Complex Concepts:

The Semantics of Noun Modification

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Ph.D. Thesis

The University of Edinburgh

2000

For my parents

Declaration

This thesis has been composed by me, and the work contained within it is my own.

Peter Hipwell

Abstract

This thesis investigates adjective-noun and noun-noun combinations: structures known as complex concepts (Murphy (1988)). Many theories have been advanced to explain how the meanings of the two words are combined to produce the meaning of the combination. However, individual studies tend to focus on a limited set of examples. It is thus unclear how far proposed models can be generalised.

The approach taken in this thesis is a data-intensive one: models are analysed and extended in the light of the range of combinations found in a large sample of natural language (over 400,000 examples are available for consideration). This gives a coverage of combination types unavailable even in previous corpus-based studies of this field (e.g. Levi (1978)). The strength of the thesis lies in this access to a large number of examples of complex concepts: the models it advances are intended to cope with the actual range of combinations found.

Models are described using schemata, representational structures that are used in both linguistic and psychological models of concept combination (e.g. the modelling of adjective meaning in the generative lexical work of Pustejovsky (1995), or in the psychological work of Smith et al. (1989)). The thesis thus serves to give a picture of complex concepts covering a wide variety of different types of combination, while using a single standard for semantic representation. Individual chapters deal with different aspects of the corpus material: a number of modelling innovations are introduced.

Modifiers indicating properties of shape, colour and size are studied in detail. The modifiers are modelled as carrying out types of *property mapping* (see Wisniewski and Love (1998)): the schema structures advanced account for the range of uses that particular modifiers have, as well as for a range of modifier types. A distinction is made between mechanisms of property replacement and property alteration, accounting for the non-intersective nature of size modifiers.

The problem of adjectival polysemy is tackled in two ways. Firstly, the event predicate description of adjectives advanced by Pustejovsky (1995) is extended to a variety of combination types that he does not explicitly consider: it is also argued that many adjectives can operate both as event and formal predicates, which accounts for well-known cases of complex concept ambiguity. Secondly, a model is proposed in which certain modifiers are taken to operate metonymically: they specify properties of objects that are not referred to by, but are standardly related to the head noun. These two approaches to polysemy show that a portion of the seeming complexity of adjectival operation can be accounted for in relatively simple terms.

The thesis also advances models of adjectival modifiers that can operate privatively (see Franks (1995)). A single operation can account for both the privative and non-privative uses of these modifiers: thus, privation is revealed to be not an effect of particular modifiers, but an effect independent of semantic combination, arising from deduction about the category status of referents of the combination.

A large scale study of noun-noun combinations shows the patterns that that particular groups of words enter into. A model of combination is described which allows for the precise relationship between modifier and head noun to be identified, unlike theories using a standard but vague set of relationship predicates (such as Levi (1978) and Gagne and Shoben (1997)).

The final chapter approaches complex concepts from a complementary angle, using quantitative analysis of corpus material (as opposed to qualitative analysis). A corpus of language data is used to generate statistical data which describes the patterns of distribution entered into by particular words: this data is used for classifying both adjectives and nouns; its role in predicting response time in psycholinguistic experiments involving word recognition and complex concept interpretation is also investigated.

Acknowledgments

It is impossible to acknowledge all the sources of advice and friendship that have helped me through the years of writing this thesis. I hope anyone that I have inadvertantly neglected will forgive me.

I would like to thank Richard Shillcock, my supervisor, for his help during research and writing of the thesis; additional feedback on various parts of the thesis by Ewan Klein and Chris Mellish also provided invaluable assistance, both in outlining areas for investigation, and in supplying feedback on more concrete, technical issues.

Sound advice and alternative perspectives were provided by a host of other people. I would particularly like to thank Scott McDonald and Will Lowe for helpful discussions of experimental, statistical and representational issues; others have helped in many and various ways, and I would particularly like to thank Bernie Jones, Alice Drewery, Steve Martin, David Foster, Mike Pake, Sally Chou, Mark Ramsay, and Al MacDonald. Daniela Blyth gave me the strength to keep going, and somehow managed to keep me sane: I can never repay her all I owe. My biggest debt is to my parents, without whose support and love I could not have managed.

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Chapter 1

Complex Concepts

1.1 Introduction

1.1.1 A Definition of Complex Concepts

The operations involved in combining the meanings of English nouns and adjectives are the primary subject of this thesis. We are concerned only with two word combinations in which the second word is a noun: the first word can either be an adjective, as in combinations such as *tall man*, *fast car*, and *clever solicitors*, or a noun, as in combinations such as *dog kennel*, *butter knife*, and *stone house*.

These language structures have been referred to in the psychological literature as **complex concepts** (see Murphy (1988)), and we adopt this description as a general term for such combinations. The first word is known as a modifier; the second word is called the head noun, being syntactically the head of the phrase.

1.1.2 The Importance of Complex Concepts

Frege's Principle of Compositionality (see Dowty et al. (1992) pp.8–10) states that the meaning of a phrase should be deducible from the meaning of the parts that are used to construct it: in the case of complex concepts, representations of the meaning for modifier and noun should somehow be combinable, producing a representation for the meaning of the phrase as a whole.

This principle is a fundamental tenet of theories of meaning. However, no general analysis of the process of conceptual combination is currently available for complex concepts, even though these structures are extremely common in natural language. A theory that could explain how meanings are composed for such combinations would be an important contribution to semantic theory.

Naturally, this field of study also provides a testing ground for theories about the representation of "simple" concept structure: theories of concept representation (i.e. the representation of the meaning of individual words) can be evaluated according to whether they allow for the construction of meanings for complex concept structures.

The goal of this thesis is to provide a theory of representation and combination that models the operation of a wide range of complex concepts. However, it is well beyond the scope of a single study to tackle the whole range of combination types: this would require an adequate semantic analysis of all English nouns and adjectives.

1.1.3 Materials Used In The Thesis

Like linguistic studies of the 1970s and 1980s such as those of Ljung (1970), Levi (1978), Warren (1978), and Warren (1984), this thesis uses an extensive sample of real world language material in order to to investigate combinatorial theories. This data driven approach allows evaluation of compositional theories on the basis of whether they can account for the meaning of examples of word combinations found to actually be used by speakers of English.

This study is unique in using corpus data in testing theories of schematic representation (see Section 1.3.3 below), rather than using such data to produce relational theories, as was done in the studies cited above. Relational theories are discussed further in Chapter 5.

There are a number of studies that have investigated schematic representations in the light of interpretations generated by experimental subjects for a large number of complex concepts (e.g. Murphy (1988) uses 100 adjective-noun combinations; Wisniewski and Gentner (1991) use 400 noun-noun combinations). However, the examples used in these studies are artificially generated combinations.[1] This leaves the studies open to the criticism that the types of material investigated are not representative of the actual structures found in natural language. On the other hand, studies of combination which examine in detail only a few, specially selected examples of combinations suffer from the problem that they may not account for the actual range of uses a word enters into in real language. The data-driven approach adopted in this thesis circumvents these problems.

In the linguistic studies cited, all the work of finding examples had to be done by hand, limiting the volume of material that could be tackled. However, the availability of large amounts of language data on computer now provides a number of advantages in

[1] Wisniewski and Love (1998) examined some real language corpus material in their Experiment 3: this is discussed in Chapter 5.

this kind of work: particular language structures can be automatically extracted from the data using programs; large, diverse samples of language can be used as data; and the range of examples that a particular word (or subpart of a word) occurs in can be rapidly found. In order to provide an adequate number of complex concepts, I extracted all uninterrupted strings of nouns and adjectives from a portion of the British National Corpus (BNC) which included approximately 10 million words of spoken language, and an equivalently sized sample of written language.

Each word in the BNC is syntactically tagged. These tags were used to find strings of words containing only adjectives and nouns, unseparated by any form of punctuation, using a specially written *Perl* program. Strings marked as containing proper nouns (names) were excluded from consideration. Separate files of two word strings, containing adjective-noun and noun-noun combinations were produced: using the UNIX *sort -u* command, multiple examples of combinations were trimmed down to single examples, ensuring that no combination is reduplicated in the files. The end result of this process was a corpus containing 292401 unique adjective-noun combinations and 123896 unique noun-noun combinations. Thus, a large pool of examples is available (only a small fraction of these are considered in the course of the thesis).

It is, however, necessary to be slightly cautious about the contents of the corpus. Inspection of the sample suggests that although complex concepts do compose the vast majority of items (or, at least, most of the pairs found could be interpreted as complex concepts), some other kinds of combination also appear, in which the meanings of the two words are not combined. For example, we find combinations ending with words such as *mummy, dad, sir*, which seem to result from a person being addressed by a title (e.g. *afternoon sir*). We also find combination commencing with adjectives such as *afraid, aware, alright, sorry* which do not normally premodify nouns; again these often contain titles as the head noun (e.g. (*alright doctor, sorry officer*). Cases in which co-taxonyms or other close associates occur together (e.g. *salt sugar* or *sand surf*) may result from general processes of apposition such as making a list. Another possibility is that some combinations are included due to inadequacies of the tagging program used to classify the words: verbs may be misclassified as nouns, for example. On the whole, these other types of combinations seem to be relatively rare.

1.1.4 Background and Theories

Work on conceptual combination in complex concepts has been carried out in a variety of disciplines. The literature is diverse, being spread through a number of disciplines, each with different terminologies and assumptions about methods of semantic analysis.

These disciplines include formal semantics, linguistics, artificial intelligence and psychology. Work on the problem is spread through time, with various methods of attack on the problem of conceptual combination produced over the last fifty years (and more).

Assumptions about methods of semantic representation vary widely from case to case, and this presents difficulties for a cross-disciplinary study. Different structures and mechanisms are assumed as the basis for representation in different fields. In addition, the literature is generally not well cross-referenced, each field proceeding independently of work done in the others.

Given this, it will be useful to review some of the basic concepts found across the literature, and discuss their relevance to the contents of the thesis as a whole.

1.2 Semantic Effects of Combination

1.2.1 Three Types Of Combination

Introduction

A common assumption is that nouns refer to sets of entities. For example, the reference of *cow* could be described as being the set of all the cows in the world. Traditionally, adjectives can be thought of as being much like nouns.[2] Indeed, some adjectives can also be described as referring to sets of objects (e.g. *brown* refers to the set of all brown things in the world).

Assuming that complex concepts also refer to sets of entities, there are basically only three ways in which the set corresponding to the complex concepts is related to the set referred to by the head noun: the relation may be intersective, subsective or privative.

Intersective Relation

Firstly, the complex concept may be **intersective**: in other words, the modifier-noun structure will refer to the set defined by the intersection of the two sets corresponding to modifier and noun. For example, *brown cow* simply refers to those entities that belong both in the set for *brown* and the set for *cow*: likewise for certain noun-noun combinations, such as *pet fish*.

[2]The differentiation between "nouns substantive" and "nouns adjective" in English is not regularly made by grammarians until the seventeenth century (see Vorlat (1975)).

Subsective Relation

Secondly, the combination can be **subsective**. While not being intersective, the modifier-noun combination refers to a subset of those entities referred to by the head noun alone. This occurs for certain groups of adjectives, one example being those that indicate size. For example, taking the case of *large*: if large dogs were included in the set for *large*, and dogs are typically small as animals go, then the intersection of sets for *large* and *animal* would not give the set of large animals. However, large dogs clearly do belong in the set of dogs: the modifier *large* is subsective rather than intersective. Subsectivity is typical for noun-noun combinations: subsective combinations such as *chicken bone, telephone number, milk bottle*, and so on, are much easier to find than intersective noun-noun combinations.

Privative Relation

Thirdly, in some cases referents of the combination do not belong to the set referred to by the head noun: these are **privative** combinations (sometimes also referred to as being **exogenous**). In the case of adjective modification, this is exemplified by combinations such as *former senator*[3] (no former senator is currently a senator) and *fake fur*. It also occurs in noun-noun combinations such as *chocolate eggs* and *toy trains*. In some cases of privation, a reversal takes place, in which the combination refers to a subset of the objects referred to by the modifier, rather than the head noun (as for *toy trains*).

1.2.2 Other Effects

There are a number of other effects that can be significant in determining the interpretation of particular complex concepts.

Idioms

Idiomatic combinations, such as *white elephant*, could also be described as privative. However, the meanings of such phrases are not systematically produced; the meaning of the phrase has nothing to do with the meanings of either *white* or *elephant*. It seems that the only way their meaning can be found is if the meaning of the combination as a whole is stored. Thus, these examples violate the principle of compositionality: such cases will not be examined in detail in this thesis.

[3]This combination does not occur in the corpus: it is, however, a classic example of privative modification.

Hybrid Readings

Some combinations require **hybrid** readings: that is, the combination refers to a category that is somehow "intermediate" between those specified by modifier and noun.

In the linguistics literature, a distinction is made between **conjunctive** and **appositional** compounds. Conjunctive compounds are simply intersective combinations, but appositional compounds refer to entities which are produced by the joining of two entities (e.g. *Bosnia-Hercegovina* or *Rank-Xerox*). Although for both types of compound we can say the referent is described by both the first noun *and* the second noun, conjunctive compounds require the "and" to be read in the sense of logical conjunction (intersection), whereas appositional compounds require the "and" to be read in the sense of "plus".

Another kind of hybrid reading is mentioned by Wisniewski (1996): that in which a combination is taken to refer to something that has some of the properties of each category, as in *moose elephant*, interpreted as meaning "a large, heavy creature sharing properties of both an elephant and a moose".

Hybrid combinations are privative. However, these readings can only arise when the meanings of the words are extremely similar, referring to objects of very similar type.

Extensional Feedback

Murphy (1988) argued that models of conceptual combination also have to take account of **emergent features**: that is, properties inferred from pieces of information that we possess due to encounters with exemplars. For example, given that the combination *apartment dog* has been interpreted as meaning "a dog that lives in an apartment", there are a number of other features that might be inferred from this, based on our knowledge about specific examples of such dogs. For example, such dogs are likely to be small, yappy, and so on. This process of reasoning is known as **extensional feedback**.

This phenomenon is attested in the psychological literature: Medin and Shoben (1988) find that subjects attribute *wooden spoons* as having a greater size than metallic ones. This is a supposition based on experience, rather than a necessary consequence of their material composition. Similarly, Halff et al. (1976) note that things described as *red* are taken to be of different shades (bricks, hair, fire engines, etc.). Further to this, Wisniewski (1996) also suggests that particular properties imply possession of enabling properties (e.g. "produces milk" implies "mammalian", "female", etc.). Property correlations in general may be sources of extensional feedback (see Holland et al. (1986), Malt and Smith (1983), McRae and Seidenberg (1993) for discussions of

the role of property correlation in concept representation).

Construal

Wisniewski (1996) discusses a process of **construal**: the radical reinterpretation of a noun, in order for it to be understood in the context of combination. He mentions the examples of *tiger chair* interpreted as "a chair covered with tiger skin", and *moose pencil* interpreted as "a pencil with an eraser in the shape of a moose head on it". Clearly, the modifying nouns in these cases receive an interpretation quite different to the one we would think of as standard.

1.2.3 Discussion

The relations of intersectivity, subsectivity and privativity can be used to define three different classes of complex concepts, but this does not imply that there are three different classes of modifiers producing these effects: particular modifiers can act differently in different combinations. For example, *wooden* is intersective in the combination *wooden steps*, but privative in the combination *wooden elephants*. However, *wooden* intuitively has the same meaning in each case, indicating the property of being "made out of wood".

Therefore, whatever classes of word types and/or mechanisms of combination are required to model complex concepts, they should probably not be based on these three relationship types. However, because certain modifiers seem to always occur in (e.g.) intersective combinations, the relations are sometimes regarded as defining such groups of modifiers.

Extensional feedback, although of great psychological interest, is not directly relevant to the explanation of conceptual combination. It is a means of specialising a representation after a meaning has been found; it is not part of the process of semantic composition. For example, we may know that a *red fire engine* is a particular shade of red, but if a fire engine happened to be painted brick-red, it would still qualify as a *red fire engine*. The meaning of the combination is, in fact, independent of our specific knowledge about exemplars of the category.

In other words, interpretation of the combination must already have occurred in order for extensional feedback to have an effect: the process simply acts to elaborate the existing representation. Discussion of processes of extensional elaboration is therefore beyond the scope of this thesis. However, as we will see, failure to take into account this separation between the process of composition of word meanings and the effect of world knowledge has produced compositional theories which rely on over-specific readings of

particular combinations: see in particular Chapter 4.

Construal is somewhat different, in that it requires the reinterpretation of a word's meaning before the meaning of the combination can be found. However, construal is not sufficiently well-defined to be separable from normal disambiguation: many words are polysemous, requiring a particular sense to be selected in context. For example, in discussing systematic types of polysemy, Copestake and Briscoe (1992), Copestake and Briscoe (1995), describe a "grinding operator" for deriving both "fur" and "meat" senses from words labelling animals: precisely what is required for interpreting *tiger chair*.

It is not clear to what extent disambiguation of the words in a complex concept can be separated from the process of combination itself. While the problems of sense selection are not central to this thesis, they do receive some discussion: Chapter 3, in particular, is concerned with modelling adjectival polysemy.

1.3 Representational Systems

1.3.1 Introduction

Having given an overview of some of the effects involved in the interpretation of complex concepts, I will now introduce theories about how the meanings of individual words should be represented, and mechanisms for combining those representations. Ideas from the literature of formal semantics, linguistics and psychology are discussed, and the structures and mechanisms used as a theoretical basis within this thesis are described in detail.

1.3.2 Formal Semantics

Classically, adjective-noun combinations have been considered to be intersective: any combination that deviates from this would be taken as a special, unusual case (see Quine (1960), Section 21). This is an attractive theory: if adjective and noun meanings are defined in terms of sets, the meaning of a combination can be simply found, intersection being a primitive operation being applied to sets directly. This is supported by the fact that many adjectives seemingly do always operate intersectively (e.g. adjectives indicating colour).

However, this is clearly insufficient to model subsective and privative combinations. One solution to this problem is to model them as examples of more complex modes of combination. There is, though, another approach: intersective, subsective and privative modification can all be regarded as particular subtypes of a more general combinatory

mechanism, as was done by Montague.

Within the theory of Montague Semantics (see Dowty et al. (1992) for an introduction), words have particular types. Nouns are described as being of type $< e, t >$. They are functions, which map from entities (e) to truth values (t): in other words, given an entity, they define whether it belongs in a particular set or not. Adjectives, on the other hand, are of type $<< e, t >, < e, t >>$: that is, they are functions that map from one entity-to-truth function to another entity-to-truth function.

In other words, given the set corresponding to a noun, adjectives return another set, corresponding to the reference of the adjective-noun combination.[4] Modelling adjectives as functions in this way gives a model that can account for intersection, subsection and privation.[5]

This more general approach has the advantage of dealing with all cases of adjective modification in a unitary way. However, there are a number of points that this model does not explain.

Firstly, although we know adjectives are functions from sets to sets, the theory has a lack of descriptive power: there is no further explanation of how this works in the case of individual adjectives or groups of adjectives. The particular way in which specific adjectives operate as functions is of great interest: detailed studies of particular adjectives and adjective types reveal a great deal of complexity (see e.g. Kamp (1975), Platts (1979), Franks (1995)).

Secondly, the theory does not cope with the ambiguity of individual adjective-noun combinations. In Montague's original formulation, words were taken as being of a single type. This strict approach to typing may be overly restrictive: Siegel (1980), for example, advances the theory that many adjectives can operate both intersectively and non-intersectively, and thus suggests they have a "doublet" type, being both $< e, t >$ and $<< e, t >, < e, t >>$ (see Chapter 3).

Finally, this theory has little or nothing to say on noun-noun combinations. Given the assumption that nouns are of type $< e, t >$, the only mechanism for combining meanings is intersection, which is only applicable for a very small number of noun-noun combinations.

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[4] In fact, things are slightly more complex than this: in order to cope with certain language phenomena, such as words referring to non-existent entities (e.g. *unicorn*), a distinction is made between the extension of a word (the set of things in the real world it refers to) and the intension of a word (the set of all things it could refer to or, more precisely, the set of all its extensions in every possible world). In Montague's approach, an adjective would map from an intension to an intension, allowing the meaning of e.g. *white unicorn* to be found.

[5] Note also that this approach can also model a fourth relation type: that in which the reference of the complex concept is to a set of entities some of which belong in the set of the head noun and some of which don't. Such combination types do exist; see Chapter 4.

1.3.3 Schematic Approaches

Introduction

In this thesis, word meaning is represented in terms of schemata. A schema is a structured piece of information that can be used in representing the meaning of a word or of a combination of words. A schema presents a decomposition of the meaning of a word: a schema representing the meaning of *cow*, for example, will be in terms of the properties that cows possess: having four legs, being a mammal, chewing cud, mooing, and so on. This detailed structure is what an adjectives operate upon, to construct a meaning for the combination.

Schemata are used as representations of meaning in psychological theories of conceptual combination such as those of Murphy (1988), Smith et al. (1989), and Wisniewski and Markman (1993). In these approaches, combination of modifier and head noun involves the production of a new schematic structure from schemata corresponding to the individual words.

Theories using set structures to represent meaning are typically divorced from psychological considerations ("Montague thought of the analysis of language as a branch of mathematics rather than of psychology", Dowty et al. (1992), p.253). However, we can regard schemata as being mental representations of word meanings: as such, they are equivalent to the formal semantics notion of a word's intension: that is, they provide a procedure for identifying every possible exemplar of that category (i.e. they do not simply list existing exemplars). Thus, if we treat adjectives as functions that carry out some operation on a head noun schema to produce a new representation, this is equivalent to describing a mapping from intension to intension: it can be used to model the relations discussed above (intersection, subsection, privation).[6]

[6]There has been much debate about the role of fuzzy sets as models of meaning, particularly in the light of psychological evidence that categories are structured with reference to the prototypicality of particular exemplars (see Rosch (1975) for a discussion of prototypes; Osherson and Smith (1981), Lakoff (1987), and Huttenlocher and Hedges (1994) discuss prototypicality and complex concepts; Smith et al. (1989) provide an explicit model of such effects for adjective-noun combinations). The debate over complex concepts is based on whether the intersection of fuzzy sets is sufficient as a model. As Lakoff (1987) (Chapter 9) rightly points out, it is well-known that intersection is not a sufficient model with respect to classical sets; thus there is no reason to assume it ought to be sufficient for fuzzy sets. I don't regard this as a central issue for the thesis: adjectives could be defined as functions on fuzzy sets in precisely the same way as they are in Montague Semantics, even having the same type assignments for words: the only difference need be that t can take values anywhere between 0 and 1, rather than just 0 or 1.

$$\begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

Figure 1.1: A feature bundle schema

$$\begin{bmatrix} \text{ALPHA} & P(x) \\ \text{BETA} & Q(x) \\ \text{GAMMA} & S(x) \end{bmatrix}$$

Figure 1.2: A schema with slots and fillers

Types of Schemata

The simplest schematic structures consist of a list of features. This model was put forward by Katz and Fodor (1964). This type of structure is displayed in 1.1.

Generally, schemata have more structure to them than this. Usually a schema is divided into particular **slots** which can contain information, known as the slot's **value** or **filler**, as in Rumelhart (1980). A schema of this type is illustrated in 1.2. Slots are indicated with small capital letters (e.g. ALPHA), with the fillers indicated in lower case italics. In this example, fillers are expressed as one place predicates.[7]

Schematic work is not confined to the psychological literature. Of particular interest for this thesis is the generative lexical work of Pustejovsky (1995), which tackles the problem of adjectival polysemy within a schematic framework. The structures used in this work are more elaborate than slot and filler models typically suggested as models of meaning within the psychological literature. This richer representational structure allows for the modelling of complex semantic effects.

Pustejovsky's use of predicates as fillers is non-standard within the formal semantics field; however, it can be regarded as a shorthand for the decomposition of clauses into relations and arguments. Thus, the first predicate from Figure 1.2 could also be represented as in Figure 1.3, following Nerbonne (1992), or as in Figure 1.4, following Copestake et al. (1999). In order to be concise, the use of predicates as slot fillers, following Pustejovsky, is maintained throughout the thesis.

[7]As discussed in Pustejovsky (1995), the use of predicate fillers allows for the schema to express relationships with other objects: however, as we will see, in some cases the filler may simply be a constant (e.g. see Section 2.4).

$$\begin{bmatrix} \text{ALPHA} & \begin{bmatrix} \text{PREDICATE} & P \\ \text{FIRST} & x \end{bmatrix} \end{bmatrix}$$

Figure 1.3: Alternative to Predicate Filler 1

$$\begin{bmatrix} \text{ALPHA} & \begin{bmatrix} & P \\ \text{INSTANCE} & x \end{bmatrix} \end{bmatrix}$$

Figure 1.4: Alternative to Predicate Filler 2

In addition, it should be noted that Figure 1.2 contains a sequence of different predicates. An alternative way to represent this would be as a list of resrictions on an index, as in Minimal Recursion Semantics (see Copestake et al. (1999)). Thus, a less abbreviated representation of Figure 1.2 would be the structure shown in Figure 1.5. The abbreviated form of Figure 1.2 is used throughout the thesis.

In Figure 1.6 we can see some of the possibilities available within the type of representation used by Pustejovsky. Firstly, the fillers of slots may themselves be schemata, containing a list of slots and fillers (the same notion is used by Murphy (1988) for describing body parts). Secondly, slots can take n-ary predicates as fillers, allowing relationships between types of objects to be expressed. Thirdly, there is a division between slot types EVENTSTR, ARGSTR, and QUALIA (the latter two only indicated in the figure): the QUALIA slots contain the features that would be thought of as conventional semantic features, e.g. specifications of colour, shape, function, and so on, while the other two specify the types of the arguments of the predicates in the QUALIA slots. Thus, 1.6 describes a physical object which is related to information in some way, and

$$\begin{bmatrix} \text{INDEX} & x \\ \text{RESTRICTIONS} & < \begin{bmatrix} \text{ALPHA} & \begin{bmatrix} \text{P} \\ \text{INST} \quad x \end{bmatrix} \end{bmatrix}, \begin{bmatrix} \text{BETA} & \begin{bmatrix} \text{Q} \\ \text{INST} \quad x \end{bmatrix} \end{bmatrix}, \begin{bmatrix} \text{GAMMA} & \begin{bmatrix} \text{R} \\ \text{INST} \quad x \end{bmatrix} \end{bmatrix} > \end{bmatrix}$$

Figure 1.5: Alternative to Predicate Filler 3

$$\begin{bmatrix} \text{ARGSTR} & \begin{bmatrix} \text{ARG1} & x : physical - object \\ \text{ARG2} & y : information \\ \text{ARG3} & z : human \end{bmatrix} \\ \text{QUALIA} & \begin{bmatrix} \text{ALPHA} & \begin{bmatrix} \text{T1} & P(x) \\ \text{T2} & Q(x) \end{bmatrix} \\ \text{BETA} & \begin{bmatrix} \text{T3} & S(x) \\ \text{T4} & T(x) \end{bmatrix} \\ \text{GAMMA} & Relation1(x, y) \\ \text{DELTA} & Relation2(x, z) \end{bmatrix} \end{bmatrix}$$

Figure 1.6: A complex slots and fillers schema

also related to humans in some way.

These structural elements are extremely useful in modelling certain types of complex concepts, and will be introduced in more detail in the appropriate places through the thesis.

The Operation of Modifiers

Given schematic representations of noun meaning such as those illustrated above, there must be a method of representing modifier meaning, and a way of combining the meaning of the two words. Mechanisms for doing this are now considered.

Feature Structure Combination The mechanism of composition for sets of features given by Katz and Fodor (1964) is simple; the sets are added together through conjunction, as is seen in 1.7. This amounts to a model of intersective combination, the representation for the combination containing all the features that define membership in both sets (i.e. those corresponding to modifier and head).

Slots and Fillers: Noun-Noun Combinations A slot and filler model is able to cope with a wider range of combinations, including a proportion of noun-noun combinations, if a mechanism of **property mapping** is used to combine schemata.

Wisniewski (1996) argues that property mapping is a strategy widely used in the interpretation of noun-noun combinations: experiments in which subjects had to describe

$$\begin{bmatrix} a \\ b \\ c \end{bmatrix} \wedge \begin{bmatrix} d \\ e \\ f \end{bmatrix} = \begin{bmatrix} a \\ b \\ c \\ d \\ e \\ f \end{bmatrix}$$

Figure 1.7: Feature Bundle Combination

the meaning of 160 artificially produced noun-noun combinations of various types indicated that a property mapping strategy was used in 41 percent of the interpretations. Later work by Wisniewski and Love (1998) suggests that the proportion of combinations for which property mapping is adopted as a strategy vary from 0 to 65 percent, depending on the types of nouns involved.[8]

Wisniewski and Markman (1993) and Wisniewski (1996) suggest that mapping is co-ordinated by the presence of **alignable differences** in the two noun schemata. The idea of alignable difference comes from recent work on analogy (see, for example, Markman and Gentner (1993)). Alignable differences occur where two schemas share particular slot types, but the values in those slots are different. In such cases, property mapping is possible. Thus, in this model of noun-noun combinations, property mapping operates in such a way that the fillers of a slot (or slots) from the modifier's schema are mapped into the corresponding slot in the head noun's schema, replacing any value previously specified there.[9] The schema thus produced represents the meaning of the combination.

The effect of alignable differences is reflected in the finding that similarity affects the interpretation process (see Wisniewski (1996)). The higher the subject-rated similarity of the words in a noun-noun combination, the greater the likelihood of a property-mapping or hybrid interpretation.[10]

Examples of property mapping interpretations mentioned by Wisniewski, with slots and fillers being described in intuitive terms, are: *elephant clay*, with the value for

[8]Clearly, then, property mapping does not account for all cases of noun-noun combination. Other models of noun-noun combination are considered in Chapter 5.

[9]Wisniewski also mentions that there must be another mechanism in operation when a hybrid interpretation is required: e.g. *fork spoon* may be interpreted as having the function of both a fork and a spoon, and thus function properties would have to be conjoined, rather than any straightforward replacement taking place.

[10]Although rated similarity decreases with the number of alignable differences, similar pairs have many commonalities as well as many alignable differences.

$$\begin{bmatrix} \text{SHAPE} & cubical(x) \\ \text{FUNCTION} & contains(x,y) \end{bmatrix} + \begin{bmatrix} \text{SHAPE} & shape(x) \\ \text{FUNCTION} & tells-time(x) \end{bmatrix} = \begin{bmatrix} \text{SHAPE} & cubical(x) \\ \text{FUNCTION} & tells-time(x) \end{bmatrix}$$

Figure 1.8: Combination of *box* and *clock*

COLOUR ("grey") being mapped; *pencil rake*, with the value for SHAPE ("thin") being mapped; and *tiger pony*, with the value for VISUAL TEXTURE ("striped") being mapped. The example of *box clock*, interpreted as being a clock that has the SHAPE properties of a box (rather than being "a clock on top on a box", or "a clock in a box") is displayed in Figure 1.8.[11]

Note, however, that the FUNCTION filler is not mapped from *box* to *clock*: this illustrates the fact that constraints other than alignability must be at work in order to prevent "overenthusiastic" mapping of properties: after all, whenever two nouns that refer to concrete solid objects are combined, there can be a large number of properties specified for both (e.g. shape, size, colour), and not all of these will be mapped. Wisniewski thus speculates about possible further constraints on mapping, such as correlations between different properties, the diagnosticity of features, and so on. Patterns of constraint for noun-noun interpretation are also discussed by Costello and Keane (1997).

Slots and Fillers: Adjective-Noun Combinations Adjectives can also be modelled as operating through the mechanism of property mapping. An example is given in Figure 1.9 for the combination of *pink* and *elephant*.[12] The adjective schema here is taken to be like that of the noun schema, but simpler in structure (indicating only a single property). The suggestion is that adjectives work through a mechanism of **selective modification**, operating on a particular slot (or small group of slots) in the head noun schema (as in Smith et al. (1989)): they would not require mechanisms of schema co-ordination like those required to model noun-noun combinations, as all fillers in the adjective schema would be mapped.

