Sag 1987). Signs provide a partial but unitary description of phonological, syntactic and semantic level information associated with linguistic expressions.

Two sorts of variables are used in the sign: cross-level variables and category variables. With cross-level variables, the same variable occurs at different levels of description. Since the same variable must be given the same instantiation, this imposes restrictions between different levels of description, restrictions which perform an analogous function to the rule-to-rule hypothesis in Combinatorial Categorial Grammar (cf. Ades and Steedman 1982; Steedman 1984; Steedman 1985; Steedman 1986). In particular, while functional application combines signs in terms of representations on the syntactic level, with the same variable on both the syntactic and semantic levels, the semantic level of the sign can be specified as a side-effect of combination. Category variables are variables which range over syntactic categories. Although previous unification grammar approaches have used variables which range over features within the syntactic level, UCG is innovative in allowing variables to range over the category types themselves (cf. Bouma 1988). One effect of this is that functors can be polymorphic: their identity, in terms of what signs they take and make, is not determinately specified but rather varies with the signs they combine with. Another effect is that UCG can offer a uniform, extrinsic definition of parts of speech. For example, verbs are signs whose categories are of the type S|X, where X ranges over the set of categories and thus the category verb includes S|NP|NP, S|NP and so on. This definition holds at each stage of combination: for example, in *Prince loves Cat*, *loves* is characterized at each stage of extension as a sign whose syntactic category is a verb.

Although grammatical representations in UCG are more complex than those in other categorial grammars, functional application is not. The simplest combination rule would be straightforward unification: the result sign is merely the (symmetrical) merging of the combining signs. This of course is not possible since functional application is necessarily asymmetrical. UCG resolves this tension between symmetrical unification and asymmetrical functional application by limiting the scope of unification. While functional application combines signs in terms of their syntactic level, only part of the functor sign, the syntactic specification of what it takes, is unified with the whole of the argument sign. Since unification is commutative, both these structures will become more determinate through successful unification. Furthermore, with cross-level variables between the syntactic level and the semantic level in the functor sign, the semantic level will also become more determinate through combination. After unification has taken place, a second, asymmetry, process takes effect: the result sign is constructed by 'stripping' the functor sign. Thus functional application is a combinatorial principle which induces a result sign by stripping the functor sign after part of it has unified with the argument sign. The advantage of this characterization of functional application is that the combination involves the simultaneous construction of different levels of linguistic description.

In UCG, the basic grammatical representation is a sign E. A sign is an structure, which has four major properties: phonology (W), (syntactic) category (C), semantics (S) and order (O). We shall consistently represent a UCG sign as a list in either vertical or horizontal format; for example, W:C:S:O. We now consider the value of each attribute in turn before describing and illustrating combination in terms of functional application.

[6] It should be noted that argument categories are not necessarily basic: although the functor must be a complex category, the argument may also be a complex category. For example, the syntactic categories S|(S|NP) and S|NP can combine as functor and argument respectively.

The value of the **phonology** property W is a phonological representation of the expression. In standard treatments of UCG this is taken to be the standard orthographic representation for convenience (cf. Calder et al. 1987: 9). We too shall ignore it.

The value of the property **category** C is either atomic or complex as in categorial grammar. Unlike categorial grammar, however, there are three atomic syntactic categories namely NP, SENT and NOUN. Two categories, SENT and NP, admit further morpho-syntactic feature specifications based on those employed in GPSG (cf. Gazdar et al. 1985). This allows for the expression of distinctions within the same 'major' category; for example, SENT[fin] for sentences with finite verb forms and NP[nom] for noun phrases marked for nominative case. Of course since values can be variables, the feature of such categories may be left unspecified: SENT can be read as SENT[F] where F is a variable ranging over morpho-syntactic features.

The value of **category** is complex when it is additionally specified for the signs with which they combine. Complex categories are of the form $C|Sign$, where C is a category, atomic or complex, and $Sign$ is the sign with which it can combine (cf. $A|B$ in standard categorial grammar). For example, the transitive verb *visit* is associated with a sign whose category attribute has the value SENT[fin]|NP|NP. Here $Sign$ is a sign with the category value NP and C is a complex category SENT[fin]|NP which is of the form $C|Sign$ where $Sign$ is a sign with the category value NP and C the basic category SENT[fin]. In other words, the sign for *visit* says it is a finite verb form and that it combines with two other signs of the category NP. Thus at each stage in the derivation of a sentence, the category value of the sign will remain constant i.e. SENT[fin].

Categories are formally defined as follows (cf. Zeevat 1988: 204):

1. An atomic category (together with a syntactic feature specification) is a category.
2. If A is a category, and B is a sign, then $A|B$ is a category.

With complex categories, B is termed the *active part* of the category (cf. A), and when $A|B$ occurs as a category it is a functor sign (or *active* sign) and the sign with which it combines can be termed the argument sign (or *inert sign*) Thus any sign which has $A|B$ as a category value combining with the sign B is a functor.

The value of the property **semantics** is a logical formula in an indexed language, INL. Interpretation in INL is closely linked to that of Discourse Representation Theory (cf. Kamp 1981, Heim 1982). For example, the semantics representation of *Prince loves Cat* is a formula where the arguments of the predicate have constant values:

LOVE(PRINCE, CAT)

One of the crucial differences between INL and DRT is every formula has a special (reserved) variable called an index[7]. The value of an index is a specification of the *type* of entity described by the expression. Index variables form a subsumption hierarchy as illustrated in figure 6.1. Finally, sort declaration can be made by a predication outwith the body of the formula. Thus (6.3) and (6.3) are notationally equivalent:

(state(a) [LOVE(a, PRINCE, CAT))
(LOVE(s, PRINCE, CAT))

where the index variable indicates that the formula describes the state of Prince loving Cat.

The value of the property **order** is either **pre** or **post**. If a sign has an **order** value **pre** and is an argument in functional application, then its functor sign precedes it. On the other hand if

[7] Other differences concern the use of polymorphic functors and the treatment of modifiers (cf. Calder et al. 1987).

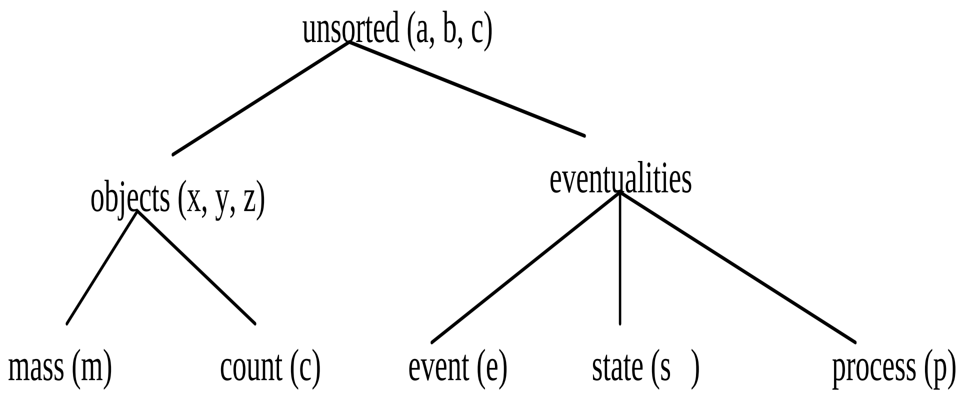

Figure 6.1: The semantic type hierarchy in UCG

it is an argument but has the value post, then its functor sign follows it. In categorial grammar the linear ordering of functors and arguments is represented in the directionality of the slash in the functor: i.e. a forward slash functor corresponds to pre and a backward slash functor to post. This imposes a strict locality constraint: only adjacent signs can combine. However, unlike standard categorial grammar, the order property can be underspecified and so the sign can combine with a preceding or following functor.

Signs are combined by functional application which relies upon two processes — instantiation and stripping. These are defined as follows (cf. Zeevat 1988: 205):

> Instantiation
> S3 is the instantiation of S1 with respect to S2 if it results from S1 by unifying S1's active part with S2.
>
> Stripping
> Given a sign S1 with category $A|B$, the result of stripping S1 is the sign S2 just like S1 except that its phonology is the concatenation of S1's and B's phonology, and its category is stripped down to A.

The combination principle, functional application, is defined as follows:

> Functional Application (FA)
> Let S1 and S2 be wellformed signs. Then stripping the instantiation of S1 with respect to S2 also results in a wellformed sign.

The set of well-formed expressions generated by UCG are defined as the phonologies of well-formed signs. The set of well-formed signs is defined as the closure of the lexicon under functional application.

We shall now illustrate how signs for the expressions *Prince*, *loves*, and *Cat* are combined with functional application to yield a sign for the complex expression *Prince loves Cat*. The lexical expressions are associated with the following signs respectively:

(6.8)	W:	Prince
	C:	NP
	S:	PRINCE
	O:	

(6.9)	W:	Cat
	C:	NP
	S:	CAT
	O:	

(6.10)	W:	loves
	C:	SENT[fin]|NP[nom]:x:post|NP[acc]:y:pre
	S:	[e][LOVE(e,x,y)
	O:	

Both proper names *Prince* and *Cat* have the following values for their major properties: W has the value of the standard orthographic representation; C has the value of the primitive syntactic category NP; and S has the values PRINCE and CAT respectively. The sign for *loves* is somewhat more complex. The value of W is its standard orthographic representation. The value of C tells us it is a complex category, $C|S$, where S is a sign E with the following attribute values: C has the value NP[acc]; S has an indeterminate value y; O has the value sf post — if E is an argument its functor follows it. The value of C is itself a complex category, $C|S$, where C has the value of finite verb form and S is a sign E1 with the following attribute value: C has the value NP[nom]; S has the indeterminate value x; O has the value pre — if E1 is an argument its functor precedes it. Crucially then the sign for *loves* imposes restrictions on its argument signs. The value of *loves* semantic property S is a formula with the sortal variable e and a two-place predicate where first variable, x, is shared with the value of the semantic attribute of sign E1 and the second variable, y, is shared with the value of the semantic attribute of the sign E. Thus *loves* denotes an event e which is the event of x loving y. Finally, the value of its order property is not specified.

The combination of these signs begins with the combination of the sign for *loves* and *Cat*. In this case, the SENT sign is the functor sign and the NP sign is the argument sign E. The instantiation process unifies the active part of the functor sign with the whole of the argument sign E. Thus the following structures will be unified:

(6.11)	W:	
	C:	NP
	S:	y
	O:	pre

(6.12)	W:	Cat
	C:	NP
	S:	CAT
	O:	

The unifying substitutions in (6.13) are made and the structure in (6.14) is recursively induced:

(6.13) W|Cat
F|acc
y|CAT
O|pre

(6.14)	W:	Cat
	C:	NP[acc]
	S:	CAT
	O:	pre

Although both signs are instantiated with this unification, the functional application is only concerned with the effects of unification on the functor sign. The result of the instantiation process is the sign given in (6.15):

(6.15)	W:	loves
	C:	SENT[fin]|NP[nom]:x:post|Cat:np[acc]:CAT:post
	S:	[e][LOVE(e,x,CAT)
	O:	

The most important effect of instantiation on the functor sign arises as a result of the cross-level variable y. Since the variable y is shared in both its category and semantic attributes, instantiation at the syntactic level has a side-effect on the semantic level: the semantics value of *loves* is now more determinate in that it describes an event in which a specific individual Cat is loved.

The second process in functional application, stripping, takes the instantiated sign in (6.15) and induces the sign in (6.16), the result sign of functional application:

(6.16)	W:	loves Cat
	C:	SENT[fin]|NP[nom]:x:post
	S:	[e][LOVE(e,x,CAT)
	O:	

Apart from the concatenation of phonological values, the effect of the stripping process has been the removal from the category value of the satisfied argument sign. Of course in this case, the category value of *loves* has not been satiated: it still has to satisfied by combining with the sign (partially) specified in its category value.

The result sign in (6.16) is the sign which combines with the sign for *Prince*. The instantiation process induces the following sign for *loves*:

(6.17)	W:	loves Cat
	C:	SENT[fin]|Prince:NP[nom]:Prince:post
	S:	[e][LOVE(e,PRINCE,CAT)
	O:	

and stripping this sign induces (6.18), the result of functional application:

(6.18)	W:	Prince loves Cat
	C:	SENT[fin]
	S:	[e][LOVE(e,PRINCE,CAT)
	O:	

which is the sign from the complex expression *Prince loves Cat*.

This example illustrates five key properties of combination in UCG. Firstly, it is surface-based: no underlying structures were invoked in the construction of the result sign *Prince loves Cat*. Secondly, it is lexicalist: the burden of combinatorial information, such as subcategorization, is located in the signs themselves. Thirdly, it is monotonic: information specified in combining signs is never lost or changed, but only added. Fourthly, the semantic value of signs is not directly affected by functional application, but rather emerges as a side-effect. Finally, and most importantly, the functor sign is central to combination as befit a categorial grammar: it partially specifies the argument sign it combines with; and it partially specifies the result sign of the combination. The result sign is thus a stripped functor sign after instantiation with the argument sign as shown in figure 6.2.

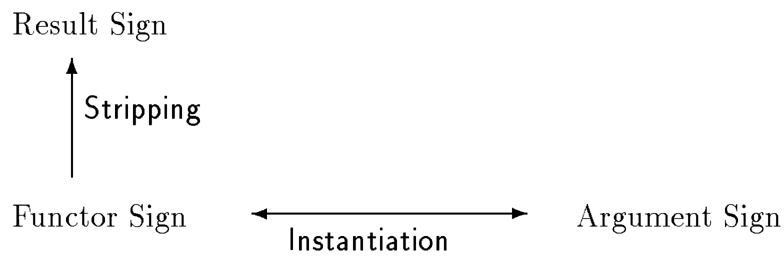

Figure 6.2: The pivotal role of the functor sign in functional application

6.4 The Head Modifier Distinction in Combination

In UCG, not only is functor argument distinction central to the combination principle, functional application, but one of the signs, the functor sign, is prioritized with respect to combination: the argument sign unifies with one part of the functor sign and, once stripped, the functor sign is the result sign. In the cognitive linguistic approach, however, combination in the linguistic processing module is based not upon the functor argument distinction but upon the head modifier distinction: signs combine as head and modifier to yield a result sign for the phrase. The head sign thus has priority in this combination process. Of course, this characterization of signs and their combination is similar to that in UCG. In fact, it might appear that 'head' and 'functor' are interchangeable terms for the prioritized sign in combination. However, this is not so. As we shall see in section 6.5, they differ in which lexical expression in a phrase is assigned priority and, as a consequence, the ease with which linguistic generalizations can be expressed. Before we compare these distinctions, we shall motivate the head modifier assignments in some simple phrases in terms of three combinatorial properties, and characterize the priority of the head sign over the modifier sign on the basis of their semantics.

6.4.1 Motivating the Priority of Heads

The head modifier assignments in the cognitive linguistic approach are based upon traditional assignments where, for example, the noun is head of the NP and verb the head of the VP (cf. Chomsky 1970: 210; Jackendoff 1977; Gazdar and Pullum 1981). Table 6.1 shows head modifier assignments in a range of simple phrases.

phrase	**head**	**modifier**	*example*
noun-verb	verb	noun	*elephants run*
verb-noun	verb	noun	*saw elephants*
adjective-noun	noun	adjective	*grey elephants*
verb-adverb	verb	adverb	*run slowly*
determiner-noun	noun	determiner	*the elephant*
auxiliary-verb	verb	auxiliary	*may run*
adverb-adjective	adjective	adverb	*very grey*

Table 6.1: Traditional head modifier assignments

In motivating priority of heads in these phrases, our starting point is the set of properties discussed in the 'Zwicky-Hudson' debate (cf. Zwicky 1985; Hudson 1987; Corbett et al. forthcoming). They discuss the following potentially distinctive properties of head signs or, more traditionally, head categories[8]:

governor the category which determines the morphological form of the other category in the construction without showing any analogous variation itself.

determinant of concord the category which determines the morphological form of the other category in the construction and does show analogous variation itself.

morphosyntactic locus the potential inflectional locus, the category in the construction on which inflectional features signalling syntactic relations between constructions will be marked if the language has the appropriate morphology.

distributional equivalent the category with roughly the same distribution as the whole construction.

subcategorizand the category which is subcategorized with respect to its ability to occur with a particular set of categories.

semantic functor the category which determines the semantic type of the phrase.

obligatory category the category which must be present for construction to be categorized as it is.

Zwicky's objective in discussing these properties is to find a notion of head useful for morphosyntactic feature percolation in the sense of the Head Feature Convention in GPSG and HPSG (cf. Gazdar et al. 1985; Pollard and Sag 1987). The head is identified as the category whose major morpho-syntactic features are passed up to, and thereby identical with, those of the result category. Zwicky identifies the head as the morphosyntactic locus: the head is identified as the category upon which inflections relevant to the construction are (potentially) located. In particular, he argues that only the morphosyntactic locus correctly identified the head: categories identified by other properties fail to systematically identify the head for feature percolation. The assignments for some constructions are illustrated in table 6.2.

phrase	**head**	**modifier**	*example*
determiner-noun	noun	determiner	*the elephant*
noun-verb	verb	noun	*elephants run*
verb-noun	verb	noun	*saw elephants*
auxiliary-verb	auxiliary	verb	*may run*

Table 6.2: Zwicky's head modifier assignments

In a reply to Zwicky, Hudson argues that, with the exception of concord, the head of a phrase possesses all of these properties: what one picks out as head, each of the others also picks out as head (cf. Hudson 1987). Hudson's head modifier assignments are illustrated in table 6.3. According to Hudson, the head is a fundamental notion in linguistics since it represents the systematic convergence of six independent properties. Furthermore, since both syntactic and semantic properties are involved, the notion provides an important point of

[8] We ignore 'ruler' of dependency-based analyses.

phrase	head	modifier	*example*
determiner-noun	determiner	noun	*the elephant*
noun-verb	verb	noun	*elephants run*
verb-noun	verb	noun	*saw elephants*
auxiliary-verb	auxiliary	verb	*may run*

Table 6.3: Hudson's head modifier assignments

contact and congruence between the syntactic and semantic structures of a sentence (cf. Hudson 1987: 124).

While we agree with Hudson in treating the head as a fundamental linguistic notion, we differ both in head modifier assignments and the distinctive properties of heads. In the first place, a comparison of assignments given in table 6.1 and table 6.3 reveals that there is disagreement over which category is head in determiner-noun and auxiliary-verb combinations: while we treat the noun and verb as heads, Hudson treats the determiner and auxiliary as heads. In the second place, Hudson's assignments are inherently weak since he does not claim that the head category necessarily possesses all of these properties. Rather he makes the weaker claim that there is a *tendency* for heads to possess these properties. As a result, a head category in a particular construction may not possess these properties, or the same property may be possessed by both the head and modifier category. Such an approach, however, is not adequate as a basis for a combination principle. That is, combination cannot be based upon a head modifier distinction if the very properties upon which the distinction is founded are not possessed by the head in a particular construction, or are possessed by both categories. Accordingly, these properties will be considered from the perspective of determining adequate properties for a head modifier combination principle.

Morpho-syntactic properties

The three morpho-syntactic properties are morpho-syntactic locus, governor and concord determinant. Unfortunately, the morpho-syntactic locus property is indeterminate and neither the government nor concord properties are systematically present in constructions.

The morphosyntactic locus is indeterminate. For this property can be used to argue that both categories in a phrase are heads, or that one or the other is head, depending upon which morpho-syntactic features are treated as relevant. Consider a noun-verb construction like *girls kiss*. Both categories are marked for number and person, but only the verb is marked for tense. Consequently, if we focus on the location of the tense feature, then the verb is identified as head. Alternatively, we could focus on the location of number and person features, in which case both categories are identified as head. Furthermore, in determiner-noun constructions such as *the boys*, the noun is the morphosyntactic locus since it, not the determiner, is marked for number. However, as Hudson himself points out, there are also examples of the construction where number is located on both categories:

(6.19) this book

(6.20) these books

Additionally, the determiner alone can be the morphosyntactic locus as with the following examples where the noun is morphologically unmarked:

(6.21) this sheep

(6.22) these sheep

A similar situation occurs in French for gender where only the determiner is marked for gender in *la femme*, but both are marked for plural number in *les femes*.

Government is not manifest in all types of construction nor in all occurrences of each type. According to Hudson, government is only manifest in three out of the four construction types given in table 6.3. In both noun-verb, and verb-noun constructions, the verb is the governor since it determines case-marking on the nouns; for example, *he kissed her*. In auxiliary-verb constructions, the auxiliary is the governor since it determines the morphological form of the verb:

(6.23) he will kiss her (infinitival)

(6.24) he is kissing her (present participal)

(6.25) he had kissed her (past participal)

Even within these constructions types, however, government is not manifest consistently. In the first two types of construction, for example, government is only manifest on personal pronoun, not on proper names or common nouns. In other constructions, such as adjective-noun, adverb-adjective and verb-adverb, there is no manifestation of government, at least in English.

Concord, likewise, is not consistently manifest in English. In some constructions, such as adverb-adjective, verb-adverb and auxiliary-verb, there is no manifestation of concord. In the remaining constructions, concord may be manifest, as with number person agreement in noun-verb constructions, but is not consistently manifest. For example, while (6.19) and (6.20) demonstrate the possibility of number agreement in determiner-noun constructions, the lack of morpho-syntactic co-variation in examples like *the book* demonstrate that it is not systematic within the construction.

In sum, morpho-syntactic properties do not provide a suitable basis for head assignments.

Distributional Equivalent

The distributional equivalent is inadequate as an identification property for heads since it is difficult to apply and indeterminate in some constructions.

The property is difficult to apply on account of its definition as 'the category which has roughly the same distribution as the whole construction'. The difficulty stems from how to interpret 'roughly' and 'distribution'. It could be argued that each construction type is associated with a distinct set of environments; for example, a noun phrase occurs in pre and post verbal positions, post prepositional positions and so on. 'Roughly' might then be taken to mean that the distributional equivalent is the constituent which occurs in most, if not all, of these environments. The difficulty with this interpretation is that there is no established threshold for determining how many environments the category needs to occur in, or whether some are more important than others. For example, *men* but not *fat* can occur in environments where the construction *fat men* can occur:

(6.26) the dietician spoke to fat men

(6.27) the dietician spoke to men

(6.28) *the dietician spoke to fat

(6.29) fat men eat too much

(6.30) men eat too much

(6.31) *fat eat too much

However, this clearly does not hold for all constructions as the following determiner-noun constructions show:

(6.32) John read a book

(6.33) *John read book

(6.34) *John read a

This property suggests conflicting head assignments in auxiliary-verb constructions, since either the auxiliary or the verb can be treated as distributional equivalent:

(6.35) the goths will kill the barbarians.

(6.36) the goths kill the barbarians.

(6.37) *the goths will the barbarians.

(6.38) he will control these penguins

(6.39) *he control these penguins

(6.40) *he will these penguins

Zwicky argued that examples like (6.35) to (6.37) show that the verb is the distributional equivalent. Hudson, on the hand, argues that examples such as (6.38) to (6.40) demonstrate that the verb cannot consistently substitute for the whole construction since they lack the appropriate morpho-syntactic form. Further, he claims that the auxiliary can be substituted for the whole construction in cases of VP ellipsis:

(6.41) why are you worrying?

(6.42) why are you?

Rather than simply admit that this property will pick out different categories as head in different instances of the same construction, Hudson gives undue weight to the elliptical examples and claims that the auxiliary is head.

Hudson adopts the same tack in another construction, the determiner-noun constructions. On the basis of elliptical examples, determiners can be the distributional equivalent[9]:

(6.43) John trimmed each carrot carefully

(6.44) John trimmed each carefully

(6.45) John trimmed the carrot carefully

(6.46) *John trimmed carrot carefully

Yet in other examples of such constructions, the reverse situation holds and the noun cannot be elided:

(6.47) John trimmed the carrots carefully

(6.48) John trimmed carrots carefully

(6.49) *John trimmed the carefully

Again, rather than simply admit that the criterion is indeterminate, Hudson maintains that the determiner, not the noun, is head in this construction.

[9] As Lyons points out, NPs with common nouns have a distribution closer to that of a proper name or personal pronoun than to a common noun (cf. Lyons 1977b: 392).

Subcategorizand

Given that morpho-syntactic properties and the distributional equivalent are not adequate to identify heads for the purposes of combination, three properties remain: subcategorizand, semantic functor and obligatory category.

The traditional notion of subcategorization derives from transformational grammar (cf. Chomsky 1965). While all lexical categories were assigned a major syntactic type, some were also assigned a subcategory type. The function of this latter type was to provide a number of subcategories of the major type. For example, lexical categories with the major type verb could be subcategorized into intransitive, transitive and di-transitive verbs on the basis of their subcategorization type. An intransitive verb like *run* would be assigned the major syntactic type verb and the subcategory NP. Both the category and sub-category type then acted as restrictions on the phrase-marker into which they could be inserted. The lexical category associated with *run* could only be inserted into a phrase-marker with the type verb where one of its sister constituents was of the type NP.

One of the consequences of the distinction between lexical and phrasal categories is that only lexical categories can be subcategorizands. Accordingly, Zwicky and Hudson agree that neither *elephants* nor *run* are subcategorizands in noun-verb constructions like *elephants run* since neither are lexical categories: they are treated as phrasal categories. They also agree that the auxiliary in auxiliary-verb constructions and the verb in verb-noun constructions are subcategorizands since the other category is phrasal. It is arguable, however, that the distinction between lexical and phrasal categories is irrelevant to the head modifier distinction in combination: it is not the status of a category as lexical or phrasal but the type and properties of combining categories which is pertinent to combination.

The subcategorizand property can be refined on the assumption that the syntactic and semantic properties of categories are directly relevant to combination. In particular, the subcategorizand property identifies as head the category which is syntactically and semantically specified by the other category. As Jesperson (1924: 96) says:

> The chief word [head] is defined (qualified, modified) by another word, which may be defined (qualified, modified) by a third word.

In other words, the head is the subcategorizand because it is specified by the modifier: combination with a modifier category (potentially) results in a more specific sort, or subcategory, of the head category. With *large elephants*, for example, the noun *elephants* is semantically specified by the adjective *large*: the size of the elephants is specified as large. The modifier may also specify syntactic properties of the head; in *two elephants* the quantifier *two* confirms the plural number on the head *elephants*. These examples illustrate two effects of specification on the head: the addition of new properties; and confirmation of existing properties.[10]

This property can be further illustrated with Vendler's classification of dynamic verbs into activities, achievements and accomplishments (cf. Vendler 1967). A verb like *paint* has an accomplishment reading when its theme role is specified. As an accomplishment, it is grammatical in durative and telic contexts:

(6.50) Picasso painted a picture

(6.51) Picasso painted a picture for three days (durative)

(6.52) It took Picasso three days to paint a picture (telic)

When theme is not specified, *paint* has an activity reading and is ungrammatical in telic contexts:

[10] There is a third effect, namely changing properties of the head. This is discussed in section 6.6.

(6.53) Picasso painted

(6.54) Picasso painted for three days

(6.55) *It took Picasso to paint a picture

Likewise, stative or dynamic readings of some verbs are dependent upon the semantics of the specifying category. With *runs*, for example, the verb only occurs as a present participle when its theme role is specified as ANIMATE:

(6.56) the seagull runs along the beach

(6.57) the seagull is running along the beach

(6.58) the seashore runs along the beach

(6.59) *the seashore is running along the beach

Finally, a verb like *opened* only has an 'agentive' reading when its theme role is specified as SENTIENT:

(6.60) the sailor opened the door

(6.61) the sailor opened the door in order to see the seagull

(6.62) the wind opened the door

(6.63) *the wind opened the door in order to see the seagull

Thus only with an agentive reading can it grammatically occur with purposive clauses.

Semantic Functor

Identifying which category in a phrase is the functor and which is the argument is not a straightforward task. As Zwicky (1985: 4) observed, either category can, in principle, be assigned the status of functor with sufficient ingenuity. Although we will return to the question of the distinctive properties of the functor in section 6.5, we will adopt as a second distinctive property of heads Hudson's notion of 'kind of' which he sees as a 'sharpening' of the semantic functor property. The 'kind of' property identifies the head as the category which provides the semantic 'kind' of the result category. In fact, this notion can be generalized into a category determinant property: the head is the category which determines, or provides, the syntactic and semantic kind, or type, of the result category (cf. Hjelmslev 1939). This ensures a systematic relationship between the semantic and syntactic behaviour of combining categories: whatever category contributes the semantic type also contributes the syntactic type (cf. Hudson 1987). This is also consistent with the head as subcategorizand: the head provides the syntactic and semantic type and the modifier specifies, or specializes, its syntactic and semantic properties. These properties, subcategorizand and category determinant, thus converge to identify as head the category which determines the syntactic and semantic type of the result category whereas the other category, the modifier, specifies properties of this category.

In noun-verb and verb-noun constructions, the verb contributes the syntactic type, a kind of verb, and the semantic type, a kind of event. The noun specializes these types by specifying one of its linguistically relevant roles. In *John laughs*, for example, the verb determines that the result category is a kind of verb and a kind of event, and the noun specializes this category as an intransitive verb and as an event with a participant called *John*. Thus the construction is kind of event rather than a kind of person. Likewise *control these penguins* describes a kind of controlling event rather than a kind of penguins. In auxiliary-verb constructions, the verb also contributes the syntactic and semantic type to the result category; in *John may control the penguins* the result category is a kind of verb, not auxiliary, and a kind of event, not possibility[11]. Likewise, in a determiner-noun construction, such as *the penguins*, the result category is a kind of noun, not determiner, and a kind of entity, not definiteness[12].

Obligatory Category

The obligatoriness property also converges with the subcategorization and category determinant (or 'kind of') properties. The obligatory category is identified as the head of the phrase (cf. Hjelmslev 1939; Miller 1985: 27; Anderson 1986: 55). The notion of obligatoriness, however, must be approached with caution since the absence of a category can indicate either optional or elliptical status (cf. Zwicky 1985: 13). Head categories are obligatory since they provide the syntactic and semantic types of the result category; without these, the result category would not be defined. Consequently, when the head category is absent, it must be elliptical rather than optional: it is implicit in the discourse and when re-constructed from context provides the syntactic and semantic types of the phrase (cf. Matthews 1981: 38–45). For example, in the context of talking about two films, the head noun (*film*) can be elided as in *I didn't see either* (cf. Nichols forthcoming). Modifier categories, on the other hand, are not obligatory in this sense. In phrases where they are obligatory, it is the head category which provides the types; for example, the result category in the auxiliary-verb phrase *the elephant may like hay* is syntactically a kind of verb and semantically a kind of event. Modifier categories are obligatory in such constructions in order to provide properties necessary for the result category, properties which are not provided by the head itself. For example, the result of combining a verb with an auxiliary verb must be specified for tense and if this is not inherent in the verb (*like*), then it must be provided by the auxiliary verb modifier (*may*).

In sum, the subcategorizand, category determinant and obligatory category properties are all properties of the same category and this category is the head of a phrase. These properties support, or at least coincide with, the traditional assignments given in table 6.1. Furthermore, these three properties underpin combination in the cognitive linguistic approach: phrases are characterized as the sign which results from the extension of a head sign through specification by a modifier sign. The head sign thus provides the syntactic and semantic type of the result sign so long as the modifier sign does not specify properties incompatible with those of the head.[13] The head sign is also obligatory since it is necessary for specification by the modifier sign and for the existence of the result sign.[14]

6.4.2 Characterizing the Priority of Heads

In the cognitive linguistic approach to combination, the systematic priority of a head sign over the modifier sign is primarily characterized in terms of their semantic types: the semantic type of a head sign outranks the semantic type of the modifier sign. Characterizing the priority of heads in the ranking of elements is well-established in dependency grammar. The fundamental notion in dependency grammar is that expressions are related by a systematic, asymmetrical 'dependency' relationship where the head has priority over the modifier expression. This notion is well-established in linguistic theory and predates modern linguistics (cf. Owens 1988). In this century, the notion has been developed informally by Jesperson and Hjelmslev to name but two (cf. Jesperson 1924; Hjelmslev 1939). The head modifier relation has been employed in formal grammars as the fundamental relation between categories within a construction (cf.

[11] See Hudson (1987: 115) for an alternative treatment where the auxiliary provides the semantic type; for example, *may like* describes a kind of possibility rather than a kind of liking.

[12] See Radford (forthcoming) for an alternative treatment.

[13] This limit on specification is one way in which head signs have priority over modifier signs: category determination, a combinatorial effect associated with head signs, has priority over specification, a combinatorial effect associated with modifier signs.

[14] Since head signs are lexical signs and result signs are identical to head signs after extension, result categories are merely extended lexical categories. As in dependency grammar, the head modifier relation is treated as a basic relation between lexical signs, and constituency as a derived relation (cf. Anderson and Durand 1986: 2).

Tesnière 1959; Hays 1964; Robinson 1970a; Robinson 1970b; Anderson 1971; Anderson 1977; Anderson 1979; Hudson 1984; Hudson 1990). In the dependency case grammar developed by John Anderson, expressions are ranked on the basis of their 'greater strength in some substantive property' (cf. Anderson 1971; Anderson 1977; Anderson 1989). Anderson identifies two types of substantive properties: phonetic and semantic. Syntactic categories are constructed out of a subset of semantic features, features which are related by dependency and association. Thus the internal structure of words determines their external structure: word combination is determined by the internal structure of words. Words are structured in terms of two categorial features: N (potentially referential) and P (potentially predicative). Each word category is defined on the basis of categorial features and subcategorial features, such as abs and erg, which are related by association (","), dependency (";") and mutual dependency (":"). This gives rise to the ranking of syntactic categories shown in table 6.4 (cf. Anderson 1989). This

category	Verb (fin)	Verb (inf)	Adj (attr)	Noun	Name
features	P	P ; N	(P :) N abl	(N ;) P	N

Table 6.4: Ranking of Syntactic Categories in Anderson's Case Grammar

ranking correlates with the behavioural properties of syntactic categories; categories with P are allowed predicative positions while those with N are allowed in argument positions. The complexity of representations is intended to reflect universality: simple representations, such as those for proper names and finite verb, are universal categories, while those with more complex representations, such as adjectives, are not necessarily universal. Augmenting the internal structure of attributive adjectives with the subcategorial feature *abl* is intended to capture the notion that they introduce a subset of the set denoted by the noun: they take an argument specifying the source from which the subset is extracted. In dependency case grammar, this ranking gives rise to the analysis of *white horses* given in figure 6.3 where since the adjective *white* outranks the common noun *horses*, the adjective rather than the noun is head of the noun phrase.

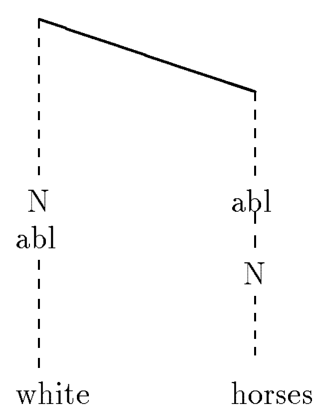

Figure 6.3: A dependency analysis of *white horses*

Anderson's approach to parts of speech is notional: syntactic categories are 'defined' or reduced to semantic categories and features. In such approaches, the syntactic category provides schematic semantic properties which are further specified within the semantic level proper (cf. Langacker 1987: 54). Furthermore, like the notional approaches of Langacker (1987) and Hopper and Thompson (1984), syntactic categories are 'defined' in terms of prototype semantic categories: nouns *tend* to refer a concrete objects and verbs to concrete actions (cf. Anderson 1989).

The cognitive linguistic approach differs in both respects. Syntactic categories and semantic categories are independent but related categorizations of expressions. They are independent since they are motivated on different grounds: syntactic categories are discerned on the basis of morpho-syntactic behaviour; and semantic categories on the basis of their function in discourse (cf. Hopper and Thompson 1984). These independent categorizations are, however, systematically related; nouns are necessarily associated with concepts of the type ENTITY, verbs with concepts of the type EVENT, adjectives and auxiliaries with concepts of the type PROPERTY and determiners and adverbs with concepts of the type PRE-PROPERTY (cf. Bates and MacWhinney 1982: 216; Bach 1986). As we saw in section 5.3.2, these semantic types constitute the major types in the ontological hierarchy given in figure 5.3. Furthermore, these semantic types can be ranked as follows (where $\succ$ signifies outranking):

(6.64) EVENT $\succ$ ENTITY $\succ$ PROPERTY $\succ$ PRE-PROPERTY

These types are then correlated with, rather than reduced to, syntactic types. The simplest correlations are given in table 6.5. The priority of a head sign over a modifier sign in a

syntactic type	**semantic type**
VERB	EVENT
NOUN	OBJECT
DETERMINER	PRE-PROPERTY
ADJECTIVE	PROPERTY
AUXILIARY	PROPERTY
ADVERB	PRE-PROPERTY

Table 6.5: Simple correlations between semantics and syntactic types

construction is thus sourced in the ranking in (6.64) and the correlations in table 6.5. It follows that a noun, for example, is the head in constructions with determiners and adjectives. Since this ordering is transitive, the verb is the head in constructions with nouns, auxiliaries and adverbs.

As might be expected from such a straightforward approach, there are some problems in applying it to constructions other than those mentioned in table 6.1. In particular, the approach fails to characterize the priority of heads in the following constructions:

(6.65) John's kissing Mary was a happy sight.

(6.66) To see the world is my goal.

(6.67) The man who died was a linguist.

(6.68) What time does the last train leave?

(6.69) A penguin limping home is a sad sight.

One problem is that both signs in construction may have the same semantic type: in (6.65) both *kissing* and *was* have the type EVENT; and in (6.66), the infinitival verb *to see the world* has the same type, EVENT, as the finite verb *is*. A second problem is that the sign which 'should' be the head is not since it is outranked by the modifier; in (6.67), if *who* is simply treated as a relative marker, then *man* has the type ENTITY which is outranked by *died* (which has the type EVENT); likewise, in (6.68), *time* has the type ENTITY which is outranked with *leave* with the type EVENT; and in (6.69), *penguin* has the type ENTITY which is outranked by the gerund *limping home* which has the type EVENT.

Some of these problems can be solved by simply elaborating the ranking so that semantic properties, as well as types are taken into account. For example, infinitives and finite verbs can be differentiated on the basis of the value of the semantic mode property tense: finite verbs have the value positive while non-finite verbs the value negative. Signs of the type EVENT with a positive value outranking those with a negative value. The other problems are more tricky. Interrogative and relative markers can be treated as case markers which are modifiers of the head noun: they specify the desc role on objects, a role which permits any type but that type does not outrank the root type (see section 5.8). This would take care of (6.67) and (6.68). (6.69) can be treated in an analogous manner, although there is no linguistic marker that the desc role is required (cf. *what* and *who*).

6.5 Heads and Functors

Adopting a functor argument distinction rather than head modifier distinction as the basis for a principle of combination in the linguistic processing module is problematic in that an extra principle is required to account for generalizations in serialization and category constancy. In addition, as we noted in section 6.4.1, the functor sign is difficult to identify. In fact, one allegedly distinctive property of functors — that the interpretation of functors, but not arguments, varies semantically with the interpretation of the other category — is actually indeterminate.

The functor argument assignments in categorial grammar, broadly in accord with Keenan (1979), are given in table 6.6[15]. Comparison with the assignments in table 6.1 demonstrates

phrase	**functor**	**argument**
adjective-noun	adjective	noun
determiner-noun	determiner	noun
noun-verb	verb	noun
verb-noun	verb	noun
auxiliary-verb	auxiliary	verb
verb-adverb	adverb	verb
adverb-adjective	adverb	adjective
verb-adverb	adverb	verb

Table 6.6: Functor argument assignments in categorial grammar

that the prioritized categories, functors and heads respectively, are not identical. In particular, functor categories differ from head categories in adjective-noun, verb-adverb, determiner-noun, auxiliary-verb and adverb-adjective phrases. Even if the correlation between the functor argument distinction and the head modifier distinction were inverted so that argument categories

[15] Since Keenan makes no assignments in auxiliary-verb, verb-adverb and adverb-adjective constructions, we have given the analyses which Hawkins takes as characteristic of categorial grammar (cf. Hawkins 1984: 113–114). While these assignments are generally respected in Unification Category Grammar, it can treat the noun as functor in noun-verb and verb-noun constructions. The reason for this is that noun phrases can be 'type-raised': they are treated as polymorphic functors seeking an argument which is itself looking for a noun phrase (syntactically, $X|(X|\mathrm{NP})$). (cf. Calder et al. 1987: 24–26).

were correlated with head categories, the problem would still persist: arguments do not correspond to heads in noun-verb and verb-noun phrases. However, a relation can be established between these assignments through an additional principle — the Endotypic Principle (cf. Vennemann and Harlow 1977; Bouma 1988).

The Endotypic Principle is based upon the distinction between endotypic and exotypic functors. An endotypic functor is a functor of the form $X|X$: i.e. its take and make categories are identical. As a corollary, exotypic functors are functors of the form $X|Y$.

> The Endotypic Principle
>
> In a construction consisting of a functor F and an argument A, F is the head, *unless* it is endotypic in which case A is the head.
>
> A functor which is not a head is a specifier (attribute).
>
> An argument which is not a head is a specifier (complement).

Of the functors given in table 6.6, only verbs in verb-noun and noun-verb phrases are exotypic: as functors they correspond to heads with their arguments as (complement) specifiers. The remaining functors are endotypic. For example, in adjective-noun phrases the adjective is a functor which, syntactically, takes a category of the type noun and makes a category of the type noun (noun|noun) and semantically it specifies a function mapping from the set of entities into the set of entities (<e>|<e>). And similarly in verb-adverb phrases, the adverb is a functor which takes a syntactic category of the type verb|noun (i.e. a verb category which itself takes a noun category) and makes a category of the same type. Thus in categorial grammar an additional principle is required to relate the functor argument distinction to the head modifier distinction. The problem with this, however, is that generalizations in serialization and category constancy are couched in terms of the head modifier distinction not the more 'basic' functor argument distinction.

Greenberg's implicational serialization universals captured cross-language statistical regularities in the linear order of categories within phrases (cf. Greenberg 1966). For example, if in a language, such as Japanese, the direct object precedes the verb, then, typically, the adjective will precede the noun and the noun the adposition. Such apparent regularities can be accounted for in a systematic manner with the following principle based upon the head modifier distinction (cf. Anderson 1979: 7):

> Head Modifier Serialization Principle
>
> Serialization in a phrase tends to follow systematically from the relation between heads and modifiers: either modifiers precede heads or heads precede modifiers.

Hawkins (1984) provides further support for the HMP in relation to language type frequency[16]. He formulates a principle which predicts the relative number of language types on the basis of serialization of heads and modifiers within phrases (cf. Hawkins 1984: 130-1):

> Cross Category Harmony Principle
>
> The more similar the cross-category positioning of head, the more languages; the less similar, the fewer languages.

In both cases then, the head modifier distinction in conjunction with serialization principles appear to provide a straightforward account of word order generalizations. However, as Dryer (1988) has shown, there are other factors at play in determining serialization. These include dominance and harmony principles, areal influence, as well as the direction of branching in branching as opposed to non-branching constructions. One effect of this is that serialization

[16] But note that Hawkins has subsequently abandoned the head modifier distinction (cf. Hawkins forthcoming).

principles based upon the head modifier distinction cannot be seen in isolation from other principles: serialization is determined by the interaction of a number of ordering principles and cannot be reduced to a single universal principle. Principles such as those above, then, do not provide a complete account of serialization: they simply provide a category-based restriction on serialization.