[11] In Figure 1.8, the combination of modifier and head schemata is indicated with the operator "+". This is merely used to indicate that some operation of combination is being applied: the operation here is not equivalent to conjunction as only some features from the modifier are relevant to the meaning of the combination as a whole. Note also that the filler for the slot SHAPE in the representation of "clock" is given as *shape(x)*: this nonspecific predicate is used because a clock may be of any shape.

[12] Note that a model using combination of sets of features would create a representation such that both *pink(x)* and *grey(x)* were features in the representation of meaning for *pink elephant*, whereas a slots and fillers model can prevent the attribution of incompatible properties. Again, the operator "+" is used as a convenience to indicate that some process of combination is operating.

$$\begin{bmatrix} \text{COLOUR} & pink(x) \end{bmatrix} + \begin{bmatrix} \text{COLOUR} & grey(x) \\ \text{SIZE} & large(x) \\ \text{SUBPARTS} & has-trunk(x) \end{bmatrix} = \begin{bmatrix} \text{COLOUR} & pink(x) \\ \text{SIZE} & large(x) \\ \text{SUBPARTS} & has-trunk(x) \end{bmatrix}$$

Figure 1.9: Combination of *pink* and *elephant*

$$\begin{bmatrix} \text{SLOT1} & m \longmapsto n \end{bmatrix}$$

Figure 1.10: Adjective Function

As we will see, the simple replacement of feature values is insufficient for modelling particular combinations, in particular the subsective and privative combinations mentioned above (Murphy (1988) and Pustejovsky (1995) also present evidence as to the flexibility of adjective use, and the complexity of modelling their operation). In some cases, a systematic pattern of *alteration* to fillers (as opposed to their straightforward replacement) is required to model the effects of adjective modification; in other cases, the adjective may have to operate on different features, according to the type of head noun it is combined with. In order to deal with this, I have modelled adjectives as being *functions* operating on noun schemata, rather than assuming a separate function that combines adjective and noun schemata.[13] This is done by describing them as carrying out pattern matching to regular expressions in the head noun schema, and performing systematic transformations on those patterns.

Several pattern matching mechanisms are introduced in Figures 1.10 to 1.14: these are inspired by the pattern matching and transformation abilities of the computer language *Perl* (see Wall and Schwartz (1991) for an introduction to the language). This limited set of mechanisms will be sufficient to cover all the adjective operations considered in this thesis.[14]

In Figure 1.10, a simple pattern matching rule is given: the adjective matches the constant m in the slot SLOT1, and maps this filler to n, as indicated by the arrow. Thus, the function acts to transform a constant to another constant.

In Figure 1.11, the meta-characters "." and "*" are used in matching. As in *Perl*, "." will match any character at all, and "*" indicates a string of any length (including

[13] In other words, in this approach, there is no separate operation to be expressed by an operator such as "+".

[14] Also used are the standard logical connective symbols $\vee$ (disjunction) and $\wedge$ (conjunction).

$$\left[\text{SLOT1} \quad .* \longmapsto n\right]$$

Figure 1.11: Adjective Function

$$\left[\text{SLOT1} \quad !R^*(!!.!!,.)! \longmapsto !1 \vee P(!2)\right]$$

Figure 1.12: Adjective Function

zero) of the type of character preceding it. Thus, ".*" will match a string of any characters (i.e. any filler of SLOT1), and the adjective maps from this to the constant n. This function is therefore the same as straightforward filler replacement.

In Figure 1.12, two other pattern matching operations are introduced.

The first of these is indicated by the exclamation marks, which are simply delimiters which allow for matched material to be duplicated elsewhere in the schema: "!1" refers to the matched string of material that is contained within the single exclamation marks (in this case "$R^*(.,.)$"), and "!2" refers to the material matched within the double exclamation marks; naturally this can be extended as far as necessary. The second is the use of, "R^*", which simply matches any predicate name: in this case, the match is to a two place predicate ("$R^*(.*)$" would match n-ary predicates in general). Thus, if the filler in the head noun was "$hits(x, y)$", then the resulting filler would be "$hits(x, y) \vee P(x)$"; if the head noun specified "$opens(y, x)$", then the result would be "$opens(y, x) \vee P(y)$". This allows for abstract matching to particular types of fillers, but reproduction of the exact elements matched to in the result.

In Figure 1.13, a notation is introduced in order for matching to be allowed to slots that appear within other slots: a path through the slots is indicated with the symbol "|". This function would match within Figure 1.6, transforming the "$P(x)$" filler to the disjoint filler "$P(x) \vee N(x)$".

In Figure 1.14, another form of abstraction is introduced, the notation "α^*", which will match any path of slots. This function would have the effect of transforming the

$$\left[\text{QUALIA|ALPHA|T1} \quad P(!x!) \longmapsto P(!1) \vee N(!1)\right]$$

Figure 1.13: Adjective Function

$$\left[\alpha^* \quad R^*(.) \longmapsto P(x)\right]$$

Figure 1.14: Adjective Function

$$\left[\text{COLOUR} \quad .* \longmapsto pink(x)\right]$$

Figure 1.15: Representation for *pink*

filler for *all* slots containing a one place predicate to "$P(x)$".

Regular Expression Mapping and Formal Representation Regular expression mapping gives a powerful method of expressing the operation of functions that act to systematically alter the structure of schemata. For example, the function in Figure 1.15 would operate to replace any filler in the COLOUR slot of a schema with the filler *pink(x)*.

The operation of such a regular expression mapping function could be reconstructed in a formal semantic framework such as categorial unification grammar (see Calder et al. (1988), Zeevat (1988)) using a representation such as that given in Figure 1.16, where $\frown \sigma$ indicates string concatenation, $\oplus$ indicates a list appending operator, and $\bigcirc$ is Reape/Kathol sequence union (see Kathol (1995), Reape (1996)).

Figure 1.16 shows a formal representation of how *pink* could operate on the meaning of a noun σ that is concatenated with it. As seen in Figure 1.5, the semantics of a noun can be modelled in terms of a list of restrictions (RESTR) on an index (INDEX). The right hand side of Figure 1.16 will correspond to the representation of any noun σ in which RESTR contains a list one element of which specifies a value for COLOUR: the list L contains all elements in RESTR except that of COLOUR. The left hand side of Figure 1.16 shows that the representation for *pink* $\frown \sigma$ (a concatenation of the phonology of *pink* with the noun σ) will contain within RESTR a list composed of the list L plus a new element which specifies a COLOUR value of "pink".

Figure 1.16 thus shows that *pink* acts as a function which replaces the COLOUR value of a noun it applies to with the new COLOUR value of "pink". For example, it would operate on the representation of *elephant* given in Figure 1.17 to produce the representation for *pink elephant* given in Figure 1.18.

This type of formal representation can be regarded as underlying the more informal

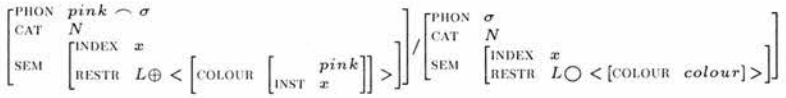

Figure 1.16: Representation for *pink*

Figure 1.17: Representation for *elephant*

Perl-style notation: both carry out a search for a specific kind of representational structure, and replace this with another piece of information. However, this provides only a single example of equivalence between the formalisms, and it is a matter for further investigation how far the other operations discussed in this thesis can be cashed out within such a framework.

While the pattern-matching operators discussed in this thesis are to some extent inspired by formal semantics, this thesis should not be taken to belong within that literature: the thesis does not provide a formal, rigorous treatment of noun modification but rather takes an intuitive and suggestive approach to the field, following the lead of psycholinguistic theories such as Murphy (1988) and Gagne and Shoben (1997).

A final caveat: many issues concerning the way in which semantic information in the lexical entries of nouns and adjectives interacts with the interpretation of nominal phrases falls ouside the scope of this thesis.[15] Wider sentential and pragmatic context also has a significant effect on how these phrases are understood.[16]

1.4 Outline of Thesis

I have described schematic mechanisms that may be used to model the process of semantic combination during noun modification in complex concepts. The term **property mapping** is used to encompass both the noun-noun alignment theory, and the mapping function description of adjectives: in both cases, fillers (properties) from a head noun's

[15] One obvious example is how multiple noun modifiers interact with each other: for example, is a *tall Hungarian man* a tall man who happens to be Hungarian, or a Hungarian who is tall only compared to other Hungarians?

[16] For example, consider examples of oxymoronic combinations such as *round square*, which could not be modelled in terms of a simple property mapping. Combinations of this sort are generally used in natural language to produce particular stylistic effects, and are not intended to be interpreted literally.

$$\begin{bmatrix} \text{PHON} & pink \frown elephant \\ \text{CAT} & N \\ \text{SEM} & \begin{bmatrix} \text{INDEX} & x \\ \text{RESTR} & < \begin{bmatrix} \text{KIND} & \begin{bmatrix} \text{INST} & x \end{bmatrix}_{elephant} \end{bmatrix}, \begin{bmatrix} \text{COLOUR} & \begin{bmatrix} \text{INST} & x \end{bmatrix}_{pink} \end{bmatrix}, \begin{bmatrix} \text{SIZE} & \begin{bmatrix} \text{INST} & x \end{bmatrix}_{large} \end{bmatrix} > \end{bmatrix} \end{bmatrix}$$

Figure 1.18: Representation for *pink elephant*

schema undergo a mapping from some value to another, creating a representation of the combination's meaning.

This thesis uses the corpus of examples described in Section 1.1.3, in order to show how these mechanisms can be used to model combination for a wide range of test cases, giving a broadly applicable, consistent and detailed picture of conceptual combination within the schematic framework. Particular theories of modification are described within the terms of this framework: the test cases are used to show where such theories apply, and where they can be extended to cope with a broader range of real language data. Individual chapters are divided to deal with particular types of property mapping: each one concerns specific mechanism and combination types.

Chapter 2 is concerned with simple cases of property mapping. It looks particularly at combinations involving mapping on the slots specifying COLOUR, SHAPE and SIZE: classic cases of intersective and subsective adjectives are considered, as well as the operation of denominal adjectives and modifying nouns. In addition, the operation of adjectives that specify general kinds of resemblance are discussed.

Chapter 3 discusses property mapping in the light of the problem of adjectival polysemy. Particular attention is paid to the theory of Pustejovsky (1995), which advances a simple mechanism for coping with such polysemy: this is evaluated with the use of corpus data. In addition, a novel approach to modelling uses of adjectives connected through metonymy is advanced.

Chapter 4 presents an analysis of cases of privative modification. Data about the full range of combinations in which particular modifiers occur is used to demonstrate that the process of combination of modifier and noun can be analysed without reference to whether the combination is privative or not.

Chapter 5 is concerned with noun-noun combinations. Theories involving relational analyses of complex concept meaning are discussed and evaluated. An alternative interpretation using schemata is presented and discussed in the light of a large scale analysis of combinations involving 30 different nouns, previously investigated by Wisniewski and Gentner (1991) in the context of artificially produced combinations.

Chapter 6 investigates the use of corpus data to produce objectively definable measurements of language structure that are predictive for psycholinguistic tasks, including

the speed of interpretation of noun-noun combinations.

Chapter 2

Simple Property Mapping

2.1 Introduction

This chapter is primarily concerned with simple cases of property mapping. This implies mapping involving intersective and subsective combinations in which polysemy is basically unimportant. Generally, these cases can be modelled with fairly simple mechanisms, typically involving only a single slot of the head noun. However, the actual representations required to account for the range of combinations found can be surprisingly complex.

These simple modifiers are investigated mainly through three case studies in which adjectives and modifying nouns relevant to the SHAPE, COLOUR and SIZE slots of the head noun are studied. These fields are especially suitable for this study because, in addition to the standard groups of adjectives we know to exist, there are also sets of compound denominal adjectives constructed such that that the particular property mapping is explicitly indicated in a hyphenated suffix. Examples of such modifiers are *egg-shaped, mustard-coloured* and *rabbit-sized*: the notion that such adjectives act to map fillers that are derived from their source nouns[1] seems unavoidable.

As mentioned in Chapter 1, only a certain proportion of noun-noun combinations are interpretable in terms of a property mapping mechanism. There is no *a priori* method of identifying combinations in which this takes place. However, the identification of source nouns in compound adjectives from which these properties can be mapped gives a starting point from which to search for noun-noun combinations in which property mapping takes place: combinations in which the source nouns (and semantically similar nouns) are used as the modifier can then be examined. Using this method, it will be

[1]The source noun being the noun that the adjective is derived from: in these cases, *egg, mustard* and *rabbit*.

possible to identify a wide range of combinations involving property mapping on the same slot.

In addition, a fourth case study was also carried out in which more complex cases of property mapping were considered: this involved examining all combinations containing a denominal adjective ending with the suffix *-like*. The suffix seems to imply that there is some form of resemblance between source and head nouns, without specifying what it is. In examples of this type, a wider range of property mapping patterns are found, giving a more general insight into the ways in which mapping occurs.

Thus, the general questions that are addressed in this chapter are: what kinds of schemata are required to account for combinations found to occur in the corpus; whether there are any differences in the types of mapping that can be carried out from adjectives and nouns; and whether the property mapping strategy is widely and systematically used in interpreting noun-noun combinations, and if so, which factors other than alignable differences are important in triggering and co-ordinating a property mapping interpretation.

2.2 Case Study: Modifiers of Shape

This first case study investigates property mapping involving the SHAPE slot. I identify three kinds of shape modifiers:

- Standard Shape Adjectives
- Compound Shape Adjectives
- Nouns

These three types will be addressed in turn.

2.2.1 Standard Shape Adjectives

Introduction

I define standard shape adjectives as being a set of commonplace denominal adjectives, derived from nouns referring to shapes. Examples are words such as *circular, conical, cubical, curved, cylindrical, hexagonal, oblong, octagonal, oval, rectangular, spherical, square, triangular.*

$$\left[\text{SHAPE } .* \longmapsto \textit{hexagonal}(x)\right]$$

Figure 2.1: Representation for *hexagonal*

$$\left[\text{SHAPE}|\text{2D } .* \longmapsto \textit{circular}(x)\right]\left(\left[\text{SHAPE } \begin{bmatrix}\text{3D} & \textit{prism}(x)\\ \text{2D} & \top\end{bmatrix}\right]\right) = \left[\text{SHAPE } \begin{bmatrix}\text{3D} & \textit{prism}(x)\\ \text{2D} & \textit{circular}(x)\end{bmatrix}\right]$$

Figure 2.2: Combination for *circular towers*

Intersectivity

These adjectives are good examples of classically intersective modifiers: sets of objects of a particular shape can be readily identified. The different shape qualities are clearly distinguishable: the sets corresponding to these adjectives do not overlap at all. In formal semantic terms, these adjectives could be described as one place predicates.

Schema Structure

In Figure 2.1, a schematic representation for *hexagonal* is given. The adjective simply operates as a function on the SHAPE feature of the head noun, mapping from any value (matched by .*) to $\textit{hexagonal}(x)$: this assumes that the argument x in the head noun always indicates the set of objects that the head noun refers to.

However, this kind of structure is not sufficient to model all of the combinations that standard shape adjectives enter into. For example, consider the combinations *circular towers*, *rectangular temples* and *hexagonal lantern*: the adjective indicates a 2-dimensional shape, whereas the head refers to a 3-dimensional object. The modifier is, in fact, specifying what a cross-section of the object looks like.

This can be modelled with a slightly more complex representation, in which the SHAPE slot of a head noun contains another schema, in which different aspects of shape are represented. Figure 2.2 demonstrates how schemata for *circular* and *towers* could be combined to give a representation for *circular towers* using a structure such as this.[2]

Further complexities are introduced by the fact that in some combinations, the adjective indicates the shape only of some subpart of the object. An example of this is

[2]Only the relevant portion of the schema for *towers* is shown; the representation of its shape. Note that the symbol $\top$ is used to indicate that a value is left unspecified.

$$\left[\begin{array}{ll} \text{SHAPE} & \left[\begin{array}{ll} \text{TOP} & \left[\begin{array}{ll} \text{2D} & \top \end{array}\right] \\ \text{LEGS} & \left[\begin{array}{ll} \text{3D} & prism(x) \\ \text{2D} & \top \end{array}\right] \end{array}\right] \end{array}\right]$$

Figure 2.3: Part-representation of *table*

$$\left[\text{SHAPE}|\alpha^*|\text{2D} \quad .* \longmapsto square(x)\right]$$

Figure 2.4: Representation for *square*

square table, in which the shape modifier is indicating the shape of the tabletop. Other cases are *square seat* and *hexagonal key*.

Assuming that the SHAPE feature contains specifications for each subpart of an object, a representation such as that given for *circular* could not be aligned with the noun schema: there is an extra "level" of schema representation in the way, as can be seen in the partial representation of *table* given in Figure 2.3. However, a shape adjective representation such as that for *square* given in Figure 2.4, with an additional * symbol (implying a "match" with any anything, but in this case with no transformation applied to the "matched" part). This kind of representation will give a modifier the ability to map to parts of the schema structure which are deeply embedded in a noun representation.

However, this approach would have the disadvantage that the schema for *square* could now match with each and every specification of 2-dimensional shape for all subparts of an object. Thus, constraints are needed to ensure that only one mapping is carried out, to the correct subpart. However, there are not a large number of examples of subpart mapping in the corpus; therefore it is difficult to discover what the systematic patterns here might be. There are two obvious candidates: firstly, the mapping could be to the most salient or important subpart; secondly, mapping could be to a part for which shape values are not strongly constrained. However, no conclusion can be drawn without further data.

Discussion

There are a few other uses of these adjectives which are not concerned with shape. For example, *circular* can refer to information structure, as in such combinations as *circular advice, circular logic, circular argument.* It is also found in combinations such as *circular letter, circular ticket, circular platform*: however, these are actually cases of noun-noun combination, rather than adjective-noun combination; *circular* is used as a noun to refer to types of printed material, and also to railways. Several idiomatic combinations are found for *square*, such as *square eyes, square meal, square root* and *square leg.*

There are also a few combinations such as *circular design, cylindrical plan, rectangular plan, hexagonal plan* which can refer to referents which do not necessarily contain any such shape, but only information about objects of that shape.

In general, however, these adjectives can be represented as simply operating on the SHAPE slot of the head noun. Shape adjectives would classically be described as one place predicates, that act intersectively with nouns. However, the corpus data suggests that the operation of standard shape adjectives is somewhat more complex than this: their use is broader than intuition would suggest. While the filler values given above suggest a one place predicate definition, the specification of shape may apply to cross-sections or subparts of an object, rather than to its shape as a whole. However, adjective schemas that are flexible enough to cope with all these possibilities may be over-powerful: thus, it is likely that additional constraints on the property-mapping operation are needed.

2.2.2 Compound Shape Adjectives

Compound shape adjectives are constructed from a source noun which is joined with the suffix *-shaped.* The meaning of such adjectives can be modelled using values taken from the SHAPE features of the source noun to construct adjectival schemata. By looking at examples of combination, we will see how this can be done.

We will first examine cases in which the source noun is used for labelling concrete objects, then move on to other cases.

Concrete Object Source Nouns

Table 2.1 lists source and head nouns found in particular combinations: thus, the first line indicates the combination *aeroplane-shaped kite*, and so on.

The range of examples found makes it clear that novel examples of this modifier type can be generated and interpreted. It is therefore necessary to specify how the

Source Nouns	Head Nouns
aeroplane	kite
boat	piece
bottle	shoulders
bowl, dog	depression
coffin	box
cup	mouthpiece, nests
dome	bags, models
egg	cupolas
heart	face, ring, cufflinks
helmet	chattri
lance, strap	leaves
leaf	body
lemon	fruits
mushroom	domes
onion	headpiece
pancake, spade	mass
pear	bend
shell	ends
slot	entrance
teardrop	face

Table 2.1: Source Nouns and Targets for SHAPE mapping

meaning of these adjectives can be derived from that of the source noun. The obvious assumption is that the source nouns have default value specifications for SHAPE, which may indicate very specific shape configurations. The compound adjectives could then be specified in terms of a function mapping from any filler to these specific values.

For example, a simple schema modelling the meaning of *pancake-shaped* is given in Figure 2.5, 2D shape being indicated iconically.[3] However, *pancake-shaped* isn't simply indicating a large circular shape: when in a combination, it will also operate to specify that, like a pancake, referents will have the quality of being flat, i.e. have no third dimension. Thus, it acts to indicate a very specific kind of shape. Given the representation of Figure 2.5, *pancake-shaped* could never indicate the shape of a cross section: this seems to be a reasonable assumption.

We again see cases in which the mapping of SHAPE values applies only to subparts of the head noun schema, as in *heart-shaped cufflinks* and *heart-shaped ring.* This

[3]There is no reason from the data to assume *pancake-shaped* can indicate the shape of object subparts.

$$\begin{bmatrix} \text{SHAPE}|\text{3D} & .* \longmapsto \textit{inapplicable} \\ \text{SHAPE}|\text{2D} & .* \longmapsto \bigcirc(x) \end{bmatrix}$$

Figure 2.5: Representation for *pancake-shaped*

$$\left[\text{SHAPE}|\alpha^*|\text{2D} \quad .* \longmapsto \heartsuit(x)\right]$$

Figure 2.6: Representation for *heart-shaped*

implies that the more powerful representation given for standard shape adjectives may also apply in these cases: a schema of this kind for *heart-shaped* is given in Figure 2.6, the shape predicate being indicated iconically. It should be noted that *heart-shaped* conventionally indicates a 2-dimensional shape, as on playing cards: this is only arbitrarily related to the shape of the body part.[4]

Shape Source Nouns

Another group of compound adjectives is derived from source nouns that can conventionally denote a shape. Combinations with adjectives of this kind are *cone-shaped heater, cone-shaped summit, cube-shaped superstar, diamond-shaped plan, diamond-shaped sections, diamond-shaped symbols, disc-shaped seeds, oblong-shaped area, wedge-shaped building, wedge-shaped piers, wedge-shaped sector.*

Again, these modifiers are also used in referring to the shape of cross-sections (e.g. *square-shaped flask*), and to subparts of objects (e.g. the blade of a *crescent-shaped knife*).

If the source nouns are conventionally used to refer to shapes, the suffix might be redundant. However, omitting the suffix from these examples produces combinations such as *cone heater*, *diamond plan*, *diamond sections*, and *wedge sector*. Clearly, these combinations could take on readings completely unrelated to SHAPE property mapping. The suffix acts to force a shape property-mapping reading.

One reason that omitting the suffix can produce a different reading is that the source nouns may have more than one sense. For example, *diamond* is used to denote both

[4]It is possible that the meaning for *heart-shaped* is thus conventional and stored. However, we see heart shapes much more frequently than we see actual hearts: ♡ is a familiar, well-defined shape. Similarly, the modifier *teardrop-shaped* refers to a standard, conventional shape.

the shape ♦ and the gem. Similarly, *crescent* and *square* may refer to types of street rather than shapes, a fact reflected in the construction *oval-shaped square*. Similarly, a *disc* can be a non-disc shaped recording, such as a floppy disc.

The fact there are these separate readings means that there must be some method of selecting the appropriate sense to map SHAPE values from when the source noun is combined with the suffix *-shaped*. This could be done simply by taking the sense of for which the SHAPE feature is most diagnostic for class membership. This will clearly always be the case for the senses referring straightforwardly to shapes – the SHAPE feature is the only feature needed to define those senses.

Letters as Source

Another group of compound adjectives are also found in which the first element is a letter: we find, for example, the constructions *j-shaped boreholes, l-shaped piece, s-shaped curve, s-shaped front, s-shaped quillons, u-shaped tubes, v-shaped park, v-shaped vein, y-shaped gully, y-shaped structure.*

It is interesting that orthographic shape characteristics are mapped in this way: one would generally think of letters as contentless, but obviously there must be a means of specifying their shape. Letters are also sometimes incorporated into nouns such as *s-curve, T-junction, u-bend, u-turn, Y-maze* where they indicate a similar shape mapping, although there are other cases where letters are used in a similar way without shape mapping occurring (e.g. *e-mail, u-boats*).

Discussion

Compound shape adjectives can generally be modelled as mapping SHAPE values from the source noun. Thus, these modifiers can specify complex kinds of shapes. They operate much like standard shape adjectives: mappings involving object cross-sections and subparts are possible, for example.

Interestingly, however, there are also some examples in which only some of the source noun's SHAPE features are mapped. For example, *bottle-shaped shoulders* seems to imply an analogy of shape from around the neck of the bottle to around the neck of a person; *egg-shaped cupola* implies a curved shape like that of part of an eggshell. In these cases, the head noun refers to an object that is configured in a way that would not allow it to possess all of the shape properties that the source noun does.

It is not always obvious what the mapping should be. For example, the meaning of pear-shaped bend is not apparent: possibly it refers to a bend with the same shape as the outline of a pear in silhouette.

However, there is only one case which cannot be interpreted in terms of a property mapping from the source noun. This is *eddy-shaped sail*: an eddy is (debatably) not something with a shape, so there may well be no property here to be mapped. This combination should probably be read as "sail shaped by an eddy".

2.2.3 Shape and Modifying Nouns

Although there are some well-established compounds in which shape properties are mapped from a modifying noun (as in *beehive hairdo, mushroom cloud*), systematic mappings of this sort seem much less common.

Nouns which standardly refer to shapes, such as *circle, cube, cone, disc, hexagon, square, sphere*, etc. do not seem to be used as shape modifiers, probably because of the existence of corresponding adjectival forms.

I could find no examples of shape property mapping from the nouns *arrowhead, banana, bowl, egg, fan, keyhole, kite, onion, pancake, pear, petal.*[5] Even *heart* and *diamond* are not systematically used for shape mapping: as a modifier, *heart* is used 71 times, but almost always used in reference to the bodypart (the only obvious relevance of the modifier to shape being in *heart shapes*); *diamond* is used 45 times, and typically refers to the gemstone (the only shape mapping being *diamond kite*).

In fact, the only example I have found of a noun being systematically used to convey SHAPE properties is *box* (suggested by Wisniewski's *box clock* example of shape-property mapping). Possible examples of shape mapping in the corpus involve *box* modifying *bed, bedroom, camera, car, file(s), frames, hat, hedges, kite(s), lamp(s), room, seat, shape, ships.*[6] Clearly, *box* is used for mapping SHAPE values from, but even some of these cases are debatable: for example, a *box seat* could be a seat shaped like a box, but the combination is more likely to refer to a seat in a box, for example at the theatre.

2.2.4 Summary

Analysis of the corpus data reveals some interesting aspects of the operation of shape modifiers. There are a number of complexities that are not intuitively obvious, such as the ability of modifiers that indicate 2-dimensional shapes to specify the cross-section of a 3-dimensional object, and the ability of modifiers generally to specify the shape of object subparts.

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[5] Most of which are used to modify the noun *shape*: words used to modfiy this noun don't, however, seem to be systematically involved in shape property mapping.

[6] A more comprehensive analysis of the uses of *box* is to be found in Section 5.5.1.

The schematic structure I have suggested for representing shape adjectives therefore allows matching of subslots within the SHAPE slot. However, this representation will allow for mapping of values to a variety of different subslots: therefore, constraints must be imposed so that only the one correct slot is chosen. Possibly the mapping is to a salient subpart, or to a part that is not constrained as to shape. More data is required to resolve whether and when these constraints operate.

In addition to the standard shape adjectives, a number of compound shape modifiers were examined. It seems that the meanings of these modifiers are generally computable: they seem to be mapping the source noun's SHAPE values.

However, there seemed to be only a few cases in which the mapping of SHAPE properties was carried out from modifying nouns. The lack of such examples could simply be due to the wrong type of nouns being examined: but there were no examples even for nouns that are obvious candidates for mapping from, such as *heart* and *diamond.*

2.3 Case Study: Modifiers of Colour

The second case study investigates property mapping involving the modifier's COLOUR slot. I distinguish between four types of colour modifiers:

- Standard Colour Adjectives
- Hybrid Colour Adjectives
- Compound Colour Adjectives
- Nouns

These types will be addressed in turn.

2.3.1 Standard Colour Adjectives

Introduction

Standard colour adjectives are simple, common words primarily used to describe colours: the examples considered in this case study are *red, orange, yellow, green, blue, purple, pink, brown, grey, black, white.*[7] Other words may also be considered as standard colour adjectives (e.g. *scarlet, mauve, buff, dun, tawny*), but uses of these in hybrid and compound adjective constructions are not considered below.

[7]This set of 11 is the same as the "basic" set of colour terms identified by Berlin and Kay (1969).

$$\left[\text{COLOUR } .* \longmapsto blue(x)\right]$$

Figure 2.7: Predicate representation for *blue*

Intersectivity

Standard colour adjectives are paradigm examples of the applicability of the intersective model of combination: a set of entities of a particular colour can be found because it is possible to judge what the colour of an object is without reference to other features of that object.[8] Thus, like shape adjectives, colour adjectives may be defined as simple one place predicates in formal semantic terms.

Feature Values

An obvious schematic definition of standard colour adjectives would consist of a single slot that mapped any COLOUR value to an appropriate filler, in the same way as shape adjectives. However, a representation of *blue* such as that given in Figure 2.7 does not adequately express what the colour is.

Colours differ from shapes, in that the standard colour adjectives divide up a *continuum* of actual shades. Colours are related in particular ways (e.g. *red* and *green* are dissimilar colours, while *red* and *pink* are somehow closely related). The set of colour adjectives is not, then, simply indicating a set of discrete, entirely separate qualities.

The fact that colours form a continuum is underlined by the existence of derivative colour terms produced by suffixation with *-y* and *-ish*. Examples are adjectives such as *greenish* or *yellowy* which are used to label shades that are similar to that indicated by the word they are derived from.

These derivative adjectives are clearly related in meaning to the standard colour adjectives: it seems that their meanings must be systematically derived from the meanings of the standard colour adjectives.[9] A *greenish* colour is one that is not quite green, a shade that falls far from the central or focal shade of green (i.e. the shade of green judged by people to be the best example of the colour).

However colour values are to be represented, the representation must have a structure which reflects these kinds of relations between colours.

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[8] Indeed, standard colour modifiers are also classified as mass nouns.

[9] I did not argue for a similar process with shape adjectives, because shape adjectives don't undergo this inflection systematically. While *squarish* might be acceptable, **octagonalish*, or **conicalish* are not.

A suitable candidate for a representation system is suggested by the work of Miller and Johnson-Laird (1976), who present an identification procedure for particular colours. This is based on Hering's theory of opponent colours, which is supported by neurophysiological evidence that certain colour pairs are encoded in the brain as opposites (DeValois and Abramov (1966)). To identify a shade, judgements are made on three axes. Each axis represents a judgment about the relative intensity of opponent colours. For example, the RED-GREEN axis might be divided into 3 regions of discrimination, labelled by a plus sign (+), a minus sign (-), and zero. If more red than green is discriminated, the judgment will be (+), if red and green are about equal, the judgment will be (0), and if there is more green than red, then the judgment will be (-). Similar three way discriminations apply on YELLOW-BLUE and BLACK-WHITE axes.

Thus, the three judgments made allow for twenty-seven (3^3) different shades to be distinguished. A system of this sort could provide a suitable framework for representing colour in schemata: Miller and Johnson-Laird (1976) go on to label the 27 different regions with 27 different colour labels, but the labels are wrong for a theory of colour property representation (as opposed to the identification procedure they are modelling). For example, they apply *blue* as a label for one region, *light blue* to a different region, and *dark blue* to a third region. A representational theory would require that *blue* encompass all three of these regions, as light blue and dark blue are clearly subtypes of blue.

However, the three axis system can be adapted to represent standard colour adjectives. In Table 2.2 I present a description of the eleven standard colour adjectives in terms of a triplet of values for these three axes: red-green (RG), yellow-blue (YB) and black-white (BW).

In the first three lines we see, as would be expected, *white* and *black* at the opposite ends of the BLACK-WHITE scale, with *grey* in between: these three have neutral (0) values for the other two axes. The next four colours, *yellow, green, blue* and *purple* have no specified value for the BLACK-WHITE scale: all shades of dark and light colours are thus included. The representations for *red* and *pink* show the similarity of the colours, the difference being that *pink* ranges across the white region of the BW scale, while *red* ranges across the neutral/dark regions: *brown* and *orange* are similarly related.