Accounts of serialization based upon the functor argument distinction, however, require an additional principle to provide these restrictions on serialization. For example, Vennemann appeals to the Endotypic Principle and is able to provide a general account of serialization in terms of functors and arguments in categorial grammar (cf. Vennemann 1976; Vennemann and Harlow 1977; Vennemann 1984). Such an account, however, relies upon a derived distinction – that between heads and modifiers (or specifiers) – and it is the latter distinction which captures category restrictions on serialization. On the grounds of descriptive economy, the head modifier distinction provides a better account since it is the head modifier (or specifier) distinction which underlies these restrictions.

The functor argument distinction also requires these additional principles to account for the semantic 'kind of' relationship discussed in section 6.4.1. For neither the functor nor the argument consistently provides the semantic type of the result category. In phrases with exotypic functors, the functor provides the semantic type. For example, in *elephants run*, the functor *run* is, semantically, a function from entities to truth values, a function which can be assigned the type EVENT. The argument restricts the domain of this function to entities of the type ELEPHANT. The result type is a more specific event: i.e. the event of elephants running. In phrases with endotypic functors, it is the argument which provides the type of the result category. For example, in adjective-noun phrases like *pink elephants*, the functor describes a mapping from the set of entities onto the set of entities with the property PINK (<e>|<e>), but the argument provides the type of the set, i.e. ELEPHANT. While functor provides a restriction on the type of the set of entities, i.e. entities with the property PINK, it is the argument which provides the type itself — entities of the type ELEPHANT with the colour PINK. Consequently, on the grounds of descriptive economy, it would be preferable if the grammar were able to directly provide the basic head modifier distinction rather than a derived distinction.

Finally, categorial grammar does not provide explicit motivation for the systematic priority of functors. One possible motivation is due to Keenan's (1979) observations on the correlation between surface form and logical form. Keenan claims that the directionality of agreement relations between expressions is systematically based upon the directionality of semantic variation. This is captured in the following principle:

> Meaning-Form Dependency Principle
> Given A and B distinct constituents of a syntactic structure E, A may agree with B iff the semantic interpretation of expressions of A varies with the semantic interpretation of expressions of B in the interpretation of E. (cf. Keenan 1979: 168)

Pursuing the question of whether 'there [is] any correlation between what varies in meaning with what and the logical structures assigned to agreement pairs' (cf. Keenan 1979: 170), Keenan develops a second principle:

> The Functional Dependency Principle
> Given A and B distinct constituents of a SF [surface form] E, A may agree with B iff in the LF [logical form] of expressions of E, the LFs of expressions of A are interpreted as functions taking the interpretations of expressions of B as arguments.
> (cf. Keenan 1979: 172)

Taking these principles together, one interpretation of Keenan's position is that semantic variation is a property of functors but not arguments: i.e. the semantic interpretation of a functor varies with that of the argument, but not vice versa (cf. Hudson 1987: 115). For example, Keenan argues that the interpretation of a transitive verb varies with the interpretation of its direct object as he shows for *cut*:

(6.70) a. cut finger ('to make an incision on the surface of')
b. cut cake ('to cut all the way through'; 'to divide into portions for the purpose of serving')
c. cut lawn ('trim')
d. cut heroin ('diminish the potency of by adding a physically comparable substance')

Likewise, in noun phrases the interpretation of adjectives, such as *flat*, varies with the interpretation of nouns as shown in (6.71):

(6.71) a. flat beer ('lacking normal taste')
b. flat road ('without bumps or depressions')
c. flat voice ('too low in pitch')

On the basis of semantic variation then, verbs can be treated as functors with nouns as their arguments and adjectives as functors with noun arguments.

The problem here, however, is that variation in semantic interpretation is not simply uni-directional. For just as the argument can affect the interpretation of the functor, so the functor can affect the interpretation of the argument. Consider, for example, the interpretation of verbs and adjectives. As functors, their interpretation can vary with the interpretation of their noun arguments as illustrated in (6.70) and (6.71). Psycho-linguistic evidence supports not only variation in this direction, but also in the opposite direction. Murphy (1988) found that the interpretation of adjectives can systematically vary with the interpretation of nouns (see also Cruse 1986: 152). For example, *long* has the interpretation 'great length', or a simple elaboration of this, in combination with *word* and *life*, but substantially different interpretations in combinations with nouns like *hand* ('expressed in complete sentences and without abbreviations'), *eye* ('towards the future') and *year* ('seeming to pass slowly'). Moreover, he also found that the interpretation of nouns varied with that of adjectives (see also Lakoff 1987: 83–4). In some cases, the interpretation highlighted different senses of noun; *hand*, for example, took on interpretations which varied from 'side' as in *right hand* to 'anatomical hand' in *bleeding hand*. In others, variation highlighted different aspects of the same sense.

Anderson and Ortony (1975) report similar bi-directional variation in the interpretation of nouns and verbs. For example, the nouns *steak* and *soup* lead to different interpretations of *eat*: the act of eating is associated with different utensils as well as actions of the lips, teeth and tongue. Conversely, the interpretation of *piano* can vary in different verb contexts:

(6.72) Pianos can be pleasing to listen to.

(6.73) Pianos can be difficult to move.

In (6.72) the sound, but not the weight, of the piano is relevant, whereas in (6.73) the opposite is true. As Anderson and Ortony put it 'in one context piano is a member of the same category as, say, harmonica, while in another it is certainly not. In the latter case, perhaps sofa would be a cohyponym' (cf. Anderson and Ortony 1975: 169).

In sum, not only does the functor argument distinction require an additional principle, the Endotypic Principle, to yield analyses which accord with serialization and semantic constancy requirements, but this evidence suggests semantic variation cannot distinguish functors from arguments. Our approach to combination, on the other hand, provides a distinction between heads and modifiers which can directly account for these requirements, a distinction which is motivated in terms of three distinctive properties of heads, and characterized, at least informally, in terms of the priority of the head's semantic type.

6.6 Defeasibility

Defeasibility is a linguistic phenomena which challenges the notions that modifiers simply specify heads by adding or confirming properties (heads qua subcategorizands). The phenomenon is manifest in phrases where there is a conflict, usually a semantic conflict, between properties of the combining signs. The conflict is systematically resolved through the 'defeat' of one sign by the other: the result sign no longer has the property of the 'defeated' sign since the property is replaced by one appropriate to the 'defeated' sign.

Four types of semantic defeasibility will be briefly described: typicality defeat, intrinsic defeat, sortal defeat and general defeat. In these types, defeat can vary along a number of dimensions. One of these is dependence upon lexical semantics: i.e. whether or not the occurrence of defeat is dependent upon specific semantics properties of the defeated sign. Another is the nature of the defeated property: defeat can involve necessary properties or default properties of a concept (cf. Murphy 1988). Since properties can also be related to each other, these relationships can in turn affect defeat. For example, given a correlation between the sweetness of food and its calorific-value — the sweeter food is, the more calories it typically contains — defeat of the sweetness property will also affect calorific-value such that we can no longer infer that it has a high value (cf. Franks et al. 1988).

6.6.1 Typicality Defeat

The first type of defeat, typicality defeat, affects default properties and is lexically dependent. In an adjective-noun phrase like *grey elephants*, the value of the colour property specified by the modifier sign is compatible with the default value grey of elephants. With *pink elephants*, however, the properties are incompatible and the default value specified by the head is defeated by the necessary value specified in the modifier sign: while *elephants* are grey, *pink elephants* are pink. Psycholinguistic experiments also suggest that conflicts over default properties are systematically resolved in favour of the modifier sign. When the properties of concepts such as *games* and *sports* are rated for typicality, the (indirect) modifier *games* consistently plays a greater role in determining the typicality rating of properties in *sports that are also games* than the head *sports* (Hampton 1987).

6.6.2 Intrinsic Defeat

With the second type, intrinsic defeat, semantic properties of the defeated sign are overridden independently of its lexical semantics. In noun phrases with privative adjectives such as *fake*, *former* and *false*, the adjective modifier consistently defeats the existence of the semantic type of the noun (Kamp 1975); for example, while the concept underlying *Renoirs* asserts the existence of paintings by Renoir, *fake Renoirs* denies their existence. Likewise, modifiers of verbs such as *never* and *not* undermine the existence of a state or event; in *John never crossed the road*, there is a denial that a 'crossing' event took place. With this type of defeat then, there is a conflict between the value of a mode property of the signs which is resolved in favour of the modifier sign; for example, with *fake elephants* the modifier's value negative for polarity defeats the head's value positive. This makes problematic the category determinant property of heads: while *pink elephants* are clearly a 'kind of' *elephants*, *false beards* are not obviously 'kinds of' *beards*. In particular, the result sign no longer contains necessary semantic properties of the head sign; *false beards*, for example, do not grown on chins. Many of their default properties, especially those which play a diagnostic role, are preserved in the result sign; with *fake Renoir*, for example, a sufficient number of diagnostic properties must be preserved so as to maintain the contrast with *fake Picasso* — a *fake Renoir* must at least appear more like a real Renoir than a *fake Picasso*.

6.6.3 Sortal Defeat

The third type of defeat, sortal defeat, is similar to intrinsic defeat in that necessary semantic properties of the head sign are lost, and this stems from the defeat of the head by the modifier (cf. Franks et al. 1988; Franks 1989). It differs from intrinsic defeat in three ways.

Firstly, the semantics of the head sign is defeated as a consequence of the defeat of a necessary core property. For example, in *chocolate elephants* the value of the material property chocolate of the adjective modifier defeats the flesh value of the noun head. Since this property is necessary for the concept, its defeat entails that the category determinant property is no longer obvious — *chocolate elephants* are not real elephants. It does, however, retain default properties such as 'elephant shape' which differentiate *chocolate elephants* from *chocolate mice*. Furthermore, the head concepts is elaborated as a result of defeat: *chocolate elephants* contains the default values sweet and brown which are not part of the concept of 'elephants'. Genter (1981) provides psycholinguistic evidence to demonstrate that a noun modifier can defeat a verb head in a similar manner. For example, when subjects paraphrased sentences such as *the lizards worshiped the sun*, they tended to produce paraphrases such as 'the small grey reptile lay on the hot rock and stared unblinkingly at the sun' (cf. Gentner 1981: 165). Here there is a conflict between the value of the agent role in the semantics of the verb head and the modifier's semantics: SENTIENT is incompatible with LIZARD. Rather than simply replace the type of agent with LIZARD, the type of this role in the head concept is 'elaborated' into ANIMATE.

A second difference is that sortal defeat is lexically dependent. For example, *stone* is a modifier capable of giving rise to sortal defeat. In *stone bridge*, however, there is no defeat since the values of the material property specified in each sign are compatible.

The third difference is that the discourse situation may play a greater role in determining which sign has priority rather than the head modifier distinction.[17] For example, if *the sunflower kissed the wall* were said in the context of a fancy-dress party, the most likely interpretation would be a metaphorical one in which semantic properties of the noun modifier were defeated: it would describe a person dressed as a sunflower rather than a real flower.

6.6.4 General Defeat

The fourth type of defeat, general defeat, offers the strongest violation of compatibility and category determination. The result sign has neither the general semantic or syntactic type of the head sign. With other sorts of defeat, only the semantic type is undermined, and undermined to a limited extent. For example, with sortal defeat in *chocolate elephants*, while the semantic type of the head is undermined through loss of necessary properties, the result sign clearly preserves its general semantic type (ENTITY) as well as the syntactic type (noun) of the head *elephants*.

Denominal verbs illustrate general defeat (cf. Clark 1983). In (6.74) *porch* is a noun with the general semantic type ENTITY.

(6.74) Newspaper boys put the newspapers in the porch.

In (6.75), however, the result sign is a verb with the general semantic type EVENT.

(6.75) Newspaper boys porch the newspapers.

This change in syntactic type and type can be seen as a manifestation of general defeat. In (6.75), the signs for *porch*, *the newspaper boys* and *the papers* are unable to combine since

[17] This is also a characteristic of general defeat described in section 6.6.4.

none can act as a head sign. They can combine, however, if *porch* is selected as the head sign and its syntactic and semantic types are systematically changed in order to accommodate the requirements of the modifier signs.

6.6.5 Significance of Defeat

These types of semantic defeasibility demonstrate that signs with incompatible properties can combine successfully, although not all properties of the 'defeated' sign are preserved in the result sign. With typicality defeat, a default value in the 'defeated' sign is overridden by a necessary value specified in the 'defeating' sign and the default value is not preserved in the result sign. With intrinsic defeat, the value of a mode property in the 'defeated' sign is overridden by a necessary value in the 'defeating' sign and, as a result, necessary core properties are lost. With sortal defeat, the value of a necessary core property in the 'defeated' sign is overridden by a necessary value in the 'defeating' sign. And with general defeat, the semantic and syntactic types are replaced with those required by the 'defeating' sign. As a consequence, the subcategorization and category determinant properties of heads seem difficult to maintain: modifiers may not simply specify properties of the head sign; and the result sign may not transparently have the syntactic and semantic types of the head sign.

Two aspects of defeasibility, however, reinforce the head modifier distinction rather than the functor argument distinction. The first is that modifiers, in general, have systematic priority in defeat: where there is a conflict, the modifier sign is the 'defeating' sign and the head the 'defeated' sign. For the utility of the semantic type ranking given in (6.64) is that manifestations of priority either systematically follow from the ranking or go against it. With defeasibility, priority systematically goes against ranking: signs with semantic types of a lower rank can override properties of those with higher types[18]. This is illustrated in figure 6.4. The second

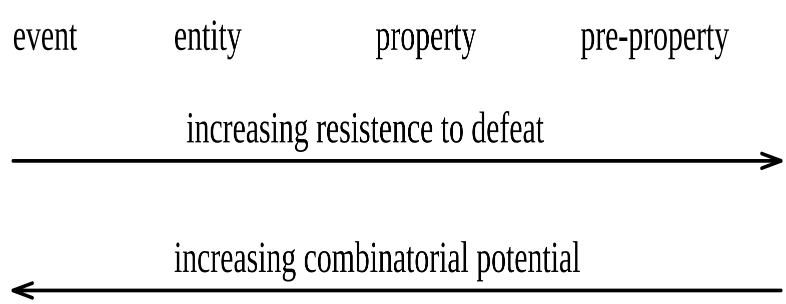

Figure 6.4: Combinatorial potential and resistance to defeat

aspect is that when defeat occurs, the head sign still provides the basis for the construction of the result sign. As Gentner says of noun-verb combinations:

> The verb meanings were not simply ignored. Other evidence from this study indicates that the verb preserved as much of its meaning as possible ... given an incompatible noun, the verb was typically extended until it fit. (cf. Gentner 1981: 165–6)

Since the cognitive linguistic approach identifies the result sign as the head sign after combination with the modifier sign, it is the nature of combination, and in particular, its relationship

[18] In this way, the semantic type ranking bears comparison with the sonority hierarchy in phonology (cf. Anderson and Durand 1986: 16).

with semantic interpretation, which needs to be addressed in the characterization of the linguistic processing module.

6.7 Conclusion

In this chapter we have discussed the nature of linguistic combination with respect to the cognitive linguistic approach to language comprehension. If linguistic combination is to maintain the same relationship between levels of conceptual structure as we posited between linguistic and discourse conceptual structure, then the relationship between lexical and linguistic structure must be extensional. Such a relationship is maintained in unification grammars where combination is based, in part, on the extension through unification of linguistic categories. However, combination is not simply symmetrical: one category has priority over the other category. In one unification grammar, Unification Categorial Grammar, combination is based upon the functor argument distinction where an argument sign unifies with part of the functor sign.

Our approach differs from Unification Categorial Grammar in that the combination is based upon the head modifier distinction. This distinction is motivated on the basis of three distinctive properties of head signs: subcategorization (or specification), category determination and obligatoriness. In particular: the head sign is syntactically and semantically specified by the modifier sign; the result sign has the syntactic and semantic types of the head sign; and the head sign is obligatory for both specification and category determination. Furthermore, the priority of the head sign over the modifier sign is informally characterized in terms of their semantic type: the semantic type of the head outranks the semantic type of the modifier. Comparison with the functor argument distinction demonstrated that linguistic regularities such as serialization and semantic category constancy can be more economically described with the head modifier distinction. We also showed that one potentially distinctive property of functors — semantic variation — was no less manifest in arguments.

Finally, we introduced evidence, defeasibility evidence, which both challenged and supported the head modifier distinction. The challenge arose from combinations where the combining signs possess incompatible semantic properties, and from combinations where not all the semantic properties of the head sign were preserved in the result sign and some new properties were introduced. On the other hand, the defeasibility evidence supports combination on the basis of the head modifier distinction in that the modifier sign, rather than the head sign, systematically had priority in defeat, and the head sign still provided the basis for construction of the result sign. Consequently, the cognitive linguistic approach to combination based upon the head modifier distinction must address the issue of how the contextually appropriate sense of ambiguous and polysemous expressions can be selected, and provide an account of defeasibility.

Chapter 7

Linguistic Processes

7.1 Introduction

In this chapter we describe how the cognitive linguistic approach characterizes linguistic combination. In accord with the architecture presented in section 2.3.2, language comprehension is characterized in terms of two modules: a discourse processing module, described in chapter 5, where linguistic conceptual structures are anchored and elaborated in the cognitive agent's discourse model, and a linguistic processing module, described in this chapter, where linguistic structures for lexical expressions are combined into linguistic structures for phrasal expressions. In chapter 6, we discussed the nature of linguistic combination and argued for an extensional approach to combination on the grounds of uniformity with discourse processes: just as anchoring and elaboration extend conceptual structures, so linguistic combination extends the linguistic structures. Since an extensional approach to combination is offered by unification grammar, the linguistic processing module can be characterized as a unification grammar. However, combination in a unification grammar is asymmetrical: the linguistic structure of one expression in a binary combination has priority over the linguistic structure of the other. In one unification grammar, Unification Categorial Grammar, the combination principle is based upon the priority of functor sign over the argument sign as in categorial grammar. We, however, argued that a combination principle based upon the head modifier distinction, as in dependency grammar, could provide a more economical account of linguistic generalizations in serialization and semantic category constancy. Consequently, we shall characterize the linguistic processing module as Unification Dependency Grammar (UDG), where the combination principle is based upon a unification process and the head modifier distinction. In UDG, the head modifier assignments coincide with the traditional head modifier assignments given in table 6.1, the priority of the head is motivated in terms of three combinatorial properties (subcategorization, category determinant and obligatoriness) and their priority is characterized in terms of the ranking of semantic types associated with the head and modifier signs.

This characterization of linguistic processing needs to address two issues in the processing of conceptual structure. The first issue is that the contextually appropriate sense of polysemous and ambiguous expressions can be selected immediately as shown in section 3.3. In the cognitive linguistic approach this issue is addressed through the interaction between discourse and linguistic processing modules: while the linguistic processing module exports a linguistic structure for expressions to the discourse processing module, the latter exports a *discourse context* to the linguistic processing module. This discourse context, consisting of simplified descriptions of concepts in a portion of the discourse model, is used to select the contextually appropriate sense of upcoming expressions. The second issue concerns the defeasibility phenomena, discussed in section 6.6, which show that, in some combinations, there can be a conflict between the combining conceptual structures, a conflict which is systematically resolved in favour of the modifier sign. Both linguistic and discourse processes are needed to account for these cases. In particular, while some of these conflicts can be avoided through the judicious application of default constraints in the anchoring process, as suggested in sections 5.5 and 5.7, other conflicts are resolved through an interaction between these processes: the discourse processing module 'transforms' the conceptual structure of the head into a structure which can combine with the conceptual structure of the modifier. In this way, the cognitive linguistic approach can account for defeasibility and immediate sense selection.

The chapter is structured as follows. Since the unification and dependency background have already been discussed in chapter 6, section 7.2 simply presents the basics of UDG: section 7.2.1 describes the structure of signs; and section 7.2.2 their combination on the basis of the head modifier distinction. We then consider how UDG interacts with the discourse processing module. In section 7.3 we characterize linguistic sense selection using a discourse context and in section 7.4, we describe the characterization the three types of defeat, typicality, intrinsic and sortal defeat. Section 7.5 concludes the chapter.

7.2 Basics of UDG

In this section, we describe and illustrate the structure of signs in UDG as well the principle of combination. Before we do so, a few general remarks about UDG are in order.

Like UCG, linguistic information about expressions is characterized as signs: i.e. partial objects with properties which can be extended into potentially less partial objects through unification with other objects. These signs can, of course, vary in specificity. Traditionally, the arguments, or modifiers, of lexical signs are specified at a general level; for example, *kicked* would be specified to combine with an argument sign whose semantic type is ENTITY and syntactic type NOUN. UDG extend this approach so as to represent fixed and partially fixed phrases in the lexicon. For example, a stock phrase like *kick the bucket* can be specified so that the subject argument is underspecified but the object argument is fully specified: i.e. while the subject argument is specified for syntactic and semantic properties, the object argument is also specified for its phonological form. In this way, the lexicon in UDG can be taken as a phrasal lexicon (cf. Becker 1975; Zernik and Dyer 1986; Zernik and Dyer 1987).

Furthermore, the lexicon can be conceived of in two ways: as a 'proto-lexicon' where different syntactic and/or syntactic properties of a lexical expression are described by a single, non-disjunctive sign; and an 'expanded' lexicon where these non-disjunctive signs can be optimized so as to specify in a disjunctive sign shared properties of the non-disjunctive signs (cf. Andry et al. forthcoming). With the proto-lexicon perspective, signs are not biased toward the interpretation or production of utterances. With the expanded lexicon, however, signs are optimized for language production or comprehension. Signs in the protolexion are optimized for production by a non-disjunctive semantic specification (the shared property) but disjunctive (or underspecified) syntactic and phonological specifications (cf. Youd and McGlashan 1992). In comprehension, signs are optimized through disjunctive specifications for syntactic and semantic properties. For example, an ambiguous expression like *bat* is associated with two distinct senses, a 'game-bat' sense and an 'animal-bat' sense. This is characterized in UDG as a sign with a disjunctive conceptual structure with a disjunct containing a GAME-BAT concepts and another containing a ANIMAL-BAT sense. When signs with disjunctive conceptual structures unify, the conceptual structure in the result sign may either preserve the disjunction or preserve only one disjunct (cf. Kasper 1987; Pollard and Sag 1987; Wedekind 1990). The first is appropriate in cases where sense selection does not take place at linguistic level and the second in cases where it does.

This disjunctive approach to signs is enhanced in UDG by the indicating the typicality of disjuncts in conceptual structure. This is motivated on the basis of the empirical evidence in chapter 3; for example, the concept *duck* subsumes *robin* and *chicken* where *robin* is more typical than *chicken*. Thus with polysemous and ambiguous expressions such as *bird*, *bed* and *bat*, the concepts in the conceptual structure are ordered in terms of typicality. Furthermore, with these expressions the different senses are not associated with different syntactic properties; for example, *bat* in either its 'game-bat' or 'animal-bat' interpretation is a noun. The senses of other expressions, however, can be associated with different syntactic properties; for example, *sink* has two senses, characterized by the concepts SINK-ENTITY and SINK-EVENT, and these are associated with syntactic structures of the type NOUN and VERB respectively:

(7.1) The sink is shiny.

(7.2) The ships sink in the storm.

The lexical sign for *sink* thus has both disjunctive conceptual and syntactic structures. Consequently, a second enhancement of signs offered by UDG is to 'synchronize' these disjunctions so that the selection of a pair of synchronized disjuncts can lead to the other pair being discarded. As we shall see, this selection can take place on the basis of either syntactic or conceptual restrictions on combination.

Finally, combination of signs in UDG is based upon the head modifier distinction: signs for lexical expressions combine as head and modifier to yield a result sign for the phrase. In particular, the combination principle is based upon two extensional processes, *specification* and *linking*. Specification is characterized as the unification of part of the head sign with all of the modifier sign (cf. instantiation in UCG). Linking is characterized in terms of the application of constraints in the head sign. These constraints, like the constraints described in sections 5.3.5 and 5.6, describe relations between substructures. Where they differ is that constraints are associated with signs, not theories, and their primary purpose is to guide the flow of information in a sign when it combines. For example, constraints can link the semantic part of the head sign specified by the modifier sign, with the semantics of the head sign itself. In this way, the head sign, like the functor sign in UCG plays a pivotal role combination: the result sign is the head sign after specification and linking. This is illustrated in figure 7.1. UDG

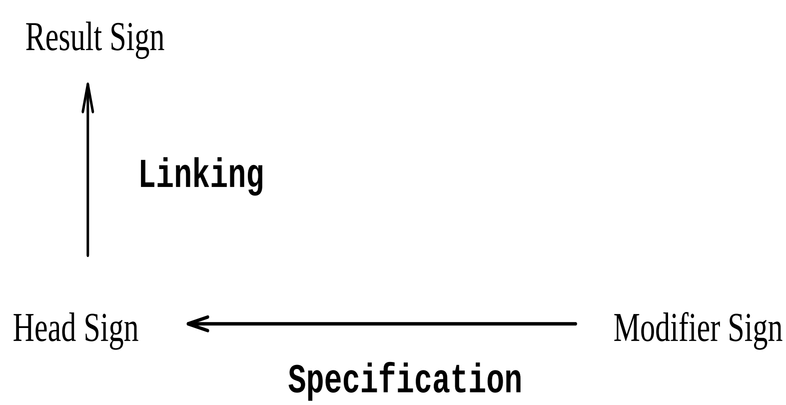

Figure 7.1: The pivotal role of the head sign in UDG

also differs from UCG in its incremental approach to combination: combination takes place on a word-by-word basis from left to right. In many categorial grammars, including UCG, the order of combination can follow the opposite order. For example, in *Prince loves Cat*, the argument sign for *Cat* is first combined with the functor sign for *loves* and then the result sign for *loves Cat* is combined as functor with the argument sign for *Prince*. In the derivation of the result sign for the whole construction then, there is an intermediate sign representing the construction *loves Cat* (see section 6.3 especially example (6.16)). In UDG, on the other hand, signs are incrementally combined in accordance with linear order: the modifier sign *Prince* is combined with the head sign *loves* yielding an intermediate sign for *Prince loves* and then this sign is combined with the modifier sign *Cat*.

7.2.1 Sign Structure

Signs in UDG are defined for four major properties as shown in (7.3):

(7.3) sign = phonology ∧ syntax ∧ semantics ∧ constraints

A UDG sign then consists of phonology, syntax, semantics and constraints properties. The value of the semantics property is a linguistic conceptual structure and its nature and structure have been described in section 5.4. Nor shall we discuss the value of phonology property; like UCG, we will simply give its value as the orthographic representation of the expression.

The value of the syntax property is complex: it consists of a head property and a modifier property as shown in (7.4) (cf. McGlashan forthcoming):

(7.4) syntax = head ∧ modifier
    head = type ∧ form ∧ order
        type = noun ∨ verb ∨ adjective ∨ auxiliary
            ∨ determiner ∨ adverb ∨ part
        form = agr ∧ nform ∧ vform ∧ tense
            ∧ aspect ∧ comp
            agr = count ∧ number ∧ person
                count = count ∨ mass
                number = sg ∨ pl
                person = first ∨ second ∨ third
            nform = nom ∨ acc ∨ gen ∨ dat ∨ abl ∨ voc
            vform = fin ∨ bse ∨ prp ∨ psp
            tense = pres ∨ past
            aspect = prog ∨ pref ∨ simple
            comp = wh ∨ that ∨ if
        order = directionality ∧ adjacency ∧ optionality
            directionality = pre ∨ post
            adjacency = next ∨ nonnext
            optionality = optional ∨ obligatory
    modifier = set-of(sign)

The head property specifies the syntactic type of the expression together with morpho-syntactic form and order information. For example, the sign for *run*, as in *the elephants run to London*, has a value for head as shown in (7.5):

(7.5)

$$\begin{bmatrix} type : verb \\ form : \begin{bmatrix} agr : \begin{bmatrix} count : count \\ number : pl \\ person : third \end{bmatrix} \\ vform : fin \\ tense : pres \\ aspect : simple \end{bmatrix} \end{bmatrix}$$

that is, *run* is a finite, simple aspect, present tense verb with an agreement properties of countable, plural number and first person.

Of course, the description of head in (7.4) is under-constrained: it allows ill-formed signs such as (7.6):

(7.6)

$$\begin{bmatrix} type : noun & \\ form : & \begin{bmatrix} agr : \begin{bmatrix} count : count \\ number : pl \\ person : third \end{bmatrix} \\ vform : fin \\ tense : pres \\ aspect : simple \end{bmatrix} \end{bmatrix}$$

where a sign of the type NOUN has morpho-syntactic properties which should only be given in VERB and AUXILIARY signs. Further restrictions on signs can be defined using feature co-occurrence rules which specify restrictions between the syntactic type of a sign and its morpho-syntactic form properties (cf. Gazdar et al. 1985). In (7.7), co-occurrence rules are given for nouns, determiners, auxiliaries and verbs (where $P \longrightarrow S$ indicates that the set of properties in S is defined if the path P is defined):

(7.7) 1.

$$< head\ syntax\ type\ noun > \longrightarrow \left\langle \begin{array}{l} < head\ syntax\ form\ nform > \\ < head\ syntax\ form\ agr > \end{array} \right\rangle$$

2.

$$< head\ syntax\ type\ determiner > \longrightarrow \left\langle\ < head\ syntax\ form\ agr >\ \right\rangle$$

3.

$$< head\ syntax\ type\ verb > \longrightarrow \left\langle \begin{array}{l} < head\ syntax\ form\ vform > \\ < head\ syntax\ form\ agr > \\ < head\ syntax\ form\ tense > \\ < head\ syntax\ form\ aspect > \\ < head\ syntax\ form\ comp > \end{array} \right\rangle$$

4.

$$< head\ syntax\ type\ auxiliary > \longrightarrow \left\langle \begin{array}{l} < head\ syntax\ form\ vform > \\ < head\ syntax\ form\ tense > \\ < head\ syntax\ form\ aspect > \end{array} \right\rangle$$

so, for example, a sign with the syntactic type NOUN is only defined for agr and nform properties — it is not defined for properties such as vform and tense. Of course, different languages may use different sets of morpho-syntactic form properties and provide different category-based restrictions on their occurrence; for example, gender may be defined in French for determiners, adjectives and nouns.

The other property of syntax is the modifier property. The value of this property is a set of 'subcategorized' signs: i.e. a set of modifier signs which can specify the head sign. For example, the value of modifier in the sign for *run* is a set of two modifiers shown in (7.8) and (7.9):

(7.8)

$$\begin{bmatrix} \mathit{syntax} : \begin{bmatrix} \mathit{head} : \begin{bmatrix} \mathit{type} : \mathit{noun} \\ \mathit{form} : \begin{bmatrix} \mathit{nform} : \mathit{nom} \\ \mathit{agr} : \begin{bmatrix} \mathit{count} : \mathit{count} \\ \mathit{number} : \mathit{pl} \\ \mathit{person} : \mathit{third} \end{bmatrix} \end{bmatrix} \\ \mathit{order} : \begin{bmatrix} \mathit{directionality} : \mathit{pre} \\ \mathit{optionality} : \mathit{obligatory} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \mathit{semantics} : \begin{bmatrix} \mathit{type} : \mathit{entity} \end{bmatrix} \end{bmatrix}$$

(7.9)

$$\begin{bmatrix} \mathit{syntax} : \begin{bmatrix} \mathit{head} : \begin{bmatrix} \mathit{type} : \mathit{noun} \\ \mathit{form} : \begin{bmatrix} \mathit{nform} : \mathit{dat} \end{bmatrix} \\ \mathit{order} : \begin{bmatrix} \mathit{directionality} : \mathit{post} \\ \mathit{optionality} : \mathit{optional} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \mathit{semantics} : \begin{bmatrix} \mathit{type} : \mathit{location} \end{bmatrix} \end{bmatrix}$$

Thus *run* is subcategorized to be specified by two modifier signs which are restricted in both their syntactic and semantic properties. In particular, the first sign, given in (7.8) has its syntactic restrictions given in <syntax head>: it is a NOUN with morpho-syntactic form properties of nominative case, countable, plural number and third person. Its relative ordering and optionality is specified in <syntax head order>: the sign is obligatory (obligatory) and precedes the verb (pre), although they are not necessarily adjacent since no value is specified for the attribute adjacency. Its semantic type is specified in <semantics>: it is restricted to be a concept of the type ENTITY. The second modifier sign,given in (7.9), is similarly restricted syntactically and semantically: it must be a NOUN with a form property of dative case, is optional and occurs after the verb; and it is a concept of the type LOCATION.

In this way, the syntax property of signs is broadly analogous with the category property of signs in UCG (see section 6.3): modifier describes the signs it can combine with (cf. 'take' signs); and the head property describes some of the syntactic properties of the result sign (cf. 'make' category). Furthermore, it is also comparable with traditional dependency grammars since the head modifier distinction has been 'pushed' inside the sign itself: properties of the head category are given as the value of head; and properties of the modifier categories are given as the (set) value of the modifier property. The key difference with traditional dependency grammars is that combinatorial information given in dependency rules is specified in the signs themselves, thereby reducing both the number and complexity of rules. For example, a verb such as *run* in *the elephants run to London*, would be characterized by the dependency rule **V ($\mathbf{N^1}$ * $\mathbf{N^2}$ (P *))**: i.e. with V as head with two modifiers N^1 and N^2 (which has P as a modifier) (cf. Robinson 1970b: 262). In UDG, the general combinatorial information in this dependency rule is captured with a general principle for combining head and modifier signs — the Head Modifier Principle discussed in section 7.2.2 — and specific combinatorial information is given in the sign. For example, in the sign for *run* the value of phonology is run, the value for < syntax head> is given in (7.10 a), the value for < syntax modifier> in (7.10 b), and the value of semantics in (7.10 c):

(7.10) a.

$$\begin{bmatrix} \mathit{type} : \mathit{verb} \\ \mathit{form} : \begin{bmatrix} \mathit{agr} : \begin{bmatrix} \mathit{count} : \mathit{count} \\ \mathit{number} : \mathit{pl} \\ \mathit{person} : \mathit{third} \end{bmatrix} \\ \mathit{vform} : \mathit{fin} \\ \mathit{tense} : \mathit{pres} \\ \mathit{aspect} : \mathit{simple} \end{bmatrix} \end{bmatrix}$$

b.

$$\left\langle \begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \\ form : \begin{bmatrix} nform : nom \\ agr : \begin{bmatrix} count : count \\ number : pl \\ person : third \end{bmatrix} \end{bmatrix} \\ order : \begin{bmatrix} directionality : pre \\ optionality : obligatory \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : \begin{bmatrix} type : entity \end{bmatrix} \end{bmatrix} \begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \\ form : \begin{bmatrix} nform : dat \end{bmatrix} \\ order : \begin{bmatrix} directionality : post \\ optionality : optional \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : \begin{bmatrix} type : location \end{bmatrix} \end{bmatrix} \right\rangle$$

c.

$$\begin{bmatrix} type : run \\ theme : \begin{bmatrix} type : entity \end{bmatrix} \\ goal : \begin{bmatrix} type : location \end{bmatrix} \end{bmatrix}$$

That is, *run* can combine with two NOUN modifiers where the first is nominative and occurs to its left, and the second is dative and occurs to its right. Combination itself involves the unification of a modifier sign with one of the signs in (7.10 b). What is missing from this sign, however, is a means of linking the syntactic and semantic information given by modifier signs with the syntactic and semantic information of the head.

The main function of constraints is to provide the means of linking this information in a sign. The constraints property of a sign specifies a set of relations between sub-structures in the sign. The format of sign constraints is the same as that of theory constraints given in section 5.3.5: i.e. they have a name which describes the relation, such as 'equality', a type for the relation — necessary or typical, possibly conditions on the relation, and specify sub-structures in terms of paths. Two of the major constraints concern the relationship between the value of <syntax head form agr> and <semantics> on a sign. For in a combination like *elephants run*, the result sign has syntactic and semantic properties which derive from not only the sign for *run*, but also the sign for *elephants*. Since combination involves unification of one of the modifiers in <syntax modifier> of the head sign with the modifier sign itself, the syntactic and semantic properties of the modifier are thus specified within this substructure in the head sign. Consequently, if constraints are defined on the sign for *run* which relate the syntactic and semantic properties of its modifiers to its syntactic and semantic properties, then application of these constraints by the linking process will result in the head's syntax and semantics being appropriately extended. For example, when the sign for *run* is specified by *elephant*, given in (7.15) below, the first modifier in (7.10 b) is instantiated as shown in (7.11):

(7.11)

$$\begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \\ form : \begin{bmatrix} nform : nom \\ agr : \begin{bmatrix} count : count \\ number : pl \\ person : third \end{bmatrix} \end{bmatrix} \\ order : \begin{bmatrix} directionality : pre \\ optionality : obligatory \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : \begin{bmatrix} type : elephant \end{bmatrix} \end{bmatrix}$$

The main effect of combination is that the semantic type of the first modifier has been made more specific: i.e. in <syntax modifier first semantics> the original ENTITY concept restriction on the first modifier in the set has been specialized as ELEPHANT (cf. (7.10 c) above). However, we need to relate this concept to the RUN concept in <semantics>. In particular, we need to equate the ELEPHANT concept with the value of the theme: i.e. the subject of *run* is the theme of a RUN event. The first constraint in (7.12) describes this relationship:

(7.12)

$$constraints : \left\langle \begin{bmatrix} name : equality \\ type : necessary \\ path1 : \text{<syntax modifier first semantics>} \\ path2 : \text{<semantics theme>} \end{bmatrix} \begin{bmatrix} name : equality \\ type : necessary \\ path1 : \text{<syntax modifier second semantics>} \\ path2 : \text{<semantics goal>} \end{bmatrix} \right\rangle$$

Accordingly, when the sign for *run* combines with the sign for *elephants*, the subject's semantics are equated with the value of <semantics theme> in the sign for *runs*.

While the constraints in (7.12) are appropriate for complement modifiers, they are inappropriate for attribute modifiers partly due to their optionality and potential for iteration. In $\overline{X}$ theory, head categories need to subcategorize for each and every modifier (cf. Jackendoff 1977); for example, nouns may need to subcategorize for determiners, quantifiers, numerals, and adjectives, and verbs for adverbs and auxiliaries. In approaches, such as UCG, the optionality and iteration of these modifiers is neatly captured by treating them as exotypic functors (cf. section 6.5). In UDG, their status as optional or obligatory is captured by the value of the optionality property; for example, *elephants* subcategories for a modifier with the syntactic type DETERMINER and an optional value for optionality — the corresponding modifier for *elephant* is specified with an obligatory value. What is not captured is the potential iteration of attribute modifiers like determiners, adjectives, auxiliaries and adverbs. Moreover, constraints, like that in (7.12), would have to be defined for each and every attribute modifier so as to link their semantics with the semantics of the head sign.

These problems can be addressed through underspecification in the modifier and constraints properties of a sign. Attribute modifiers can be divided into two types: mode modifiers, such as determiners, auxiliaries and adverbs, which modify mode properties of the head and are subsumed by the general semantic type PRE-PROPERTY; and core modifiers, such as adjectives and adverbs, which modify its core properties and are subsumed by the type PROPERTY. Consequently, a head sign need only specify the general type of its attribute modifiers and provide constraints which link the semantics of any of these modifiers to *some* role in their semantics[1]. Consider the (simplified) signs for *the*, *pink* and *elephants* given in (7.13), (7.14) and (7.15) respectively. In (7.15), the value of phonology is shown in (7.15a), the value of <syntax head> in (7.15b), the value of <syntax modifier> in (7.15c), the value of semantics in (7.15d), and the value of constraints in (7.15e).

(7.13)

$$\begin{bmatrix} phonology : the \\ syntax : \begin{bmatrix} head : \begin{bmatrix} type : determiner \\ form : \begin{bmatrix} agr : \begin{bmatrix} count : count \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : \begin{bmatrix} type : definite \\ value : positive \end{bmatrix} \end{bmatrix}$$

[1]This assumes that the modifiers also share the same form and order properties. If they do not, then each modifier will have to be specified in modifiers.

(7.14)

$$\left[\begin{array}{l} phonology : pink \\ syntax : \left[\ head : \left[\ type : adjective\ \right]\ \right] \\ semantics : \left[\begin{array}{l} type : colour\text{-}propery \\ value : pink \end{array}\right] \end{array}\right]$$

(7.15) a.

$$\left[\ phonology : elephants\ \right]$$

b.

$$\left[\begin{array}{l} type : noun \\ form : \left[\ agr : \left[\begin{array}{l} count : count \\ number : pl \end{array}\right]\ \right] \end{array}\right]$$

c.

$$\left\langle \begin{array}{l} \left[\begin{array}{l} syntax : \left[\ head : \left[\begin{array}{l} type : determiner \\ form : \left[\ agr : \left[\begin{array}{l} count : count \\ number : pl \end{array}\right]\ \right] \\ order : \left[\begin{array}{l} directionality : pre \\ optionality : optional \end{array}\right] \end{array}\right]\ \right] \\ semantics : \left[\ type : pre\text{-}property\ \right] \end{array}\right] \\ \left[\begin{array}{l} syntax : \left[\ head : \left[\begin{array}{l} type : adjective \\ order : \left[\begin{array}{l} directionality : pre \\ optionality : optional \end{array}\right] \end{array}\right]\ \right] \\ semantics : \left[\ type : property\ \right] \end{array}\right] \end{array} \right\rangle$$

d.

$$\left[\begin{array}{l} type : elephant \\ definite : \left[\ type : definite\ \right] \\ polarity : \left[\ type : polarity\ \right] \\ colour : \left[\ type : colour\text{-}property\ \right] \end{array}\right]$$

e.

$$\left\langle \begin{array}{l} \left[\begin{array}{l} name : equality \\ type : necessary \\ path1 : \langle \text{syntax modifier NUMBER semantics} \rangle \\ path2 : \langle \text{semantics ROLE} \rangle \end{array}\right] \\ \left[\begin{array}{l} name : equality \\ type : necessary \\ path1 : \langle \text{syntax modifier NUMBER syntax head form agr} \rangle \\ path2 : \langle \text{syntax head form agr} \rangle \end{array}\right] \end{array} \right\rangle$$

The sign for *elephants* given in (7.15), contains two underspecified equality constraints. In the first constraint, which relates to the semantics of a modifier to the value of a role in its semantics, neither the number of the modifier nor the role in its semantics are explicitly specified: *NUMBER* is a variable which ranges over the modifiers in modifier just as *ROLE* ranges over the role properties in semantics. The second constraint performs an analogous function with respect to the syntactic head property agr: it relates the value for agr in the <syntax head form> of any modifier to the value for agr in <syntax head form agr>. When the mode modifier *the* in (7.13) combines with the sign for *elephants*, it unifies with the first modifier (DEFINITE is subsumed by PRE-PROPERTY) and application of the first constraint then equates its semantics with the definite role contained in the head category's semantics attribute. Likewise, the core modifier *pink* in (7.14) unifies with the second modifier (COLOUR-PROPERTY is subsumed by PROPERTY) and the same constraint equates its semantics with the colour property in the head's semantics. Since the semantic constraint does not specify which role the modifier's semantics is to be equated with, different occurrences of attribute modifiers can be equated with different roles in the head's semantics[2]. The only restriction is that the properties must be compatible; this rules out phrases like **black pink elephants* where incompatible colour properties are specified. Thus, using underspecified constraints, UDG can overcome the iteration problem traditionally associated with frameworks which treat attribute modifiers as arguments rather than functors.