Thus, although there are only 27 regions in the colour space, there are more possible specifications of colour than this, because definition of a colour does not require that a value for each axis is precisely specified.

From this, it is simple to suggest schemata for all of the 11 standard colour adjectives: the proposed representation for *blue* is presented in Figure 2.8: the triple of values is ordered in the same way as those in Table 2.2.

Colour	**Triplet: RG, YB, BW**
black	$(0, 0, -)$
white	$(0, 0, +)$
grey	$(0, 0, 0)$
yellow	$(0, +, \top)$
green	$(-, 0, \top)$
blue	$(0, -, \top)$
purple	$(+, -, \top)$
red	$(+, 0, 0 \vee -)$
pink	$(+, 0, +)$
brown	$(+, +, 0 \vee -)$
orange	$(+, +, +)$

Table 2.2: Values for 11 standard colour adjectives

$$\left[\text{COLOUR} \quad .* \longmapsto \left[\text{REGION} \quad (0, -, \top)\right]\right]$$

Figure 2.8: Representation for *blue*

This representational scheme does not allow us to represent the meanings of derivative colour adjectives such as *greenish*. But it is also the case that more than 27 shades can be discriminated by humans. As Miller and Johnson-Laird (1976) point out, the axes can be divided into more than three regions. If, for example, we were to divide each of the three axes into five regions instead, then the system would be able to specify 243 (3^5) different shades. In such a system, *green* could be represented with the triplet $(-2, 0, \top)$ and *greenish* with $(-1, 0, \top)$.

Thus, the model of colour representation using only 27 shades is overly simplistic. However, the *precise* numerical details here are not important: what is important is that this *type* of representation gives an internally structured description of colour that allows for the relationships between colours to be described. As we will see in Section 2.3.2, this is necessary to explain how other types of colour modifier operate. The simple type of representation suggested in Figure 2.7 is inadequate.

Polysemy

Standard colour adjectives are not only used to indicate colours. In some cases, they can instead be used to suggest a political character, as in *green alliance, red army, black consciousness.*

Therefore, it seems that a value for political orientation (POLITIC) must also be specified in the modifier schema: as there is no specific systematic connection between colour and political orientation, only arbitrary imposed relationships, there can be no means by which the value of POLITIC can be derived from that of COLOUR, or vice versa. Both slots and values must be explicitly stored.[10] Such a representation for *red* is shown in 2.9.

Possible mappings are constrained by the type of object under consideration. Values for COLOUR can be mapped to any noun schema representing a concrete object: such objects must always have a colour. However, where the head noun refers to an abstract object, there will be no such slot: no such mapping can occur.

What the adjective means is therefore affected by the structure of the head noun schema. If the noun has slots for both COLOUR and POLITIC, potential ambiguity of the combination will result.

[10] In other cases, systematic connections between different senses of a modifier do exist: this is explored in Chapter 3.

$$\left[\begin{array}{ll} \text{COLOUR} & .* \longmapsto \left[\text{REGION} \quad (+, 0, 0 \vee -)\right] \\ \text{POLITIC} & .* \longmapsto \mathit{socialist}(x) \end{array}\right]$$

Figure 2.9: Representation for *red*

Discussion

Few corpus examples have been presented in this analysis of standard colour adjectives: this is because in practically all cases they operate to indicate colour in a straightforward manner. What is not straightforward is the type of description that is necessary for the relatedness of different colour terms to be described. A theory in which colours correspond to regions defined in a three dimensional space, the axes measuring the relative intensities of red-green, yellow-blue, and black-white, was adopted.

As mentioned in Section 1.2.3, colour adjectives may be interpreted differently depending on the noun they modify. However, this is not relevant to the process of combination: *red ants* and *red apples* may well be of different shades, but both combinations *could* label objects that fell anywhere within the part of the spectrum that is covered by *red*. Extensional feedback can only operate on the *result* of the combinatory process.

2.3.2 Hybrid Colour Adjectives

Introduction

Hybrid colour adjectives are composed of two standard colour adjectives (or derivatives) joined by hyphenation. Examples from the corpus are shown in Table 2.3. I have described these as hybrid adjectives, as they are similar to the hybrid compounds described in Section 1.2.2. Like those examples, the meaning of these modifiers is derived from the meaning of the component words in one of two ways: conjunctively, where the modifier suggests a single colour that is somehow intermediate between the two colours; or appositionally, where the referent is vari-coloured: striped, spotted, alternating in colour over time, etc.).[11]

[11] Hybrid modifiers may also refer to political orientation (e.g. *red-green coalition*).

2nd element	1st elements
red	black, purple, orange
orange	browny, reddish, pinky
yellow	brownish, purple
green	blue, bluey, grey, greyish, yellowy, red, browny
blue	green, grey, greyish, purple, purpley
purple	greenish, greyish, browny
brown	grey, greyish, red, reddish, yellowish, pinky, black
grey	blue, reddish, yellow, brownish, purply, green
black	blue, grey, greyish
white	black, blue, grey, yellow, yellowy

Table 2.3: Colour Hybridization

$$\left[\text{COLOUR} \;\; .* \longmapsto \left[\text{REGION} \;\; (+,0,0 \vee -) \vee (-,0,\top)\right]\right]$$

Figure 2.10: Appositional Hybrid: red-green

Hybrids as Modifiers

All other things being equal, the default assumption must be that a hybrid colour modifier is appositional: vari-colouration is possible in all cases, but only some colours have a definable intermediate.

In the case of appositional hybrids, colour could simply be represented as a disjunction of the values from the two different COLOUR slots, as shown for *red-green* in Figure 2.10. Where varicolouring is present, some parts of the object will be one of these shades, some parts another.

In many cases, the hybrid modifier is conjunctive, indicating a single colour. However, each of the 11 standard colour adjectives is defined in terms of a separate part of colour space in Table 2.2. How, then, can intermediate colours be calculated from the disjoint values given in the schema?

A few simple rules make this possible. Firstly, there cannot be an intermediate colour if both (+) and (-) values are specified for one axis by the two colours. Otherwise, (0) and (+) for one axis implies the intermediate has (+); (0) and (-) implies the intermediate has (-); two identical values imply the same value. If a colour can have more than one value for an axis, the combination takes values shared by both colours,

if there are any, otherwise disjoint values can be treated as (0).[12] These rules ensure that combination can be achieved if there are no conflicting judgments necessary for each colour to be recognized: where a judgment is neutral for one colour, the positive judgment for the other colour "overwhelms" this.

Applying these rules allows for the definition of hybrid colours such as *blue-green*, corresponding to the triplet $(-,-,0)$ and *purple-red*, corresponding to the triplet $(+,-,0 \vee -)$.

The only hybrids given in Table 2.3 that cannot specify an intermediate colour, according to these rules, are *purple-yellow, browny-green, red-green* and *black-white.* Non-occuring combinations that the theory would predict could not be conjunctive hybrids are: *pink-black, orange-black, yellow-blue, brown-blue, brown-purple, orange-blue, orange-purple, green-purple, green-pink, green-orange.* This seems to to be generally accurate.

Discussion

The description of colour values we have adopted allows for an explanation of how definitions for hybrid colour adjectives can be constructed.

The default specification must be as an appositional modifier: after all, any object might be vari-coloured.[13]

Whether the modifier can be interpreted as a hybrid depends on the noun it modifies: if objects denoted by the head noun are not typically vari-coloured, then a hybrid reading is possible. If they are typically vari-coloured, then the appositional reading may still hold (e.g. because we know that a *tiger* is striped, we are likely to assume striping for a blue-green tiger, even though no blue-green tiger has ever been encountered).

The appositional schema is sufficient to model the operation of these modifiers; a decision as to whether the hybrid is conjunctive or not is a process reliant on extensional feedback. However, the method of defining intermediate colours has been discussed, as it illustrates the importance of having a detailed means of representing colours.

[12] I am assuming that derivative adjectives have the same representation as the adjective they are derived from. More complex rules along similar lines could be devised for representations with a greater number of regions defined along each axis; e.g. opposites would still be incompatible, with the value for intermediates being defined on the basis of the relative intensity of each colour for each axis.

[13] However, the inflectional structure of the first element in the compound also seems significant. Where the first element is a derivative form, this seems to indicate a disjunctive reading is not possible: if something is a *greenish-grey*, it is unlikely that it is part *grey*, and part *greenish.*

Fruit and Flowers
apricot, chestnut, lavender, lilac, orange, peach, raspberry, rose, saffron, sage, strawberry, vanilla, violet
Minerals
bone, copper, gold, ivory, lemon, mud, ochre, pearl, peat, platinum, sand, sienna, silver, slate, sludge, sulphur, tin, tooth

Table 2.4: Source Nouns occuring with *-coloured*

2.3.3 Compound Colour Adjectives

Introduction

In addition to compound colour adjectives constructed from a source noun and the suffix *-coloured*, there are also adjectives constructed from a source noun that is suffixed with one of the standard colour adjectives, such as *brick-red, sky-blue.*

Both types of compound adjective will be considered; those constructed with *-coloured* will be taken first, and then adjectives produced with a colour adjective suffix will be examined.

Compound Colour Adjectives: Part One

Nearly all adjectives constructed with *-coloured* involve colour property mapping. In most cases, the source noun labels a concrete object. Table 2.4 shows two groups of source nouns from which COLOUR values are mapped: nouns referring to fruit and flowers, and nouns referring to types of minerals.

The operation of these modifiers will be to map properties from the COLOUR slot of the source noun schema. This allows for colours to be specified in very precise terms. Given (say) 243 regions over which colours can be defined, the standard and hybrid colour adjectives will cover a lot of regions. However, a particular noun might have a COLOUR value that pinpoints just one of the 243 regions: a particular pale kind of green, for example. In addition, there are other aspects of visual texture that may be conveyed by using a compound adjective: whether the surface is matt or gloss, qualities of translucency, iridescence, and so on.[14]

The types of nouns from which mapping occurs are therefore those for which a COLOUR value can be very precisely specified. For example, in many cases fruit, flowers

[14]The examples *peacock-coloured* and *rainbow-coloured* seem to be more mappings of a complex visual texture than of a colour.

and minerals are distinctively coloured, and all examples in the class are consistently in this way: the range of colours for a *strawberry* is very restricted.[15] The colour characteristic has a high diagnostic value for identifying fruit. Naturally, there are other senses in which some of these nouns can be interpreted: nouns such as *apricot, chestnut, lemon, peach, raspberry, strawberry* may refer either to a whole plant, or specifically to the fruit of the plant. However, it is the fruit that has the most distinctive colour: the colour of leaves, for example, is usually not a quality used to distinguish between plants; it is a characteristic low in diagnostic value. [16]

Other source nouns from which colour properties are mapped are foodstuff nouns (*chocolate, cream, honey, tea, wine*), animals (*lobster, mole*), and a variety of others (*bruise, flame, flesh, heather, khaki, moon, parchment, tuppence*). The mappings for some of these must be conventionalised: *flesh-coloured* refers to a specific skin tone, for example, and *wine-coloured* suggests a red colour. However, others of them are clearly novel, freshly created mappings (e.g. *tuppence-coloured, moon-coloured*).

Only a few examples could not easily be analysed in terms of colour property mapping. Two were clearly not colour mappings: *hand-coloured*, which refers to the method by which colouration occurs, and *warning-coloured*, referring to the function of the colouration. The constructions *atlantic-coloured regard* and *branch-coloured collar* are more obscure: it is not clear how these should be interpreted. There are also cases in which the source noun can be a colour adjective: *pink-coloured, grey-coloured.* These seem to operate just like the standard adjectives.

Compound Colour Adjectives: Part Two

The range of compound adjectives constructed with an adjective suffix are displayed in Table 2.5. The types of source nouns used here are similar to those found in adjectives constructed with *-coloured*, with nouns referring to plants and minerals predominating. Their functioning also seems similar, with the source noun acting to indicate a very specific colour value.

The suffix indicates that this is a colour mapping adjective. However, in some cases it has the additional function of specifying which of a range of alternative colours is meant. For example, a *brick* may either be orange or blue; the suffix in *brick-orange* makes it clear which of these shades is meant. Similarly, the colours of particular subparts are suggested by the suffixes in *kingfisher-blue* and *turkey-red.*

[15] At least, prototypical examples will always have a very specific colour.

[16] Costello and Keane (1997) suggest that mapping in noun-noun combinations is likely to be from features that are diagnostic for class membership; it seems likely the more consistent a property's value is across a class of objects, the higher its diagnosticity.

Adjective Suffix	**Source Nouns**
red	blackcurrant, blood, brick, henna, mahogany, ruby, rust, tile, turkey, wine, fire, rhubarb
orange	brick, flame
yellow	canary
green	almond, apple, cabbage, grass, olive, snot, cabbage, moss, jade, lime, spinach, pistachio, sea, snake
blue	sky, steel, lavender, slate, kingfisher
pink	apricot, piggy, rose
brown	chestnut, chocolate, peat, shit, mud
grey	ash, concrete, dove, iron, lichen, silver, slate, steel
black	coal, eye, ink, jet, pitch, raven, soot
white	ash, bone, flour, milk, pearl, snow, sheep

Table 2.5: Compound Colour Adjectives

However, there are a number of other examples which are not so easily interpreted: these are cases where the association between the head noun and the adjective suffix is not obvious. For example, the adjective *cardinal-red* seems to be carrying out a mapping from the colour of the robe that a cardinal wears in his official capacity; the modifier *death-white* refers to the skin colour of a corpse; *midnight-blue* suggests the darkness at midnight. In other cases, the colour associations seem to be completely arbitrary, being based on tradition as in the cases *baby-pink, baby-blue, navy-blue* and *royal-blue*. The meanings of at least some of these must be stored wholesale in order for interpretation to be possible: no compositional process could produce the colour values for these modifiers.

In addition, some of these compounds can be interpreted as *hybrid* colour modifiers in which the first element is a noun rather than another standard colour adjective. Examples of this are *cherry-brown, smoke-brown, gold-white, gold-brown, blood-pink, blood-black*: most of these suggest the existence of intermediate colour values, although *chocolate-purple* seems to be necessarily appositional. The modifier *blood-orange* might be of this type, or might be taken as involving mapping of the colour of a blood orange.

Discussion

A number of interesting mapping patterns were found for compound colour adjectives. Nouns that can refer to concrete objects are frequently found in these modifiers: it seems that the extremely specific colour values that they contain are what is being

Mapping to Clothing and Fabric
lavender shoes, lavender tweeds, lilac coat, lilac cotton, lilac skirt, lilac tie, marigold hats, apricot knickers, champagne silk, champagne dress, chocolate sweater, cream blouse, cream jodphurs, cream shirt, cream silk, cream tights, cream trousers, mustard shirt, maize silk, oatmeal sweater, peach dress, peach jumper, saffron satin
Mapping to Face/Features
chestnut hair, ginger hair
Mapping to Animals
chestnut mare, chestnut thoroughbred, ginger cat, marmalade cat
Mapping to Furniture and Rooms
chocolate compartment, cream rooms, mustard kitchen, primrose room
Other Mappings
lavender mist, violet pen, violet light, rose quartz

Table 2.6: Mappings from Fruit, Flowers and Food

mapped: they pinpoint a small region within the colour space, as opposed to the large areas specified by standard and hybrid colour adjectives.

The nouns from which colour values are mapped seem to have an extremely specific and consistent specification of COLOUR: these values are highly diagnostic for membership in the class. Thus, we find that groups of semantically similar nouns occur frequently as the source noun: in particular, nouns that can refer to minerals and plants are frequently used.

I have not specified a schematic structure for these adjectives: fundamentally, it would be like that of Figure 2.8, involving a straightforward replacement of the head noun's COLOUR slot value with a specific triplet. Possibly other features relevant to colour (e.g. lustre) are also mapped.

2.3.4 Colour and Modifying Nouns

There are a reasonable number of examples of colour mapping occuring directly from the kind of nouns found in compound colour adjectives, and there do appear to be systematic patterns in the kinds of mapping that take place. Examples in which the modifying noun can refer to a flower, fruit or foodstuff are given in Table 2.6; examples in which the head noun can refer to a type of mineral are given in Table 2.7.

Naturally, there is no way to identify cases of noun-noun colour mapping directly. Some combinations can receive different interpretations: for example, there are a very large number of uses of *silver* and *gold* as modifiers that could be either colour map-

Mapping to Clothing and Fabric
amber shirts, jade skirt, ivory silk
Mapping to Face/Features
amber eyes, emerald eyes, ivory face, ivory cheek, ruby lips, silver eyes, silver hair
Mapping to Animals
amber snake, ochre camel, emerald snails, silver fishes, silver trout, silver horse, silver chicken
Mapping to Furniture and Rooms
gold furniture, gold curtain, gold cushions, mud rug
Other Mappings
amber fluid, amber light, amber oil, charcoal cumulus, gold card, gold paint, gold leaves, gold light, silver mist

Table 2.7: Mappings from Minerals

pings, or refer to the material composition of an object. Similarly, it is unclear whether examples such as *mandarin head-dress* or *salmon sheets* are colour mappings. Nevertheless, a colour mapping interpretation is highly plausible for all the examples given in the two tables.

Even though the above sample is limited, it is suggestive of a strong patterning in the types of objects that are mapped to and from, e.g. mappings to fabric and clothing are relatively commonplace. There are pragmatic reasons why these particular patterns should exist. As discussed in Section 2.3.3, for a noun to be a good candidate for mapping from, it must have a *distinctive* value for COLOUR, which is *consistent* across exemplars of the category (as is usually the case for flowers, fruit, foodstuffs, animals and minerals). In contrast, the nouns that are mapped to are those that refer to objects that can have radically different colours (e.g. clothing and fabrics can take be any colour at all: the default value for the slot must be left as unspecified ($\top$)).

In other words, the narrower the range a particular noun specifies as the default values for COLOUR, the better a candidate it is for mapping the value from. The less diagnostic COLOUR is for the head noun, the more likely it is to have this property mapped to it.

Derived colour adjectives can be constructed from some of these nouns, examples being *orangey, peachy, silvery, muddy, mustardy, rusty, creamy.* There are also a number of examples such as *gingery-red, steely-blue, smoky-blue, mousy-grey, creamy-white* which also seem to be hybrids, the first element being a denominal colour adjective rather than a noun.

There are also cases in which mapping is of a complex visual texture rather than a specific colour. As with compound colour adjectives, mappings from *peacock* and *rainbow* occur, examples being *peacock glass, peacock sky* and *rainbow petals, rainbow serpent, rainbow snake, rainbow streaks, rainbow stripes, rainbow van.* This kind of mapping is also reflected in common species names such as *peacock butterfly, rainbow trout, zebra finches, tiger beetles, tiger lily* and *tiger moth*: see Section 5.7.2 for discussion of property mapping and species names.

2.3.5 Summary

For the most part, colour modifiers operated straightforwardly as property mapping modifiers, feature values from the modifier replacing those in the schema for the head noun, as for shape modifiers. The COLOUR feature was described in terms of a triplet of values corresponding to regions of three axes. A detailed description of the structure of colour such as this is necessary for a variety of reasons: firstly, to allow the meanings of colour adjectives, both standard and derivative, to be represented as systematically related; secondly, to allow the definition of "intermediate" colours corresponding to hybrid colour modifiers; thirdly, to allow modelling of the mapping of highly specific colour values from nouns.

The corpus shows a wide range of compound colour adjectives, but also contained a range of noun-noun combinations which are best interpreted in terms of colour property mapping. Unlike compound adjectives, in which the property to be mapped is indicated by the inflectional structure, any feature value from a modifying noun could potentially be mapped. As discussed in Section 1.3.3, the existence of alignable differences allows for mapping, but further constraints on the mapping possibilities are required.

The kinds of noun-noun combination seen in this section suggest that, for colour mapping at least, the value that is mapped is precisely specified and highly diagnostic for class membership in the modifying noun, and is mapped to a slot the value of which is of low diagnosticity for the head noun: in many cases, the colour value for the head noun could vary so greatly for case to case that it would be unspecified (e.g. for clothing and furniture). It should, however, be noted that ambiguity does remain, for example, in the competing COLOUR mapping and physical composition readings that *silver* and *gold* can have in many cases.

2.4 Case Study: Modifiers of Size

The third case study involves property mapping from the modifier's SIZE slot. Three types of modifier are investigated:

- Standard Size Adjectives
- Compound Size Adjectives
- Nouns

2.4.1 Standard Size Adjectives

Introduction

In this section, I examine the operation of standard size modifiers such as *small, large, long, short, tall, big, little, wide, narrow.* These are prominent members of a class of adjectives known as **relative** or **gradable** adjectives (those that can be premodified by degree adverbs such as *very, extremely, quite*: see Huddleston (1984)).

Subsectivity

Gradable adjectives cannot in general be intersective, because often there can be no procedure for identifying a set of entities that fits the description: the existence of sub-set relations would make the collection incoherent. For example, taking the case of *large*: if large dogs were included in the set for *large*, and dogs are typically small as animals go, then the intersection of sets for *large* and *animal* would not give the set of large animals. In general, size adjectives operate subsectively: they cannot be modelled as standard one-place predicates. In this section, I will demonstrate how schemata can be used to model the operation of size adjectives.[17]

Size Adjectives and Scales

It seems natural to suggest that adjectives indicating size are in some way associated with measurement scales: objective numerical scales for measuring length, width, height, etc. give us a way of describing size precisely (and we can imagine that modifiers such as *large, small* refer to general bulk or volume).

A scalar definition will allow us to define size qualities in terms of cut-off values on the scale. That is, we can define a point on the scale which divides between entities that are correctly described by the adjective, and those that are not. For example, if we specified the cut off value for height as being 6 feet, then anyone over 6 feet would

[17]It should be noted that I will not be presenting a general account of gradability in adjectives. There are many gradable adjectives that do, in fact, act intersectively. One group we have already examined: the standard colour adjectives. For example, the quality of being *red* is definable without reference to a comparison class. Yet *red* is perfectly readily gradable; there is no semantic peculiarity in saying that something is *very red*, or that one thing is *redder* than another.

be tall; anyone under 6 feet would not be tall. Because the sizes of different classes of tall things varies radically (compare *tall fern, tall man, tall tree, tall mountain*), it is clear that a specification of the cut-off value for height cannot be stored in the adjective's schema: the value can change greatly, depending on the head noun that is being modified.[18] This suggests that in the process of combination with the adjective, the noun somehow supplies a value that is used to define a cut-off point on the scale.

In most cases, we can assume **linearity** of the adjective: that is, the adjective will be associated with a particular scale which will allow all entities referred to by nouns modifiable by the adjective to be serially arranged on the scale in a way that reflects the degree of the quality that individual possesses. For example, each individual described by *tall fern, tall man, tall tree* and *tall mountain* can be placed on the same scale for height. The quality is the same, regardless of what the head noun is.

However, not all size adjectives are linear. For example, *long time* and *long beard* cannot be compared on a single scale. In order to account for this, we must assume that different senses of the adjective are associated with different scales: thus, *long* is concerned with (at least) two linear scales, one for physical size, and one for temporal duration. Similarly, *large* can apply to either physical size of an object, or the number of elements in a group (compare, for example, *large dog* and *large family*).[19]

It is also clear that certain size adjectives are related to one another. In particular, they can generally be paired into opposites (tall and short, large and small, big and little, wide and narrow, and so on). It seems that both the members of such pairs indicate values on one particular scale: e.g. both *tall* and *short* are somehow specifying a measurement of height.

Figure 2.11 shows precisely how pairs of opposite adjectives are related. Across the scale, there will be some entities (e.g. people) classified as *short*, and some as *tall*, but there is also a large gap between them, where entities are neither tall nor short: they are normal size. Thus, gradable opposites are not contradictory (i.e. it is possible to say that an item is "neither tall nor short") but are incompatible (i.e. we can't say something is "both tall and short").

The figure also suggests there may be a smaller gap between tall and not-tall (and short and not-short). It does not seem right to suggest that a precise cut off value

[18] More precisely, it depends on a comparison class of some sort. Cases in which the head noun may not be the correct class for comparison are discussed by Klein (1980) and Beesley (1982). For example, it is unclear whether a *tall mathematician* is tall in comparison with mathematicians, or in comparison with people in general. Usually, however, the head noun is the correct class for comparison.

[19] More radical cases of non-linearity exist for other types of gradable adjectives (see Kamp (1975)). For example, an adjective such as *good* suggests a different scale for perhaps every noun modified. Chapter 3 investigates models that can deal with this kind of polysemy.

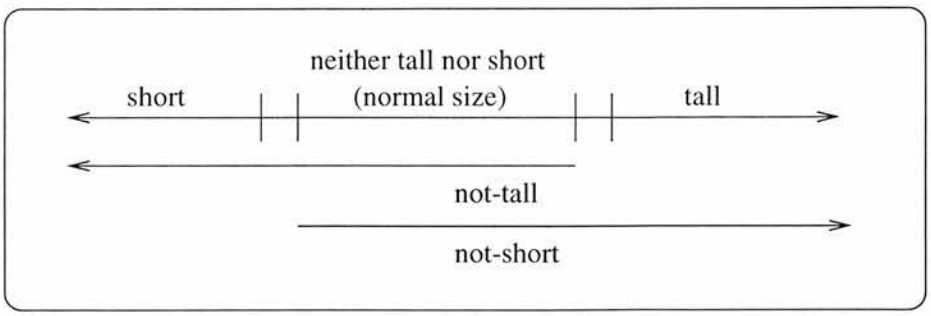


Figure 2.11: Extension Gaps

specifies a class of tall objects: judgment about membership of the class is not as clearcut as this. For example, we may judge that John is definitely tall, and that Mary is definitely not tall, but be unsure whether Kim should be classified as tall or not-tall. The boundary for the adjective is somewhat vague.[20] However, in the following sections, we will assume that the cut-off point can be described in terms of a precise value: in actuality, the boundary must be more fuzzily defined to account for the gap between (e.g.) tall and not-tall.

Two Approaches to Gradability

Given that size adjectives can be modelled in terms of specifying a cut-off value for a scale, there must be some method of finding such a value from the head noun that is being modified.

However, approaches that have attempted to represent the meaning of gradable adjectives in terms of specifying a simple cut-off value seem to have a number of problems associated with them. Platts (1979) discusses criticisms of what he calls the "statistical" and "non-statistical" approaches to modelling the meaning of gradable adjectives in terms of a cut-off value.

The statistical approaches Platts describes operate by requiring that a member of adjective class X be X-er than "most", or "many" of the objects in a comparison class. For example, a large elephant would be an elephant that is larger than most elephants (or many elephants). Note that this is an informal description; the "statistical" approach as described here does not actually use any technical statistical concepts. In any case, the cut-off value will be defined depending on the distribution of members of the comparison class across the scale. The fundamental problem with this notion is that the statistical distribution may not give a correct answer about class member-

[20]Kamp (1975) in fact models gradable adjectives as being vague one-place predicates. This theory will be discussed further below.

ship. Wallace (1972), for example, gives the example of a lawnmower company that manufactures a few special small lawnmowers for children; in that case, *most* Wallacian lawnmowers will be *large* Wallacian lawnmowers. Platts extends the criticism further by noting that skewed distributions in general could produce problems: "top heavy" distributions might actually need to be defined such that "most" or "many" of the population fall into the adjective category X. The extreme example of skewed distribution is exemplified by the category *sharp knife*: if all the knives in the world were sharpened at the same time, *every* knife would be a sharp knife.

In the alternative non-statistical approach membership of adjective category X would require that an entity be X-er than the "average", "typical" or "normal" object in that class. A large elephant would be an elephant larger than an average elephant. Platts again sees this as problematical, primarily because it is unclear precisely how "average" values are to be specified without recourse to some kind of statistical approach. If the statistical approach does not hold in defining what the average is, then we need some other notion. Non-statistical possibilities might include feature familiarity or perceptual saliency, but it is difficult to see how these might be applied at all in the case of SIZE without some notion of statistical distribution being applied.

Schematic Representation of Size Adjectives

From this, it seems that the non-statistical approach is hopelessly vague, and the statistical approach hopelessly wrong. However, it is worth noting that the statistical approach Platts is criticising is based on defining the cut-off point in terms of the *statistical distribution* of the comparison class across the scale. It is being assumed that the distribution is somehow important. A thought experiment will show that this is wrong: imagine two sets of blocks, distinguishable by their red and green colours. Both sets come in a range of sizes from $1cm^3$ to $5cm^3$, but their distributions across this range are different: while 90% of the red set are in the range $1 - 2cm^3$, 90% of the green set are in the range $4 - 5cm^3$. Does the difference in distribution make a difference to the range of blocks in each set that are considered to be *large*? Intuitively, it seems not. The large blocks are simply those that are in the upper part of the range of sizes: the proportion of the distribution that falls in the range is unimportant.

Thus, an alternative way of specifying size seems plausible: a *tall* object, for example, would simply be one that falls in the upper part of the *range* of the scale across which objects in the comparison class fall. Assuming that size is represented in noun schemata in terms of pairs of values that specify the upper and lower bounds for a particular size quality, the operation of an adjective such as *tall* could then be modelled

$$\left[\text{SIZE}\ \left[\text{HEIGHT}\ \ (m,n) \longmapsto (n - \tfrac{n-m}{4}, n)\right]\right]$$

Figure 2.12: Representation of *tall*

as operating to redefine these values so that a portion of the range only is specified: for example, the top quarter of the range. A representation for *tall* that works in this way is shown in Figure 2.12, where m and n are constants, numerically specifying the upper and lower bounds for the SIZE|HEIGHT feature, which will be specified by the head noun. [21]

Note that, unlike shape and colour adjectives, *tall* will not replace the head noun's *height* filler with a prespecified replacement, but instead takes a pair of numbers that specify a range, and from these redefines the lower bound of the range. Thus, if the head noun had the HEIGHT filler (2,10), specifying that objects in the class can be between 2 and 10 units of height, *tall* would act to map it to (8,10). In other words, *tall* is not carrying out property replacement, but rather carries out a form of systematic property alteration. Naturally, *short* would carry out the opposite, redefining the upper bound to give the filler (2,4).

The schematic model given above works with two numbers that simply bound the possible range of values for a quality: they specify an interval within the scale which objects on that category may appear within. Modelling size adjectives in this way means that the actual distribution of items across the scale has no effect on the way the cut-off point is defined: the proportion of objects that are correctly described by the adjective can vary enormously depending on how skewed the distribution across the range is. This effect is illustrated in Figure 2.13: the shaded areas represent the top quarter of the range: the proportion of the population shaded changes radically depending on the distribution.

For more extreme distributions, the top quarter of the range could even include "most" of the comparison class. However, it might be objected that this model of gradable adjective operation could not cope with the example that *all* knives could be sharp knives. However, this criticism only applies if the specification of range found in the head noun is based on the *extension* of the class. As mentioned in Section 1.3.3, we can regard a mental representation of meaning as being equivalent to an *intension*:

[21] The operation of degree modifiers such as *very* could be modelled in terms of a further restriction on the range.