Constraints perform two other functions. The first of these is to specify typicality relations in disjunctive conceptual structures. For example, the conceptual structure for *bed* consists of two top-level disjuncts, which characterize the 'mattress-bed' and 'plant-bed' senses, and nested within the later disjunct, two further disjuncts which characterize the 'vegetable-bed' and 'flower-bed' senses (cf. (5.56) in section 5.8). The typicality of these senses is indicated by constraints in the sign for *bed* as illustrated in (7.16):

(7.16)

$$
\begin{bmatrix}
\mathit{phonology} : \mathit{bed} \\
\mathit{semantics} : \left\{ \begin{array}{l} \left[\mathit{type} : \mathit{mattress\text{-}bed} \right] \\ \begin{bmatrix} \mathit{type} : \mathit{plant\text{-}bed} \\ \left\{ \begin{array}{l} \left[\mathit{type} : \mathit{vegetable\text{-}bed} \right] \\ \left[\mathit{type} : \mathit{flower\text{-}bed} \right] \end{array} \right\} \end{bmatrix} \end{array} \right\} \\
\mathit{constraints} : \left\langle \begin{array}{l} \begin{bmatrix} \mathit{name} : \mathit{gtypicality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path1} : \langle \text{semantics first} \rangle \\ \mathit{path2} : \langle \text{semantics second} \rangle \end{bmatrix} \\ \begin{bmatrix} \mathit{name} : \mathit{gtypicality} \\ \mathit{type} : \mathit{necessary} \\ \mathit{path1} : \langle \text{semantics second first} \rangle \\ \mathit{path2} : \langle \text{semantics second second} \rangle \end{bmatrix} \end{array} \right\rangle
\end{bmatrix}
$$

A gtypicality constraint describes a relation of 'greater typicality' between the values of its paths. Thus the MATTRESS-BED concept is more typical than the PLANT-BED concept, and VEGETABLE-BED is more typical than FLOWER-BED.

The second function performed by constraints is to 'synchronize' semantic and syntactic disjunctions within a sign. As we saw in (7.1) and (7.2), *sink* can be associated with two distinct senses, the 'kitchen-sink' sense and the 'boat-sinking' sense, and each of these is associated with distinct syntactic descriptions: the 'kitchen-sink' sense is associated with a syntactic description whose type is NOUN; and the 'boat-sink' sense is associated with a syntactic description whose type is VERB. In UDG the value of both semantics and syntax are disjunctive structures and the relationship between these syntactic and semantic disjuncts is described by synchronization constraints (cf. Wedekind 1990). This is illustrated for *sink* in (7.17), where the value of < syntax head> is shown in (7.17 a), the value for <syntax modifier> in (7.17 b), the value for semantics in (7.17 c) and the value for constraints in (7.17 d):

[2] Note that when a sign subcategorizes for both complement and attribute modifiers, specified constraints take precedence over underspecified constraints. For example, the set of modifiers for *run* given in (7.10 b) can be augmented to take mode modifiers, such as the auxiliary *will* in *the elephants will run*, the semantics of the NOUN modifier is related to the theme role by a specified equality constraint while the AUXILIARY is related to a aspect (mode) property by means of an underspecified constraint.

(7.17) a.

$$\left\{ \begin{array}{l} \begin{bmatrix} type : noun \\ form : \begin{bmatrix} agr : \begin{bmatrix} count : count \\ number : sg \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \begin{bmatrix} type : verb \\ form : \begin{bmatrix} agr : \begin{bmatrix} count : count \\ number : sg \end{bmatrix} \\ vform : fin \\ tense : pres \\ aspect : simple \end{bmatrix} \end{bmatrix} \end{array} \right\}$$

b.

$$\left\{ \begin{array}{l} \left\langle \begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : determiner \\ form : [\ \ldots\ ] \\ order : \begin{bmatrix} directionality : pre \\ optionality : oblig \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : [\ type : \mathit{pre\text{-}property}\ ] \end{bmatrix} \right\rangle \\ \left\langle \begin{array}{l} \begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \\ form : \begin{bmatrix} nform : nom \\ \ldots \end{bmatrix} \\ order : \begin{bmatrix} directionality : pre \\ optionality : obligatory \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : [\ type : entity\ ] \end{bmatrix} \\ \begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \\ form : [\ nform : dat\ ] \\ order : \begin{bmatrix} directionality : post \\ optionality : optional \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ semantics : [\ type : location\ ] \end{bmatrix} \end{array} \right\rangle \end{array} \right\}$$

c.

$$\left\{ \begin{array}{l} \begin{bmatrix} type : \mathit{sink\text{-}entity} \\ definite : [\ type : definite\ ] \end{bmatrix} \\ \begin{bmatrix} type : \mathit{sink\text{-}event} \\ theme : [\ type : entity\ ] \\ place : [\ type : location\ ] \end{bmatrix} \end{array} \right\}$$

d.

$$\left\langle \begin{array}{l} \begin{bmatrix} name : synchronize \\ type : necessary \\ path1 : \langle \text{syntax first} \rangle \\ path2 : \langle \text{semantics first} \rangle \end{bmatrix} \\ \begin{bmatrix} name : synchronize \\ type : necessary \\ path1 : \langle \text{syntax second} \rangle \\ path2 : \langle \text{semantics second} \rangle \end{bmatrix} \end{array} \right\rangle$$

where the first constraint synchronizes the first syntactic disjunct with the first semantic disjunct; the second constraint does likewise with second disjunct. The utility of synchronization constraints is two-fold in UDG. Firstly, if the combining sign imposes syntactic and/or semantic restrictions which select one of the synchronized disjuncts, then the corresponding disjunct is selected too. The other pair of synchronized disjuncts can be discarded at this stage. Secondly, if the discourse context restricts the semantics of the sign so that either the SINK-ENTITY or SINK-EVENT are selected, then not only is the other semantic disjunct discarded, but so too is its corresponding syntactic disjunct.

7.2.2 Sign Combination

Combination in UDG is characterized in terms of the head modifier distinction: in a binary construction, one sign is the head sign and the other the modifier sign. This distinction was motivated in section 6.4.1 in terms of subcategorization (or specification), category constancy and obligatoriness properties. In section 6.4.2, the distinction was informally characterized in terms of a head sign's priority with respect to semantic type: a head sign has a semantic type which outranks the type of the modifier sign in the ranking given in (6.64). The head modifier assignments in this framework are thus the traditional assignments given in table 6.1 and reproduced here as table 7.1 with their syntactic and semantic types.

phrase	**head**	**modifier**
noun-verb	verb, EVENT	noun, ENTITY
verb-noun	verb, EVENT	noun, ENTITY
adjective-noun	noun, ENTITY	adjective, PROPERTY
verb-adverb	verb, EVENT	adverb, PROPERTY
determiner-noun	noun, ENTITY	determiner, PRE-PROPERTY
auxiliary-verb	verb, EVENT	auxiliary, PRE-PROPERTY
adverb-adjective	adjective, PROPERTY	adverb, PRE-PROPERTY

Table 7.1: Head modifier assignments in Unification Dependency Grammar

Combination is more formally characterized in terms of the Head Modifier Principle below:

Head Modifier Principle (HMP)

1. Signs in a binary construction combine as head sign S^H and modifier sign S^M to yield a result sign S^R.
2. $S^R = S^H$ after *specification* and *linking*.
3. *Specification*: S^H is specified by S^M iff there exists S such that $S \in S^H$:<syntax modifier> and $S \sqcup S^M$.
4. *Linking*: S^H is linked to S^R iff the equality constraints specified in S^H:<constraints> are applied.

The head modifier distinction in the HMP is ground out in terms of the structure of signs: i.e. a sign is the head if there is a sign in the set value of its modifier property which can unify with the other sign. Combination itself is characterized in terms of two processes which extend the head sign into the result sign. Specification extends the head sign through unification of a modifier in its modifier property with the modifier sign. Linking extends the head sign by equality substructures within the head sign: in particular, by equating the semantics of the modifier in the modifier property with some role in the head's semantics. In this way, the conceptual structure of a modifier sign is used to extend the semantics of the head sign.

Note that, unlike UCG, a stripping process is not necessary in UDG. In UCG stripping is necessary because a functor only combines with an argument sign which matches the Sign in E|Sign. The order in which argument signs are combined is determined by the complex value of the category property in the functor sign; for example, with the value S $|\text{NP}^1|\text{NP}^2$, the functor sign first combines with NP^2 and then combines with NP^1. Thus to combine with NP^1, NP^2 must be stripped from the value of category. This is unnecessary in UDG since modifiers are represented as a set where members of the set are specified for obligatoriness, order and adjacency[3]. With these specifications, while combination itself is constrained, the order of combination is not. The main advantage of this is that combination can take place incrementally and linearly; the combination process does not have to wait until a direct object is available before combining a transitive verb with its subject.

We shall now illustrate combination in UDG. We begin with a simple, non-disjunctive example:

(7.18) The pink elephants run to London.

Since the signs for *the* and *pink*, given in (7.13) and (7.14) above, are unable to combine, the first combination is of the sign for *the* and *elephants*[4]. According to the HMP, these sign can combine if one of the modifiers in <syntax modifier> of (7.15) can be specified by the sign in (7.13). Of these modifiers, the second is clearly incompatible: the signs have conflicting values for <syntax head type>. The modifier sign can specify the first modifier in <syntax modifier>, however, since not only are all their syntactic and semantic properties compatible, but *the* precedes *elephants* as required by the value of the directionality in <first syntax head order> in (7.15 c). The modifier sign which results from their unification is given in (7.19):

(7.19)

$$\begin{bmatrix} \mathit{phonology} : \mathit{the} \\ \mathit{syntax} : \begin{bmatrix} \mathit{head} : \begin{bmatrix} \mathit{type} : \mathit{determiner} \\ \mathit{form} : \begin{bmatrix} \mathit{agr} : \begin{bmatrix} \mathit{count} : \mathit{count} \\ \mathit{number} : \mathit{pl} \end{bmatrix} \end{bmatrix} \\ \mathit{order} : \begin{bmatrix} \mathit{directionality} : \mathit{pre} \\ \mathit{optionality} : \mathit{optional} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \mathit{semantics} : \begin{bmatrix} \mathit{type} : \mathit{definite} \\ \mathit{value} : \mathit{positive} \end{bmatrix} \end{bmatrix}$$

where the modifier has been given specific values for phonology and semantics. According to the HMP, combination now involves a linking processes whereby the constraints defined in (7.15 e) are applied. Concentrating on the semantics constraint given in (7.15), this constraint equates the value of semantics in (7.19) with some role in the semantics of (7.15). Of the three possible roles, two have incompatible types: DEFINITE is incompatible with POLARITY and COLOUR-PROPERTY. Since <modifier semantics type> is compatible with <semantics definite type>, the semantics of the modifier is unified with the value of <semantic definite>. The semantics of the result sign *the elephants* is given in (7.20):

(7.20)

$$\begin{bmatrix} \mathit{semantics} : \begin{bmatrix} \mathit{type} : \mathit{elephant} \\ \mathit{definite} : \begin{bmatrix} \mathit{type} : \mathit{definite} \\ \mathit{value} : \mathit{positive} \end{bmatrix} \\ \mathit{polarity} : \begin{bmatrix} \mathit{type} : \mathit{polarity} \end{bmatrix} \\ \mathit{colour} : \begin{bmatrix} \mathit{type} : \mathit{colour\text{-}property} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

In the second combination, the sign for *the elephants* combines with the sign for *pink* given in (7.14). Of the the two modifiers in <syntax modifier> of (7.15), only the first is compatible and so it is specified by (7.14) resulting in (7.21):

[3] In UCG, stripping also accounts for the concatenation of phonology. Thus could be accounted for in UDG in terms of constraints.

[4] This order of combination is arbitrary: if the sign for *pink* combined with the sign for *elephants* first, the series of combination would yield the same result sign for *the pink elephants*.

(7.21)

$$\left[\begin{array}{l} \mathit{phonology} : \mathit{pink} \\ \mathit{syntax} : \left[\mathit{head} : \left[\begin{array}{l} \mathit{type} : \mathit{adjective} \\ \mathit{order} : \left[\begin{array}{l} \mathit{directionality} : \mathit{pre} \\ \mathit{optionality} : \mathit{optional} \end{array}\right] \end{array}\right] \right] \\ \mathit{semantics} : \left[\begin{array}{l} \mathit{type} : \mathit{colour\text{-}property} \\ \mathit{value} : \mathit{pink} \end{array}\right] \end{array}\right]$$

The second process, linking, then equates the value of semantics in (7.21) with the value of some role in the (7.20): COLOUR-PROPERTY is incompatible with DEFINITE and POLARITY, but compatible with COLOUR-PROPERTY, so the concept is unified with the value of colour yielding the result semantics in (7.22):

(7.22)

$$\left[\mathit{semantics} : \left[\begin{array}{l} \mathit{type} : \mathit{elephant} \\ \mathit{definite} : \left[\begin{array}{l} \mathit{type} : \mathit{definite} \\ \mathit{value} : \mathit{positive} \end{array}\right] \\ \mathit{polarity} : \left[\mathit{type} : \mathit{polarity} \right] \\ \mathit{colour} : \left[\begin{array}{l} \mathit{type} : \mathit{colour\text{-}property} \\ \mathit{value} : \mathit{pink} \end{array}\right] \end{array}\right] \right]$$

In the third combination, the result sign for *the pink elephant* combines with the sign for *runs* given in (7.10) together with the constraints in (7.12). This time the either sign could be the head sign since both are specified for <syntax modifier>. However, the sign in (7.10) is neither compatible with any of the modifiers of (7.15) nor does it respect their ordering requirements. The sign for (7.15), however, can specify the first modifier of (7.15): their properties are compatible and the ordering requirements are met (cf. the second modifier where the value of directionality is post). Specification results in the modifier sign given in (7.23) (the value of modifier is omitted for clarity):

(7.23)

$$\left[\begin{array}{l} \mathit{phonology} : \mathit{the\ pink\ elephants} \\ \mathit{syntax} : \left[\mathit{head} : \left[\begin{array}{l} \mathit{type} : \mathit{noun} \\ \mathit{form} : \left[\begin{array}{l} \mathit{nform} : \mathit{nom} \\ \mathit{agr} : \left[\begin{array}{l} \mathit{count} : \mathit{count} \\ \mathit{number} : \mathit{pl} \\ \mathit{person} : \mathit{third} \end{array}\right] \end{array}\right] \\ \mathit{order} : \left[\begin{array}{l} \mathit{directionality} : \mathit{pre} \\ \mathit{optionality} : \mathit{obligatory} \end{array}\right] \end{array}\right] \right] \\ \mathit{semantics} : \left[\begin{array}{l} \mathit{type} : \mathit{elephant} \\ \mathit{definite} : \left[\begin{array}{l} \mathit{type} : \mathit{definite} \\ \mathit{value} : \mathit{positive} \end{array}\right] \\ \mathit{polarity} : \left[\mathit{type} : \mathit{polarity} \right] \\ \mathit{colour} : \left[\begin{array}{l} \mathit{type} : \mathit{colour\text{-}property} \\ \mathit{value} : \mathit{pink} \end{array}\right] \end{array}\right] \end{array}\right]$$

The linking process, in accordance with the second constraint in (7.12), unifies the value of semantics with the value of the theme role, yielding the result semantics in (7.24):

(7.24)

$$\begin{bmatrix} \textit{type} : \textit{run} \\ \textit{theme} : \begin{bmatrix} \textit{type} : \textit{elephant} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \\ \textit{polarity} : \begin{bmatrix} \textit{type} : \textit{polarity} \end{bmatrix} \\ \textit{colour} : \begin{bmatrix} \textit{type} : \textit{colour-property} \\ \textit{value} : \textit{pink} \end{bmatrix} \end{bmatrix} \\ \textit{goal} : \begin{bmatrix} \textit{type} : \textit{location} \end{bmatrix} \end{bmatrix}$$

In the fourth and final combination, the sign for *the pink elephants run* is combined with the sign for *to London*. For *the pink elephants run* cannot directly combine with the sign for *to* since it lacks a modifier in its modifier property with the type PART (for particle). However, *to* can combine with *London* since the sign for the latter, as with all NOUN signs, has the appropriate modifier slot. In addition, the sign for *London* is defined for a constraint which equates the value of the path <syntax head form nform> with its own nform property. Consequently, the sign for *to London* can specify the second modifier of modifier in the sign for *the pink elephants run* and linking yields the result semantics in (7.25):

(7.25)

$$\begin{bmatrix} \textit{semantics} : \begin{bmatrix} \textit{type} : \textit{run} \\ \textit{theme} : \begin{bmatrix} \textit{type} : \textit{elephant} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \\ \textit{polarity} : \begin{bmatrix} \textit{type} : \textit{polarity} \end{bmatrix} \\ \textit{colour} : \begin{bmatrix} \textit{type} : \textit{colour-property} \\ \textit{value} : \textit{pink} \end{bmatrix} \end{bmatrix} \\ \textit{goal} : \begin{bmatrix} \textit{type} : \textit{city} \\ \textit{value} : \textit{london} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

In this series of combinations, no sign contained disjunctive structures. As we mentioned in section 7.2.1 disjuncts in syntactic and conceptual structure can be synchronized so that the selection of one disjunct in a pair leads to the other pair being discarded. Signs with disjuncts can unify if at least one of the disjuncts is compatible with the other sign: if both disjuncts are compatible, then both are unified; and if one is incompatible, it is discarded (cf. Kasper 1987). Consider again the examples given in (7.1) and (7.2). In (7.1), the sign for *the* in (7.13) combines with the sign for *sink* given in (7.17). According to the HMP, the head sign is specified by the modifier sign. Since the sign for *the* has no modifier property, *sink* is the head sign and *the* the modifier sign. Of the modifier properties in the syntactic disjuncts, the sign for *the* is only compatible with the modifier is the first disjunct. Furthermore, since this disjunct is part of a synchronized pair, as indicated by the synchronize constraint, the linking process only attempts to equate the modifier's semantics to a role in the synchronized semantics of the head. The result sign's semantics are given in (7.26) where the other disjunct has been stripped:

(7.26)

$$\begin{bmatrix} \textit{type} : \textit{sink-entity} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \end{bmatrix}$$

In the second example, (7.2), the other pair of disjuncts are discarded. For this time, the sign for *the ships* combines as a preceding NOUN modifier of *sink* and the semantics of the specified modifier is linked with the theme role in the SINK-EVENT concept as shown by the result semantics in (7.27):

(7.27)

$$\begin{bmatrix} \textit{type} : \textit{sink-event} \\ \textit{theme} : \begin{bmatrix} \textit{type} : \textit{ship} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \end{bmatrix} \\ \textit{place} : \begin{bmatrix} \textit{type} : \textit{location} \end{bmatrix} \end{bmatrix}$$

What these disjunctive examples illustrate is that the appropriate sense of ambiguous expressions can be immediately selected on the basis of local syntactic context. With polysemous expressions, however, the different senses share the same syntactic structure. For example, in

(7.28) The bat eats mice.

the sign for *bat* has only a disjunctive conceptual structure: i.e. one disjunct contains the GAME-BAT concept and the other the ANIMATE-BAT concept. However, in (7.28) the appropriate sense is selected on the basis of semantic compatibility with one of combining signs. In the first combination, the sign for *the* combines with the sign for *bat* yielding a result sign which preserves the conceptual disjunct:

(7.29)

$$\begin{bmatrix} \textit{semantics} : \left\{ \begin{matrix} \begin{bmatrix} \textit{type} : \textit{game-bat} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \end{bmatrix} \\ \begin{bmatrix} \textit{type} : \textit{animal-bat} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \end{bmatrix} \end{matrix} \right\} \end{bmatrix}$$

In the second combination, the sign for *the bat* combines as a modifier of *eats*. This time the disjunction is resolved in favour of the ANIMAL-BAT concept: the modifier sign specifies a modifier slot with the semantic type animate, a type which subsumes ANIMAL-BAT but not GAME-BAT. Consequently, the result sign of this combination has the value for semantics given in (7.30):

(7.30)

$$\begin{bmatrix} \textit{type} : \textit{eat} \\ \textit{agent} : \begin{bmatrix} \textit{type} : \textit{animal-bat} \\ \textit{definite} : \begin{bmatrix} \textit{type} : \textit{definite} \\ \textit{value} : \textit{positive} \end{bmatrix} \end{bmatrix} \\ \textit{theme} : \begin{bmatrix} \textit{type} : \textit{entity} \end{bmatrix} \end{bmatrix}$$

Let us now consider how the appropriate sense of ambiguous and polysemous expressions can be selected on the basis of the discourse context imported from the discourse processing module.

7.3 Linguistic Sense Selection

In the cognitive linguistic approach, linguistic combination and discourse interpretation are interactive rather than autonomous. Two types of interaction have been identified. With the first type, the linguistic process requests the transformation of conceptual structure, a request which is occasioned by a unification failure. This type of interaction is used to account for sortal defeat, as we will see in section 7.4. The second type of interaction occurs after each sign is sent to the discourse processing module for interpretation: the later module returns a discourse context. These interactions between the linguistic processing and discourse processing modules are illustrated in figure 7.2. In this section, we discuss and illustrate the second type of

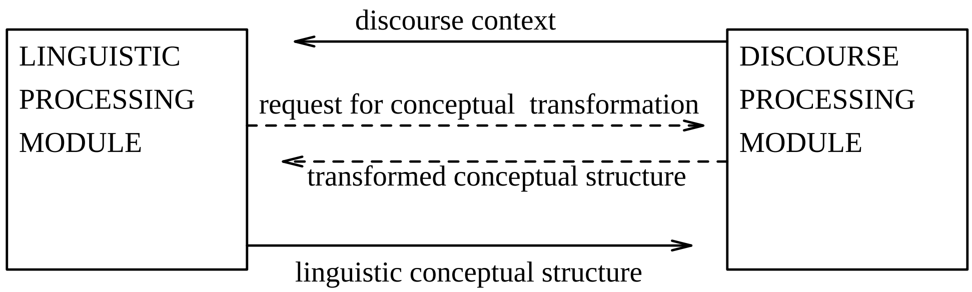

Figure 7.2: Interactions between linguistic and discourse processing modules

interaction and its contribution to linguistic sense selection: i.e. the selection of the contextually appropriate sense of ambiguous and polysemous expressions prior to combination.

The function of the discourse context is to contextually restrict upcoming signs; in particular, to resolve disjunctions in its conceptual structure. The discourse context is a set of 'simplified' descriptions of concepts anchored in the discourse model. The set consists of all the explicit concepts in the local domain together with implicit concepts which are (immediately) embedded in explicit concepts; implicit concepts embedded within implicit concepts are not included. Each of these concepts is simply described using its id and type. For example, the discourse context after the interpretation of *The boy walked into the shop* is given in (7.31):

(7.31)

$$\left\langle \begin{array}{l} \begin{bmatrix} id : sentient1 \\ type : sentient \end{bmatrix} \\ \begin{bmatrix} id : go1 \\ type : go \end{bmatrix} \\ \begin{bmatrix} id : shop1 \\ type : shop \end{bmatrix} \\ \begin{bmatrix} id : window1 \\ type : window \end{bmatrix} \\ \begin{bmatrix} id : door1 \\ type : door \end{bmatrix} \end{array} \right\rangle$$

This discourse context contains only the anchored concepts referenced by *the boy*, *walked into* and *the shop*, but also implicit concepts, WINDOW1 and DOOR1 created by the SHOP theory.

With linguistic sense selection, the linguistic processing module attempts to recursively reduce disjunctive conceptual structure in the upcoming sign using the current discourse context. Disjuncts in conceptual structure are reduced by checking each disjunct against the concepts in the discourse context. If one, but not the other, disjunct is compatible with one of these concepts, then this disjunct is unified with the concept in the discourse context (its id is given the same constant value) and the other disjunct discarded. If both disjunctions are compatible, or neither are compatible, then the disjuncts are preserved and other concepts in the discourse context are checked for compatibility. If no reduction takes place, then the discourse context is not sufficiently constraining to select the contextually appropriate sense at the linguistic level.

This approach to linguistic sense selection, however, is too simple since it fails to acknowledge the role of typicality, or dominance, in sense selection. For we shall follow Tabossi (1988b) (see section 3.3.4) and require that context and dominance restrictions converge for sense selection on the basis of discourse context:

> <u>Discourse Context Restriction</u> (DCR)
> If there is a concept C in the discourse context which is compatible with the disjunct $D1$, but not the disjunct $D2$, in the semantics of the upcoming sign, and $D1$ is more typical than $D2$, then unify C and $D1$, and discard $D2$ and any disjunct in syntax synchronized with it.

With the DCR, the linguistic processing module can select the appropriate sense of polysemous and ambiguous expression prior to combination. Furthermore, where semantic and syntactic disjunction are correlated with synchronization constraints, a secondary effect of the DCR is that the corresponding syntactic disjuncts may be selected or discarded.

We shall first illustrate the DCR with the examples given in section 5.8 where selection takes place in the discourse rather than the linguistic process. In such cases, the discourse context is not sufficient to select between the alternative senses of an expression. Consider examples (5.53) and (5.54) here given as (7.32) and (7.33):

(7.32) The accountant decorated her new house. Then she bought a bed.

(7.33) The accountant went into the garden. She walked over a bed planted with vegetables.

Again, we shall focus on the interpretation of *bed* whose sign is given in (7.16).

With (7.32), the discourse model immediately prior to the interpretation of *bed* is given in figure 7.3. The discourse context for this state of the discourse model is given in (7.34):

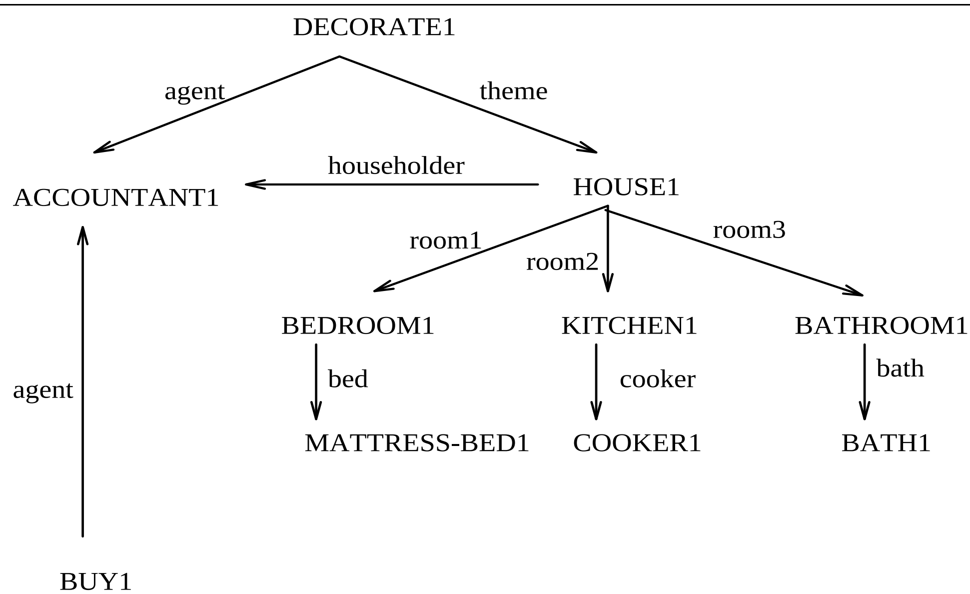

Figure 7.3: Discourse model after interpretation of *The accountant decorated her new house. Then she bought*

(7.34)

$$\left\langle \begin{bmatrix} id : accountant1 \\ type : accountant \end{bmatrix} \begin{bmatrix} id : decorate1 \\ type : decorate \end{bmatrix} \begin{bmatrix} id : house1 \\ type : house \end{bmatrix} \begin{bmatrix} id : bedroom1 \\ type : bedroom \end{bmatrix} \begin{bmatrix} id : kitchen1 \\ type : kitchen \end{bmatrix} \begin{bmatrix} id : bathroom1 \\ type : bathroom \end{bmatrix} \right\rangle$$

where the implicit objects, MATTRESS-BED1, COOKER1 and BATH1 created through elaboration of the explicit HOUSE concepts, are not included since they are implicit concepts embedded within the implicit concepts BEDROOM1, KITCHEN1 and BATHROOM1 respectively. When the sign for *bed* is retrieved from the lexicon, the DCR is applied. Neither of the concepts in its top-level disjuncts, MATTRESS-BED and PLANT-BED, are compatible with any of the concepts in (7.34): neither are compatible with ACCOUNTANT1 since ACCOUNTANT is subsumed by ANIMATE, and both MATTRESS-BED and PLANT-BED are subsumed by INANIMATE; neither are compatible with DECORATE1 since it is subsumed by EVENT and MATTRESS-BED and PLANT-BED are subsumed by ENTITY; and neither are compatible with HOUSE1, BEDROOM1, KITCHEN1 and BATHROOM1 since although they are all subsumed by INANIMATE, there is no type which subsumes any of these types as well as MATTRESS-BED or PLANT-BED. Consequently, the conceptual disjunctions in the sign for *bed* are not resolved.

With (7.33), the discourse context prior to interpretation of *bed* is given in (7.35):

(7.35)

$$\left\langle \begin{bmatrix} id : accountant1 \\ type : accountant \end{bmatrix} \begin{bmatrix} id : go1 \\ type : go \end{bmatrix} \begin{bmatrix} id : garden1 \\ type : garden \end{bmatrix} \begin{bmatrix} id : vegetable\text{-}bed1 \\ type : vegetable\text{-}bed \end{bmatrix} \begin{bmatrix} id : flower\text{-}bed1 \\ type : flower\text{-}bed \end{bmatrix} \right\rangle$$

where ACCOUNTANT1, GO1 and GARDEN1 are explicit concepts and VEGETABLE-BED1 and FLOWER-BED1 are implicit concepts created through elaboration of GARDEN1 (see (5.59)). This time, there are conceptual disjuncts in (7.16) which are compatible with concepts in the discourse context in (7.35). In particular, PLANT-BED but not MATTRESS-BED is compatible with both FLOWER-BED1 and VEGETABLE-BED1: PLANT-BED subsumes FLOWER-BED and VEGETABLE-BED. Furthermore, since both disjuncts embedded within PLANT-BED in (7.16) are also compatible with concepts in this discourse context, the disjunction could only be reduced to PLANT-BED: reduction cannot go any deeper since the DCR requires that one disjunct in a disjunction is incompatible for reduction to take place. However, no reduction takes place since, according to the gtypicality constraint in (7.16), PLANT-BED is the subordinate rather than dominant sense, and reduction only takes place when contextual restrictions and typicality coincide. Here they diverge. Consequently, the disjunctive conceptual structure for *bed* is not resolved at the linguistic level.

Let us now consider a case where sense selection does take place at the linguistic level on the basis of the discourse context.

(7.36) The accountant decorated her bedroom. Then she bought a bed.

In (7.36) context and typicality converge to select the MATTRESS-BED concept of *bed*. The state of the discourse model immediately prior to the interpretation of *bed* is given in figure 7.4. In

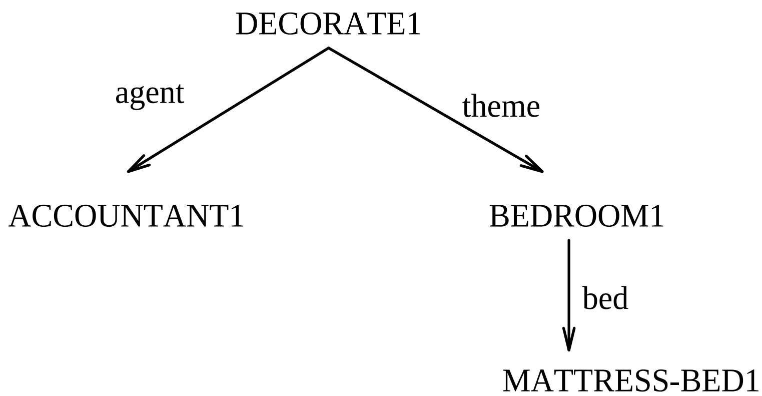

Figure 7.4: Discourse model after interpretation of *The accountant decorated her bedroom. Then she bought*

figure 7.4 there are three explicit concepts, ACCOUNTANT1, DECORATE1 and BEDROOM1, and one implicit concept MATTRESS-BED1, created by the theory for BEDROOM and immediately embedded in BEDROOM1. This time all these concepts are exported as the discourse context to the linguistic processing module. Application of the DCR reveals that only one of the disjuncts in *bed* is compatible with one of the concepts in the discourse context: MATTRESS-BED in the first disjunct is compatible with MATTRESS-BED1 in the discourse context. Furthermore, according to the constraints in (7.16), this concept is more typical than the other disjunct. Since both context and typicality converge, the top-level conceptual disjunction is resolved in favour of MATTRESS-BED prior to combination. As a result, the linguistic conceptual structure for *she bought a bed* is as given in (7.37) where the value for the id of MATRESS-BED is assigned the value mattress-bed1 prior to interpretation in the discourse model:

(7.37)

$$\begin{bmatrix} type : buy \\ agent : \begin{bmatrix} type : accountant \end{bmatrix} \\ theme : \begin{bmatrix} id : mattress\text{-}bed1 \\ type : mattress\text{-}bed \end{bmatrix} \end{bmatrix}$$

When the value of theme is interpreted, the anchoring process need only unify the concept with the MATTRESS-BED1 peg in the discourse model: it does not have look for an accessible peg since this has already been determined by application of DCR in the linguistic processing module.

Finally, linguistic sense selection with a discourse context can lead to the resolution of syntactic disjunctions through synchronization constraints in the sign. Consider the interpretation of *count* in (7.38) (cf. (3.13) and (3.14) in section 3.3.2):

(7.38) The children were learning arithmetic. The teacher told them to count the blocks.

According to Simpson (1981), the 'enumerate' senses of *count* is more typical than the 'nobility' sense and each sense is associated with different syntactic properties. Consequently, its sign, like the sign for *sink* in (7.17), has disjunctive conceptual and syntactic structures, and its constraints indicate that the disjunct with the ADD concept is more typical than the disjunct with the NOBLE concept, and that these disjunctions are synchronized with disjuncts in the syntactic structure. Prior to the interpretation of *count* in (7.38), the discourse context is as illustrated in figure 7.5. In figure 7.5, the ARITHMETIC concept has been elaborated by

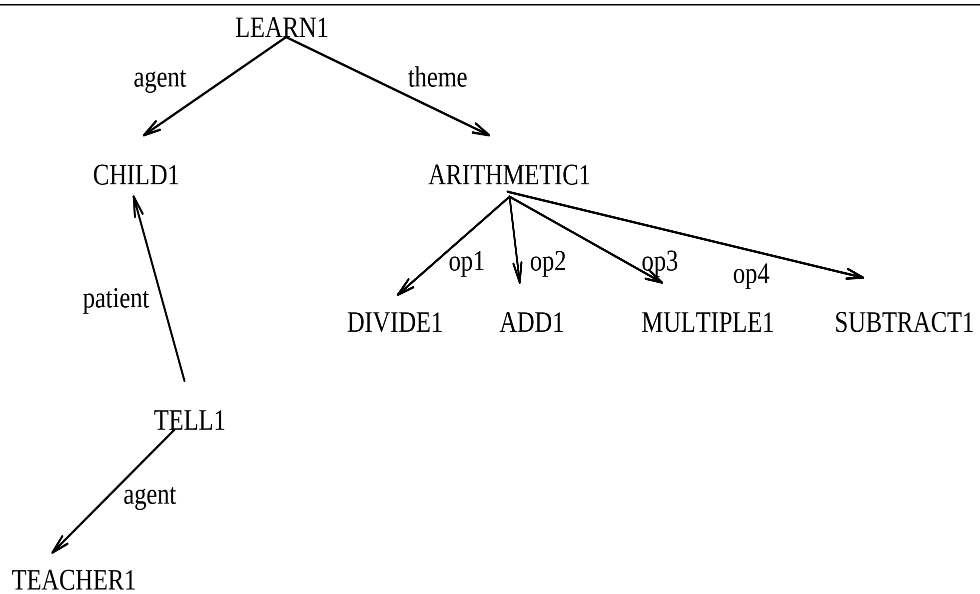

Figure 7.5: Discourse model after interpretation of *The children were learning arithmetic. The teacher told them*

a theory which creates four implicit concepts — ADD1, SUBTRACT1, DIVIDE1, MULTIPLY1 — which describe the basic arithmetic operations. Since these implicit concepts are immediately embedded in an explicit context, they are included in the discourse context exported to the linguistic processing module. Application of the DCR with the upcoming sign for *count* results in the selection of the ADD disjunct: ADD is compatible with ADD1 while NOBLE is not; and ADD is the more typical according to the typicality constraint. Furthermore, since these conceptual disjuncts are synchronized with syntactic disjuncts, the VERB disjunct is selected and the NOUN disjunct discarded. Consequently, prior to combination, the sign for *count* is refined so as to have the value for semantics in (7.39) and the value for syntax in (7.40) respectively (order and form properties are not shown for the sake of clarity):

(7.39)

$$\begin{bmatrix} type : add \\ agent : \begin{bmatrix} type : sentient \end{bmatrix} \\ theme : \begin{bmatrix} type : entity \end{bmatrix} \end{bmatrix}$$

(7.40)

$$\begin{bmatrix} head : \begin{bmatrix} type : verb \end{bmatrix} \\ modifier : \left\langle \begin{bmatrix} syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \end{bmatrix} \end{bmatrix} \\ semantics : \begin{bmatrix} type : sentient \end{bmatrix} \\ syntax : \begin{bmatrix} head : \begin{bmatrix} type : noun \end{bmatrix} \end{bmatrix} \\ semantics : \begin{bmatrix} type : entity \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

Thus by using a discourse context exported from the discourse processing module and the Discourse Context Restriction Principle, not only can the contextually appropriate sense of ambiguous and polysemous expressions be selected in the linguistic processing module prior to combination, but through synchronization with the different syntactic structures, the appropriate syntactic structure can also be selected.

7.4 Coping with Defeat

As we have seen in section 6.6, expressions can successfully combine even if they are incompatible. Typicality defeat in section 6.6.1 involves a conflict between necessary and default core semantic properties, as in *pink elephants*. Intrinsic defeat in section 6.6.2 involves a conflict between necessary and default mode semantic properties as with *fake elephants*. On the other hand, sortal defeat in section 6.6.3 involves a conflict between necessary core properties, as in *chocolate elephants*, and general defeat in section 6.6.4 involves a conflict between necessary semantic and syntactic properties. Furthermore, it is the modifier rather than the head which has priority in defeat: unless the discourse situation suggests otherwise, the result expression has the properties assigned, or required by, the modifier. In section 6.4.2, this priority of modifier with respect to defeat was systematically related to the ranking of their semantic types in (6.64). In this section, we shall extend the account of sense correction, given in section 5.7, so as to characterize typicality, intrinsic and sortal defeat; space prohibits an adequate treatment of general defeat.

Typicality and intrinsic defeat can be accounted for without recourse to an interaction between the linguistic and discourse processing modules: default anchoring and elaboration can account for them on the assumption that default values for mode and core properties are not given in lexical and linguistic structure. Thus with the signs for *pink* and *elephants*, while the necessary value pink for COLOUR-PROPERTY is given in (7.14), the default value grey is not given in (7.15 d). According to the HMP, their signs combine as modifier and head to yield a result sign with the semantics in (7.41)[5]:

(7.41)

$$\begin{bmatrix} type : elephant \\ material : \begin{bmatrix} type : material \\ value : flesh \end{bmatrix} \\ shape : \begin{bmatrix} type : shape \\ value : \text{`}elephant\text{-}shape\text{'} \end{bmatrix} \\ colour : \begin{bmatrix} type : colour\text{-}property \\ value : pink \end{bmatrix} \end{bmatrix}$$

The 'conflict' arises when this conceptual structure is elaborated with the theory for ELEPHANT in the discourse model. The theory for ELEPHANT is shown in (7.42):

[5] The material and shape properties are necessary properties of ELEPHANT. They will discussed in relation to intrinsic and sortal defeat.

(7.42)

$$\left[\begin{array}{ll} type : elephant & \\ constraints : & \left\langle \begin{array}{l} \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : <\text{material value}> \\ value : flesh \end{array}\right] \\ \left[\begin{array}{l} name : vequality \\ type : necessary \\ path : <\text{shape value}> \\ value : \text{`}elephant\text{-}shape\text{'} \end{array}\right] \\ \left[\begin{array}{l} name : vequality \\ type : default \\ path : <\text{colour value}> \\ value : grey \end{array}\right] \\ \left[\begin{array}{l} name : vequality \\ type : default \\ path : <\text{size value}> \\ value : large \end{array}\right] \\ \left[\begin{array}{l} name : vequality \\ type : default \\ condition : <\text{material value flesh}> \\ path : <\text{taste value}> \\ value : \text{`}elephant\text{-}flesh\text{-}taste\text{'} \end{array}\right] \end{array}\right\rangle \end{array}\right]$$

The 'conflict' between *pink* and *elephants* then stems from a conflict between the necessary value of colour assigned by *pink* and the default value specified in a constraint in the ELEPHANT theory. However, as discussed in sections 5.3.5 and 5.7, while necessary constraints must hold, default constraints need not hold for a concept to be well-defined. Consequently, since colour is already specified for a value, the default colour constraints does not apply, and application of the other constraints results in the elaborated concept in (7.43):

(7.43)

$$\left[\begin{array}{ll} type : elephant & \\ material : & \left[\begin{array}{l} type : material \\ value : flesh \end{array}\right] \\ shape : & \left[\begin{array}{l} type : shape \\ value : \text{`}elephant\text{-}shape\text{'} \end{array}\right] \\ colour : & \left[\begin{array}{l} type : colour\text{-}property \\ value : pink \end{array}\right] \\ colour : & \left[\begin{array}{l} type : size \\ value : large \end{array}\right] \\ colour : & \left[\begin{array}{l} type : taste \\ value : \text{`}elephant\text{-}flesh\text{-}taste\text{'} \end{array}\right] \end{array}\right]$$

A similar sort of account can be given for the intrinsic defeat in *fake elephants*. Again, the signs for *fake* and *elephants* combine as modifier and head to yield a result sign with semantics similar to that given in (7.41); they differ in that the colour property is replaced with a polarity property with the value negative. The linguistic conceptual structure is then anchored and elaborated in the discourse model. However, the elaboration process assumes that concepts will have a positive value for their polarity property: i.e. this value is a default within the elaboration process. When concepts lack a positive value, necessary constraints are undermined: i.e. the relationship between the concept and necessary properties is thrown into doubt. Consequently, while the default constraints can apply — there are no values already specified for the default properties of ELEPHANT — necessary ones are suspended pending further positive information about the concept. Thus unlike default constraints, which apply in the absence of information at the closure of the current utterance domain (see section 5.7), these necessary constraints are only applied when information is provided which confirms, for example, that ELEPHANT should have the value flesh for its material property. Consequently, the elaborated concept for *fake elephants* has, by default, the colour and size of 'real' elephants, but not necessarily their material or shape. In fact, it also lacks their taste: although the value 'elephant-flesh-taste' is assigned by a default constraint in the ELEPHANT theory in (7.42) it does not apply since its condition — that the concept has the value flesh for its material property does not hold.