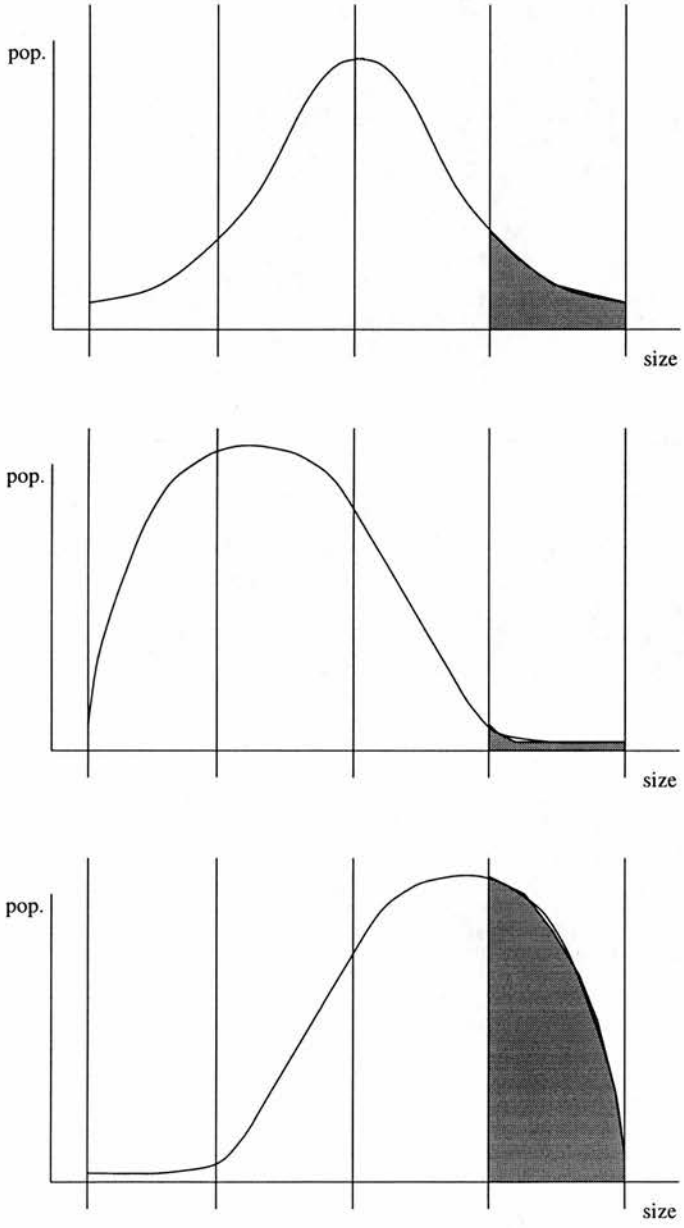


Figure 2.13: Normal and Skewed Distribution

$$\left[\text{SIZE}\ \left[\begin{array}{ll}\text{HEIGHT} & (m,n) \longmapsto ((n - \frac{n-m}{4}, n) \\ \text{HEIGHT} & .* \vee p_n \longmapsto p_n\end{array}\right]\right]$$

Figure 2.14: Version of *tall* for continuous and discrete distributions

the noun schema should specify the range of sharpness that we know it is *possible* for knives to fall under. In this way, the *sharp knife* example can also be coped with.

The other distribution mentioned above was the "Wallacian" one. This distribution is not continuous across the range of size; a size value can only fall into one of two discrete classes. In a case where the distribution is discrete, rather than continuous, the adjective is operating differently. Membership of each size class is well-defined, and in this use *large* is not, in fact, gradable (there can be no such thing as a *very large* Wallacian lawnmower). In cases where discrete categories for size exist, size may be represented in the noun schema as a set of disjoint values (e.g. HEIGHT $= (p_1 \vee p_2 \vee p_3)$), the adjective operating to select the largest of these. An appropriate schema is shown in Figure 2.14.

Discussion

I have presented a schematic theory in which continuous variables of size are represented in terms of boundary values for the range within a scale over which a particular class of entities is distributed. This allows for an attractively simple schematic model of size adjective operation that can cope with the kinds of skewed distributions that proved problematical for earlier "statistical" theories of gradable adjectives.

The model for standard size adjectives is unlike those proposed for shape and colour adjectives, in that it does not work by carrying out a complete replacement of values from the head noun schema, but instead carries out a form of systematic property alteration, in which the values of size features specified in the head noun are used to define new boundary values for referents of the complex concept.

This model of standard size adjectives was inspired by the formal semantic models of Kamp (1975) and Klein (1980), which describe gradable adjectives as *vague* one place predicates.

In Figure 2.11, there was a region on the scale that fell between tall and not-tall. This is the **extension gap** for *tall*. Kamp (1975) models extension gaps by defining a one-place predicate R(x), for which truth values values are only partly determined: if the "x" under consideration falls into the extension gap, R(x) has no assigned truth

value. This is why this is a *vague* predicate. In order to account for the different extension of vague predicates in different contexts (e.g. when different comparison classes are used) there must be some function that is able to reassign truth values taking this into account. The size adjective schema I have described gives an explicit model of this how such a context based reassignment function operates, although in slightly different terms.[22]

Note that in the theories Platts criticises, gradable adjectives are analysed in terms of the comparative: in order to be in adjective category X, an object must be X-er than a proportion of the population. Defining gradable adjectives as vague one place predicates allows the reverse, the definition of the comparative in terms of the standard (attributive) form.[23] As Klein (1980) notes, it is more plausible that the meaning of a morphologically complex form is based on the meaning of its base form than vice versa. Defining the adjective *tall* as referring to bounds on a scale likewise does not require defining the adjective in terms of its comparative.

2.4.2 Compound Size Adjectives

Compound adjectives which specify a size are constructed from a noun with the suffix *-sized.*

Like the size and colour compound adjectives, there are many examples in which the mapping of a value seems direct (i.e. one could map the values specifying a size range from the source noun). Cases that seem to be of this type are *allotment-sized farms, aquarium-sized representation, bite-sized pieces, foot-sized object, foot-sized steps, gazelle-sized giant, monkey-sized tamandua,*[24] *pencil-sized beams, pocket-sized manual, rabbit-sized relative, snack-sized bites* and *squirrel-sized pygmy.* The case *sand-sized particles* requires a mapping from the size of individual grains (the mass noun interpretation could, in any case, have no default SIZE specification); *clay-sized materials* presumably has a similar interpretation.

However, there are also other cases in which a more indirect approach is needed for interpretation to be correct, because a literal direct mapping of size values would give

[22] I have not specified an extension gap between (e.g.) *tall* and *not-tall*, but this could be done by defining the lower boundary in a fuzzy manner.

[23] Given the ability to find the extension of an adjective predicate R in different contexts, a technical definition of entity relationships such as "x is at least as R as y" can be produced on the basis of "x" being present in every extension of R that "y" is (or on the basis of a probability calculated with reference to a subset of all the possible assignments). Similarly, for "x is R-er than y" to be true, then "y" must be present in a subset of the extensions of R that "y" is. We can think of this in intuitive terms as redefining the cut-off points for the extension gap until an assignment is found in which "x" is definitely in the extension of R while "y" is definitely not.

[24] *An arboreal anteater.*

an absurd result. Examples of this sort are *bed-sized pillow, child-sized table, family-sized tins* and also *man-sized nappies.* In these cases, the appropriate SIZE values will be those that allow the referent of the head noun to be somehow used by or with referents of the source noun. This cannot be modelled in terms of property mapping. It is unclear how systematically this indirect mapping is used; possibly such a reading is triggered if the SIZE values for the source noun fall outside the range of values specified for the head noun.

The combinations *bite-sized problems* and *man-sized job* have more metaphorical interpretations, being roughly "problems that can be solved in small steps" and "job that only a man is suited to do". The construction *midi-sized equivalent* does not have an obvious interpretation.

There are also a number of compound adjectives constructed with the suffixes *-long* and *-wide* (none of the other standard size adjectives seem to be used as suffixes).

For *-long*, the source noun is a specification of extent, either physically (with *four-foot, metre, mile*), or temporally (exactly determined by *day, decade, fortnight, hour, month, six-month, thirty-year, week, year* and inexact in combinations with *age, life*). The only exception is *side-long glances.* The suffix *-wide* is used very differently, only rarely measuring a width (when combined with *centimetre, metre, three-foot*). In the vast majority of cases, the initial noun refers to a particular area or organisation of some sort (the cases are *city, community, continent, country, county, district, economy, enterprise, europe, firm, garden, group, industry, organisation, party, province, republic, species, world*, and the combination as a whole indicates that the object referred to by the head noun is distributed across that indicated by the initial noun. The combination *jaa-wide applicability* is not readily interpretable (but perhaps is relevant to a computer system).

Discussion

Compound adjectives that indicate size may be related to the source noun by directly mapping the default SIZE fillers from the noun as a replacement for the head noun's fillers, but they may also have a more indirect relation with the source noun, indicating that the object referred to is of the right size for members of the source noun class to use.

Thus, the pattern of interpretation for these adjectives is more complex than those found for compound adjectives indicating shape or colour. It is unclear, however, how systematically indirect mappings are used; possibly there are only a few modifiers that are interpreted in this way.

2.4.3 Size and Modifying Nouns

Analogical Mapping

The examples of compound constructions do not suggest particular patterns of mapping of SIZE values from nouns.

In fact, where noun modifiers are relevant to SIZE, it seems that mapping of values often does not occur directly: simple feature alignment will not be enough, as complex analogies are required for interpretation. For example, consider the case of *elephant bird*, interpreted to mean "a very large bird". Clearly this is not a literal mapping of magnitude. Nor can it be modelled as a direct mapping from the schema for *elephant* of a straightforward "*big*" filler from the SIZE slot (as is suggested in Costello and Keane (1997)); elephants are only *big* in relative terms, compared to some class of things. If "*big*" was the SIZE feature for *elephant*, it is unclear how the size of *big elephant* would be represented.

What is relevant in this example is the difference in size between sub- and super-ordinate classes. Elephants are large compared to animals in general; an elephant bird would be large compared to birds in general. Similarly, an interpretation of *pencil rake* to mean "thin rake" is a mapping of the relative proportions of different SIZE dimensions, rather than being a direct mapping of a magnitude, or a SIZE value specifying "*thin*".

Systematic Patterns of Analogy

The examples given above are isolated cases of interpretation (e.g. *elephant* is not systematically used to indicate size; see Section 5.6. There are, however, systematic patterns of size modification that occur within the corpus. For example, the words *giant, dwarf* are often used as modifiers[25]. These modifiers indicate that the exemplar is a particularly large or small example of the class indicated by the head noun. Similarly, *baby*, when used as a modifier, can indicate small size for a category. The examples of *baby carrots, baby beetroot, baby vegetables, baby prawns* might be taken to be literal mappings of an AGE value, size differences being inferred from this, but this certainly won't explain the combinations such as *baby canoe, baby jars, baby lake*, which suggest a similar analogy of size without any suggestion of "youth". An alternative definition in this latter cases would be in terms of the relationship "for use by a baby". However, the analogical size mapping interpretation of *baby* would account for both sets of combinations.

[25]The BNC analysis gives *giant* as an adjective, but *dwarf* as a noun modifier

More complex patterns of analogy are also found. For example, the noun *king* is used to indicate size, as in the examples *king prawn, king seal, king vulture.*[26] Here the analogy is more indirect: a connection is made between rank/importance within a comparison class, and SIZE.[27]

Discussion

There are a number of nouns that are used as modifiers indicating size. However, no example was found in which size was directly mapped; that is, the actual filler for SIZE in the modifier is not mapped. Instead, the modifying nouns are indicating a complex type of analogy: they refer to a class of objects that are a particular size in comparison to their superordinate class, and the complex concept will bear the same comparison to objects falling in the head noun class, e.g. elephant birds fall into the same range of size for birds that elephants do for animals (the extreme upper end). A mechanism for modelling this would thus require a means to extract SIZE values from both the modifying noun, and its superordinate, carry out a comparison, and then modify the values in the head noun in the appropriate way.[28]

Of the systematically used examples I have given, only *giant* and *dwarf* appear to be highly productive: these can be combined with practically any noun that has a SIZE specification. The words *baby* and *king* seem much more restricted in their application (at least in terms of indicating size). They are used mostly in indicating sizes of animals (and possibly vegetables).

2.4.4 Summary

I have suggested the numerical representation of size, based on the existence of underlying linear scales for dimensions such as HEIGHT, LENGTH and WIDTH.

The representation of a default SIZE value for noun schemata can simply consist of a pair of numbers specifying the lowest and highest possible values for that variable across the class.[29]

The operation of standard size adjectives can then be defined as using the representation in the head noun schema to produce a new specification, indicating that the SIZE value must fall within a more restricted band of values than that given in the head

[26] And also in combinations such as *king-size bed.*

[27] This is a common analogical transfer in English; we find combinations such as *high aristocracy, top businessmen, lower class*, and so on.

[28] The modifier *king* is slightly different: here the analogy is between high rank compared to the superordinate class (people) and large size.

[29] Obviously, where the noun referred to an individual, a single specific value would characterise SIZE.

noun. This is not like the mechanisms of property alteration suggested for shape and colour adjectives, but rather a form of systematic *property alteration* in which information contained in the head noun's schema affects the outcome of combination. This explains why such modifiers are subsective: they require information from the head noun's schema to be able to specify values for a slot.

I have shown that this approach to modelling allows for different proportions of the population to fall into the adjective categories, depending on how the distribution of the value across the range is skewed. This answers the arguments that have previously been made against statistical modelling of entities' membership of such categories; evaluation of whether an object is (e.g.) *large* does not have to be simply in terms of an entity being "X-er" than "most" or "many" of the entities in a comparison class. Indeed, it does not rely on use of the comparative form at all.

Compound adjectives and modifying nouns are also used to indicate size. While some compound adjectives involve direct replacement, using SIZE values taken from the source noun, there are also some more indirect mappings, in which size is calculated as being that which allows referents to be used by specific types of people, or in specific tasks. It is unclear how common this indirect mapping is.

Modifying nouns that indicate size do not do so through a mapping that involves direct property replacement: a complex type of analogy is implied, in which the relationships of size between superordinate and subordinate categories need to be taken into account.

2.5 Case Study: General Resemblances

2.5.1 Introduction

Case studies of mapping of SHAPE, COLOUR and SIZE properties give us some insight into the patterns involved in and mechanisms required to model conceptual combination for complex concepts. However, the fact that only three types of property have been studied may mean that important patterns have been entirely missed.

In order to broaden the range of examples considered, a case study was undertaken in which compound adjectives constructed from nouns with the suffix *-like* were examined. Intuitively the suffix implies that such modifiers will indicate some kind of resemblance between the referent of the complex concept and the referent of the source noun: in other words, some properties of the source noun should be attributed to the complex concept. There is, however, no specification of which properties. A variety of types of property mapping were thus found for these adjectives.

2.5.2 Sub-Superordinate Mapping

One general pattern of property mapping found is that in which the head noun is a superordinate of the source noun. Subordinates denote particular types of the superordinate; the superordinate represents all the types of subordinate in one word (particular slots that might take different values for different subordinates should therefore be left with the property value unspecified, or as a disjoint of the possible alternatives). Thus, the source noun and the head noun should not "conflict" in any way; the source noun refers to a subclass of those things referred to by the head.

In some cases, the head noun could refer to practically any object. Any number of properties could be mapped from the source noun. Combinations of this kind are *bellows-like set-up, gallows-like contraption, molecule-like objects, snail-like objects, socket-like thing, machine-like structures, morphine-like substances.* In these cases, the head noun schema can provide little or no information about the properties of referents: thus, there will be little or no constraint placed on what properties can be mapped.

In other cases, the head noun provides a more specific description. For example, there are a number of examples in which the head noun is *creature(s)*; the first nouns are *bear, brownie, elephant, fairy, god, priest, sylph*, all referring to an animate entity or similar but irreal entities such as ghosts, spirits, gods. Other examples of sub-superordinate mapping are: *daisy-like flowers, aids-like syndrome, dioxin-like compounds, mansion-like residence, myofibroblast-like cells, trance-like state, vat-like tax*, and probably also *court-like body* (if "body" is taken to mean "group of people"). Mappings also occur from particular individuals, as in *kravchenko-like conservative, god-like role* and *puck-like part* (in the latter case, I am assuming "part" refers to a part in a play).

In all these cases, the referent of the combination belongs in the superordinate class, but does not properly belong in any subordinate class (despite being similar to members of one such class). Thus, although referents will have some of the properties of the subordinate class, they must lack some of the defining properties of that class.

2.5.3 Co-Taxonym Mapping

In some cases, the mapping is between two co-taxonyms (two terms at the same level in a hierarchy). In these cases, the two referents should be similar in many ways; there should be a great number of similarities and alignable differences between the two noun schemas.

We see mapping between animates in *ape-like man, christ-like emperor, god-like showman, vampire-like spirits, waif-like gothette, wraith-like girl*; between forms of

Mappings of Shape
arrow-like lips, bow-like arc, column-like trunks, comb-like leaves, feather-like clouds, gun-like tube, hair-like cilia, hair-like growths, head-like figure, idol-like figures, nipple-like protruberances, ribbon-like fin, sausage-like curlers, spire-like crown, sphincter-like aperture, step-like indentations, stick-like antennae, stick-like nicola, stilt-like limbs, string-like strands, sucker-like weeds, tadpole-like components, tentacle-like fingers, thread-like neck, tree-like chest, trumpet-like salpiglossis, wart-like lumps

Table 2.8: Shape Mappings

musical composition in *anthem-like tunes, minuet-like scherzo, refrain-like line*; and various others in *park-like field, pew-like bench, salon-like suite, machine-like robots, title-like statements.*

In these cases, a large number of properties will already be shared between source noun and head noun. Mapping of those property values which are alignable differences would be expected; the end result is that they refer to examples of the head noun class that are extremely similar to members of the source noun class.

2.5.4 Mapping Specific Properties

In other cases, the two nouns come from different semantic fields, and specific properties are mapped from the source noun.

The most common mapping seems to be one for SHAPE (see Table 2.8): it is likely that other property mappings are also intended in some of these cases, e.g. mappings of chemical composition, behavioural characteristics, or visual properties, but these will necessarily accompany the shape mapping.

Other properties mapped include size (*barn-like halls, hangar-like stables*), behaviour (*puck-like successor, puppet-like women*), texture (*porridge-like mucus, rasp-like tongue*), particular characteristics such as "slow-moving" in *tortoise-like negotiations* or "self-destructive" in *lemming-like institutions*, plus a variety of others (*country-like surroundings, dance-like contrapunctus, feather-like landings, furnace-like emanations, summer-like spells, cyst-like sacs, prison-like camps*).

2.5.5 Mapping to Bodypart Nouns

In cases where the first noun is an animal, and the head noun is a body part of some kind, a form of indirect mapping occurs. The construction *bat-like wings* provides a good example: this does not describe "wings that are like a bat"; rather, it refers to "wings that are like *the wings of* a bat". This is a common type of construction: similar

examples are *calf-like heads, cat-like face, fish-like bodies, jackal-like smile, lemur-like eyes, moose-like antlers, owl-like countenance, ox-like shoulders, parrot-like eye, snake-like head, snake-like tongue, sphinx-like smile, stork-like necks.*[30] There are a couple of non-animal mappings like this: *carrot-like root, aeroplane-like wing.*

Although some form of property mapping is taking place in these examples, the mechanism of alignment is novel. Properties specified for subparts of the animal are aligned with the head noun schema.

Mapping of this kind is not simply applicable to physical parts; a similar process frequently occurs in mapping of psychological and behavioural traits characteristic of the first noun, examples being *child-like enjoyment, child-like excitement, child-like innocence, child-like selfishness, schoolgirl-like crush, sleuth-like pertinacity.* Mapping can also occur from names, as in *demille-like ambition, god-like wisdom, karajan-like suavity, othello-like jealousy,* and even from non-humans that might be imputed to have such traits, as in *sheep-like attitude, sheep-like condition, tardis-like mood, god-like power.*

2.5.6 Mapping to Feature Nouns

The head noun can actually refer to kinds of feature/properties. We might regard the particular characteristics of an object as being special kinds of subparts. Certainly, the same mechanism of mapping appears in cases in which the head noun refers to such characteristics: a mapping from a part of the initial noun's schema to the head noun.

For example, a *vulture-like quality* is not a "quality like a vulture", but rather a "quality like some quality of a vulture". Similar cases, in which the type of the feature is left unspecified, are *data-like features, tube-like character, troll-like traits, plastic-like properties, solid-like properties, courtier-like qualities, fighter-like qualities, nest-like quality, chameleon-like tendencies, chamber-like nature, desert-like conditions, october-like conditions.* There is no explicit guide as to what is mapped in these cases. However, mapping cannot simply be for a property value; the type of property, the slot-type, must *also* be mapped; the schema definition of a word such as "quality" presumably does not contain any specific feature specification. It seems plausible to expect that the mapping will be of values for the most characteristic/diagnostic features of the initial noun.

In other cases, the type of the feature is specified more precisely, as in examples such as *rock-like colours, dough-like consistency, chimney-like proportions, machine-like*

[30]The combination *snail-like nose* might also be of this type. I am, however, unsure whether a snail has anything that can reasonably be called a nose; this could simply be a more general mapping of SHAPE, "nose that is shaped like a snail".

appearance. In these cases, feature values only need be mapped. Several head nouns refer specifically to the arrangement of subparts into a whole, as in *sheet-like form, sponge-like form, grid-like pattern, rope-like patterns, bird-like configuration, face-like configurations*, which suggests a mapping of SHAPE feature values.

2.5.7 Other Mapping Types

There are also a number of smaller patterns, some of which involve quite complex interpretations. In addition, there are a number of residual examples for which I could find no obvious meaning.

Firstly, we have some obvious examples of construal: the combinations *bear-like trousers, reptile-like suit.* In these examples the combination is likely to denote an object that has properties like those it would have if made from the skin of the animal referred to be the first noun.

Secondly, there are examples in which the head noun is a psychological or behavioural trait, with the first noun referring to an object that is somehow associated with that state (e.g. it may induce it): *cathedral-like aloofness, dinosaur-like terrors, fairy-like mysticism, tomb-like claustrophobia.*

Thirdly, the head noun may be similar to an object designed or constructed by the person/organization/method described by the first noun. Possible examples of this type are *karst-like forms, predella-like frieze, tatlin-like towers, tessera-like snaps, verdon-like wall.*

Fourthly, the head noun may denote a mode of action, and the head noun a human, with the mapping being a "manner of action." Examples are *cinderella-like fashion, workman-like way.*

Fifthly, there are examples in which the head noun denotes something that is like a portrayal of that object within the first noun (which, roughly, denotes some form of narrative structure). Examples are *cartoon-like characters, dream-like world, dream-like ease, dream-like sequences, dream-like settings, fairytale-like world.*

Sixthly, the head noun can denote an object which is like something "produced" by referents of the first noun. The mapping can be from classes of objects, as in *car-like comfort, commando-like accuracy, family-like atmosphere, fashion-like process, monk-like existence, psychotic-like disorders, smallpox-like contagion, speech-like noise, wraith-like presence* or from individuals, as in *buddha-like speech, matisse-like simplification, svengali-like hold.*[31] In particular, there are a number of examples of this sort in

[31] The combination *clarinet-like writing* may also belong in this group.

which the head noun refers to a kind of motion or other activity, such as *bird-like movements, corpse-like stupor, fish-like turn, fluid-like flow, lemming-like dash, piston-like motion, snail-like motion, vice-like grip.*

Finally, there are also several examples in which the adjective *business-like* is used. This adjective does not indicate resemblance to business, but instead refers to a manner of behaviour that is a "paragon" of how business should be conducted; we may paraphrase this quality with words such as "brisk, competent, efficient, professional, to-the-point". Nouns so modified are: *attitude, event, footing, man, mood, thing, way.*

There are also a number of residual examples, which I could see no obvious interpretation for: *class-like phenomena, eagle-like ambiguity, day-like persona, gem-like species, god-like number, leaf-like earth, pacifist-like promotion, ride-like assaults, stick-like eyes.* Others are hard to interpret due to the use of technical terms: *burkitt-like lymphoma, cadherin-like glycoproteins, dipole-like transducers, ec-like cells, immunoglobulin-like domains, lectin-like domains, wt-like trna.*

2.5.8 Discussion

Within this class of compound adjectives, there are a whole range of different mappings that are possible. The different types of mapping seen arise simply because there are different relationships between the source noun and the head.

Several of these types of mapping involve replacement of slot fillers in the head noun's schema with fillers taken from the corresponding slot(s) in the source noun: no novel mechanisms are required to explain how these adjectives operate. As was observed above, there is little constraint on the properties mapped where there is a sub-superordinate relation between source and head. Where the two are co-taxonyms, extreme similarity between the referent and members of the source noun class is implied. Where the two nouns are from different semantic fields, the mapping can be of any characteristic that both classes of objects can possess, although many examples seem to involve mappings of SHAPE.

However, a variety of other mappings cannot be modelled in terms of the mechanisms so far discussed in this chapter. For example, where the head noun refers to properties in the abstract (as in *plastic-like properties*), the actual slot type in question may have to be mapped as well as the filler, which will require an adjective schema like that in Figure 2.15. In this, no filler is specified for replacement: a slot and filler are instead added. The new slots and fillers would presumably be those most diagnostic for membership of the source noun category.

Where there is a partitive relationship between the source and head nouns, the

$$\left[\text{QUALIA} \longmapsto \left[\text{NEW-SLOT} \quad filler(x)\right]\right]$$

Figure 2.15: Adjective Mapping Slot Type

relevant properties to be mapped are those of a subpart of the source noun referent, rather than the whole. This requires a different method of mapping. I suggested that property values might be specified separately for different subparts, as in the specification of SHAPE given in Figure 2.3.[32] To model a combination such as *bat-like wings* would require a search of all the slots to see where values specific for WINGS are specified: the mapping of properties to relevant slots in the head noun is then required.

However, the meaning of *bat-like* itself will change radically from case to case. What is mapped as a SHAPE value for a combination with *wings* will not be what is mapped as a SHAPE value in a combination with *ears*. Like compound size adjectives such as *family-sized*, the meaning of the adjective cannot easily be expressed in schematic terms, as the precise mapping it carries out depends on what the noun it is modifying is.

2.6 Conclusions

Research Contribution

The research contribution of this chapter lies in the use of real-world corpus material to driving and constraining the development of property-mapping models of modifier-noun combinations.

The corpus-based approach to studying complex concepts is not a novel one. However, most studies of this nature have concentrated on representing complex concepts in relational terms. This chapter has presented four case studies, each of which tackled a wide range of examples, and shown how they might be analysed in terms property mapping in a schematic framework: some very specific representational issues were tackled (e.g. how shape, colour and size properties might be represented), and mechanisms described that allowed for the process of combination to be modelled.

The extent of the corpus material that is uncovered by searching for all examples of

[32] It could be specified the other way around, features and fillers being specified for each subpart of an object, but this would give no easy way to assign a global value when all subparts have the same value for a property such as colour.

combination containing a particular word requires that models are constructed at this level of detail: it is necessary if they are to deal with the broad range of combinations the words are actually found in. For example, without reference to corpus material to direct these models, it would not have been apparent that shape adjectives are used to indicate the configuration of object cross-sections and sub-parts, nor would the systematicity of colour property mapping in noun-noun combinations have been apparent. By using such a large corpus of computer-searchable material, these semantic effects are discovered.

Similarly, the necessity to compare the operation of different types of modifiers suggests particular wide-ranging strategies for representation. For example, the use of nouns to specify colours requires that there is some method of representing colour in a fine-grained way, so that these specific shades can be dealt with; a view of colour adjectives that regarded them as one place predicates would be limited to only dealing with a small range of adjective modifiers that can be used to specify colour. The models suggested in this chapter try to deal with as broad a range of cases as is possible.

Property Mapping: Adjectives

In general, I have modelled adjectives as being of one of two types. Firstly, there are the adjectives that simply replace values in the head noun schema: these are property replacement adjectives. Secondly, there are adjectives that systematically alter the values in some slot, carrying out some form of calculation (fairly straightforward in the case of standard size adjectives, but more complex for indirect mapping in compound size adjectives): these are property replacement adjectives.

Describing adjectives in these terms allows for both intersective and subsective combinations to be accounted for: intersective adjectives are carrying out a straightforward replacement, while subsective adjectives are carrying out a systematic alteration of some value.

Adjectives containing the suffix *-like* suggested that there are also more complex patterns of mapping available. For example, in the combination *bat-like wings*, the modifier is used to indicate a similarity with bat's wings: in other uses, it could suggest a similarity with other subparts of the bat, the whole of the bat, or with behaviours or other attributes of the bat. In other words, the property that such adjectives indicate can change radically with the head noun they modify: it seems as though any information in the schema for the source noun can be mapped as part of the process of combination. It seems almost as if property mapping is being carried out from the source noun in these cases.

Property Mapping: Modifying Nouns

Property mapping interpretations for modifying nouns were found for both colour and size: a few examples were also found for shape, but no widely systematic patterns of mapping were found for this area. This was unexpected: it might simply be due to the inability to find the kind of noun-noun combinations were such a mapping is commonplace; however, it does suggest that property mapping may not be a mechanism used for mapping every type of property value.

Only the examples of colour property mapping could be modelled in terms of a straightforward property replacement. Mapping was carried out between specific classes of words (e.g. the colour of fruits and flowers is frequently mapped to clothing).

It might be that this mapping is simply a standard interpretation when these types of words are combined: the potential ambiguities of complex concepts are (at least in part) resolved because of our knowledge about the ways in which word-types inter-relate in property mapping. For example, we know in cases such as "twenty two" that the number as a whole is the sum of the two values, rather than their product; the meaning of the combination is arbitrary, and the pattern for combination must be learnt, but it is systematic. The same must apply to other noun combinations. However, more general principles may also be at work: in particular, colour seems to have a high diagnostic value for the modifying noun, but a low diagnostic value for the head noun. Costello and Keane (1997) argued that property diagnosticity has a high value for predicting what property values can be mapped in noun-noun combinations; here we see such a pattern in real-world language.

Size is mapped from modifying nouns via a much more complex type of analogy, in which a comparison must be made between the size range of a subordinate class and the size range of the superordinate class. These combinations cannot be interpreted in terms of a direct property replacement; like standard size adjectives, they seem to be carrying out a form of systematic property alteration.

While the examples found of property-mapping for noun-noun combinations do suggest that there it is a systematically used mechanism for interpretation, it is unclear how widely it is used. For example, few examples of mapping for SHAPE properties were found: the only modifier for which there were examples was *box*, and some of the cases considered were debatable.

Chapter 3

Polysemy and Property Mapping

3.1 Introduction

3.1.1 Contents

In general, the modifiers in the previous chapter were modelled as only operating on a particular slot. This may not be generally true. There are adjectives that may operate on more than one slot at once (e.g. Smith et al. (1989) note that *shrivelled* is relevant to both colour and texture). In addition, there are also adjectives which have a wide range of different meanings, and it seems that these might have to be modelled in terms of property mapping to a variety of different slots, depending on the noun they are modifying. This chapter tackles the problem of modelling adjectival polysemy.

In the last chapter, the mechanisms of property replacement and alteration were introduced and explored. In this chapter, the property-mapping framework is extended to cope with aspects of polysemy in the modifier noun-combination. I look at: (1) how some kinds of adjectival polysemy can be modelled with a mechanism of **selective binding**; (2) how binding is resolved when there is more than one potential candidate for binding to; (3) the modelling of adjectival polysemy produced through metonymy.

3.1.2 Flexibility of Adjective Meaning

Murphy (1988) showed that ten adjectives were interpreted by subjects as having, on average, seven different meanings across ten different contexts (i.e. when attributively modifying ten different nouns). In addition, it was found that the interpretation of the head noun can be affected when the modifier changes. This suggests that the interpretation of the words composing a complex concept can change greatly with context (at least when adjectives enter into artificially constructed combinations).

An examination of corpus material also suggests this variability: in terms of property-mapping, it seems as though adjectives may operate on different slots in different contexts of modification.

Some of the distinctions between different uses of an adjective are obvious. For example, *long* can be relevant to a physical dimension as in *long alley* or to the temporal dimension as in *long absence*. Less obviously, objects can be *large* in different ways. For a singular or plural noun (e.g. *large stone(s)*), the modifier indicates the relative physical size of the relevant object(s) (mapping to the slot SIZE). However, in a case such as *large family*, the head noun refers to a finite collection of similar objects, and the relevant characteristic is the number of objects in the collection (mapping to a slot such as QUANTITY). Further complication is provided by abstract magnitude, as in *large number*: the relevant slot here would not be QUANTITY, as a large number is a single object and not, itself, numerous.

It is sometimes difficult to categorise what slot an adjective is mapping to: many adjectives have diverse, complex sets of uses. However, their diversity of use can be indicated by sampling the range of nouns particular adjectives modify. For example, objects may be *soft* in various ways: the modifier may be relevant to VISUAL features (e.g. when modifiying *crimson, glow, haze*), to AUDITORY features (with *bang, cackles, music*), to TACTILE features (*bed, carpet, clay, food*), and to others (*accent, approach, drinks, option, persuasiveness*). Even wider ranging are the groups of nouns that are modified by *healthy*, which combines with nouns denoting animate entities (*animals, tree, species, woman, workforce*), animate entities' component physical material and subparts (*body, cells, flesh, skin, smile, tan, tissue*), psychological components and states (*appetite, conscience, curiosity, fear, mind, reluctance, scepticism, terror*), linguistic entities (*advice, debate*), abstract entities (*appearance, behaviour, competition, environment, profit, recovery, sales, society, surplus*) and others (*bread, city, diet, exercise, gloss, soil*). Another adjective with diverse uses is *heavy*, which combines with nouns denoting bodyparts (*brows, eyelids, feet, heart*), agentive nouns (*smoker, spenders*), actions (*fall, lifting, polishing, snoring*), linguistic entities (*criticism, sarcasm*), monetary entities (*charge, loss, mortgage*), and various others (*bandaging, veil, pastes, pigment, traffic, influence, dinner, industry, goods, infantry, water, reliance, footsteps*).

Thus, it does not seem at all uncommon for adjectives to be put to a wide range of uses: typically, they are highly polysemous. The existence of multiple senses for a single word suggests that there must be both multiple representations for its meaning and methods for selecting the correct sense in a particular context of use. In the case of property-mapping modifiers, polysemy such as this seems to imply different senses

mapping to different slots, as was suggested for the modelling of *red* (Figure 2.9).

3.1.3 Systematic Separation of Senses

In the examples given above, as in Murphy's work, the distinctions that are drawn between senses are purely intuitive; individuals might disagree about the distinctions drawn between senses (although in Murphy (1988), two raters closely agree as to the mean number of interpretations that adjectives receive). There are, however, more formal methods for detecting a separation between different senses of a word.

For example, Cruse (1986) notes that where two senses of a word are implied in one sentence with only one occurrence of the word, a semantic anomaly (zeugma) results, as in the sentence "They took the door off its hinges and went through it" (see Cruse (1986)). Sentences of a similar type could be constructed for gradable adjectives, by using the comparative form (this assumes that the comparative form has a meaning related to that of the attributive form, and can of course only be applied to gradable modifiers).

Using such a test, we find that semantic anomalies arise in such cases as:

- ?The fluorescent tube is longer than the grass
- ?The rock is larger than the family
- ?The paste is heavier than the veil
- ?The cushion is softer than the music
- ?The car is faster than the watch
- ?The day is hotter than the controversy
- ?The approximation is better than the smell
- ?The mathematician is cleverer than the choice

The appearance of zeugmatic anomaly shows that there are restrictions on the *comparative range* of given modifiers.[1] Where such restriction occurs, then it seems that two different senses of the adjective are used with the two nouns present.[2]

The separation of senses in this way could be taken to imply that a separate description of meaning is required in each case: it implies the existence of a set of unconnected

[1] However, there are constructions in which two very different types of object are compared for effect; e.g. "his shirt is louder than the music".

[2] The assumption of linearity, introduced in Section 2.4.1, is violated.

senses, each with its own particular application. In schematic terms, we could conclude that the adjective operates on a different slot (or set of slots) in its different uses, assuming that property-mapping is used in these cases.

3.1.4 Connections Between Senses

The notion that one may be able to enumerate all the separable senses of a word in such a way has been questioned in both the psychological and the linguistic literature on word meaning. This is reflected in theories of categorisation which seek to explain how the meanings of words are creatively extended to novel uses (see e.g. Lakoff (1987), Copestake and Briscoe (1995)). The zeugma test has been specifically criticised (e.g. by Pustejovsky (1995)) on the grounds that it does not capture any of the similarities between the senses differentiated.

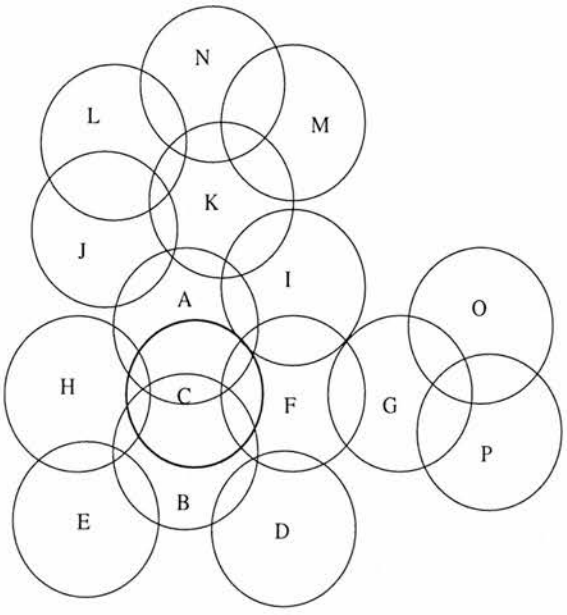
These approaches to semantics are primarily concerned with the significance of the connections between different uses of a word. There are two major ways in which these connections have been analysed: firstly, as resulting from *property overlaps* between words; secondly, as the result of the *systematic generation* of new word senses. We will look at these two different possibilities in turn.

Property Overlaps

Wittgenstein (1953), Austin (1965), Putnam (1975) and Lakoff (1987) have all argued that while different exemplars of a class may share no properties (other than the ad hoc property of being included in that class), different exemplars do often share *some* properties. The classic example of this is Wittgenstein's discussion of *game*; two games need not have any of the same characteristics, but different games may have some things in common (e.g. use of a ball, division into teams, point scoring, etc.). While referents for senses A, B, C and D may share some common properties, A overlapping with B, B with C, and C with D, there might be no property overlap between A and D. This "chaining" of senses can, in some cases, provide an explanation of why the same word is used to refer to disparate entities.

An early example of similar work on adjectives is provided by Rudskoger (1952), who gives a detailed analysis of the historical development of senses for *fair, foul, nice* and *proper*. Figure 3.1 shows his analysis of the linking between senses for *fair*. Although the diagram is concerned with historical developments of senses (some of which are now archaic), rather than with contemporary uses only, there is a marked similarity to the more recent studies.

In such a diagram, there a variety of overlapping senses. We can see how uses



A: Physically beautiful
B: Morally beautiful, noble
C: Specious, seemingly beautiful
D: Accomplished, excellent
E: Equitable, just, accurate
F: Favourable, promising
G: Considerable, ample
H: Gentle, kind, calm
I: Pleasant, attractive, agreeable
J: Light-coloured, blond
K: Clean, pure
L: Clear, bright
M: Smooth, even, unobstructed
N: Plain, distinct, neat
O: Moderate, tolerable
P: Complete, sheer

Figure 3.1: Various Senses of 'Fair'

that seem totally separate may be linked via connections to intermediate meanings. However, the criteria for separating particular senses are unclear, nor is it obvious precisely what the nature of these connections are (the senses overlap due to having evolved from one another).

The obvious suggestion is that a property-overlap account would also suffice for adjectives. However, if property-mapping modifiers only operate on single slots, there would be no basis for any kind of overlap or link. The view of property-mapping we have taken so far has emphasised this one-dimensionality of mapping. However, multidimensionality is also possible. Smith et al. (1989), for example, note that mapping may be to multiple slots for a case such as *shrivelled apple* (the modifier being relevant to both COLOUR and TEXTURE). If property-mapping adjectives are generally multidimensional, then links between senses could be accounted for: if sense A of an adjective operates on a particular group of slots, sense B may also operate on some of those slots, and so on.

However, there is no systematic way to tell what overlaps might occur; they would have to be traced by hand, as Rudskoger did. This would provide no account for novel uses of words. More preferable would be an approach that can explain systematic uses of a word in a simple way, accounting both for the diversity of current uses and the generation of novel senses.

Systematic Generation of Senses

An alternative approach to polysemy models how senses of a word can be generated from a single (base) semantic representation, without the need for storage of all the separate uses of a word. In addition, this should allow for an explanation of how novel uses of a word could be understood. This approach is exemplified by the work of Copestake and Briscoe (1995) and Pustejovsky (1995).

A model of adjectival polysemy is provided by Pustejovsky: his main example is that of *fast*. While there are obvious standard interpretations of *fast* (e.g. short in duration, moving fast) that could be specified in terms of mappings to a particular slot, Pustejovsky argues that enumeration of such senses will be insufficient to account for the full range of its uses. For example, a *fast typist* is "a typist who **types** fast", a *fast book* is "a book that can be **read** fast", a *fast motorway* is "a motorway that can be **driven on** fast", and a *fast garage* is "a garage that **fixes** cars fast".[3] In each case, the interpretation involves *fast* specifying the speed of an event (indicated in bold) which is characteristically associated with the object type. The number of "separate meanings" that *fast* might have is limited only by the range of events that nouns are associated with.

Pustejovsky's claim is that the wide range of seemingly different uses of adjectives such as *fast* can be analysed in terms of their being **event** predicates[4]: that is, predicates that take a specification of an event as their argument. These are distinct from **formal** predicates, which take specifications of objects as arguments: adjectives such as *opaque, expensive* are analysed as being formal predicates.[5]

In the cases that Pustejovsky discusses, *fast* is always analysed as operating on the filler of the TELIC slot of the head noun. The TELIC slot is described as containing a filler which "defines what the purpose or function of a concept is, if there is such a constraint associated with it"(Pustejovsky (1995). p99).

The schema for *book* might thus contain TELIC $= read(e, x, y)$; *fast book* would contain TELIC $= read(e, x, y) \wedge fast(e)$.[6] Thus, *fast* is acting adverbially, to specify a quality of an event.

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[3]Note that the four nouns given in the these examples cannot be conjoined with the comparative, *faster*. By the zeugma test, there are four different senses of *fast* displayed. Such a list of senses could be extended indefinitely, and is thus impractical as a description of the word's meaning.

[4]Other adjectives are mentioned, but only *fast* is treated in detail.

[5]Presumably, the class of formal predicates would include all those adjectives that are traditionally thought of as being one-place predicates or intersective adjectives.

[6]TELIC would be a QUALIA slot; the arguments are all assigned a type elsewhere in the schema: x and y would be typed in ARGSTR, and e in EVENTSTR features. Thus, object arguments may be constrained to be a mass object, a concrete object, and so on, while events may similarly be constrained to be processes, states, transitions, and so on.

$$\left[\text{TELIC } !R^*(!!e!!, .*)! \longmapsto !1 \wedge fast(!2)\right]$$

Figure 3.2: A schema for *fast*

One possible schema modelling *fast* would therefore be that given in Figure 3.2: it operates to conjoin an event predicate with the relationship already specified in the head noun's TELIC slot. This would function in the manner Pustejovsky suggests (p.129), "treating the adjective as a function and applying it to a particular quale within the N' that it is in composition with." In this analysis, *fast* operates on a single schematic slot, carrying out a form of property alteration, rather than straightforwardly replacing a value. The appearance of different senses for *fast* arises because the slot may have different fillers in different cases: however, the similarities between senses are accounted for in terms of *fast* being an event predicate in each case, rather than there being a number of haphazard overlaps in the range of features it acts on.

In fact, Pustejovsky's account allows the operation of event predicate adjectives to be a little broader than this: they can operate on different slots. Instead of having to operate on just TELIC, they can select for and operate on specific *types* of features. This ability is known as **selective binding**. Pustejovsky defines it formally as follows: If α is of type $< a, a >$, β is of type b, and the qualia structure of β, QS_β has quale q of type a, then $\alpha\beta$ is of type b, where $\|\alpha\beta\| = \beta \cap \alpha(q_\beta)$. Rather than the adjective acting as a function that can only alter a particular quale, it can instead alter any quale defined as being of type a.

The only case that Pustejovsky advances in which an adjective might bind to two different slots is *good knife*. He suggests that *good* could operate on TELIC, to specify that it cuts well, or on another slot, the AGENTIVE slot, in order to specify that the knife is well made.[7] There is no suggestion that *fast* operates on anything but TELIC.

However, it is easy enough to produce a schema for *fast* which could operate only on the slots that contain an event argument: Figure 3.3 gives such a schema for *fast*. This would allow for the alteration of fillers for both TELIC and AGENTIVE.[8]

[7]The AGENTIVE slot is structured exactly like the TELIC slot, but contains a specification of the process that creates the object.

[8]It would also allow *fast* to operate on any other quale that contains an event argument.

$$\left[\text{QUALIA}|\alpha^* \quad !R^*(!!e!!, .*)! \longmapsto !1 \wedge fast(!2)\right]$$

Figure 3.3: Alternative schema for *fast*

3.1.5 Summary

Some adjectives seem to be highly polysemous. Precisely how this is to be modelled is unclear. Particular senses of a word can be seen as overlapping to some degree: this is sometimes analysed in terms of different senses referring to similar sets of properties. However, it is not clear how this model might apply to adjectives. A more formal approach to modelling adjectival polysemy is given by Pustejovsky (1995), who discusses how various uses of *fast* could be analysed in terms of the adjective operating on the TELIC slot of the head noun, carrying out a form of systematic property alteration.

3.2 Case Study: Uses of *fast*

3.2.1 Introduction

Pustejovsky's account of *fast* is based on his discussion of a few examples, each of which requires interpretation in terms of a particular event associated with the noun. It is unclear if this analysis can cope with the full range of different uses that *fast* has. In order to assess whether his account does broadly apply to *fast*, I examined all the combinations in the BNC corpus sample that included attributive uses of *fast*, and attempted to account for them in the terms of Pustejovky's theory. This should demonstrate whether the theory can cope with a selection of real world language use (134 examples were found). All cases were analysed in terms of what was considered to be the most likely reading, although obvious ambiguities are noted, and examples not easily analysed are listed separately.

3.2.2 Explict Associations with Processes

Good support for the notion of *fast* acting as an event predicate is supplied by examples of compound adjectives in which *fast* is suffixed by a verb participle. The participle explicitly specifies the type of event which is relevant in these cases: examples are shown in Table 3.1.

The event type in these cases is usually not one that would be closely associated with the head noun, and thus would not be expressed in TELIC as a default filler. Hence

Examples
fast-approaching deadline
fast-changing times
fast-changing world
fast-darkening city
fast-expanding city
fast-fit centres
fast-fit service
fast-flowing river
fast-flowing wharfe
fast-growing collection
fast-growing engineering
fast-growing religion
fast-growing species
fast-growing stable
fast-moving clouds
fast-paced lesson
fast-paced tale
fast-talking cockney

Table 3.1: Explicit Specification of Event Types

$$\left[\begin{array}{ll} \text{EVENTSTR} & \longmapsto \left[\text{NEWEVENT} \;\; e : process\right] \\ \text{QUALIA}|\text{TELIC} & .^* \longmapsto grow(e,x) \wedge fast(e) \end{array}\right]$$

Figure 3.4: Schema for *fast-growing*

the event is specified explicitly as part of the modifier; constructing a schema for such modifiers is relatively straightforward: one for *fast-growing* is given in Figure 3.4: the only complication is that a new event specification also has to be added to EVENTSTR, so that all filler arguments are typed.

3.2.3 Operation on the TELIC Quale

Many examples of simple adjective-noun combination are found that fit with Pustejovsky's analysis of *fast* operating on the TELIC quale.

Deverbal Head Nouns

Several examples of deverbal agentive nouns in which TELIC is relevant are found: *bowler(s), copier, learner, mover, reactor(s), runner, seller, starters, stunters, tanner, worker(s).* In order that there is no confusion caused by discussion of the AGENTIVE quale below, I shall henceforth call these "teleological nouns": that is, nouns which primarily describe the function of the referent.[9]

In these cases, *fast* will be associated with a TELIC feature that is analogous to the verb that the noun is derived from. Thus, *bowler* will contain TELIC = $bowl(e, x, y)$, and *fast* will modify this to TELIC = $bowl(e, x, y) \wedge fast(e)$, and so on.[10]

Non-Deverbal Head Nouns

There are also many cases of *fast* modifying non-deverbal nouns which denote surfaces moved upon (or structures moved within), examples being *corners, ground, lane, road, route, network, surface, track* and possibly also *line.* In order for Pustejovky's model to account for these cases, the schema must contain TELIC = $moved - on(e, x, y)$, or something similar: it does seem that this use of *fast* is a commonplace one.

Some such nouns (e.g. *approaches, ascent, bend, descent*) are ambiguous between a reading in which they represent a place where motions occur, and a reading in which they represent the motion itself. For example, an *ascent* can be either a pathway on which one may move upwards (for example, particular paths up a mountain are called ascents), or the motion of moving upwards itself (as in the ascent of an airplane). This reflects a pattern of systematic polysemy for such nouns: the combination of *fast* with nouns that refer to actual motions is discussed below.

In addition, *fast* modifies *aircraft, boats, car(s), chariots, trains*: all nouns that denote vehicles. The schema for each of these will, roughly speaking, contain TELIC = $transport(e, x, y)$; combination with *fast* will create TELIC = $transport(e, x, y) \wedge fast(e)$. The combination *fast engine* is similar to these, but the filler for TELIC will involve generating motion, rather than being in motion.

Other Cases

There are also a number of cases in which *fast* seems to be acting as an event predicate, but indicates the rapidity of an action which we would not expect to be specified in

[9] In any case, not all these words exclusively describe agents. For example, *fast seller* might refer to either "one who sells x fast", or "x which is sold fast": the noun is ambiguous. In either case, the filler for TELIC would be relevant.

[10] I am assuming that *fast stunters* refers to something that stunts growth fast.

the mechanism of selective binding, which allows modifiers to map to slots of specific *types* rather than just specific slots. The implications of this idea are not well-explored for adjectives: the only example given by Pustejovsky for an adjective operating on AGENTIVE is for *good knife*, interpreted in terms of the referent being "well made" (see Pustejovsky (1995), Chapter 7, notes 19,20). The following examples should show that this mapping can, in fact, account for a large number of uses of *fast*.

Deverbal Head Nouns

There are many words modified by *fast* that refer to particular kinds of motion events: examples are *eddy, exit, lap, launch, glance, growth, race, ride, skip, tango, tows, trot, trundle, turns.* These words could be described as deverbal nouns: they are examples of a pattern of systematic polysemy, that in which a word may label both a process (when acting as a verb) and the object that results from that process occurring (when acting as a noun). In other words, the occurrence of a particular kind of motion *creates* this kind of object. Given this, the natural analysis of the operation of *fast* in these cases is that it modifies the event specification given in AGENTIVE, an event specified by the verb these words are derived from. Thus, the schema for *skip* will contain AGENTIVE $= skip(e, x)$, and *fast* operates to change this to AGENTIVE $= skip(e, x) \wedge fast(e)$, and so on. This type of analysis will also apply to nouns such as *approaches, ascent, bend, descent* which, as mentioned above, have readings in which they denote motion events (thus meaning that these combinations are ambiguous; either TELIC or AGENTIVE may be modified, depending on the reading the noun takes).

Other examples of deverbal nouns that refer to entities created by an event or series of events, for which *fast* will indicate the speed, duration or tempo of those events include activities such as *bowling, shooting, skiing*, and also the nouns *access, answer, communication, decisions, resolutions, minipreparation, movements, pulse, replay, tan, turnover, variation.*

Non-Deverbal Head Nouns

The AGENTIVE quale is also relevant in modelling the combination of *fast* with a number of non-deverbal head nouns.

There are several non-deverbal head nouns that are modified with *fast* for which AGENTIVE also seems to be the quale that is modified. For example, *bit, leads, passage(s), progress, tune* can refer to events that are produced rapidly[11]; the combinations *fast buck, fast money, fast food* and *fast fire* also seem to describe objects

[11] The combination *fast leads* can refer to lead solos played on a musical instrument.

the head noun's schema. For example, when *fast* combines with the head nouns *men, women, cavalry* or *turtle*, it suggests that the referents can move fast, just as it does for vehicles. However, motion isn't really a specific function/use for these object types: we would not expect TELIC = $move(e, x)$ to be specified as a default filler. Similarly, *fast right-hander* suggests the speed with which some event is carried out (with the right hand), but it is unclear precisely what this is from the combination alone; likewise for *fast machine.*

3.2.4 Operation on the AGENTIVE Quale

Pustejovsky is exclusively concerned with TELIC in accounting for *fast.* Some examples from the corpus provide difficulties for this account.

As *fast* is taken to be an event predicate, it should apply naturally to nouns that denote events. However, no explicit description of how this is to be done is given by Pustejovsky. Mapping in terms of TELIC for these cases does not give a correct reading: we are concerned with the speed, duration or tempo of an event itself, rather than with the events it secondarily causes or is used for. This is reflected in the ambiguity of combinations with words such as *ascent*, which may refer either to a physical path (e.g. the way up a mountain) or to the event of ascending. In the first case, the path can be **moved on** rapidly; in the second, it is the event of **moving** itself which occurs rapidly. The distinction can also be seen in a case such as *fast race*: the purpose of a race may be loosely described as "finding a winner", but the process of deciding who wins may be no faster just because the race itself is fast (consider a photo-finish). Similarly, the purpose of shooting may be loosely given as "hitting something", but this is not necessarily speeded by *fast shooting.*

It might be suggested that where *fast* is not applicable to TELIC, it is instead mapping to a formal feature indicating temporal structure (i.e. an analogue of SHAPE and SIZE features for physical structure). However, I propose another explanation, in terms of *fast* operating on the AGENTIVE quale in these cases. The AGENTIVE quale has the same kind of structure as TELIC (i.e., specifies events), but contains information about the processes that act to bring a referent into existence, rather than the processes it is actively or passively involved in after creation. For a referent which is itself an event, the processes which bring it into existence are identical with the subevents that compose it over time: indication of their rapidity would therefore be equivalent to a feature of temporal structure.

This solution fits neatly with Pustejovsky's general framework: the notion that event predicate adjectives can operate on both TELIC and AGENTIVE is already present with

$$\left[\text{QUALIA}|\alpha^* \quad !R^*(.*!!e!!, x, .*)! \longmapsto !1 \wedge fast(!2)\right]$$

Figure 3.5: Alternative schema for *fast*

that are rapidly produced or prepared. Taking the general form of AGENTIVE to be something like AGENTIVE = $create(e, x, y)$, then *fast* will operate to give the filler AGENTIVE = $create(e, x, y) \wedge fast(e)$.

However, there are other nouns that seem to require a slightly different interpretation. For example, the head nouns in *fast pace, fast rate, fast speed, fast tempo* refer to measurements of event characteristics, rather than events themselves. The objects that these measure nouns refer to are simply created by measuring the speed (or other characteristic) of some event: thus, their schemata will contain a feature such as AGENTIVE = $measure(e_1, e_2, x)$: *fast* would simply act to produce AGENTIVE = $measure(e_1, e_2, x) \wedge fast(e_2)$. In other words, they are created by the event of measuring (e_1): what is measured is a characteristic of some other event (e_2). A couple of other combinations, *fast programme* and *fast schedule*, in which the head nouns denote types of information, can be dealt with in a similar way, the AGENTIVE filler in these cases indicating a scheduling of events, rather than a measurement, however (e.g. AGENTIVE = $schedule(e_1, e_2, x)$). A similar interpretation seems necessary for cases in which the head noun refers to a method of carrying out some action (i.e. a schedule for carrying out the action): these are *fast process, fast technique, fast ways.*

The schema given in Figure 3.3 is not sufficient to model this. However, a slight modification makes it able to deal with the cases just discussed, as well as those already mentioned above. A schema able to do this is given in Figure 3.5.[12]

3.2.5 Other Uses

My analysis follows Pustejovsky's in suggesting that the function of *fast* can be analysed as the same in most of its uses: it operates as an event predicate. However, there are a number of cases in which this interpretation may be incorrect.

Most importantly, there is another sense of *fast*, in which it can be paraphrased as "unmoveable, unalterable, or sealed". In this sense, it is related to the verb *fasten*, and constructions such as *hold fast, stick fast.* It also occurs in this sense in the phrasal modifier *hard and fast*: the program that extracted complex concepts from the BNC

[12]The event argument that is matched as !2 must be adjacent to an object argument: this copes with all cases mentioned so far.

would not include *hard and* from cases where this occurs. Thus, *fast* may be used in this sense when modifying *definition, distinction, friends, requirements, rule(s)* or *text*, although an event predicate reading is also possible in some of these cases.

A few other cases are more idiosyncratic, idiomatic, or difficult to interpret: *fast day* refers to the subjective tempo at which events occur within a day; a *fast forward* is a control for an audio or video player; *fast overhead* could refer to something held unmoveable in a position, or to rapidly occurring financial expense; a *fast number* is often interpreted as meaning a "deceitful action", but could also mean a rapidly-moving entertainment; the meaning of *fast heads* is unclear, but could refer to people who "think fast"; *fast 12-shot* also is unclear, but could refer to a gun that can shoot rapidly; *fast scsi* is presumably technical terminology.

There are also a couple of examples involving possible syntactic misclassifications of the head. For example, *fast acting, fast emptying* are probably compound adjectives, but could possibly belong with examples such as *fast shooting.*

3.2.6 Discussion

My survey of the uses of *fast* shows that Pustejovsky's account can be applied to a much broader range of uses than those he explicitly considers.

The notion of selective binding allows for an account to be given of the combination of *fast* with nouns in cases where mapping to TELIC would not give the correct reading. This AGENTIVE mapping is especially appropriate for modelling combination with many event nouns, but there are also other cases in which it applies.

Given that there are (at least) two slots to which *fast* might map, there seems to be broad scope for ambiguity. However, the type of double meaning possible for *fast ascent* does not seem to be available for combinations such as *fast car*: the natural reading is to do with speed of movement, not speed of manufacture. A question that naturally arises from this is what causes the selection of TELIC or AGENTIVE as the slot which is operated on by the adjective.

Selective Binding

Mappings to TELIC are preferred for particular groups of nouns. In particular, we saw that mapping to TELIC is commonplace for deverbal teleological nouns. An observation in Putnam (1975) is relevant here: deverbal teleological nouns (agentives) require only one criterion for definition: that of carrying out the action specified by the base verb (i.e. the filler for TELIC). No other information about the referent is required for the definition to be correct. If this analysis is correct, then *fast* operates on TELIC in these

cases, simply because AGENTIVE is left unspecified.

Some non-deverbal nouns can also be described as teleological nouns, in the sense that they, too, are adequately defined in terms of the TELIC slot alone. This will include words such as *mathematician, scientist* and *musician*, denominals derived from one of the arguments of TELIC, and also many artifacts, both deverbals such as *iron, drill, hammer, toaster, saw*, and possibly also words such as *car, garage, road.*[13]

In contrast, there are other words which may be adequately defined by AGENTIVE alone. Event nouns are the most obvious of this type; an event may occur without there being any specific purpose to it (e.g. a motion need not have a purpose). Similarly, measurements such as *rate, speed* do not, in themselves, have any characteristic function: they describe objects that exist simply as the result of events occurring. Other words without an obvious TELIC specification are *tan, tango.*

Some of the mappings to AGENTIVE do, however, seem to be purely conventional: *fast money* and *fast food* could perhaps have readings involving "fast payment" and "fast eating" respectively, although if these readings do occur, they are highly infrequent.

Mapping is not always restricted to just one slot: this is shown by the potential ambiguity of *fast approaches, fast ascent*, etc. However, the different senses of these words would, presumably, have different specifications of TELIC and AGENTIVE. For example, if we take *ascent* as a route, its purpose is well defined, while its origin is not; if we take it as a kind of movement, its origin is obvious, but its purpose need not be specified. Thus, mapping in these cases may be governed in the same way as the cases mentioned above, but this depends on the sense of the head noun being resolved by context.

In general, we can say that the adjective *fast* is operating like the adverb *fast*, to specify characteristics of an event. Ullmann (1957) notes that this sense of the adjective is actually derived from the adverbial use.

Event Predicates

A question which we have not tackled up to now is how, precisely, the event predicate $fast(e)$ is to be interpreted. Describing *fast* simply as an event predicate requires the assumption that the effect it has on the description of event structure is not itself as

[13]It is debatable whether a noun such as *car* does not possess a default specification of AGENTIVE; however, it seems that TELIC should be more diagnostic for class membership. If both slots have a filler specified, the more diagnostic feature will probably be the one modified. For cases such as *fast man, fast turtle*, the AGENTIVE feature will be specified, but duration of the creating process is unalterable, and thus a reading in terms of TELIC must be forced.

problematically diverse as the number of meanings that the zeugma test would give us. As we saw in the case study of colour adjectives, what seems to be a simple predicate may require a more complex description when considered in detail. Different types of events might be *fast* in different ways.

In fact, there seem to be at least three ways in which *fast* specifies the substructure of an event: it can be relevant to the duration of the event as a whole; it can specify the tempo of subevents; or it can indicate the speed of a motion. However, these three types of events are interlinked at the level of subevents. The duration of an event as a whole depends on the duration of its subevents; if the subevents occur rapidly, the tempo of transition between them will be rapid, and if the event is bounded in time, then its duration will be short. The speed of motion can be regarded as a special measure of the tempo of subevents, as is reflected in measurements of speed such as m.p.h., r.p.m., w.p.m., etc. which count a number of events occurring within a unit of time. Thus, it does seem that a reasonably general account of the operation of *fast* across a range of event types could be given.

However, there is another sense in which the meaning of *fast* differs: this depends on whether it is bound to TELIC or AGENTIVE. It seems that, for all the examples in which *fast* binds to TELIC, the event specified is only possibly fast: for example, a *fast car* or a *fast runner* can move fast, but don't necessarily do so; likewise, a *fast road* can be moved on fast, but not all motion on it is necessarily fast. Indeed, something can be a *fast car* without ever having moved fast; so long as it has the potential to do so the description applies. On the other hand, when *fast* binds to the AGENTIVE quale, the event is necessarily fast: a *fast launch, fast tango* or *fast tempo* must be created by an event that is fast.

This might suggest two different senses for *fast* are being applied. Alternatively, this effect might be more due to the way in which the two slots should be interpreted in general. The default TELIC filler for a noun only applies contingently: we may describe someone as a *runner* without them having to be continuously running. However, the AGENTIVE process that creates something has occurred in the past, once, and is complete and finished; it has necessarily occurred. Thus, it seems that predicates in TEXTSC are (implicitly) quantified as only possibly applying, whereas for AGENTIVE they are (implicitly) quantified as necessarily applying. Thus, the interpretation of $fast(e)$ differs in these two slots, due to the different ways in which they are implicitly understood.

3.2.7 Summary

My analysis of the uses of *fast* found in the BNC corpus generally supports Pustejovsky's description of its operation as an event predicate which selectively binds to particular qualia. However, Pustejovsky focussed exclusively on its binding to TELIC: I show that the AGENTIVE quale is also of great significance in accounting for the adjective's semantic functions.

A number of patterns of modification that are not described by Pustejovsky are apparent from this corpus sample: for example, the use of *fast* to modify measurement nouns, and the different mapping possibilities for the different senses of words.

Following this, I provided an account of why *fast* bound to specific features: I argued that in many cases there is no choice, because only one of the two qualia will have a specified filler.

If adjectives generally do operate with the same degree of selectivity in binding to feature types that *fast* seems to, it seems that a large portion of adjectival polysemy is potentially explained: some adjectives may operate as event predicates, systematically altering the fillers of TELIC and AGENTIVE. Pustejovsky suggests that adjectives do in fact fall into two classes, those that are event predicates like *fast*, and those that are formal predicates, operating on slots describing properties of the physical object, rather than associated events, examples of this sort being *opaque, expensive.*

3.3 Polysemous Adjectives: Doublet Operation

3.3.1 Introduction

It is unclear whether adjectives can simply be divided into classes of formal predicate and event predicate. It is clear that at least some adjectives can operate as both.[14] An obvious example is that of *long*, which operates to indicate both physical size, and the duration of events. Indeed, Pustejovsky notes its operation as an event predicate in *long record*, meaning "LP that **plays** for a long time"). The use of *long* as an event predicate is extremely common; it acts this way when it modifies nouns such as *absence, addiction, battle, conversation, delay, groan, lease, monologue, occupation, shower, siege, swig.*[15]

[14]We saw that even *fast* itself has some uses in which it is not an event predicate (e.g. those in which it indicates "fixity").