Sortal defeat is somewhat more complex since it requires the transformation of the head's semantics. With the sortal defeat in *chocolate elephants*, the signs for *chocolate* and *elephants* are unable to combine since their linguistic conceptual structures have incompatible values for material. The sign for *elephants* is given in (7.15) and the semantics of the sign for *chocolate* in (7.44):

(7.44)

$$\left\{ \begin{array}{l} \left[\begin{array}{l} type : material \\ value : chocolate \end{array} \right] \\ \left[\begin{array}{l} type : chocolate\text{-}entity \\ material : \left[\begin{array}{l} type : material \\ value : chocolate \end{array} \right] \end{array} \right] \end{array} \right\}$$

where the concept in the first disjunct is subsumed by PROPERTY and the concept in the second disjunct is subsumed by ENTITY. Note that these senses are related: the first concept is contained in the second as the value for its material property. These disjuncts are synchronized with disjuncts in the syntax: i.e. the first is associated with the type ADJECTIVE, appropriate for combination in *chocolate sweets* and the second with the type NOUN, appropriate for combination in *some chocolate*. With *chocolate elephant*, combination is initially successful: the sign for *chocolate* can syntactically and semantically specify the sign for *elephants* as an adjectival modifiers where its type, MATERIAL, is subsumed by PROPERTY. However, combination fails during the linking process: while MATERIAL is compatible with the type of the material property in the semantics of the sign for *elephant*, its value is not — chocolate and flesh are incompatible values.

This conflict is resolved in UDG through the transformation of the head sign semantics in the discourse processing module. For with this combination failure, the value of semantics in one of these signs needs to be transformed into a structure compatible with the semantics of the other. Once it has been transformed, it's semantics are returned to the linguistic processing module and combination should then succeed. Which sign is transformed is determined by the following principle based upon the head modifier distinction:

> The Transformation Principle
> In a binary combination, when there is a conflict in linking the semantics of the modifier sign to a role in the semantics of the head sign, transform the semantics of the head sign with respect to the semantics of the modifier sign.

Accordingly, the semantics of the both head and modifier signs are exported for transformation of the head's semantics.

In the discourse processing module, the concept referenced by *elephants* is transformed in three phases. Firstly, a new peg is created for the concept in the discourse model, say CHOCOLATE-ELEPHANT1, and it is assigned a type, say CHOCOLATE-ELEPHANT, which is subsumed by ELEPHANT. Secondly, a theory for this concept must be created. This theory must not only assign the material property the value chocolate, but must also be a theory for concepts subsumed by ENTITY as CHOCOLATE-ELEPHANT is. Such a theory can be created by inheriting constraints from two theories subsumed by ENTITY, namely the ELEPHANT theory given in (7.42) and the CHOCOLATE-ENTITY theory, which elaborates the CHOCOLATE-ENTITY concept in the second disjunct in the semantics of *chocolate*, given in (7.45)[6]:

(7.45)

$$
\left[\begin{array}{l}
\textit{type} : \textit{chocolate-entity} \\
\textit{constraints} : \left\langle \begin{array}{l}
\left[\begin{array}{l} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{necessary} \\ \textit{path} : \text{<material value>} \\ \textit{value} : \textit{chocolate} \end{array}\right] \\
\left[\begin{array}{l} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \text{<colour value>} \\ \textit{value} : \textit{brown} \end{array}\right] \\
\left[\begin{array}{l} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \text{<size value>} \\ \textit{value} : \textit{small} \end{array}\right] \\
\left[\begin{array}{l} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \text{<taste value>} \\ \textit{value} : \textit{sweet} \end{array}\right] \\
\left[\begin{array}{l} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \text{<shape value>} \\ \textit{value} : \textit{`bar-shape'} \end{array}\right]
\end{array}\right\rangle
\end{array}\right]
$$

The theory for CHOCOLATE-ELEPHANT1 is created from these theories by inheriting constraints on the basis of the Property Assignment Principle which always succeeds in determining which of the two theories constraints are inherited from:

> The Property Assignment Principle (PAP)
> When a concept is assigned properties from two sources, one of these is a *prioritized* source (PS) and the other is a *non-prioritized* source (NPS).
>
> Theories associated with concepts in a head modifier relationship are prioritized: the theory associated with a concept in the head sign is the NPS; the other theory, which may be associated with a concept in the modifier sign, is the PS.
>
> A property P^1 assigned by a constraint in PS has priority over the property P^2 assigned by a constraint in NPS **unless** P^1 is assigned a value by a default constraint in PS and P^2 is assigned a value by necessary constraint in NPS.

Since the ELEPHANT theory is associated with the concept in the head sign *elephants* it is the non-prioritized source; the CHOCOLATE-ENTITY theory is the prioritized source. Application of PAP results in the theory for CHOCOLATE-ELEPHANT given in (7.46):

[6] With other cases of sortal defeat, the modifier may not have another sense associated with a suitable theory. Consequently, the conceptual hierarchy will need to be search for a theory which assigns the same value to the conflicting property as given in the modifier's semantics.

(7.46)

$$\begin{bmatrix} \textit{type} : \textit{chocolate-elephant} \\ \textit{constraints} : \left\langle \begin{matrix} \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{necessary} \\ \textit{path} : \langle \text{material value} \rangle \\ \textit{value} : \textit{chocolate} \end{bmatrix} \\ \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \langle \text{colour value} \rangle \\ \textit{value} : \textit{brown} \end{bmatrix} \\ \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \langle \text{size value} \rangle \\ \textit{value} : \textit{small} \end{bmatrix} \\ \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{default} \\ \textit{path} : \langle \text{taste value} \rangle \\ \textit{value} : \textit{sweet} \end{bmatrix} \\ \begin{bmatrix} \textit{name} : \textit{vequality} \\ \textit{type} : \textit{necessary} \\ \textit{path} : \langle \text{shape value} \rangle \\ \textit{value} : \text{`}\textit{elephant-shape}\text{'} \end{bmatrix} \end{matrix} \right\rangle \end{bmatrix}$$

where the default constraints for taste, size, colour and taste have been inherited from the CHOCOLATE-ENTITY theory, i.e. the prioritized source, since none of these properties are assigned by necessary constraints in ELEPHANT theory, the non-prioritized source. The necessary constraint for material is likewise inherited from the CHOCOLATE-ENTITY theory since it is the prioritized source and the constraint is not a default constraint in this theory. The necessary constraint for shape, however, is inherited from the non-prioritized source: since the property is assigned by a default constraint in CHOCOLATE-ENTITY, but by a necessary constraint in ELEPHANT, the non-prioritized source supplies the shape constraint. Consequently, CHOCOLATE-ELEPHANT1 has all the properties of CHOCOLATE-ENTITY with exception of SHAPE — *chocolate elephants* are chocolate things which look like elephants.

Finally, the third phase of transformation is that this new concept, with its necessary, but not default, properties, is added to the semantics for *elephants*:

(7.47)

$$\left\{ \begin{bmatrix} \begin{bmatrix} \textit{type} : \textit{elephant} \\ \textit{material} : \begin{bmatrix} \textit{type} : \textit{material} \\ \textit{value} : \textit{flesh} \end{bmatrix} \\ \textit{shape} : \begin{bmatrix} \textit{type} : \textit{shape} \\ \textit{value} : \text{`}\textit{elephant-shape}\text{'} \end{bmatrix} \end{bmatrix} \\ \begin{bmatrix} \textit{type} : \textit{chocolate-elephant} \\ \textit{material} : \begin{bmatrix} \textit{type} : \textit{material} \\ \textit{value} : \textit{chocolate} \end{bmatrix} \\ \textit{shape} : \begin{bmatrix} \textit{type} : \textit{shape} \\ \textit{value} : \text{`}\textit{elephant-shape}\text{'} \end{bmatrix} \end{bmatrix} \end{bmatrix} \right\}$$

when this conceptual structure is returned to the linguistic processing module, it replaces the semantics in the sign for *elephant*. Combination can now succeed since the semantics of *chocolate* can be linked to a role within the CHOCOLATE-ELEPHANT concept in the second disjunct of *elephants*. Furthermore, this new concept can be retained as part of the lexical sign for *elephants*. In this way, the UDG treatment of sortal defeat is an example of information correction with its tension between linguistic inertia and linguistic force (see section 5.7).

7.5 Conclusion

In this chapter, we have characterized the linguistic processing module in the cognitive linguistic approach as Unification Dependency Grammar. UDG is based upon the two aspects of combination discussed in chapter 6: the conceptual structure associated with linguistic expressions can be extended through combination in a unification grammar; and combination is characterized in terms of the head modifier distinction, as in dependency grammar. In UDG expressions are characterized as signs whose syntax property consists of a head, which describes its syntactic properties, and a modifier property, which describes the set of signs with which it can combine. The semantics property is a linguistic conceptual structure as discussed in section 5.4, and its constraints property describes relations between substructures, such as equality, typicality and synchronicity, and have the same format as the constraints discussed in section 5.3.5. Combination itself is characterized in terms of two processes: a specification process in which a modifier sign is unified with a modifier in the modifier of the head sign; and a linking process which applies the constraints associated with the head sign so that, for example, the conceptual structure of the modifier sign extends the conceptual structure of the head sign. The result sign can thus be defined as the head sign after specification and linking. These processes were illustrated with combinations where the expressions were associated with disjunctive values for their semantics; and with examples where the combination process could not only resolve these disjunctions, but resolve disjunctions in syntax (and vice versa) by means of synchronization constraints.

Furthermore, we demonstrated how this approach to combination can account for the immediate selection of the appropriate sense of ambiguous and polysemous expressions as discussed in section 3.3, and some of the sorts of defeasibility discussed in section 6.6. The account of linguistic sense selection relied upon the discourse module exporting a discourse context — a set of concepts anchored in the discourse model — and a principle which compared these concepts with concepts in the disjunctive conceptual structure of an upcoming sign. If a concept in one of these disjuncts was compatible with a concept in the discourse context, and it was the more typical concept according to a typicality constraint in the sign, then this concept is selected and the concept in the other disjunct discarded. Cases of defeasibility were accounted for in two ways. With typicality and intrinsic defeat, there was no conflict between the concepts in the head and modifier signs since linguistic concepts do not contain default values for core and mode properties: they only arise when the concept is anchored and elaborated in the discourse model. As discussed in sections 5.6 and 5.7, these 'conflicts' are resolved through necessary constraints having priority over default constraints. The account of sortal defeat, however, required an interaction between the linguistic processing and discourse processing modules. For combination fails in examples of sortal defeat: in particular, the linking process fails through an incompatibility between necessary properties of the concepts in the head and modifier signs. This conflict is resolved by the discourse processing module transforming the conceptual structure of the head sign into a structure which can be specified by the modifier. The transformation itself involved creating a new type of concept whose properties were supported by a theory created, in part, from the theory associated with concept in the head sign. However, this theory supports the necessary property associated with the modifier concept, not the head concept. With defeat then, while the resolution of 'conflict' in typicality and intrinsic defeat is merely consistent with the priority of the modifier in defeat as discussed in section 6.6.5, the modifier's priority here is essential to our account of sortal defeat since it is the head concept, rather than the modifier concept, which undergoes transformation. This gives modifiers a more influential role in combination than simply specification — specification by a modifier can lead to a **change** in the conceptual structure of the head, although this conceptual structure still provides the basis for the semantics of the result sign.

Chapter 8

Conclusions and Consequences

In this short chapter, we summarize the conclusions which have emerged from the cognitive linguistic approach to language comprehension, and briefly consider some of the consequences of the approach for future work.

8.1 Summary of Conclusions

In chapter 1 we differentiated the cognitive linguistic approach from the traditional linguistic approach on the grounds that linguistic description is an integral part of the description of cognition, and that its focus is not the grammaticality of sentences, but the nature of conceptual structure, the processes which relate different levels of concept structure and the effects of context on these processes.

In chapter 2 two issues pertinent to this approach were addressed. The first issue was methodology: i.e. the methods we might employ to support, test or validate whether a description of linguistic behaviour is a characterization of cognitive representations and processes. For while the traditional linguistic approach claims that it is a description of our cognitive abilities, the methods it employs, especially testing by example, contrasts with the methods employed by other disciplines, such as cognitive psychology, which also claim to offer cognitive descriptions. Consequently, we advocated a hybrid approach where both informal and experimental observation provide complementary perspectives. The second issue concerned the manner in which cognition is to be described. We adopted the computational theory of mind which claims that cognition is described in computational terms: i.e. both humans and computers are described as 'cognitive agents' capable of processing information. The cognitive linguistic approach was characterized as a functional computational description with two modules, a linguistic processing module and a discourse processing modules. The relationship between these modules was viewed as bi-directional: the linguistic processing module exports a linguistic description of expressions to the discourse model, and the later module exports a portion of the discourse model to the former module. The notion of symbol processing in these modules was given an information-theoretic characterization: rules express global invariance while constraints within symbols express local invariance. Furthermore, we made two claims about the effects of context on language comprehension. Firstly, it was claimed that semantic interpretation in the discourse module can be affected by the discourse context so that contextually inappropriate senses of ambiguous and polysemous expressions are not integrated and elaborated as concepts in the cognitive agent's model of the discourse. Secondly, it was claimed that the discourse context can affect linguistic symbols in the linguistic processing module such that contextually inappropriate senses of ambiguous and polysemous expressions can be discarded prior to combination.

In chapter 3 we discussed two conceptual approaches to categorization, the classical and prototype approaches. Both approaches were shown to be problematic, especially with respect to context effects on categorization. However, the evidence did emphasize the importance of typicality in conceptual structure. For not only do concepts contain characteristic or typical features, but concepts, and levels of concepts, are also related by typicality. Such a treatment is compatible with organizing concepts in terms of the subset relations as we observed in the classical approach. In other words, concepts can be internally and externally organized by necessary relations, such as the subset relation between concepts, and typicality relations, such as the typicality relation between a concept and one of its features. We then discussed lexical access, evidence pertinent to our claim that context can affect the construction of conceptual structure in the discourse processing module as well as the construction of conceptual structure in the linguistic processing module. The evidence was interpreted as supporting these claims. In the case of expressions with multiple senses described in their lexical conceptual structure, a discourse context which is sufficiently specific to discriminate between these senses can lead to the selection of the contextually appropriate and the discarding of inappropriate senses. Contexts which lack this degree of specificity can still play a role in sense selection but only when conceptual structure is processed in the discourse module.

In chapter 4, we developed the cognitive linguistic approach by addressing two related issues: the nature of the relation between conceptual structures, and the motivation for necessary and typicality relations within these structures. We rejected the characterization of the relation between semantic representation and semantic interpretation, as a correspondence between independent levels of conceptual structure partly on the grounds that the approach is positively non-cognitive and partly because of problems with realism. Instead, the relationship was characterized in terms of the extension of dynamic, partial structures. In interpretation, conceptual structure is extended into a conceptual structure which then becomes part of a dynamic model of discourse available to cognitive agents. Furthermore, we motivated necessary and typical relations within conceptual structures on the basis of criterial necessity and symptomic evidence relations. The interpretation of linguistic expressions involves background knowledge, or theories, and this background knowledge supports necessary and typical relations within and between conceptual structures. One important aspect of this criterial motivation is that interpretations are revisable: our interpretation of linguistic expressions needs to be revised in light of further information incompatible with current background knowledge.

In chapter 5 interpretation in the discourse processing module was characterized. Interpretation involved the extension of linguistic conceptual structure into anchored conceptual structure by an anchoring process, and the extension of anchored conceptual structure into elaborated conceptual structure by an elaboration process. Each of these levels of conceptual structure, as well as theories, share the same ontology: they are constructed from the same set of basic elements. The linguistic conceptual structure is a linguistically relevant description associated with an expression; expressions with multiple senses are characterized as disjunctive linguistic conceptual structures. The concepts in this conceptual structure are added to the discourse model by an anchoring process which attempts to find compatible existing concepts in the current discourse model: if such a concept is found, then the two concepts are unified; and if not, a new anchored concept is created in the discourse model. The concepts in the discourse model are then elaborated by theories whose constraints describe necessary and typical relations between a concept and its properties. As a result, anchored concepts are extended into elaborated concepts. This approach to interpretation countenanced two sorts of extension in the discourse model: in the normal circumstances, concepts are montonically extended; and in bizarre circumstances, their extension is non-monotonic — the interpretation of concepts may be revised. However, we suggested that many cases of non-monotonic extension can be avoided through judicious anchoring and elaboration. Finally, we demonstrated in detail how this approach accounts for sense selection at the discourse level.

In chapter 6 we established that an extensional relation between the conceptual structure associated with lexical expressions, and the conceptual structure associated with phrases can be maintained in a unification grammar. However, the process of combination is not simply symmetrical: one expression has priority over the other. In one unification grammar, Unification Categorial Grammar, combination is based upon the functor argument distinction, as in categorial grammar: expressions are characterized as signs, with phonological, syntactic and semantic properties, and combination involves the unification of an argument sign with part of the functor sign to yield a result sign for the phrase. Our approach differed in that the combination is based upon the head modifier distinction, as in dependency grammar. This distinction was motivated on the basis of three distinctive properties of head signs: subcategorization (or specification), category determination and obligatoriness. In particular: the head sign is syntactically and semantically specified by the modifier sign; the result sign has the syntactic and semantic types of the head sign; and the head sign is obligatory for both specification and category determination. Furthermore, the priority of the head sign over the modifier sign is informally characterized in terms of their semantic type: the semantic type of the head outranks the semantic type of the modifier. Comparison with the functor argument distinction demonstrated that linguistic regularities such as serialization and semantic category constancy can be more economically described with the head modifier distinction. Finally, we introduced evidence, defeasibility evidence, which both challenged and supported the head modifier distinction. The challenge arose from combinations where the combining signs possess incompatible semantic properties, and from combinations where not all the semantic properties of the head sign were preserved in the result sign, and some new properties were introduced. On the other hand, the defeasibility evidence supports combination on the basis of the head modifier distinction in that the modifier sign, rather than the head sign, systematically had priority in defeat, although the head sign still provided the basis for construction of the result sign.

In chapter 7, the linguistic processing module in the cognitive linguistic approach was characterized as Unification Dependency Grammar. Linguistic expressions were characterized as signs with constraints which express, for example, equality, typicality and synchronization relations between substructures in a sign. Combination was characterized in terms of two processes: a specification process in which a modifier sign is unified with part of the head sign; and a linking process which applies constraints associated with the head sign so that, for example, the conceptual structure of the modifier sign extends the conceptual structure of the head sign. The result sign can thus be defined as the head sign after specification and linking. These processes were illustrated with combinations where the expressions were associated with disjunctive conceptual structures; and with examples where combination could not only resolve these disjunctions, but resolve syntactic disjunctions by means of synchronization constraints. Furthermore, we demonstrated how this approach to combination can account for the immediate selection of the appropriate sense of ambiguous and polysemous expressions as well as some types of defeat. The account of linguistic sense selection relied upon the discourse module exporting a discourse context — a set of concepts anchored in the discourse model — and a principle which compared these concepts with concepts in disjunctive conceptual structures in upcoming signs. The account of defeat also required an interaction between the linguistic processing and discourse processing modules. For combination fails in some cases of defeat due to incompatibility between necessary properties of the concepts in the head and modifier sign. This conflict is resolved by the discourse processing module transforming the conceptual structure of the head sign into a structure which then allows it to combine with the modifier sign.

8.2 Consequences for Future Work

One of the attractive features of the cognitive linguistic approach to language comprehension is its uniform treatment of conceptual structures and processes: conceptual structures are consistently characterized as partial objects; and conceptual processes — specification, linking, anchoring and elaboration — are characterized as processes which extend these partial objects into (potentially) less partial objects. This treatment facilitates the construction of a level 1 computational model in prolog; for example, modules can be implemented as prolog modules, conceptual structures as incomplete lists of attribute value pairs, and processes as prolog predicates which map these lists into (potentially) more complete lists. The development of this model can address some of the less attractive features of this approach; namely, that it is incomplete — hence the title *Towards a Cognitive Linguistic Approach to Language Comprehension*; and that while it has been supported with plentiful examples, it has not been supported with examples of 'everyday language' as suggested in chapters 1 and 2. Consequently, the approach will be extended by building a computational model capable of combining and interpreting all expressions in passages from the corpus given in appendix A. This will make the approach more concrete in at least three ways: the conceptual hierarchy, outlined in figure 5.3, will be extended to include the concepts and theories required for interpretation within the gardening domain; likewise, the lexicon will be extended to include all the signs required for combination of linguistic expressions within this domain; and the processes will be augmented so as to account for the instances of combination and interpretation within this domain. Finally, as mentioned in section 5.5, the approach can be further augmented by analyzing the discourse relations between conceptual structures in this domain. This raises the possibility that these relations can be characterized in terms of constraints defined for discourse theories, rather than conceptual theories, and these constraints further extend the concepts in the discourse model.

Appendix A

Gardener's Question Time

This appendix contains a transcription of the radio programme Gardener's Question Time. The programme was broadcast on the 31^{st} of March 1991 from 1400 to 1430 on radio four. A short pause is indicated by a comma, and a longer pause by '( )'.