[15]There are also various complexities to its use as an event predicate: although a *long night* or *long evening* may be measured in terms of the actual proportion of a day that is dark, these combinations might also be interpreted as being similar to *long week*, which implies a subjective perception of time as slowly moving, or of many tiresome events occurring within this period of time. Some combinations,

In the case of *long*, this duality of use might be explainable in terms of the type of noun that is being modified. However, in some cases, complex concepts are ambiguous because both event and formal predicate readings are available for the adjective: such ambiguity has been noted back to the time of Aristotle. Take, for example, the combination *poor violinist*: this could refer to "a violinist who is poor" (i.e. penurious) or "someone who plays the violin poorly" (an event predicate reading). Other classic examples of this are *beautiful dancer*, referring either to "a dancer who is physically beautiful", or "a dancer who dances beautifully"; and *old friend*, which could refer to "a friend who is old" (i.e. aged), or "someone who has been a friend for a long time". Cases such as these were discussed in some detail by Siegel (1980), who suggested that such duality of use for adjectives is extremely common. We shall examine Siegel's theory and see how it relates to the distinction made above between formal and event predicates.

3.3.2 The Doublet Theory of Adjectives

Intersective and Non-Intersective Adjectives

Siegel (1980) argues that adjectives frequently have a "doublet" nature: that is, that there is frequently a duality in their semantic operation. This is not a formal/event predicate distinction: she analyses the doublet nature in terms of adjectives having both intersective and non-intersective (subsective and privative) uses.

This distinction is supported on the basis of the different possible syntactic structures that complex concepts can be paraphrased by. For example, only when an adjective is used intersectively can it be predicated of the head noun: while a "brown cow" is "a cow that is brown", a "provincial governor" is not "a governor who is provincial".

Siegel states that the most important test for non-intersectivity is that the meaning of the adjective can be paraphrased using a related adverb (e.g. a "beautiful dancer" is "one who dances beautifully"). This fits well with the analysis given above of event predicates; in indicating a quality of the event structure, they act adverbially. Furthermore, Siegel's examples of ambiguity usually contain teleological nouns (frequently *dancer* or *lutist*), for which event predicate interpretations will be available.

However, there is a problem with Siegel's analysis of adjectives as either intersective or non-intersective. The ambiguity of *beautiful dancer* may arise because the adjective can operate in two different ways (has a "doublet" nature), but *beautiful* is clearly

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such as *long book, long journey* imply a physical length (number of words, number of miles) which will generally correlate with the duration of a related event (reading or moving, respectively).

not intersective in either reading. Therefore, Siegel introduces a class of "measure adjectives", which are supposedly similar to intersective adjectives.

Measure Adjectives

Measure adjectives are taken to be similar to intersective adjectives, because their meaning is, in some sense, independent of the meaning of the head noun. Siegel makes two main points in support of this.

Firstly, they are supposed to "pick out a measurement scale": the idea that they pick out such a scale *independently* of any head motivates the comparison with intersective adjectives. For example, Siegel claims that *fast* in *fast car* is a measure adjective because one doesn't need to know "much about what a car is", only "how fast things called cars normally go". Thus, the information required to interpret *fast car* is, she suggests, derived from knowledge about the extension of *car*; it is not part of the meaning (intension) of *car*.

Secondly, measure adjectives are described as requiring a comparison class for interpretation, in order to pick out a norm for the scale e.g. *tall* could mean "tall for a woman", "tall for a basketball player", "tall for a building", and so on. Again this is supposed to be pretty much independent of the meaning of the head: to know that something is a *tall library*, she suggests, one only needs to know something about how tall these buildings typically are. Again, she suggests that a specification of height is not part of the meaning (intension) of *library*.

Note that both these ideas describe measure adjectives as being linear (non-polysemous) gradable adjectives, such as those discussed in Section 2.4.1. If Siegel was right about the scale and comparison class being selected "independently" of the head, we would expect that there should be no restriction on the comparative range of these adjectives: application of the zeugma test would never produce semantic anomaly. However, our study of the diversity of uses of *fast* showed that Siegel's argument about "picking out a measurement scale" is wrong. What *fast* "measures" can be extremely case-specific; and as the zeugma test indicates, *fast* is clearly a non-intersective adjective, its meaning depending crucially on what the head noun denotes. Similarly, the idea that a comparison class is specified independently of the head noun is not convincing: in the case of SIZE adjectives, the comparison being performed depends very much on precisely which noun is the head. As for the argument that these adjectives can be interpreted in terms of characteristics from the noun that are not part of the intension of the word, this may be correct: however, it is unclear which characteristics are, in fact, relevant intensionally; and even if we accept that the adjective is not operating intensionally,

this does not establish that these adjectives are, in some sense, acting intersectively.

It seems clear to me that *beautiful*, when modifying *dancer*, is acting subsectively *whatever sense we take the modifier as having*: its doublet nature is not the result of it being both intersective and non-intersective. We can account for ambiguity of the combination because *beautiful* has: (a) a formal predicate reading, in which it indicates physical beauty, and (b) and an event predicate reading in which it indicates qualities of the action of dancing.

3.3.3 Discussion

Siegel's analysis is based on a discussion of **non-extensional** adjectives by Kamp (1975). Kamp defines these as being a group of adjectives that might not have the same application to a set of referents appearing under different descriptions. For example, a *skillful cobbler* may not be a *skillful darts player* even if *cobbler* and *darts player* have the same extension (are co-extensive). Similar considerations apply for such pairs as *clever mathematician, clever solicitor*; *competent biologist, competent cornettist*; *good actor, good boxer*; and so on.

Such adjectives cannot be extensionally defined: an entity could be both a member and not a member of the set of e.g. *skillful* things, depending on which noun-description it was considered under. This is why Kamp calls them non-extensional. Siegel is arguing that adjectives can be both non-extensional when interpreted in some ways (e.g. "beautiful dancer" = "one who dances beautifully"), but extensional (i.e. applying in the same way to every head noun) when interpreted in others (e.g. "beautiful dancer" = "person who is physically beautiful"). She attempts to capture the extensional/non-extensional division in terms of adjectives being intersective or non-intersective (Montague types t/e and CN/CN). However, this is inadequate: an adjective may have both extensional and non-extensional uses neither of which are of type t/e; the doublet nature is better analysed as being a division between formal and event predicate uses of the adjective. Note that all the examples of non-extensionality for adjectives given above involve teleological head nouns: this suggests that the non-extensional nature of these adjectives arises from the different uses they have as event predicates.

3.3.4 Summary

While Siegel suggests that most adjectives in English (and Russian) have a doublet nature, it seems that interpreting this in terms of a distinction between intersective and non-intersective uses of adjectives is incorrect: an interpretation in which adjectives can operate both as formal and event predicates seems a better analysis of the doublet

nature of adjectives.

However, Siegel's analysis identifies dozens of examples of doublet adjectives: *bad, cheap, clever, clean, crazy, difficult, intentional, plain, public, shallow, skillful, terrible*, and many others (see Appendix IV of Siegel (1980) for a complete list). If my identification of doublet nature with ability to act as both formal and event predicate, this suggests that adjectives often cannot be classified as purely event or purely formal predicates: they can act as both, and any account of polysemy in adjectives will have to incorporate this.

3.4 Case Study: Formal/Event Predicates

3.4.1 Introduction

In the following case study I look at two adjectives: *clever* and *competent.*[16] The study will examine the range of combinations that these adjectives enter into, and suggest how their operation can be modelled in terms of their uses as formal or event predicates.

3.4.2 Uses of *clever*

The adjective *clever* is often mentioned as having multiple meanings (e.g. in Kamp (1975), Siegel (1980)). Unlike an adjective such as *fast*, however, the zeugma test does not indicate its operation on different events. For example, "the mathematician is cleverer than the lawyer" makes perfect sense. This is because we assume there is a generic, formal kind of cleverness which can be measured, for example by an IQ test: this is a reading which takes *clever* as a formal predicate. There are also specific types of cleverness applicable only to performance within a specialist field: for example, in combinations such as *clever mathematician* and *clever lawyer*, the implication is that the individual has specific talents that make them good at carrying out tasks within their field. These seem to be readings taking *clever* as an event predicate.

A survey of corpus uses will reveal to what extent *clever* is used as a formal or event predicate; in addition, it should reveal if there are other types of modification that *clever* carries out.

[16] Originally the intention was to look at *clever* and *skillful*, both of these being examples given by Kamp (1975) of non-extensional adjectives difficult to model due to their flexibility of meaning. However, as there were only two examples of combination with *skillful* in the corpus, *competent* was substituted for it.

$$\left[\text{PSYCH}|\text{IQ} \quad (m,n) \longmapsto (\tfrac{n-m}{4}, n)\right]$$

Figure 3.6: Representation for *clever*

Formal Predicate Uses

There are many examples in which the head noun specifies a type of human such as *bloke, boy(s), chap, fella, fellow, girl, lad, man, men, people, person, woman, women,* without implying any particular teleological role. Other words, such as *dad, father, husband, mother* could be regarded as teleological, but use of the adjective does not strongly suggest operation on a specific TELIC filler for these cases. In these cases, a general kind of cleverness seems to be implied (something like an IQ measure), which is not tied to specific characteristic actions: these combinations suggest a formal predicate use of *clever.* The same seems to apply for derogatory nouns (*bastards, devil, shit, swine*) and the idioms *clever clogs, clever dick.* In all these cases, it seems that *clever* should operate on a slot indicating psychological qualities such as intelligence (the slot PSYCH).

For example, if we imagine general intelligence is represented by something like IQ, this being represented in terms of the bounds to the value, then *clever* could be modelled as shown in Figure 3.6, indicating that someone *clever* falls in the top quarter of the IQ range.

There are other cases which also suggest this general kind of intelligence. For example, *clever* also combines with animal nouns such as *bear* and *dog*; presumably these, too, are regarded as having a general kind of intelligence. We also find the combination *clever minds*, which will also allow for a mapping to an IQ slot.[17]

Event Predicate Uses

Where the head noun in combination with *clever* is a teleological noun, such as *critic, operator, politicians, reader, scholars, solicitors, thief, thinkers, tradesmen*, the modifier can be interpreted as being a formal predicate, indicating a type of general cleverness.

However, in many cases, another reading is available, in which the quality of cleverness specifically pertains to the activities that the referent performs. This is clearly revealed by the fact that a clever person would not necessarily be a clever critic, clever

[17]We also find that *clever* modifies the nouns *eyes, looks.* This is part of a more general pattern in which psychological states and characteristics can be communicated with body subparts, motions, etc. This pattern of modification is examined in detail in Section 3.5.2.

politician, or clever thief; similarly, clever critics, clever politicians and clever thieves could be unintelligent in general terms (the separation between general and specific intelligence is, however, debatable for some cases such as *clever scholar, clever thinker*). In addition, the combination *clever filters* requires such a reading, as the head noun refers to a device without psychological states.[18]

This use of *clever* to indicate aspects of the performance of some task can be modelled in terms of the adjective operating on the TELIC slot, conjoining the event predicate *clever*(e) to the filler specified in the head noun: it is interpreted adverbially. Thus, we can describe a *clever critic* is someone who **criticises** cleverly, and a *clever thief* is someone who **steals** cleverly. It is, however, harder to specify a single TELIC filler for head nouns such as *politicians, solicitor*; they are associated with a range of different activities.

There are many cases in which the head noun denotes a form of communication or information: *adverts, answer, campaign, casuistry, chat, comment, idea, letter, name, oratory, pattern, promises, put-down, research, speech, verse, yarn.* Clearly there will be no PSYCH features specified for these nouns. However, an event predicate interpretation can account for these combinations: *clever* could operate on the AGENTIVE slot for these cases. For example, a clever advert is produced by someone advertising cleverly; a *clever letter* is one that's written cleverly; *clever research* is produced by researching cleverly.[19]

Combinations in which the head noun refers to a process could also be modelled in terms of *clever* operating on AGENTIVE. Head nouns of this type are *accounting, formatting, tailoring, marketing, pitching* and *opportunism*, referring to types of activity that people can undertake, and *advancement, move, ploy, trick(s), use*, referring to particular kinds of events.[20]

Note that in all the cases in which AGENTIVE can be modified by *clever*, we cannot say that associated TELIC events are carried out cleverly: although this may be an obvious inference in many cases, the two are separable. For example, the existence of *clever marketing* does not lead to objects that **sell** cleverly; a *clever answer* can be the

[18]We also find combinations with the head nouns *device, machine, syndicate*: in these cases, the use of *clever* suggests that they are used to carry out some process cleverly, but the nouns are not such that a TELIC filler can be specified precisely.

[19]Where *clever* modifies nouns indicating communication or information, it may be said that this is more an indication of the communicator's psychological characteristics rather than a property of the information itself or how it is produced. However, this interpretation is undermined by the consideration that "clever communication" is not *necessarily* produced by someone who is clever. See Section 3.5.2 for more discussion of adjectives indicating mental states.

[20]Possibly other head nouns are interpreted as referring to events: *clever ball*, for example, could refer to the trajectory of a ball producing by throwing or hitting it cleverly.

$$\begin{bmatrix} \text{QUALIA}|\alpha^* & !R^*(.*!!e!!, x, .*)! \longmapsto !1 \wedge clever(!2) \\ \text{PSYCH}|\text{IQ} & (m,n) \longmapsto (\frac{n-m}{4}, n) \end{bmatrix}$$

Figure 3.7: Representation for *clever*

product of someone who **replies** cleverly (e.g. a witty insult, an evasion), rather than something that **answers** cleverly.

Other Cases

There are a number of cases which are not so easy to interpret. For example, *clever* is used to modify a number of vague nouns (i.e. nouns not strongly specifying a particular kind of object), such as *bit, effort, piece, situation, stuff, thing(s).* In other cases, the combination can't easily be interpreted out of context: examples are the combination of *clever* with *accessories, cover, going, nature, platform, popsey, ride, stick, subjects, trousers, way.* In most of these cases, animate objects are not denoted by the head noun, and thus the formal predicate interpretation of the modifier which operates on a slot within PSYCH could not be used. Thus, *clever* in these cases must generally be operating as an event predicate, but it is unclear which slot is relevant.

Summary

The adjective *clever* can function as both event and formal predicate: both uses seem common. A representation of *clever* which reflects the duality of operation is given if Figure 3.7; it selectively binds to slots specifying events, in the same way as *fast*, but can also operate on a slot indicating IQ as a formal predicate.

The formal predicate reading is only available when *clever* modifies nouns that have the IQ slot. Where a TELIC filler is also specified, *clever* can also operate on this. In most other cases, the AGENTIVE slot seems to be operated on.

3.4.3 Uses of *competent*

The adjective *competent* seems intrinsically to be concerned with the carrying out of some function, suggesting that it might function solely as an event predicate. However, as we shall see below, it does also have a formal predicate interpretation.

Event Predicate Uses

Teleological nouns commonly occur as head nouns with *competent*, and in all these cases the correct interpretation seems to be for *competent* to operate on TELIC, adding the event predicate *competent*(e) to the head noun's filler. Examples of this type in the corpus are the combinations with *biologist, breadwinner, caretakers, cornettists, driver, electrician, handyman, interviewers, leadership, librarians, lover, mother, politicians, riders, skipper, student, supplier, witness, writer.* In some cases, the specification of TELIC is not inherent in the definition of the word, but should be apparent from the context, as for words such as *amateur, high-flier, member.* The combination *competent roof* seems odd, but presumably the adjective is relevant to the TELIC feature, indicating its ability to provide shelter.

For other nouns the inference is that the referent was produced competently, and thus the mapping is to AGENTIVE. Examples of this type are: *competent french*, which is **spoken** competently; *competent victory*, which is **won** competently; *competent shot*, which is SHOT competently (in fact, this case is ambiguous; *competent shot* could also refer to someone that shoots competently, as in "He is a competent shot."). Other cases in which AGENTIVE is relevant are *commentaries, interpretation, result, views.*

Formal Predicate Uses

For words denoting decision making bodies such as *authorities, authority, body, community, court, groups, jurisdiction, organisation(s)*, it might be assumed that *competent* refers to the functions which they carry out, and thus to the TELIC slot. In fact, competency of this kind often does not imply that the functions are carried out competently, or that the entity was competently created, simply that the body has the *authority* to make a decision regarding some matter. In this sense, *competent* is being used as a purely formal predicate, presumably mapping to a LEGAL STATE feature that specifies the referent is properly constituted to carry out its functions.

Similarly, when *competent* combines with non-teleological nouns that indicate individuals (*bloke, boy, individuals, kid, person*), the adjective may be indicating a non-specific formal legal competence (e.g. being mentally normal). However, in these cases, there is also the possibility that the adjective operates on a TELIC feature specified by context.

Summary

Again we see division of operation into event and formal predicates. A schematic representation of *competent* is given in Figure 3.8.

$$\begin{bmatrix} \text{QUALIA}|\alpha^* & !R^*(.*!!e!!, x, .*)! \longmapsto !1 \wedge competent(!2) \\ \text{LEGAL STATE} & .* \longmapsto competent(x) \end{bmatrix}$$

Figure 3.8: Representation for *competent*

3.4.4 Discussion

On Pustejovsky's analysis, *fast* operates solely as an event predicate. That is, the selective binding of *fast* to events always produces $fast(e)$; *fast* is taken to always operate in an "adverbial" manner. Pustejovsky thus suggests that adjectives can be classified as being either formal predicates (*opaque, expensive*) or event predicates (*fast, bright*). However, this brief survey of the uses of *clever* and *competent* suggests that certain adjectives are "doublets", able to act both as event and formal predicates. The schematic model, which allows for the variety of uses of these adjectives to be specified in terms of simple property mapping mechanisms, seems preferable to Siegel's analysis, which describes "doublet" adjectives as being either intersective or non-intersective. The schematic approach gives a relatively simple analysis of what is, at first glance, a chaotic mixture of different uses for an adjective: the adjective operates on either TELIC, AGENTIVE, or some specified formal feature of an adjective, with the head noun influencing which mappings are likely.

However, an obvious question is whether the event predicate description of adjectives is sufficiently detailed to really be modelling the operation of *clever* or *competent*. To describe an adjective as being "adverbial", or in terms of an event predicate such as $clever(e)$ could be seen as over-simplistic: if we are explaining the meaning of *clever letter* in terms of it being "written cleverly" (i.e. containing the feature AGENTIVE = $write(e, x, y) \wedge clever(e)$), then we should be able to state what constitutes cleverness in the act of writing.

Previous analysis of adjectives such as *clever* and *skillful* has relied on describing particular, ad-hoc sets of features which are relevant to the adjective's use only with particular head nouns (see Kamp (1975)). For example, the skillfulness of a darts player can be evaluated using criteria that will be irrelevant in possibly any other context: ability to score 180, ability to hit the bullseye, ability to score doubles, and so on. This is the sort of approach that Pustejovsky's analysis of adjectival polysemy was aimed at moving away from, but it is unclear to what extent it succeeds with these more complex adjectives: it could be argued that interpretation of $competent(e)$ or $clever(e)$ in their different contexts of use will require the deduction of similarly context specific features.

On the other hand, it does seem plausible that there are general characteristics associated with competency or cleverness that apply whatever the particular action being carried out is. One obvious example is the number of errors made: when an action is carried out competently, there should be a low number of errors made in carrying out the action. Another characteristic of competency is that the action should frequently be effective in producing the desired outcome (reaching a goal). These are general characteristics of the event structure which $competent(e)$ should act to specify, whatever type of event it is concerned with. Similarly general strictures apply for $clever(e)$; again, errors will be infrequent and the action should be effective in reaching a goal; in addition, goals may be reached using an unexpected, novel method, this perhaps being simpler than a standard approach (but allowing for a greater degree of success), or perhaps more complicated (requiring a deal of skill in carrying out the action successfully). I do not suggest this provides a complete analysis of the event characteristics associated with competency and cleverness. However, it does seem as though the principles involved can be specified in a general manner such that they will relate to all kinds of actions, rather than it being necessary to invoke particular properties only relevant to a specific combination (although extensional feedback will suggest that certain such properties will be attributable to referents of a combination).

Thus, Pustejovky's analysis of adjectives as being event predicates is a useful generalisation about the combinatory process, which accounts for a portion of adjectival polysemy. However, as we have seen, it does not justify the classification of adjectives into event and formal predicate classes: a certain set of adjectives can operate as both.

3.5 Case Study: Metonymy and Adjectives

3.5.1 Introduction

The types of polysemy we have considered so far cover various uses of adjectives as event and formal predicates. However, this only covers a portion of the examples of polysemy that were mentioned in the introduction to this chapter.

In this section, I discuss another type of polysemy, which arises because some adjectives have different uses that are linked together through **metonymy**. Metonymy is a common language phenomenon, in which a word referring to one aspect of an entity is used to label another aspect or the whole of the entity (see Gibbs (1994), p.231). For example, a name may be used to indicate the type of object produced by the entity with that name, as in *moog, xerox, hoover.*[21]. Another common type of metonymy is

[21]This particular type of metonymy is known as *eponymy*: companies use trademarking to try and

the use of a word as both noun and verb, indicating both an action, and also entities produced by or involved in the action (*fish, jump, tunnel, flash, drink, bill, file, burn, bottle*, etc.).

Lakoff (1987) briefly mentions the relevance of metonymy for complex concepts. He analyses the examples of *healthy exercise* and *healthy complexion* as displaying metonymy: *healthy* is taken to describe three different qualities. Bodies with a certain quality (A) are *healthy*; exercise of a certain quality (B) produces bodies with quality A; a complexion of a certain quality (C) results from having a body with quality A. The word *healthy* has a "core" sense A; it metonymically also labels the qualities B and C, which are derivative from A. However, Lakoff's discussion of metonymy in complex concepts goes no further than this.

Another case in which metonymy is displayed is that of the adjective *big*. Intuitively, this is a formal predicate, concerned with the physical structure of the referent. Many of the examples of modification by *big* in the corpus are best interpreted in this way, and in these cases, the adjective should operate like the standard size adjectives discussed in Chapter 2. However, another reading is available for certain cases in which *big* modifies a animate teleological noun, such as *drinker, eater, employer, farmers, gambler, killer, soldier, spenders, spy, tester*.[22] For example, in the case of *big drinker*, the reference is to the amount of drink habitually consumed; in the case of *big employer*, the reference is to the number of people employed; in the case of *big gambler*, reference to the size or frequency of risks taken. These readings have nothing to do with the physical size of the referent of the combination.

Although it seems that *big* is somehow relevant to the TELIC slot in these cases, we cannot simply describe it as an event predicate.[23] In many such cases *big* is not specifying anything about the event structure at all, but rather specifies formal qualities of objects specified as arguments *within* the TELIC predicate.

The operation of *big*, then, is unlike both *clever* and *competent*: even when these combine with teleological nouns, there is no necessity for clever or competent *objects* to be involved in the event itself. The polysemy of *big* in these cases does not arise from it being an event predicate: *big* operates metonymically, indicating formal qualities of objects that are *associated* with those referred to in the head noun.[24]

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ensure product names do not become generic words in the language.

[22]This reading is not available when *big* modifies an inanimate teleological noun such as *boiler* or *cleaver*: only the physical size reading is available for these cases.

[23]It may be worth noting that there is no adverb neatly derivable from *big*; it seems that *big* is not operating adverbially in these cases.

[24]Other combinations suggest that *big* also has other interpretations: *big fan* and *big believers*, for example, seem to be best interpreted in terms of *big* implying an intensity of feeling.

$$\left[\text{QUALIA|PSYCH|EMOTION } .* \longmapsto happy(x)\right]$$

Figure 3.9: Representation for *happy*

However, metonymic interpretation does not seem to be systematically required for size adjectives. There are a couple of uses in which *small* might also be interpreted in this way (e.g. *small employer*), there are not enough cases to show how metonymic interpretation might apply across a large range of examples.

3.5.2 Metonymy and Polysemy in Emotion Adjectives

In order to illustrate the types of combinational mechanisms required to model metonymic effects, a case-study of adjectives concerned with emotional and other mental characteristics (such as *happy, sad, angry*) was undertaken. These adjectives seem to systematically have an interpretation in terms of metonymic connections. I have assumed that the core sense of these words is that in which they specify a filler for a slot such as **mental state**: this reading applies only when modifying nouns referring to people, or other entities with mental states, animals, gods and robots being possible examples. However, the set of nouns they combine with ranges much wider than entities that can be regarded as having mental states. For example, in the combination *sad eyes*, we do not assign the quality of sadness to the eyes themselves; rather, the eyes indicate the mental state of the entity they are a subpart of: a clear case of metonymy.

I will not discuss examples in which the combination can be analysed in terms of a direct mapping to a MENTAL STATE slot. A schema for *happy* that could be used for modelling such combinations is given in Figure 3.9: this operates to replace the filler for EMOTION in the head noun schema with a formal predicate.

Other cases in which emotional/mental-state adjectives occur will be broken down into a few categories on the basis of what the head noun refers to: bodyparts, actions, periods of time and events, psychological states, and other (miscellaneous). I will take each of these categories in order.

3.5.3 Bodyparts

A variety of examples in which emotional adjectives modify bodypart nouns are given in Table 3.2. All nouns in the table refer to (parts of) the face: the bodypart that conventionally signals emotion. Associated combinations are *guilty expression, worried*

face	anguished, anxious, brave, calm, courageous, disgruntled, eager, exasperated, gloomy, happy, hopeful, melancholy, miserable, quizzical, sad, sorrowful, terrified, troubled, worried
eyes	agonized, amazed, angry, anxious, baleful, clever, cunning, curious, cynical, doubting, eager, hopeful, horrified, incredulous, jealous, scared, scornful, shrewd, startled, suspicious, tender, worried
mouth	cruel, despondent, generous, smart, woeful

Table 3.2: Psychological Mappings: Facial Parts

look; combinations referring to the overall arrangement of the face. There are two obvious possibilities for modelling these combinations in schematic terms.

The first approach relies on the fact that the bodypart must display certain qualities that allow for the emotional state to be "discovered" by an observer: one possibility then, is that the meaning of the combination can be represented by specifying these qualities by modifying the schema for the head noun. However, to model the combination in these terms is problematical: it is unclear that the relevant qualities can be specified in a detailed enough manner, as they might change radically from case to case. For example, in the case of *eyes*, this method requires storing a list of qualities such as "moistness", "degree of pupil dilation", "blink rate", and so on, for each emotion – it seems unlikely that a comprehensive, accurate analysis could be produced this way.

Alternatively, the combination might be modelled simply by indicating that the emotion applies to the entity that the bodypart is a part of. The schema structure used by Pustejovsky (1995) gives a straightforward way of doing this.

Pustejovsky models features as being divided into different types: the ones we have been discussing above are all QUALIA features. The ARGSTR features are separate, but are co-referenced with arguments within the QUALIA features. This is indicated in Figure 3.10, which indicates the meaning of the noun *eye*.[25]

In this representation, we see how the arguments for QUALIA features are typed within ARGSTR. This gives the basis for a mechanism that can model metonymic uses of adjectives: the type of the related objects specified in ARGSTR can be matched to by an adjective schema, and particular features specified for any argument. An example schema, for *anguished*, is given in Figure 3.11, and the resulting representation for *anguished eyes* is given in Figure 3.12.

[25]The feature CONST|PART (short for constitutive) is used to indicate what the referent is a part of: in this case, it simply indicates that an eye is part of an animate being. See Section 5.2.2 for further discussion of CONST features.

$$\begin{bmatrix} \text{ARGSTR} & \begin{bmatrix} \text{ARG1} & x : \textit{bodypart} \\ \text{ARG2} & y : \textit{animate} \end{bmatrix} \\ \text{QUALIA} & \begin{bmatrix} \text{QUANTITY} & \textit{plural} \\ \text{CONST|PART} & \textit{part}-\textit{of}(x,y) \\ \text{TELIC} & \textit{see}(e,y) \end{bmatrix} \end{bmatrix}$$

Figure 3.10: Representation for *eyes*

$$\left[\text{ARGSTR}|\alpha^* \;\; !.! : \textit{animate} \longmapsto !1 : \textit{animate} \wedge \left[\text{PSYCH|EMOTION} \;\; \textit{anguished}(!1)\right]\right]$$

Figure 3.11: Representation for *anguished*

$$\begin{bmatrix} \text{ARGSTR} & \begin{bmatrix} \text{ARG1} & x : \textit{bodypart} \\ \text{ARG2} & y : \textit{animate} \wedge \left[\text{PSYCH|EMOTION} \;\; \textit{anguished}(y)\right] \end{bmatrix} \\ \text{QUALIA} & \begin{bmatrix} \text{QUANTITY} & \textit{plural} \\ \text{CONST|PART} & \textit{part}-\textit{of}(x,y) \\ \text{TELIC} & \textit{see}(e,y) \end{bmatrix} \end{bmatrix}$$

Figure 3.12: Representation for *anguished eyes*

wink	coy, knowing, sympathetic
glance	agonised, amused, baleful, cunning, cynical, disapproving, dismissive, heartless, jealous, longing, nervous, quizzical, serious, sly, worried
smile	amazed, amused, appreciative, bitter, blissful, bold, cautious, cheerful, complacent, confident, cynical, eager, friendly, greedy, grim, happy, kindly, knowing, mischevious, mocking, naughty, nervous, rueful, sardonic, satisfied, sly, sulky, tolerant, triumphant, unhappy, wry
frown	puzzled, troubled, worried

Table 3.3: Psychological Mappings: Facial Actions

In this way, an emotion modifier can operate to specify the EMOTION value of one of the arguments specified within the head noun. This avoids the problem of having to specify too closely the specific bodily manifestation that the emotion produces, but does use relevant schematic information about the referent's relationship to other objects. The operation of the modifier is restricted by its necessity to match an appropriate type specification within the ARGSTR slots: I have suggested that emotional states can only be specified for *animate* nouns.

3.5.4 Actions

Examples in which emotional adjectives modify nouns indicating an action of some sort are shown in Table 3.3. While the examples in the table are all facial actions, there are also other kinds of movement and gesture that can convey emotions: examples of this are *frightened spasms, arrogant shrug.*

In these cases, the adjectives would operate in exactly the same way as for body-parts. The actions are produced by an animate entity: thus, the object producing the action will be specified as an argument of the AGENTIVE slot of the head noun. The *animate* specification given within ARGSTR will allow for the emotion predicate to be attached to this, as before.

This analysis would also seem to extend to other (non-action) nouns, such as *tears*, which can be modified by (e.g.) *angry, offended, penitent, sorrowful.* Clearly, these objects are also produced by an animate being in a particular mental state.[26]

[26]This example provides a good argument against an analysis in which qualities are directly assigned to the head noun; the properties of tears do not themselves change according to the emotion that is being experienced.

3.5.5 Mental Entities

Other combinations suggest that, in some sense, emotions can be taken to occur "within" other mental entities. For example, an emotion may exist in some "psychological container" within a person, as shown in combinations such as *honest feeling, uneasy feeling, sick feeling, anxious feeling, happy memories, happy disposition, frightened mind.* These "containers" do not, in themselves, possess mental states, thus could not be modelled as possessing an EMOTION slot.

A better interpretation is that the modifiers work in the same manner as they do with nouns labelling physical subparts: the only difference here is that the nouns are labelling a *mindpart* rather than a *bodypart.* Thus, the operation of the adjective in these cases would be exactly the same as above. This can also be used to model the meaning of such cases as *desperate hope, guilty relief, lusty enjoyment, happy anticipation*: rather than being hybrid types of emotions, these are interpreted rather as being "hope felt by someone desperate", "relief felt by someone guilty", and so on.

3.5.6 Information

Emotion adjectives may also occur with nouns indicating "information-carrying" entities.

In the combinations *anxious question, happy chatter, proud records* and *quizzical retort*, the emotion adjectives again seem to be operating as above: in all these cases they specify the emotional state of the person producing the question: the appropriate argument will be specified in AGENTIVE.

However, the combinations *happy story, happy news* and *happy music* can be interpreted in a variety of ways. They could be taken as implying: that the author/creator of the piece was happy; that the consumer of the piece is likely to be made happy; or, possibly, that they depict happiness. It is not quite clear how this should be interpreted schematically; however, the schematic mechanism given above will allow both the author and the consumer to have happiness attributed to them.

3.5.7 Time and Place

Another common type of combination is that in which emotion adjectives modify nouns indicating periods or time or events, a few examples being *sad day, proud day, happy afternoon, happy childhood, worried time, happy holiday, happy coincidence* and *joyous celebration.* Similarly, emotion adjectives may combine with nouns indicating place, to indicate that people occupying the place experience an emotion. For example, *happy* combines with *cafe, home, land, place.* In addition, emotion may also be "contained"

$$\left[\begin{array}{l} \text{ARGSTR}|\alpha^* \quad !.! : \mathit{event} \longmapsto !1 : \mathit{event} \wedge \left[\text{CONST}|\text{MADE} \quad \mathit{subjective}(!1, x)\right] \\ \wedge\ \text{ARGSTR} \quad \longmapsto x : \mathit{human} \wedge \left[\text{PSYCH}|\text{EMOTION} \quad \mathit{happy}(x)\right] \end{array}\right]$$

Figure 3.13: Representation for *happy*

within very abstract location types: for example, *happy* combines with *situation, atmosphere, circumstance, event, effect.*

The informal interpretation of these is simple: events occurring within that period of time, or at that place, either cause or result from that emotion being experienced by someone (or many people). However, an analysis in schematic terms is more difficult to give: the subjective experiencing of events does not seem to be something that should be part of the definition of these words.

This suggests that these cases may have to be modelled in different terms to those above. A schema is presented in Figure 3.13 that can model the combinations for head nouns that refer to periods of time (events).[27] This will operate on a head noun schema in two ways: firstly, if the head noun does refer to an event, it specifies that the event is constituted as (i.e. "made of") the subjective experience of "x". It then also specifies what the argument "x" is: something of the type *human*, which has, as a filler for the EMOTION slot, a specification of happiness. A similar schema would be able to model combinations with types of place, by specifying a locative relationship between the place and people, rather than a relationship of subjective experience.

3.5.8 Summary

Some adjectives are polysemous due to the existence of metonymic uses: that is, they operate to indicate a quality of some object that is associated with the noun they are modifying. This use is commonplace for adjectives that indicate emotional states: the nouns they modify may refer to bodyparts, actions, mental entities, information, periods of time, and places. Thus, these adjectives can apply to a broad range of noun types.

A model for the operation of emotion modifiers was presented, in which the modifier operates to specify qualities of arguments specified in the head noun schema. This

[27] Unlike the schemata presented earlier which had two matches, this one must be understood as carrying out both the mappings specified; or rather, the second mapping can only be carried out if the first is. This is indicated in the schema by the conjunction ($\wedge$) preceding the second ARGSTR slot.

used the novel mechanism of carrying out mappings on arguments specified in the ARGSTR features of the head nouns: if there was an argument of the appropriate type specified, then the modifier indicated that the emotional quality applied to that object. The model for cases in which the head noun indicated a time or place was slightly more complex, involving specifying a relationship between the time/place and people experiencing the emotion. This explicit model of metonymy in adjectives is, as far as I know, completely novel.

However, there must be some constraints on the way in which these senses are applied: the metonymic reading of these adjective will only be applicable if the head noun does not possess a QUALIA|MENTAL|EMOTION slot; this is required to prevent combinations such as *happy lawyer* being read in the sense of having happy clients. Metonymic readings are only applicable for emotion adjectives where the "core" reading is not available. It is unclear how widespread such constraints on metonymic readings are: combinations such as *big gambler* are ambiguous through the adjective having both a "standard" and metonymic interpretation.

3.6 Conclusions

Research Contribution

Once again, examination of semantic combinatory mechanisms in the light of an extensive sample of real-world language use, rather than in the light of carefully selected or artificially generated examples, allows for the behaviour of adjectives across a range of contexts to be examined, and mechanisms that can describe their operation across a wide a range of uses as possible to be described.

In this chapter, two main methods for systematically dealing with adjectival polysemy have been advanced. The first main method is that suggested by Pustejovsky, analysing adjectives as being event predicates. The second main method identifies metonymy as a source of polysemy; this can be dealt with by allowing adjectives to map to features of the noun's arguments, specified within the ARGSTR portion of the head noun schema.

I have argued that Pustejovsky's analysis applies to a much broader range of combinations than those he explicitly considers, operation on the AGENTIVE slot being equally as important as those on TELIC. This raises the possibility of ambiguity due to the availability of a multiplicity of different property mappings: this is supported by the existence of such ambiguities (e.g. two readings for *fast ascent*), but there are also constraints which should act to limit these possibilities (e.g. the fact that teleo-

logical nouns can be adequately defined in terms of the TELIC feature alone, implying that this feature is highly diagnostic and thus more likely to be the target for property alteration).

I have also suggested that a strong categorisation of adjectives into classes of event and formal predicates is too strong. There is good evidence that many adjectives can operate in a "doublet" manner, as indicated by classic ambiguities, such as that of *poor violinist* and *beautiful dancer*. This seems to reflect the fact that many adjectives can operate as *both* event and formal predicates: this breakdown of their operation seems to provide a more convincing analysis of the range of adjective meanings than Siegel's suggestion that the duality is caused by the adjective being both intersective and non-intersective.

The idea that polysemy can also be modelled in terms of the metonymic nature of adjectives is a relatively novel one. The detailed structure given for schematic representations in Section refmetomechs gives an explicit model for how emotion adjectives operate metonymically, by specifying features for arguments of the head noun, which are given typed in the ARGSTR features. The mechanism of property mapping operating on slots other than QUALIA slots allows for a range of adjective uses that were previously not modelled to be explained.

Other Sources of Polysemy

This chapter has examined models that can capture a certain range of adjectival polysemy, the use of adjectives metonymically and as event predicates giving rise to systematic patterns of use. However, adjectival polysemy can also arise from a third, less systematic source: analogical links between types of quality.

The existence of such analogies means that one adjective may indicate several types of quality, depending on the type of the head noun. For example, some adjectives can label both spatial and auditory qualities (*high, low, deep*); visual and auditory qualities (*loud, soft*); or visual and mental qualities (*bright, dim, dull*). Other examples are the use of size and position modifiers to indicate importance, as in *small favour, bigger hero, high rank* and the description of emotions in terms of temperature, as in *cold mind, coolest election, hot controversy, warm friendship, hot duel* or in terms of brightness, as in *dark look, bright smile, gray gloom.*

Thus, individual adjectives can apply to nouns indicating radically different object types. Whether the correspondence of adjective descriptions in these cases indicates a correspondence of understanding of the structure of those domains is an open question: it is not clear, for example, whether the relevant features in each case have some overall

abstract similarity. It seems clear, however, that these different uses are not linked in any direct sense; they are not mapping to the same slots, or referring to arguments of the head noun. The different uses occur when describing objects of different types: to model these uses in terms of property mapping it would seem necessary that particular mappings be specified for different slots, and that the type of the head noun conditions which of these is used.

Chapter 4

Privative Modification

4.1 Introduction

4.1.1 Terminology and Definitions

In the combinations we have seen so far, the modifier operates subsectively; the referents of the combination will be a subset of those things that can normally be referred to by the head noun alone. In this chapter, we look at cases in which adjectives and modifying nouns do not operate subsectively, and consider how this might be modelled.

When a modifier-noun combination refers to entities that do not fall within the extension of the head noun, the modifier is **privative**, and the combination is non-subsective, or **exocentric**. The modifiers in such cases are sometimes called *syncategorematic* (e.g. in Quine (1960), Fodor and Pylyshyn (1988)), but I avoid this term, as it is not applied the same way in Montague Semantics. Some linguistic studies of adjectives call modifiers of this type "adverbial adjectives" (e.g. Levi (1978), Warren (1984)): by this they mean intrinsically non-predicatable modifiers, and are thus classifying them syntactically rather than semantically, placing them in a group with degree adverbials such as *very, extremely.*

Kamp (1975) suggests that only a certain subset of adjectives are privative by nature, and gives the definition that "If A is a privative A then each sentence *No AN is an N* will be a logical truth". This definition makes it clear that the combination refers to entities that do not fall within the extension of the noun. An example is *former senator*: no former senator is (currently) a senator. In this case, privative modification so alters reference that the combination describes entities that may have *none* of the definitionally relevant properties of *any* referent of the noun.

Franks (1989) notes that Kamp's definition is not sufficient to cover all examples of privative modification. Firstly, some adjectives are not intrinsically privative, as a

comparison of *wooden elephants* and *wooden steps* shows. This effect of context means that a complete set of privative adjectives cannot be listed. Secondly, examples such as *fake diamond, toy train, stone lion, play money, Easter egg, fools gold* show that noun modifiers as well as adjectives may be privative: again, not intrinsically so. Where modifiers are contingently privative, the phrase "No AN is an N" (or "No N_1N_2 is an N_2") may be true with respect to combination with particular head nouns.

In some cases, there is a yet greater contingency: only *some* of the referents of a phrase may not belong within the head noun category. Such is the case for the combination *apparent friend.* Clearly in these cases, the combinations may refer to entities not within the extension of the head noun: they are, in this sense, privative. A definition of privation such as "If A is acting privatively then the phrase *Possibly some AN are not N* will be logically true" will incorporate these examples also.[1]

4.1.2 Negation and Equivocation

Franks (1989, 1995) argues that there are two types of privative modifiers: those that work through **negation** and those that work through **equivocation**. His approach uses schematic representation, and distinguishes between features that are diagnostic for category membership (those that are used to judge whether an exemplar belongs in some category), and a set of "essence" features (those properties which must be possessed for an exemplar to really be in the category).

Negation is defined using the example *fake gun.* A fake gun is taken to have the diagnostic properties of *gun* (the appearance of a gun) but not the essence properties (the ability to shoot bullets). Negating privatives (negators) thus act to definitely deny that essence properties are applicable. In the case of *fake gun*, referents can be regarded as guns with respect to appearance (a violation of Kamp's definition).[2]

Equivocation, on the other hand, can occur without a definite denial that the essence properties are present. The example Franks gives here is *apparent friend*: in this case, the attribution of essence properties to the referent is "undercut" (i.e. put in doubt) without necessarily being negated. Thus, in these cases, a referent might be included in the head noun class, but resolution requires further evidence. Additionally, there are degrees with which uncertainty may be expressed: for example, equivocating modifiers may imply negation (e.g. *apparent*) or affirmation (e.g. *probable*).

Franks also suggests that epistemic attitudes play a role in the operation of privation:

[1] This is the "fourth" type of combination mentioned in Chapter 1, Note 5.

[2] If we can state that "A fake gun is a gun with respect to appearance", this denies the logical truth of the statement that "No AN is an N".

where negation occurs, the describer of the entity knows that the essence properties are not present; where equivocation occurs, the describer of the entity does not know whether essence properties are present in a referent. We might call this the difference between the referent being "proven not" and "not proven" to be a member of the category of the head noun.

4.1.3 Mechanisms of Privation

Franks suggests two different schematic mechanisms for modelling the two types of privation by adjectives. Negators would act to mark essence features as not applicable (by negating them, showing they are definitely inapplicable), while leaving diagnostic features intact. Equivocators would "undercut" essence features by simply removing them from the representation: they are not assumed to be present, but are not marked as being definitely inapplicable.

As Franks discusses only a very limited number of examples, there is considerable uncertainty as to how generalisable these ideas are. Thus, I use corpus data to explore various uses of nominally privative modifiers, and discuss the mechanisms of combination that must be in use for the observed effects to arise. These examples are divided into sections that reflect the reasons why privation arises for these cases.

4.2 Change In Referent Status

One reason negation occurs is that a referent can change its state through time: thus, a description which applies at one point in time may not apply at the referential point of time (frequently the time of utterance, although this may change with context). In other words, the referent once *was* in some class, but now no longer belongs in it. The classic case of this is *former senator*: the referent is no longer a senator.[3]

Modifiers of this type can be readily dealt with by using intensional logic (see Dowty et al. (1992), pp.163–4): the set of former senators is simply the set of all entities falling under the description of *senator* at previous times that no longer do so.[4]

Franks' theory would treat *former senator* as a negating privative; the resulting representation would thus indicate the inapplicability of essence features. In fact, for the case of *former senator*, the denial of both essence *and* diagnostic properties must be complete: the referent possesses none of the defining characteristics of *senator*. But if

[3]There are no examples of the use of *former* in my corpus of complex concepts.

[4]Thus, *former* can be modelled in Montague Semantics as an intensional adjective, as discussed in Chapter 1.

$$\left[\text{QUALIA} \mid \text{AGENTIVE} \;\; !R^*(e,x)! \longmapsto H(!1) \wedge G(\neg(!1))\right]$$

Figure 4.1: Representation for *former*

modified so that all these characteristics are denied, then the schematic representation of *former senator* will not be distinct from that of *non-senator*. Thus, the information that the referent was once a senator would be lost, although this is clearly central to the definition of the combination.

This problem is simply solved by modelling *former* simply as acting upon the AGENTIVE feature, the feature that specifies the process that causes referents to come into being.[5]

In schematic terms, we need a means to specify the fact that the referent was at one time elected a senator, but currently is not. This is easily done using the kind of temporal operators described in Allwood et al. (1977) (pp. 121-124). Given the definitions that: (1) $H\alpha$ is true relative to a point in time t iff α is true relative to a point in time that precedes t; (2) $G\alpha$ is true relative to a point in time t iff α is true relative to all points in time that follow t; and the assumption that the schema for *senator* contains AGENTIVE = $elected(e,x)$, then *former* should operate such that the combination contains the quale AGENTIVE = $H(elected(e,x)) \wedge G\neg(elected(e,x))$. This specifies that the state of being elected applied prior to a point in time t, but that the state of being not elected applied subsequent to this same point. A more general schema that could carry out this mapping is presented in Figure 4.1: however, it is unclear whether *former* will always operate in such a way, there being no cases of its use in the corpus to evaluate.[6]

It might be taken for granted that this AGENTIVE feature may be the *only* feature that can reasonably be assigned to a former senator. However, this is not necessarily so; various quibbles with this could be raised. For example, Caesar might be described as a *former senator*, but one having all senatorial privileges. This being the case, negation here cannot necessarily be modelled as denying the applicability of specific features; this is something to be resolved by context.

[5]One could argue that, in this case, AGENTIVE is an essence feature. However, *former*, being concerned with a referent's recategorisation over time, should always operate on AGENTIVE. Thus, there is no need to posit essence features that are different for different words: *former* will always operate on one specific feature.

[6]The model of *former* given in Figure 4.1 will only apply if the head noun refers to a status which is allocated to the referent only following a qualification process, this process being periodically repeated.

4.3 Uncertainty About Referent Status

There are a variety of modifiers that indicate uncertainty about whether the head noun can describe the referent correctly. The referent "may", "might", or "could" be a member of the category in question. Specific examples of current uncertainty as to referent status are provided by *alleged genius, probable error, dubious honour.* These are examples of equivocation: they fail Kamp's test for privation because, in some cases, the head noun classification may turn out to be correct for referents of the combination. Franks' method of modelling such equivocation is for essence features from the head noun's schema to be undercut: the relevant features are simply not included in the representation for the combination, being neither clearly applicable or inapplicable. Only further evidence can resolve which is the case.

Similarly, some modifiers indicate whether the head noun may *become* an applicable description of some referent: there can be no fact of the matter that allows for a decision. We cannot tell whether a *potential enemy* will become an enemy, or whether an *expectant mother* will become a mother.[7] Like *former senator*, changes of description for a currently existing referent are involved, but in these cases, any change of status will occur in the future. Thus, these appear to cases of negation, the referent not currently belonging to the head noun class: however, this is not quite correct. Sometimes referents can belong to the head noun class in the present. For example, an *expectant mother* may or may not *already be* a mother. We have no a priori knowledge of this. In many cases, reference to the potential future status of an object is not clearly separable from uncertainty about whether a noun description is applicable in the present. For example, *possible sources* may be sources of something (but there is uncertainty about the fact), or might become sources of something in the future. Similar ambiguities apply to *possible answer, possible contamination, possible liability.* Thus, these too are best modelled as cases of equivocation.

Modelling these cases as undercutting essence features does not require simply removing the fillers from some slots, however. We can specify an alternative, and more detailed approach, in which these modifiers carry out an operation on the AGENTIVE quale of the head noun's schema, indicating that it is unclear whether the conditions for entry into the class have been met with. As all diagnostic features may be present, there is no necessity to alter anything but the filler of AGENTIVE. For example, for *possible sources*, the modifier should act on AGENTIVE = $produce(e, x, y)$ to create a filler which indicates uncertainty about both present and future category status of the

[7] These are thus distinct from examples in which the future coming-into-existence of a referent is taken for granted, such as *future arrests, future earnings, forthcoming reports.*

$$\left[\text{QUALIA} \mid \text{AGENTIVE} \;\; !R^*(.*)! \longmapsto \Diamond(!1) \vee \Diamond F(!1)\right]$$

Figure 4.2: Representation for *possible*

referent.

Uncertainty about current category status can be modelled using the modal quantifier of possibility ($\Diamond$), which ranges across possible worlds ($\Diamond\alpha$ is true iff α is true in some (accessible) possible world). A function which produced the filler AGENTIVE = $\Diamond produce(e, x, y)$ would thus indicate possible current status as a source of something. Allwood et al. (1977) define a temporal operator F such that $F\alpha$ is true relative to a point in time t iff α is true relative to a point in time that follows t. A function that produced the filler AGENTIVE = $\Diamond F(produce(e, x, y))$ would thus indicate the possibility of future status as a source of something. An operator that acted to produce the filler AGENTIVE = $\Diamond produce(e, x, y) \vee \Diamond F(produce(e, x, y))$ would thus indicate the possibility of either current or future status as a source. A schema for carrying out this operation is given in Figure 4.2.

Specific modifiers can carry out more detailed mappings. One aspect of this is temporal specificity; *alleged*, for example, implies uncertainty about classification at the current moment, rather than involving any element of reference to future status change. Another aspect of this would be that different modifiers suggest different degrees of uncertainty about classification: this could be treated by replacing $\Diamond$ with a series of quantifiers for different degrees of probability. In all cases, however, it is the AGENTIVE quale which will be operated on: this is what specifies the process involved in becoming a member of the class.[8]

[8]There are also modifiers that indicate the "dubiousness" of membership in the head noun class. Some of these indicate simply that a referent is a poor example of the class (e.g. *bad, poor*). Others, such as *so-called, purported, rough, approximate, abnormal, partial* plus the terms *de jure, de facto* and the prefixes *quasi-, pseudo-, crypto-* indicate, in various ways, that the noun does not describe referents accurately, in certain cases indicating that it applies only in some "technical" sense. In other words, they are types of "hedges" (see Lakoff (1973)), although in some cases they can operate privatively: for example, it is not clear whether an *approximate solution* is a solution or not. Hedging modifiers could be modelled as undercutting features of the head noun schema. The modifier *so-called*, for example, usually indicates that although referents can be labelled with the head noun, they are deficient in some diagnostic characteristics of the class.

4.4 Portrayals of Objects

4.4.1 Introduction

There are a number of adjectives which indicate that referents of the combination are **portrayals** of objects in the head noun class: that is, in some way, they are similar to "real" members of the head noun class. Often this is the result of a deliberate attempt to make the referent resemble members of the head noun class as closely as possible, one aspect of which is deceit through counterfeiting. Examples of combinations that refer to portrayals are *fake gun, forged passport, false moustache, artificial life, toy train, model railway, bogus officials, virtual reality, phantom limb, simulated injury, imitation leather, ostensible destination, ersatz coffee.* Some of these modifiers are also used as nouns to refer to such portrayed objects (e.g. *fake, model, imitation*).

Modifying nouns can also act such that the referent will be a portrayal of the head noun class, often such that the object is made from the material they describe (e.g. *chocolate money* is made of chocolate, *plastic giraffes* are made of plastic, and so on). Other nouns used in this way are *model, toy.*

We will examine different kinds of portrayal in the following sections, and analyse how this kind of combination can be described semantically. We begin by examining the kinds of adjectives mentioned above, and proceed to considering the modifying nouns.

4.4.2 Counterfeits

Some adjectives indicate that referents of the combination are deliberately constructed counterfeits, resembling "true" members of the noun category as closely as possible. The most obvious examples of this are *fake* and *forged*: we will examine combinations containing these examples, and suggest a model for their operation.

Uses of *fake*

Franks models *fake* as a negator. His analysis centres on *fake gun*; he does not examine a wide variety of the combinations that *fake* can actually occur in. In his analysis, *fake* is described as negating essence properties, while diagnostic properties remain present. In the case of *fake gun*, this could be described as negating the filler of TELIC, while retaining formal properties relevant to the appearance of the gun. As *gun* is a teleological noun, then TELIC is the logical choice as an essence feature.

However, there is a problem with this account: we cannot be sure that a fake gun will not actually be usable. It is a reasonable inference, but is entirely defeasible. It

$$\left[\text{AGENTIVE } .^* \longmapsto \top\right]$$

Figure 4.3: Representation for *fake*

depends how good the faking is. There may be fake guns which are perfectly functional: a good replica of a valuable antique could create a functional gun that is still a fake.

This might seem to be a case of special pleading, a case in which a very specific context is invoked to defeat the natural reading (that a fake gun doesn't shoot). However, the point of this argument becomes clearer if we consider cases in which *fake* modifies teleological nouns but does not necessarily negate TELIC or, indeed, any other feature which can be directly observed: an example of this sort is *fake permits*. The origin of *fake permits* is not that of "real" members of the category, but in *all* other respects the referent can be absolutely identical to the "true" category members. Thus, the differences between a fake and non-fake can be purely in terms of *origin*. Indeed, this would seem to be the case for all fakes: whether they are crudely obvious or completely undetectable, there will always be a difference in origin from "real" members of the head noun class.

I therefore suggest another interpretation of *fake*, which provides a consistent account of its operation: *fake* undercuts the AGENTIVE feature of the head noun, and *always* the agentive feature in every combination. While the undercutting of AGENTIVE may imply the inapplicability of TELIC or other features in some cases, these differences are founded in deductions based on world knowledge, rather than being an absolute fact that must be applicable in all cases. The only thing we know for *sure* is that a fake object is produced differently to members of the head noun category. Everything else regarding its qualities is uncertain, and must be deduced through extensional feedback.

Describing *fake* as simply undercutting AGENTIVE gives an interpretation of the operation of *fake* which is consistent across cases, and does not require particular features to be selected for modification according to context. Thus, it would explain combinations from the BNC such as *fake fur, fake leopard-skin, fake magritte, fake stamps, fake tan* and *fake charm*, all of which clearly can have completely identical properties to non-fake examples of the category, except the way in which they originate.

The list of the other nouns that *fake* modifies in the BNC corpus is *colonel, fag, fats, goods, mantle, marriage, thing*: all these can be interpreted in terms of AGENTIVE

$$\left[\text{AGENTIVE } paint(e_1, x, y)\right]$$

Figure 4.4: Representation for *painting*

$$\left[\text{AGENTIVE } paint(e_1, x, z) \wedge attribute(e_2, x, y, z) \wedge y \neq z\right]$$

Figure 4.5: Representation for *forged painting*

being undercut.[9] Thus, *fake* could be simply modelled as it is in Figure 4.3.

Uses of *forged*

A similar argument applies to *forged*: certainly for the nouns *banknotes, bond, documents, letter, note*, AGENTIVE must be the relevant feature, the modifier indicating the process that creates them is abnormal.[10]

However, the meaning of *forged* is slightly different to that of *fake*, and this provides a compelling reason for adopting the idea that modifiers indicative of counterfeit operate solely to alter AGENTIVE: the fact that such modifiers are not inherently privative. For example, a *forged painting* is clearly a painting, but a *forged Picasso* is not a Picasso (i.e. a painting by Picasso).[11] The difference between *forged* and *fake* is revealed here: a *fake Picasso* would not be a Picasso, but in addition, a *fake painting* would *not* be a painting. Nevertheless, one single operation can model the meaning of *forged* for both the privative and the non-privative case. While *fake* undercuts everything in AGENTIVE, *forged* is more specific, indicating only that the referent is not created by the entity that is attributed as creating it. This is true for both *forged painting* and *forged Picasso* (as well as for other uses of *forged*).

Suggested fillers for AGENTIVE in *painting* and *forged painting* are given in Figures 4.4 and 4.5: a painting is described as being created by a process of painting, whereas a forged painting is described as being painted by a person who attributes it to someone else. The specification of $y \neq z$ in Figure 4.5 is required to specify that two different people are involved.

[9] The only other cases are *fake making* (the activity of making fakes), and *fake bookcase*, which is possibly interpretable as "an object holding fake books".

[10] The case *forged stop* may be different, possibly relating to a different sense of the verb.

[11] These two examples are not from the corpus: they are created to demonstrate the following points.

$$\left[\begin{array}{ll} \text{ARGSTR} & \longmapsto \left[\text{NEWARG } z : human\right] \\ \text{EVENTSTR} & \longmapsto \left[\text{NEWEVENT } e_n\right] \\ \text{AGENTIVE} & !R^*!(!!e!!, !!!.!!!, !!!!.!!!!) \longmapsto !1(!2, !3, z) \wedge attribute(e_n, !3, !4, z) \wedge !4 \neq z \end{array}\right]$$

Figure 4.6: Representation for *forged*

The schema given in Figure 4.6 would carry out the mapping for *forged*: it would be able to carry out the mappings for both *forged painting* and *forged Picasso*, as well as the other examples given above. It simply specifies that the same process of creation is carried out by a different agency, while the resulting item produced is attributed to someone who creates "real" objects of that type. Thus, it accounts for both privative combinations and non-privative combinations (such as *forged documents, forged note, forged painting.*)

Summary

Franks' model of privation requires sets of essence and diagnostic features to be identified for each noun being modified. However, in my approach to counterfeits, the modifiers are modelled as always acting on AGENTIVE. This allows for the modelling of both privative and non-privative uses of *forged*: more generally, this approach has the advantage of not having to arbitrate about what "true" category membership is defined by.

In many cases, there may be no clear answer as to whether an object "really" belongs in a category or not. For example, it might be concluded that a *forged passport* really belongs in the class of passports, because it has the same visual and TELIC features as real passports. Alternatively, it might be argued that the different AGENTIVE status of a forged passport means that it really isn't a passport. This latter approach would fit with the idea that privation is linked with epistemic attitudes: the violation of the "social contract" properties would be apparent to the describer, but this violation may have no effect on appearance or operation. Thus, forged passports would not belong in the set of passports.

Without any method to arbitrate as to which properties are or aren't diagnostic or essential, there is no way to decide which of these two evaluations is correct. Two people may disagree about whether a forged passport is "really" a passport or not, even if they agree that violation of socio-legal properties is what makes the object a

forgery. From the semantic perspective, the debate is a spurious one. The relevant point is the status of the AGENTIVE feature: *forged* indicates that the object is not created by its purported originator, and nothing more definite than that. So long as this is understood as the meaning of the combination, people can argue forever about whether the referent is "really" a member of that category or not. This shouldn't be relevant to semantics; the meaning of the combination can be modelled without having to take sides on the issue. Any other approach will entangle semantics with legal issues.

The operation of adjectives such as *forged* can be modelled in general terms, as operating on AGENTIVE, making absolutely no distinction between their privative and non-privative uses. Franks, along with other authors, sets privation apart as a distinct semantic phenomenon *in its own right*, requiring distinct semantic mechanisms to model. In contrast, the model advanced above suggests that privation is just an epiphenomenon sometimes arising from the operation of particular combinatory mechanisms: the privative nature of a particular combination can often only be deduced on the basis of extensional feedback (i.e. world knowledge).

Both *fake* and *forged*, like adjectives indicating change of or uncertainty about the referent's state, were modelled as operators on the AGENTIVE slot. We will now examine other modifiers, to show that other types of operation on this slot can be used to model other privative adjectives, while also accounting for their non-privative uses.

4.4.3 Manufactured Objects

A number of modifiers indicate that referents of the combination are manufactured by some process: examples are *artificial, imitation* and *false*. These modifiers do not generally imply that there is any intent to counterfeit: however, they do frequently act privatively, indicating portrayals.

Uses of *artificial*

The adjective *artificial* provides another example in which AGENTIVE is the feature operated upon, but in this case, far fewer cases judgeable as privative are produced: only a few combinations seem obviously not to belong within their head noun categories, and these are examples where the head noun refers to plant material such as *grass, lilies, plants, rose, trees, turf* or bodyparts such as *arm, hip(s), knee, leg, organs, teeth.*

On the other hand, there are numerous examples of other objects that are not privatively modified by *artificial*: physical object nouns such as *additives, aromas, environment, fertilisers, foods, lakes, light(s), pitch, reservoir, satellites, stimulants, tubes, vowels* and event nouns such as *abortion, brightening, feeding, insemination, preser-*

$$\begin{bmatrix} \text{ARGSTR} & \longmapsto \begin{bmatrix} \text{NEWARG} & y : animate \end{bmatrix} \\ \text{EVENTSTR} & \longmapsto \begin{bmatrix} \text{NEWEVENT} & e_n \end{bmatrix} \\ \text{QUALIA} \mid \text{AGENTIVE} & R^*(e, !.!, .*) \longmapsto construct(e_n, !1, y) \end{bmatrix}$$

Figure 4.7: Representation for *artificial*

vation, respiration, selection, separation, treatment, ventilation. In addition, *artificial* may combine non-privatively with abstracta such as *argument, competitiveness, criteria, deficit, distinctions, incentives, jobs, lesbianism, obstacles, procedures, restrictions, rule, problems, targets.*

The division between privative and non-privative reflects the distinction between "natural kind" and "artifact" nouns. Roughly, this would be mirrored in the AGENTIVE quale by a distinction between types of growth, and types of manufacture. The operation of *artificial* seems to be that it affects AGENTIVE in order to explicitly specify that the referent is manufactured: a schema for this operation is given in Figure 4.7: the process specified in AGENTIVE is replaced with a filler indicating the referent is constructed by some animate object (i.e. is deliberately built).

The operation of the schema for *artificial* produces a big difference for the "natural kind" nouns, which are naturally created through a growth process that usually does not require any human intervention: when modifying these nouns, it will tend to be privative. However, *artificial* is usually not privative in combination with artifact nouns, which are, in any case, always artificially manufactured. This prompts the question as to what the function of *artificial* is in modifying non-natural kind nouns. One reason is that many words can label both natural kind and artifact (e.g. *satellite*, and all the event nouns). In these cases *artificial* just identifies a particular subset. Another reason is that *artificial* can also imply the fact that deliberate, conscious intervention (construction) creates the referent deliberately or in a "contrived" manner, rather than it arising in a more usual, "natural" way (e.g. *artificial problems, artificial restrictions*).

There are a number of cases in which it is unclear whether *artificial* is privative. For example, when *cloud, coffee, manure(s), snow* of *tears* are modified, it is unclear whether the process of manufacture makes the referent unacceptable as a member of the noun category. But, as above, the debate has little relevance to understanding how *artificial* operates semantically. Consider the case of *artificial life*: much dispute has occurred about whether computer models or robots can ever be regarded as being

$$\left[\begin{array}{ll} \text{ARGSTR} & \longmapsto \left[\begin{array}{ll} \text{NEWARG} & x : \textit{object} \\ \text{NEWARG} & z : \textit{human} \end{array}\right] \\ \text{EVENTSTR} & \longmapsto \left[\text{NEWEVENT} \quad e_n\right] \\ \text{AGENTIVE} & R^*(e, !.!.*) \longmapsto \textit{copy}(e_n, x, !1, z) \end{array}\right]$$

Figure 4.8: A schema for *imitation*

life (living entities) or not.[12] Individuals may regard the modifier in this case as non-privative, equivocating, or negating, depending on their stance as to the definition of "life": different people know (intuit) different diagnostic or essence properties for the category. Yet, whatever the intuition on this question, agreement exists about what kinds of things *artificial life* refers to.

It seems, then, the privative nature of *artificial* arises as a result of the semantic operation it effects: privation is once again not a semantic effect that must be modelled in itself; it occurs independently of the semantic effect of modification.

Uses of *imitation*

A third modifier that indicates artificiality is *imitation*. It has some privative uses, as when it modifies *antiques, carnation, fireplaces, marble, trees* (and, presumably, *nostrils*). However, *imitation attack* is non-privative (presumably referring to an "attack in imitation of another attack"); similar non-privative modification occurs with *forms, glows, window*. The schema given in Figure 4.8 gives a general method for modelling this: it acts to specify that the referent is an object that is created through someone copying an example of the head noun class.