CJ: you are welcome to join us in the village hall in aberporth in cardiganshire once a fishing village and now a popular holiday resort with visitors from home and abroad () here we are guests of the local flower arrangers club () aberporth has two lovely sandy beaches that are amongst the cleanest in the country and from the village there is a winding cliff path that takes you over to the adjoining village resort of tresaith () team, the soil varies a great deal from light and sandy to heavy stony clay () frost is not generally a problem but salt laden winds can be, that's it () ladies and gentlemen your gardeners' question time team doctor stefan buczacki of stratford upon avon sue philips of chichester and fred downham of lancaster

(applause)

thank you very much, and we are ready from the first question please

JR: jo richards () as flower arrangers past retiring age they are often forced to exchange their large gardens for a tiny plot, due to the work load, to avoid this I have started using permeable plastic mulch with bark or pebble covering in certain areas of my country garden () what other modern devices would the team advise to avoid this heart breaking situation

CJ: so, yes, jo richard you are looking forward to the day you retire

JR: i am retired

CJ: are you, oh, i'm surprised () so really it is a question of weed control, i take it, in a large garden

JR: ah yes

CJ: yes

JR: mainly yes

CJ: mainly that so what else can jo richards do fred

FD: i would grow ground cover plants which you could also use for floral art () not just any kind of ground cover plant but something you could put there you could use, and i would not bother with fiddlely little things where you have gotta put a lot of plants in, because you'll be causing a lot more work i would go for things which use the clime () things like clemitis, ivies, the large leaf ivies, you know, silver-heart all those sort of things one plant will cover yards () so get those going, and leave them covered with your permeable mulch, chippings and bark if you wish () but also do that and plant that upon that () it'll cover it all green you have plenty to cut at () no weedings () it'll be lovely

CJ: err sue

SP: well i think it is very tempting to tell you to re-arrange your garden so as to get rid of the all things that are gonna cause you any work but you in the process also be getting rid of some of those things you most like arranging with, and, from my knowledge of flower arranging, a lot of people like to use things like green nicosheanna and heally crison and other annual plants () and if you cannot live without them, then i would suggest that you make yourself a raised bed, perhaps eighteen inches high which is a convenient height you can sit on the edge of it and work from a comfortable seated position () and grow them very intensively, fill the bed with a very good quality compost and grow the plants reasonably close together, because they have got a deep root run in good compost, and i would install one of these irrigation systems, that trickles water onto the bed and you can either connect this up to a fiddlely or, if you are likely to run out of water in the summer, you could go to the luxury of getting one of these gadgets that you can fit into the down pipe from your bath, so that you can pipe your bath water straight out onto your flower bed, because that way you can grow the plants you without it taking you a lot of effort

JR: that's a good idea thank you

CJ: thank you very much

SP: thank you

CJ: and the next please

JR: jill reece () in centrally heated homes is there really a dormant period for house plants or should they be feed through the year

CJ: thank you jill reece sue the question is () do all house plants retire for the winter

SP: well i think the answer is simply no all house plants do not retire for the winter but in deciding how to look after them we really need to know what kind of house plants you have got, what do you grow

JR: erm i have geraniums, erm shrimp plants, erm, swiss cheese plant, rubber plants and all these seem to sprout forth right throughout the winter

SP: well i think all the ones you describe certainly will do, because the tropical plants, the foliage plants, erhm, the things that come from warmer countries, including the semi-tropical things like geraniums () they will all keep going during the winter () in case of the semi-tropical ones so long as there is enough light and warmth () they will tend to go a bit dormant if you keep them cooler for the winter and certainly you should continue watering them and feeding them () you will find that they will, perhaps, grow slightly less vigorously in the winter, erm, but the amount you are feeding them is going to be based on the amount you are watering them () you know, the less water they need the less feed they need so there is quite a simple ratio there, and the only thing to do is check by sticking your finger into the compost, a lot of people don't like sticking their finger into the compost i don't know if they expect something to come out and bite them or something, but that really is the very best water meter you've got and it is already installed all ready to use no batteries or anything () so use your finger () there are some plants, like some bulbs, that will go dormant at various times of year depending upon what sort of bulb it is () cacti and succulents usually go dormant for the winter cacti invariably and some kinds of succulents do and some don't it is a question of knowing what you have got

CJ: erm, stefan

SB: the general maxim that i follow is that if you are providing plenty of heat and the plant obviously is still growing, is that if it is a foliage plant, or if it is a plant that flowers during our summer and does flower indoors in the winter then i would certainly keep it watered, not soddened but watered on a reasonably regular basis during the winter () erm every two or three weeks perhaps depending on how warm the house is () but if it is a flowering house plant if it is one that is actually in flower during the winter then i would give it feed as well, and, erm () the ones that are not in flower in the winter start feeding them again, well within a month or so from now when they are looking forward to summer if you like, they can sense spring is in the air and their natural flowering period is ahead of them, then start feeding () erm but certainly a plant that is in growth should be given at least some water during the winter, the possible exception being cacti and succulents which as sue has said really do go, go into a pretty dormant state

CJ: but it is surprising i think, mrs reece, that the number of plants that, because they don't grow very much in the winter because they don't flower in the winter, you can almost dry them right off, and certainly cacti you can () i suppose that as a general rule let the plant tell you () if it is flowering and looks good then it obviously needs water () and feeding thank you

JR: thank you

CJ: another one

VW: vivene watson my garden consists mainly of flag stones and gravel () can the team recommend some trees and shrubs that can be grown in tubs to use for flower arranging () also what size of tubs do you recommend

CJ: how big is the garden

VW: very large it is about thirty, by twenty five

CJ: feet

VW: yards () yes it is a very large courtyard

CJ: so it is enclosed as well

VW: enclosed as well, wall all round

CJ: right () we have the picture mrs watson and you are seeking advice on what trees and shrubs you can grow in tubs for flower arranging () erm () quite a few stefan

SB: oh yes, more than quite a few, many, dozens () rather than give a whole long list of names i am just going to make one or two general points () one being clearly if the plants are being grown primarily for use in flower arranging they have got to stand have lumps chopped off them at regular intervals they should therefore be pretty vigorous, pretty tough and relatively fast growing it is no point having something that is slow growing and going to take ten years to replace what you have taken off for one week's worth of flower arranging () so those are the criteria for the plants, for the container in which they grow () these plants by their very nature are going to have to be fairly large otherwise one week's cutting will get them down to ground level () and therefore the container should also be large and i would suggest that the best containers to use are going to be wooden half barrels () err drill some holes in the bottom () i used to paint them inside with preservative what i now do and find better in fact () is to line them with plastic sheet () so the compost that they are filled with doesn't in fact come into contact with the wood itself and that prolongs the life of them enormously () so my general advice is grow whatever you like () and whatever you think you can adapt to a flower arrangement, but make sure it's vigorous, make sure it is tough and will stand being chopped around, grow it in a half-barrel with a good compost in it

CJ: right () eh coming to you fred () a few things that can be grown once you've lined this tub

FD: you've got a choice of growing the acid lovers, and the lime lovers, the alkaline lovers, because you can change the compost in the tubs () and i think that is a very good idea because you, you known, you could grow heathers and comileans and things like that in one and switch other to things like vermums in another () and a lot of the plants that quite often down here, i would imagine, that get hit with wind burn from the salt air () a lot of plants with soft foliage like grislinea, that some of thing, which burn () i think in this situation you would be able to grow them in a tub () and being enclosed all round the side it would protect them () so i would be looking at things that none of the other floral art people have got in their garden, so the ones that they can't grow

CJ: now then, vivenne watson, can i ask you what you would like to grow particularly, anything

VW: yes () i am particularly fond of variegated things

CJ: ahh right

VW: yes they're more difficult erh () but

CJ: well () i don't think they need be sue need they variegated plants are easy in tubs

SP: well yes and if you are growing the plant primarily to decorate your courtyard i think you have got to think of the effect that they are going to create there too () so you have got to balance out, you know, how you are going to chop for flower arranging and how much you are going to leave the things looking presentable for appearances sake () but having said that i think there are a few things that will give you what you want () bamboo for instance always makes a smashing plant for a tub, it is not one that is widely promoted as a tub plant but it's good and of course you can cut it down, you known, you can cut some of it down quite regularly () eucalyptus, a lot of eucalyptus will stand being pollarded () one that i particularly like to cut and bring indoors is the spinning gun which us eucalyptus perennia () now it is not terribly hardy and i don't honestly know whether you would get away with it outside in winter even here () but in a tub you could always just, erm, quietly put it in a porch or somewhere where it has got a bit of shelter () petis sporum () now there are a number of quite attractively variegated petis sporum, they are going to grow a bit slower than the plain green one () but in a sheltered courtyard in this part of the country i think petis sporum would be very nice () and formeum, they are some absolutely sensational beautifully variegated formeums around now () salmon pink and cream and green variegated ones () and you could easily pinch a leaf off there from time to time

CJ: i jotted down one or two fortinia () you know fortinia with its wine coloured young leaves and peeris because there you have got the lovely young foliage and you have also got the lily of the valley centred flowers as well () erm holly I think you could in a tub () and rubennia () i know that we think of rubennia as a tree but if you are continually hacking at it () it makes a nice bush and you have got that () yes don't you you do flower arrangers you hack at the things (laughter) this lovely golden foliage you see () how about that

VW: well that's given me (   )

CJ: a few (   )

VW: (   )

CJ: something to think about

VW: thank you very much indeed

CJ: thank you madam () and next please

MG: moreen gittings () i want to make a labenum covered archway over a three foot path about fifteen feet long () can the team tell me how to start off, number of trees and how to train

CJ: thank you for the question because i am reminded of that superb labullum arch in bobmin gardens in north wales () have you seen it

MG: no

CJ: ahh well you don't know what you missed () its a long long arch, and in may when they are in bloom () you just walk through a haze of golden yellow as the rashes hang down () ah it's indescribable () anyway, that's beside the point, how should mrs gittings begin fred

FD: well I don't think you'll need to go to bodmin because you'll have your own in a few years time aren't you () people will be coming to visit your garden and walk through your labullum archway () when you do anything like this i think you got to remember you to have something for them to hang onto so you want some sort of support and i would suggest that you had made some metal supports, hoop shaped, so you have got their shape of the arch to start with () and then what you is what we call labullum whips, which are one year old plants just like a fishing rod just one straight stem, and you plant those, one at the bottom of each of these hoop, and i suggest that you plant six each side () so you have got them almost three feet apart () so you want six hoops, twelve labullum plants and that's where you start () and you prune them, whenever they want pruning () let the leaders grow, let them meet over the top and when they do meet graft these two together almost, plaid them together and they almost join () and then of course you take the ends out because they have gone far enough () they will also start to produce side growths () and again these side growths will want pruning you can spur prune these, that is any growth that comes off these side growths should be shortened back and it is normally done straight away after they have flowered () but of course in the first few years when yours are growing () then they may not flower so i would say you do these around the end of june beginning of july and you start off from there () and really when you get into it, it's quite easy and i would suggest that you use the variety bossi because you got the loveliest colour and the longest ( ) of flowers () it'll be absolutely beautiful

CJ: how tall should the archway be in the centre

FD: well it wants to be, i would say, at least about eight foot if you can manage it so you know you got a three foot pathway () but as long as it has got plenty room each side, i mean, you can go much further out than that () so you want to be eight or nine foot in the middle really, or you'll be dangling them on the top of your head

CJ: yes, and certainly needs to be more than three feet wide you see

MG: oh yes

CJ: can you make it, say, ten feet wide or something

MG: well i make it, yes probably

CJ: good, good, excellent () you'll enjoy it once it starts blooming you really will () thank you very much

VW: thank you

CJ: yes madam

BR: betty rooten () i have an eight year old mulberry tree, or bush, it is five foot high () how long will it be before it bears fruit and does it need a partner

CJ: thank you () now then betty rooten, stefan, has a eight year old mulberry, morus nigra () it will go to twenty feet won't it () so when indeed will it fruit () if it remains celibate

SB: erm, yes, it will grow to twenty feet or more in the fullness of time () now you said, clay, it's morus nigra () is it in fact morus nigra, is it the black mulberry

BR: i don't know () i've lost the label

SB: ahh () and it's not easy to tell without a label () and with no fruit () but i hope, i hope you have morus nigra because morus nigra, the black mulberry, is certainly the one to grow for the delicious mulberry fruit () the white mulberry will also produce fruit but not as dark coloured and not as tasty () but most nurseries when they sell them () for for, as fruit trees in fact do sell the black ones so i hope that is what you have () not a lot to do with a mulberry () except buy yourself a bench () put it underneath it () put your feet, up, sit back and wait () and wait, it'll take a time () what did you say it was, how old now, eight years old

BR: about eight years

SB: i would have said () if i was going to snatch a figure out of the air i would have said ten years for a mulberry to produce its first fruit so i don't in fact think you have a long time to wait () doesn't need a partner no they're self-fertile () but the one thing i would is that once your mulberry does start to fruit, as it well do most assuredly, then is the time to more your bench away from the mulberry tree, because the mulberry fruit stain clothing like nothing else () and if the fruit fall onto the bench and you then sit on them, then you'll wish hadn't

BR: thank you

CJ: fred, any more advice on mulberries

FD: the whole art of growing mulberries is that the fruit almost fall off when ready () shake the tree and they'll drop down () so what i would do as well as buying the bench () i would think about some net hammocks or something like that to catch the fruit on because if they drop on the ground, of course, they are damaged and they aren't that good, they don't keep very well () i think you'll find that () they will manage all by themselves because there are male and female flowers on the one tree () the male flowers, i'm afraid, are very small little slender things, and the big ones, almost like catkins, are the females and those are the one of course that you eat () of course they are the most delicious () like all females i suppose

CJ: ahh ladies men () sue do you like mulberries

SP: well i never actually tasted mulberries to be honest, but, the tree, whether it is fruiting or not, makes a very attractive shape () they tend to look sort of old and gnarled even when they are quite young () but i would expect that a mulberry tree has got to be about fifteen years old before it actually starts, fruiting, so i think that you have got a bit of a wait yet () but for anybody thinking of getting a mulberry tree, who doesn't want to wait fifteen years, there is a variety called chelsea which will start fruiting when it is as young as two or three years old, and you can even grow it in a pot if you like, so you could move it under glass and get early mulberries

CJ: erhm in the old gardening books the advice was that on the ground below the mulberry tree you spread a very soft cloth, and then you shook the tree () and they dropped and that's the way you harvested mulberry, be patient and try not to lose labels either () thank you very much

BR: (   ) thank you

CJ: thank you () and the next please

GW: geoffrey waters () i would like to start growing orchids () can the team please give me some advice on the species best suited for a beginner bearing in mind that i don't wish to use too much heat () i have a eight feet by six feet greenhouse that's keep just frost free

CJ: right sir () fred what can he start with

FD: i would go for the pleonis () these are all little tiny orchids () grow them in bowls or in pots () erhm they are very short but they do grow great big flowers on them there are several varieties available () the only trouble is that they flower during the spring and early summer, and during the winter they do die down as nothing left, but that is the time of course when you start to pot them up so you work on them at that time, and you think about the lovely show they are going to give you during the spring, and of course they grow outside or in a frame during the summer when other things are in the greenhouse () so beautiful things, and those are the ones i would recommend you started with and once you have started you'll be hooked, and you'll carry on growing them

CJ: so fred's choice is pleonis, which is a short little thing, but, you know, you have them in a half, half pot or a pan they look very very pretty () sue our choice

SP: yes if you want to grow orchids in a cool or cold greenhouse i think pleonis are definitely your best bet () but erm, do you have to grow these orchids in the green house, what about having a few indoors () the ones i would go for for house plants, are the moth orchids, phallanopsis, which are quite small plants, you usually get about three or four leaves on a plant at any one time, and they are quite large boat shaped leaves with a keel down the middle, perhaps about nine inches long, so they fit quite happily into a six inch half pot, and the flowers are magnificent they mostly flower during the winter, but you can get odd flower at all sorts of times, you get a great big arching spray of what look like, coloured moths hovering above the plants, you get a spray about perhaps eighteen inches long, with perhaps dozen or more flowers and they come in white and pink and all sorts of strips and spots and blotches most attractive, and very easy to grow if you can grow african violet you can grow phalanopsis () the great trick though is to, stand them on a tray of gravel so that there is plenty of humidity around them all the time they actually want air movement, so it is no good sticking them in a dingely little corner () they don't want to be in bright sunlight, but they do want reasonably good light () i grow mine on a coffee table inside the room where they are out of direct sun, but they have got moving air round them and they do very well indeed they're beautiful

CJ: if i could just say mr walters that i think sue is absolutely right and best of luck with them () thank you sir

GW: thank you very much

CJ: thank you () now then madam

JD: joy dawson () sadly my greenhouse is very ill with dry rot and this year it will be pulled down and re-built () my problem is that i have two black hamburger grape vines inside () they have been pruned and bark stripped () is it possible to keep them in a state of dormancy this year by continual pruning of new growth () obviously i don't want them damaged when work commences on the new house which is to be built around them

CJ: thank you () now then team, mrs dawson's greenhouse is dying of dry rot () its got to go, and hopefully a new one will rise like a phoenix from the ashes () but the point is what happens to the black hamburger vines in the meantime fred

FD: well i don't think you are going to keep them dormant whatever you do because these things will want to burst into growth () but what i do suggest you do is keep them tightly pruned () i think you can keep grape vines happy, living and well-being, just by having almost one or two leaves at every joint and nothing else, maybe even take some of the shoots off as they arise, and maybe space them two feet apart as long as you have got some growth there that grape vine will stay alive () it will stay happy, you can then protect it with hessian when the builders are there putting the greenhouse up and it be quite happy () don't feed it, keep it watered, and i'm sure it'll be there and it'll be happy again next year but don't let it go (   ) dormant whatever you do () in fact you won't be able to stop it

CJ: in fact i think fred has said it all () have not worries () thank you very much

JD: thank you

CJ: do we have another one

IS: iris saunders () i bought some gerburghs plants last summer which flowered to late autumn and they have been dried off from winter () what treatment is required to start them into growth and how soon should i start

CJ: oh you've mentioned one of my favour flowers iris saunders, the gerburghs, gerburgh jamesoni and there are new varieties now happy pot is one, lovely house plant, lovely also in window boxes i think () so what now stefan

SB: not any problem at all i don't think, yes clay's right there are a number of new gerburghs come on the market in recent years and they are beautiful for anyone not familiar with them they are, the characteristic shape of a south african daisy and this is basically what they are a genus of daisy-like plants from south africa and jamesoni, the one that was grown traditionally for many years has a lovely rich orange colour but there are others now these compact ones like happy pot, and ones that are routinely grown as annuals from seed () yours, erm, i think it is simply a matter of potting it up, anytime now () in fact i would pot it up in a soil base not peat base compost, use a john innes number one compost, pot it up start watering keep it warm erh temperature if you can manage it reasonably constant temperature of round about fifty () begin to water, begin, to feed when it is in growth again and off you go and i agree with clay i think they are absolutely superb () lovely lovely things

CJ: fred

FD: in the spring, around about the beginning of march, i take all the dead leaves off , pull them all off, and what i have got left is almost a dry root it looks as if its almost dead, knock it out of the pot, shake that old compost off, give it some new compost start them off again, water them, and then when you have used that, about eight weeks after they have been repotted then start to feed, don't get them too wet, and in the summer they'll be full of flowers again and they go and go on every year get bigger and bigger, more and more flowers, i would do without them

CJ: they are superb aren't they () who named them the thing, that variety happy pot i'll never know () sounds more like a baby's toilet doesn't it () it really does

(that's a nappy)

has that answered the question

IS: yes thank you very much

CJ: oh good thank you () and we have time for just one more question please

BD: betty davis () i have a problem with my red current bushes () i just get no fruit in them at all i've had them, this'll be the third year () they are very healthy looking () last year i had one string of red current and that was all what am i doing wrong

CJ: a lot () must be

BD: must be

CJ: eh any idea what the variety is

BD: i think it’s a dutch name, is it john her
venmets, or a name like that

CJ: do you know that one fred

FD: yes () have you done any pruning at all

BD: i haven’t pruned it at all ( ) i’m not quite
sure how to prune it

FD: well i’m glad that you haven’t because i don’t
think you should have done () but i think you are
being a bit impatient and i think this year you will
get a good crop of red currents, because red
currents fruit on two year old wood () they don’t
fruit like black currents on the first year’s wood,
they fruit on two year wood () and what you have
to do is let the plants grow their ordinary stems
then what they do they start to grow laterals, out
from those main stems, and it is on those side
branches, where your fruit will occur, but these
side branches have got to be one year old before
they will grow fruit () i would say this year, you
are going to enjoy your first red current pie () not
all crust like it was last year with two or three
berries () but big, thick, red current pies and they
are absolutely beautiful, and if you don’t want to
leave them until they go red you try having green
red current pie, it is absolutely delicious () the juice
runs down the side of your mouth ()

(laughter)

BD: thank you

CJ: so you have done nothing wrong it is just a
question of waiting until they are ready hmm
thank you for that question () well as we come to
the end of the programme team, as usual, i ask
you for your topical tips please, starting with you
stefan

SB: over the next few weeks we shall be planting
a great deal of plants and sowing a great many
seeds outdoor in the vegetable garden so what
you have to do is have the soil warmed before you
do that and the way to warm the soil, is to lay
plastic sheet over it and if any of you know any
physics at all you’ll realize it should be black

plastic because that absorbs heat, not white plastic
which reflects it, and certainly not clear plastic
which just encourages weeds to grow underneath

CJ: thank you stefan () sue

SP: if your lawn has any broken edges now is a
very good time to repair them, and you can do
that easily by cutting out a square of turf round
the broken part, lifting it, turning it round, and
replacing it the same spot, because now the
broken bit is inside the lawn and you can simply
fill the hole in with a bit of soil, and sprinkle some
new grass seed over the top () in next to no time
you won't even know that it was there

CJ: thank you sue () and finally fred

FD: i like to have flowering pot plants right
through the summer () and one of my favorites
have become the (   ) petunias, sow a few seeds
now () prick them out when they are large enough
() pot eventually three into a six inch pot, and you
will have potfuls of colour right through the
summer months

CJ: thank you fred and that's it () we have been
the guest of the aberporth flower arrangers club in
cardiganshire () please join us again next week,
and until then it is good bye, good gardening and
a very happy easter to you all, from doctor stefan
buczacki, fred downham, sue philips and from me
clay jones () a very good day to you

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