At first glance *imitation soul* seems harder to interpret in this way, although it might just refer to an imitation of soul music. Other cases are *imitation chap* and *imitation task(s)*, which probably mean, in rough terms, "a chap who produces imitations" and "task(s) in which one has to carry out an imitation"; in these readings, *imitation* is taken as a noun rather than an adjective.

[12] The term *artificial* has a specialised sense relating to "computer simulations", as used in *creature, earths, intelligence, world.*

Uses of *false*

The corpus contains a very large number of combinations containing *false*: I have selected a variety of examples, which show that this modifier has a number of different uses.

Clearly privative uses of *false* are only obvious for a few cases of manufacture, such as when it is modifying bodypart nouns (*beard, eyelash(es), leg, moustache(s), nail, nose, teeth, tooth*), or certain emotional/behavioural characteristics such as *bravado, brightness, cheeriness, heartiness, optimism.* In these combinations, *false* indicates that the referents are produced by a non-standard process. There are a few other cases of (debatably) privative operation (e.g. in modifying *economy, germans, hem, money, passport, pockets, roof, snow, weights*), but on the whole *false* is not privative.

As an antonym of *true*, *false* is frequently used to indicate that information-containing entities contain untrue information. A few examples of the many of this type are *account, allegation, confessions, data, declaration, equation, evidence, memories, picture, pretences, reports, reputation, story, teaching, understanding.* On occasion, this may be taken to undermine the category status of the referent: e.g. it can be argued that *false alibis* are not alibis. In the majority of cases, this does not occur: e.g. *false statements* are definitely statements.

In other cases, the referent is "incorrect" for the context it occurs in (*move, note, turn*), or is produced without necessary enabling conditions being true (*imprisonment, hope(s), modesty, smile*), but again there is no privation in the majority of such cases (although modification of *alarm(s), start* could be debated).

A model for uses in which it implies manufacture could be constructed along the lines of that for *artificial.* However, such a representation could not account for the full range of its uses: *false* acts as antonym to a variety of adjectives, including *real, true, correct,* and *rightful,* indicating that it has a multiplicity of different senses.

Summary

The schematic models of *artificial* and *imitation* given above again model the operation of privative modifiers in terms of their effect on the AGENTIVE slot. A model for *false* that covers a portion of the combinations it enters into would similarly operate on this slot.

The notable thing about these adjectives is the operation of *artificial,* which has a large number of both privative and non-privative uses, which can all be modelled in the same way. This provides a good example of the contingent nature of privative modification: it is whether the head noun refers to a natural kind or artifact category

$$\left[\text{AGENTIVE } !R^*(!!e!!, .*)! \longmapsto !1 \wedge virtual(!2)\right]$$

Figure 4.9: A schema for *virtual*

that influences whether the combination is privative or not, rather than the modifier having two senses, or having to be modelled in terms of two separate operations. Once again, it seems that privation is a phenomenon that we can separate from the actual process of finding the meaning of the combination.

4.4.4 Other Adjectives

A variety of other adjectives also occur in privative combinations in which they indicate portrayal. We will examine a range of different examples, and discuss how they might be modelled.

Event Privatives

The adjective *virtual* generally occurs in privative combinations. When it modifies *absence, annexation, certainty, cessation, extinction, guarantee(s), harmlessness, havens, immunity, impossibility, imprisonment, landslide, monopoly, revolution* and *synchronisation*, it seems to be indicating that referents of the combination are, in some way, extremely like members of the head noun class. A general way to model this is for *virtual* to act to deny the "completeness" or "totality" of the process producing the referent; the process is far enough advanced for the referent to fall into the head noun class, but some element is missing, making the process incomplete. Thus, in these cases, *virtual* can be modelled as introducing an event predicate into the AGENTIVE slot, as is indicated in Figure 4.9. The event predicate will act to specify that the creating event is not finished.

In the combination *virtual newcomers*, however, it does not indicate incompleteness of creation: instead, it specifies that the referent is no longer a newcomer; the process making something a newcomer is too far in the past for the head noun description to currently apply. In addition, it also indicates computer representations in combination with nouns such as *documents, folder, machine, reality, world(s)*: here it indicates to specify the medium in which these objects exist. Its privative nature is debatable in some of these cases.

Another generally privative adjective is *bogus*. This is often used to modify teleological nouns such as *asylum-seekers, collectors, doctor, gardeners, officials, police,*

$$\left[\begin{array}{ll} \text{ARGSTR} & \longmapsto \left[\text{NEWARG} \;\; y : information\right] \\ \text{EVENTSTR} & \longmapsto \left[\text{NEWEVENT} \;\; e_n\right] \\ \text{AGENTIVE} & R^*(e, !.!, .*)! \longmapsto describe(e_n, !1, y) \end{array}\right]$$

Figure 4.10: A schema for pure privatives

policeman, refugees. In these cases, it implies that a disguise has been adopted in order to facilitate the carrying out of the TELIC filler for that noun. In other cases, it indicates dissimulation about the existence of a non-existent entity, as when modifying *affability, bankruptcy, companies, sale, security,* and can also indicate the invalidity of entities as members of a class, as for *application, budget, claim, points.* In another use it indicates the quality of being "badly or wrongly made or carried out", as when modifying *collections, journey, science, videos.*

In all these cases, the operation of *bogus* can be modelled as introducing an event predicate to AGENTIVE, the predicate being used to indicate that the creating event is in some way bogus: the event is invalid in some way, through not following the correct procedure for creating an entity of the head noun type.

Pure Privatives

Franks (1989) identifies a form of negation in which the referent belongs in a non-real domain (the obvious examples of this being fiction and imagination). He calls modifiers that explicitly indicate this domain **pure privatives**. Where these modify a head noun, the referent can only be an abstract/informational entity, the described characteristics of which may only be vaguely related to the characteristics of a real world exemplar, if such an entity exists at all: examples are *imaginary friend, fictional detective.* A schematic model for such adjectives would operate as shown in Figure 4.10: the AGENTIVE feature is replaced by a predicate indicating that the head noun type is described in a piece of information (particular modifiers could specify a more precise type of information).

However, an examination of uses of these adjectives in the BNC corpus shows that it is not quite true that these are "pure" privatives: *fictional*, for example, has a number of uses in which the reference of the combination could be to certain properties/elements of fiction itself (e.g. in *fictional drama, fictional literature, fictional narrative, fictional storylines, fictional texts, fictional treatments*). Thus, where the head noun itself refers

to a piece of information, pure privatives may have a different interpretation. In each case, however, the combination is ambiguous, as the reference could also be to examples of the class portrayed in fiction.

Other Examples of Privation

Referents for *phantom limb* or *phantom pregnancies* have many of the diagnostic features of the head noun class, except that no object corresponding to the head noun exists. Similar existence of diagnostic features without the referent is also the case for all examples of "ghost-like" phenomena, as when *phantom* modifies *chessboard, bridegroom, dog, lunatic, ship, squadrons*, although the privative nature of the modifier is questionable when modifying *music, touch.* The case of *phantom writer* is possibly like *ghost writer*, referring to the actual writer of a piece rather than the attributed author.

Privative uses of *simulated* are found where it modifies *controls, reality, operations, woods* (in which it presumably indicates the referent to be a model, especially a computer model, of the type of objects referred to by the head noun), and where it modifies *interest, pleasure*, which will be "dissimulated". However, its modification of *copies, version* may be taken to be non-privative.

The modifier *ostensible* indicates that the referent is not truly the individual or sub-type from the head noun class that it is specified to be. In the corpus sample, it modified *aim, authority, headquarters, objectives, purpose, rank, representative, subject, supplier.*

The final case is *ersatz*, which modifies *coffee, religion, music.* In indicating that the referent is "a substitute" for referents of the noun, it denies the referent's status as a member of the head noun class.

Summary

In general, the operation of these other adjectives seems similar to those discussed above: typically, diagnostic features may be present, but these features are possessed by an object whose origin is different from members of the head noun class: referents of the combination may be incompletely made (*virtual*), wrongly made (*bogus*), not exist in the real world (*fictional, virtual, simulated*), originate in a non-standard way (e.g. *ersatz*), and so on.

4.4.5 Discussion

We have seen many examples of adjectives that occur in privative combinations, indicating that referents of the combinations are portrayals of "real" examples of the

head noun class. However, alongside these examples we have also seen non-privative combinations containing these same modifiers: examples are *forged documents, forged painting, artificial light, artificial reservoir* and *fictional narrative.* Models for many of these adjectives were advanced: they all shared the common property of operating to modify the filler of the AGENTIVE slot.

Modelling these adjectives as operating on AGENTIVE has a number of advantages over Franks' model of privative modifiers: firstly, there is no need to deduce what the "essence" slots are for a particular word, as there is no difference in operation from case to case; secondly, this approach to modelling allows for specific differences between the modifiers to be represented, whereas Franks' approach allows only for the negation of undercutting of features; thirdly, models of this type can account for both privative and non-privative uses of the same modifier.

Naturally, this does not account for all the effects that the modifier can have (e.g. suggesting that particular properties common to all members of the head noun class are not possessed by referents of the combination). However, I have argued that such effects should be attributed to extensional feedback, rather than being assumed as part of the process of semantic composition. An analysis of *fake gun* that takes as central the fact that a fake gun cannot shoot is not, in fact, analysing combinations according to the one fact we can be certain that *fake* always implies: that the origin of referents of the combination is not like that of referents of the head noun. This difference in origin is the one fact that is always true for every privative combination (and many non-privatives), and should thus be the basis of modelling for these cases.

4.4.6 Privative Modifying Nouns

Wisniewski and Gentner (1991) noted that modifiying mass nouns are often interpreted by subjects as indicating the material that an object is composed of, even though this means that mass-noun modifiers are frequently privative when modifying natural-kind words. For instance, *chocolate snake* would be interpreted as chocolate in a snake-like shape, rather than as being a snake that eats chocolate, a snake coloured like chocolate, or so on. Wisniewski (1996) also found this effect, noting frequent construal of head nouns denoting animals. A few other examples of these compositional privatives are *stone lion, chocolate mice, china dog, wooden elephants, golden calf, glass eye* and *plastic flowers.*[13]

Mass-noun modifiers often act privatively because they are interpreted as specify-

[13]A broader look at the combinations entered into by particular mass-nouns is presented in Section 5.4.

ing composition when modifying head nouns that refer to animate entities. Clearly the operation of specifying composition will not always have privative effects: the composition of artifacts usually does not affect their function (as mentioned in Section 3.2.6, they are adequately defined in terms of the TELIC filler alone), and so combinations of mass-noun and artifact noun will generally be intersective.[14]

Franks (1995) presents a model of compositional privatives that uses a property-mapping strategy (unification) such that, for the combination *stone lion*, only information in *lion* that does not contradict information in *stone* survives combination: basically, features specifying shape. This over-ruling of features specified for *lion* implies that semantic combination in these cases is not based on the mapping of alignable differences from modifier to head: instead, the reverse is true, with alignable differences being mapped from head to modifier. The combination would thus have to be recognised as privative before combination could take place (e.g. this mechanism could be evoked whenever a mass-noun modifies an animate-noun).

There are other noun modifiers that are privative, indicating that the referent is a replica of those entities denoted by the head noun. For example, uses of *toy* to refer to replicas occur when it modifies *acrobats, airplane, bus, cannon, cups, dog(s), mice, soldiers, tractors, trains, weapon.* For *model*, reference to replicas is possible when modifying head nouns such as *aeroplanes, glider(s), railway, ships.* This "replica" sense also extends to computer models of the functioning of entities.

All of these nouns are only contingently privative, obviously so for the mass nouns, but also for the other modifiers. For example, non-privative uses of *toy* are available for the combinations *toy awards, toy factory, toy inventor, toy shelf* and *toy store.* There is ambiguity here, as many of these (those with a head noun denoting a concrete object) could possibly refer to a "toy" version of that object. There are also non-privative intersective uses, e.g. when modifying *balloon, puppets.* Non-privative uses are also possible for *model*, as when modifying *citizen(s), constitutions, democracy, employer(s), landlord, pupil.* In these cases it indicates a perfect ("model") exemplar of a category.[15]

The operation of *toy* and *model* as modifiers seems to be substantially similar to the mass-noun modifiers, except more features are mapped from the head noun. For example, in addition to size, toys and models frequently have the same colour and,

[14]There are a few exceptions to the general pattern, such as *chocolate teapot, chocolate money*, in which combination of a mass-noun and a teleological noun is privative. It should also be noted that mass-noun modifiers are not always interpreted in terms of composition, as we saw in Chapter 2. For example, COLOUR properties alone are mapped from such terms (e.g. *chocolate sweater*).

[15]This reading could possibly also apply to combinations such as *model aeroplanes*, cited above.

in some cases, can carry out the same actions as "real" exemplars of the head noun category. In addition, the TELIC slot of *toy* should specify that the object is for children to play with.

4.5 Discussion

4.5.1 Context and Categorisation

Examples of privation are generally advanced with the assumption that there is something fundamentally different and "abnormal" about these types of combination (e.g. Quine (1960)). This is based on the classical assumption that clearly defined sets of objects corresponding to a noun can be identified independently of particular uses of that word; privation presents us with examples in which a noun labels objects outside such a set.

Certainly, objects can frequently be labelled with nouns, and there is often a substantial degree of agreement about such labelling, at least for concrete nouns – people usually can identify examples of guns, or tigers, or lemons, and agree about such identifications. Yet there are areas where classification is not so easily decidable. For example, prototype theories of meaning (see Rosch (1975)) focus on atypicality within a class: an ostrich is an atypical bird, for example, so it is therefore a "less good" member of the class of birds. Although the typicality of an entity is often irrelevant to its membership within the class (an ostrich is still definitely a bird) in some cases of extreme atypicality, classification uncertainties do arise: it is not obvious whether radios or curtains should be classified as furniture, for example.

The inexactness with which the boundaries of sets are drawn leads to some counterintuitive effects on categorisation tasks involving connections between different sets. For example, effects of category "intransitivity" and "overextension" are demonstrated in Hampton (1982, 1988).

Category intransitivity arises with superordinate relations: for example, while subjects may agree that a deckchair is a kind of garden furniture, and that garden furniture is a kind of furniture, they may not agree that a deckchair is a kind of furniture. So, given particular technical contexts, A may be a type of B, and B may be a type of C, but there may not be a *single* technical context which allows for A to be a type of C.

Category overextension is demonstrated by the fact that although subjects may agree that something is a game, but not a sport (or vice versa), they may still agree that it is describable as a game which is a sport (or a sport which is a game). So, while an entity may be classified as A but not B when the categories are considered in

isolation, in the context in which the words are conjoined a new category is produced which cannot simply be defined in terms of the intersection of sets for A and B.

Thus, the classifications that people actually use are imprecise, and also affected by context; they do not correspond to well-defined sets of objects. They are also unstable; see Barsalou (1987).

4.5.2 Disagreement and Resolution

The inexactness with which category boundaries are made will give rise to disagreements about which combinations are privative or not. As I have argued, privation is an emergent phenomenon of combination, not a semantic type requiring a different combinatory mechanism. However, it could be argued that disagreement about what is privative arises simply from particular individuals having a lack of knowledge about how a word is properly defined, rather than being due to a fundamental inexactness in classifications.

Obviously individuals can classify things erroneously: a complex concept such as *fools gold* indicates this. Arbitration by some definitional authority may be used to decide whether the individual's classifications are wrong or right. Putnam (1975) uses the notion of experts as authoritative definers for certain classes of words (e.g. scientific criteria might be used to define things such as *oxygen, gold, water*, based on chemical structure. The correct definitions would be those using properties agreed upon between experts within a linguistic community: the properties given by an expert definition would not have to be known by a layman – so long as an expert-defined test of category status is known to exist.[16]

However, any reliance on expert definitions to judge classification will require that experts agree on a definition, and on the interpretation of that definition. For chemical elements this is straightforward, but in other fields there may be many competing theories: experts can disagree just as lay-individuals can. In some cases, the definition may even be publically available, yet disagreement will still arise between experts as to which entities fall within a class, because the definition must itself be interpreted.

This is obviously the case where socio-legal definitions are involved. For example, Dean (1953) discusses a number of cases in which the definition of *libel* was disputed, and the meaning of the word reinterpreted. Particularly interesting is the fact that a case may be ultimately undecidable, if two equally powerful defining authorities come

[16]This suggests the possibility that the division between diagnostic and essence properties could be more formally defined as the distinction between properties known by the lay-individual to apply to a class and those that only an expert is able to test for.

to opposing decisions, as happens in the cases discussed in his chapter *The Westminster Libel Shop*, in which the central issue became whether the courts or parliament have the ultimate authority to decide what legal privileges parliament is entitled to (the issue was not resolved, and new law put the case permanently into abeyance). Similarly, scientific dispute over particular issues may last for decades: the evolution of theory may require not only redefinition of terms, but even the adoption of an entirely new ontology.

While processes such as scientific and legal disputation may eventually impose new "correct" definitions by fiat, new difficulties of interpretation can be expected to arise. So, while an expert's definition may generally be expected to be more detailed and specific than a layperson's, there is no reason to assume it is particularly more correct (if by "correct" we mean it cannot be gainsaid or interpreted in a variety of ways).

4.5.3 Novel Word Uses

Words are flexible in meaning, altering their reference depending on the context of occurrence: novel uses of words allow for reference to objects that do not normally fall within the extension for the word. For example, we have already seen the case of *tiger chair* interpreted as "a chair covered in tiger skin". A more radical example is that of Nunberg (1979) – a customer in a restaurant may be called a *ham sandwich*, being named after their order (an example of metonymy). Privation is another case in which a particular context of use for a word produces a radically different new meaning.

Novel word uses could be described as "non-literal" uses of words, and thus would not have to be considered as part of the "normal" operation of language. It has often been suggested that special semantic methods must be used for the interpretation of metaphors.

There are two problems with this idea. Firstly, as Gibbs (1994) notes, the boundary between literal and metaphorical meaning has never been precisely drawn; there is no easy way to clearly separate out, for example, examples of construal from normal polysemy. Secondly, novel uses for words may emerge at any speed. For example, Mithun (1986) details a gradual process of linguistic evolution, showing how noun classifier systems arise, nouns becoming classifiers that indicate generic kinds or qualities, then eventually ending up as members of a closed class of words with semantically opaque reference. Surely, though, it cannot be argued that the end result of this evolution is a set of metaphorical word uses: followed to its logical conclusion, this argument would imply that *no* current day language could therefore be regarded as literal, as all have evolved from earlier, different forms. But the only difference between a gradual process

of evolution and a sudden, novel use of a word is in the speed with which the new use has been adopted: the difference is quantitative, not qualitative.

Sense-generation approaches to meaning, such as those of Franks (1995) or Pustejovsky (1995) accept the fact that the occurrence of novel word uses is an intrinsic feature of language. Such theories offer the possibility of producing a potentially infinite number of senses for a word: there is no "canonical" selection of objects that fall under the description. Rather, there is some "base" representation from which specific meanings may be generated. The flexibility of word use seems to require such an account: unconventional interpretations of words are regularly and systematically needed.

While Franks' approach to privation is in the generative tradition, and treats the phenomenon as a sort of radical polysemy, he fails to examine a wide enough range of examples to find commonalities between privative and non-privative uses of particular modifiers. Thus, he posits special mechanisms to model privation, but tends to ignore the non-privative uses of those same words. I suggest that less specialised mechanisms are required in many cases: there is really not a class of privative modifiers, only a phenomenon of privation. These modifiers generally operate systematically: there is nothing different or "abnormal" about them; they are the same as other words.

4.6 Conclusions

Research Contributions

English contains a number of modifiers that allow nouns to label objects beyond their intuitive range of reference in a regularised, conventional way. The classification system that language imposes needs to be used flexibly in order to describe entities in terms of categories that they do not "naturally" fall within. There are a variety of reasons why a noun may need to refer to objects that it would not usually describe: e.g. because objects are reclassified over time; because it may be unclear which category an object belongs in, or which it is going to belong in; and because objects resemble (portray) those in particular classes.

Modifiers that are privative can simply be described in Montague Semantics as being of type $<< e, t >, < e, t >>$, but gives no method for constructing the meaning of the combination; something along the lines of a schematic theory is needed for that. Indeed, if modifiers are modelled as being of this type, meaning postulates are required to specify whether the adjective is privative or non-privative. However, the corpus-based study of so-called "privative" modifiers in this chapter suggests that privative operation

is generally not intrinsic to the modifier itself, but arises from its use in a particular context. While Franks' model addresses, through the mechanism of equivocation, the contingency of privative combinations such as *apparent friend* for which only some referents fall outside the extension of the head noun, it does not explain a more important contingency: the fact that many modifiers are privative only when modifying particular nouns.

I have proposed methods for modelling the operation of privative adjectives. The semantic mechanisms required to model the operation of these modifiers do not seem to be any more complex than those required in more "standard" types of property mapping and alteration: I showed that many could be modelled in terms of property mapping operations carried out on the AGENTIVE quale.[17] Thus, these modifiers can be adequately described without having to make privation a phenomenon that affects the process of semantic composition: I suggested that privation is instead an effect arising from the combination of particular words that has to be *deduced* as occurring in particular cases (and the course of this deduction may vary from individual to individual). Viewing privation in this light has the advantage that the meaning of individual adjectives can be modelled in such a way that both its privative and non-privative combinations can be accounted for in the same way: no a priori distinction need be made between the two types.

What is a sub-set relation in one situation (or to one person) is a case of privative modification in another. As we have seen, a decision as to what belongs in a class cannot always be straightforwardly made, either by individuals or experts. The privative aspects of modification arise due to our application of world knowledge, the process of "extensional elaboration" discussed by Murphy, rather than being intrinsic to the operation of such modifiers. Extensional elaboration will occur *after* the actual semantic process of schema-combination has taken place. While the processes of extensional elaboration (see Chapter 1) responsible for producing privativity are of interest in their own right, they arise from processes of reasoning with general knowledge, rather than being specific effects occurring with a specific type of word combination.

In addition, modelling these modifiers in terms of broadly applicable mechanisms does not require identification of a specific set of "essence" properties (although I have assumed elsewhere in the thesis that particular properties can be regarded as more or

[17]Privative modifiying nouns were treated slightly differently; in these cases, it is the combination of particular types of modifier and head noun that triggers a privative interpretation: these can be regarded as the reverse of typical noun noun combinations, in that it is the modifier that specifies the majority of properties for the referent, at least in the case of modifying mass nouns. The modifiers *toy* and *model* act in a similar way, although more properties may be mapped from the head noun in these cases.

less diagnostic for a given noun). Thus, there is no assumption that there is a method for identifying the entities that "really" belong in the category: human judgments about category membership are thus not taken as approximations to an abstract, perfect method of classifying objects.

Chapter 5

Relational Combinations

5.1 Introduction

This chapter is exclusively concerned with noun-noun combinations. It discusses relational theories of interpretation, shows how such relations can be modelled in schematic terms, and presents a large scale analysis of the range of combination types which particular nouns enter into.

5.1.1 Thematic Relations

So far, the main focus of the thesis has been on adjectives. Although we have seen some examples in which the mechanism of property-mapping can be used to model noun-noun combinations, not all such combinations can be modelled in this way.

For example, the referent of *dog kennel* has none of the properties of a dog. Instead, a relationship holds between the words, an appropriate paraphrase of the meaning being "a kennel **lived-in** by a dog". Within the psychological literature it is often assumed that there are, in fact, two different strategies that are used in interpreting complex concepts: one is property mapping, and the other is the deduction of the appropriate **thematic relation** (i.e. relating predicate). It is unclear which of these is the most important strategy for interpretation of noun-noun combinations (see Wisniewski and Love (1998)), although some studies emphasise the importance of thematic relations (e.g. Gagne and Shoben (1997)).

5.1.2 Previous Work

The earliest relational theories are probably that of Lees (1960) and Vendler (1968), who both suggested that a Chomskyan syntactic transformation took place during

the production of modifier-noun combinations: complex concepts were taken to be derived from a sentence via the deletion of the verb. Interpretation therefore required "un-deletion" of the appropriate verb, i.e. reconstruction of the deep structure, and therefore recovery of the relating verb. For example, to interpret a combination such as *dog kennel*, a predicate such as **lives-in** needs to be found.[1]

Subsequently, Levi (1978) abandoned the idea that the relationships are expressed in terms of actual English words. To make the task of recovering the relationship computationally simpler, as well as less language-specific, she described the relationships in terms of a limited set of highly abstract predicates (e.g. MAKE, HAVE, IN), including prepositional as well as verbal predicates. Given such a set, an investigator can take many examples of complex concepts from a language corpus, and classify them in terms of one of these relationships. Many different sets of predicates that could describe the range of possible relationships between head noun and modifying noun have been suggested.[2] However, Levi's theory remains influential, being used as a basis for representation in a number of works, including Warren (1978), Finin (1980), Jones (1992), Vanderwende (1994), and Gagne and Shoben (1997). All these examples present slightly different sets of predicates from Levi (e.g. distinguishing between whole-part and part-whole relationships, or separating the locative predicate into place and time relations).

Thus, relational theories are basically transformational: a predicate relation between head and modifier is taken to be deleted during transformation from deep structure (i.e. canonical semantic representation of sentence) to surface structure (i.e. language as observed). Interpretation requires recovery of this deleted predicate. Most of the systems cited above are based on the idea that the range of possible relationships can be described in terms of just a few possible predicates. The assumption is that the fewer the possible relationships, the simpler the problem of recovery of the correct relationship.

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[1] Adjectives were similarly interpreted by Vendler (1968): a combination such as *easy problem* would need to be interpreted in the light of a relationship such as **to solve**. This seems equivalent to an event predicate model of adjective operation.

[2] Levi (1978) is concerned primarily with noun-noun combinations, although nonpredicating denominal adjectives are also considered. For example, the adjectives in *criminal lawyer, rural policeman, royal hat* are not read in the sense they have in constructions such as "the lawyer is criminal", "the policeman is rural", or "the hat is royal". Levi suggested that these adjectives are operating fundamentally like nouns. Relational theories for other classes of adjectives are discussed by Ljung (1970), Aarts and Calbert (1979), and Warren (1984).

5.1.3 Levi's System

Outline of the System

We will examine the influential classification system of Levi (1978) in order to show the structure of such theories. In her system, there are nine abstract semantic primitive relations: the verbal predicates CAUSE, HAVE, MAKE, USE and BE (which will account for intersective modifiers), and the prepositional predicates IN, FOR, FROM and ABOUT. These predicates are intended to give a broad characterisation of all possible relationship types. The limitation this provides is intended to make the process of interpretation a computationally feasible process: i.e. not requiring complicated deductions using encyclopaedic knowledge.

The predicate categories are arrived at on the basis of intuition about adequate paraphrases of the meaning of particular concept combinations. For example, both *peanut butter* and *sea breeze* are interpreted in terms of the predicate FROM, because they can be paraphrased as "butter from peanuts" and "breeze from the sea". These nine predicates incorporate subcategories intended to allow for more precise expression of the relationship; perceived similarities between the subcategories licence their amalgamation into broader categories.

5.1.4 Problems with the System

One problem with this idea is that there is no objective way of producing such a set of categories. This means that there can always be disagreement about the number and type of relating predicates that are required for modelling combinations, and also about which predicate category describes any given combination. Levi cites the influence of Fillmore's case grammar (Fillmore (1968)) on developing her theory of basic relationship types. Fillmore described his cases as being a "set of universal, presumably innate, concepts"; however, there is little evidence to justify this, and a variety of competing theories of case have since been advanced (see Somers (1986)).

Levi regards the broad nature of the predicates as an advantage, noting that IN groups together combinations as diverse in meaning as *urban families, water lilies, logical impossibility, spring showers, phonological pattern* and *industrial strikes.* She states that "it cannot be accidental" that combinations analysed as belonging to the IN category can have paraphrases that "include the locative preposition IN". Clearly this is not accidental, simply because the paraphrases given have been constructed deliberately to conform to this pattern: it is much less convincing to argue that this is the only possible way in which they could have been interpreted. Certainly, there are a wide range of uses of *in* in English: Herkovits (1988) notes a wide range of possibilities

even for simple geometric uses of the word.[3] Other studies of prepositions such as Lindkvist (1976) and Brugman (1983) similarly show a wide variety of different uses. For example, "the water in the bucket" gives an example of containment, "the bird in the tree" gives an example of positioning in the interior of an object, "the oil in the pan" gives an example of surface-covering, "the crack in the vase" gives an example of structural incorporation, and "the bulb in the socket" gives an example of structural attachment. Thus, any predicate relationship IN which is based on the use of *in* can naturally include relationships of both position and structural relationship: *phonological pattern* could be interpreted as both "phonemes **in** a pattern" or "a pattern **made** from phonemes".

Downing (1977) argues that this broadness in fact creates problems for the theory. For example, *headache pills* and *fertility pills* are both classified by Levi as being pills FOR something. However, this neglects the important difference that headache pills *cure* headaches, while fertility pills *cause* fertility. Thus, it seems that the classes are not specific enough to incorporate relevant aspects of meaning: Downing suggests that Levi's top-level relationships could equally well be placed together in a single category RELATED TO.[4]

Levi (1978) replies that although the top level relations may be vague, individual cases of the more detailed meaning relationship are not ambiguous: classificatory subgroups provide more specific descriptions.[5] She provides the most detail of subgroups for the predicate IN. Its six subgroups are given as INHABIT, GROW-IN, ACCORDING-TO, DURING, FOUND-IN, OCCUR-IN. Although the first two subgroups are very specific relation-types, the last two seem to admit of as broad an interpretation as the superordinate predicate. It is thus unclear how well these specific subgroups serve to precisely classify examples.

Some commentators on noun-noun combinations have suggested that an extremely specific interpretation is very often required. For example, Downing (1977) discusses the combination *apple juice seat*, referring to a place at a table which has a glass of apple juice at it. Elaborate, precise relations such as this can only be deduced on the basis of extensional elaboration, or from the context in which the utterance is made: the interpretation of *apple juice seat* is thus not based on the meanings of the words themselves.

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[3]We also find *in* used to indicate abstract locations such as "in memory", "in a hurry".

[4]Ljung (1970) notes that "related to" is frequently given as part of dictionary definitions of denominal adjectives.

[5]Downing's objection would seem to be coped with rather better by classifying *fertility pills* as an example of the CAUSE predicate rather than FOR.

5.1.5 Summary

Many noun-noun combinations are best interpreted in terms of a thematic relation that holds between modifier and head.

Relationship classification systems are transformational in nature: they are generally based on the production of structures containing semantic primitives that are not part of natural language. Such systems are constructed in order to allow for specification of the relationship between modifier and head in general terms. Although the limited repertoire of predicates in such systems constrains the relational permutations possible for combinations, their limited expressivity produces ambiguity, each predicate being used to cover a wide range of specific relationship types.

The types of predicates described in Levi's system are intuitively attractive as descriptors of the types of thematic relations found in noun-noun combinations. However, the broadness of the categories tells against such theories: more precise descriptions of the relationships are required in order to avoid ambiguity.

5.2 Schema Representation and Relations

5.2.1 Relations vs. Property Mapping

In the psychological literature, relational and property-mapping mechanisms are regarded as mutually exclusive alternatives for the combination of noun-noun combinations: it is even suggested that the strategies are applied serially, with property-mapping only being used after attempts to find a thematic relation have failed (see Wisniewski and Love (1998)). The two mechanisms sit uneasily together because their basic assumptions about the representation of meaning are different. While property-mapping theories describe word and combination meanings in terms of schemata that possess a good deal of internal structure, representations involving thematic relations do not require any detailed description of individual word meanings, and describe combination-meanings in terms of two arguments related by a predicate (i.e. in terms of a fragment of a sentence either in English or a formal logical language).

However, it is possible to incorporate both strategies in a unified theory of representation, by modelling "relational" combinations in terms of operations on the head noun schema, rather than as transformations: Wisniewski (1996) discusses the idea that particular types of relations could be modelled as being slots within the head noun's schema. Instead of a property being mapped from a modifier noun, the noun itself

could be used as a slot filler.[6]

Any method of modelling that did use such slots would suffer from the same problems as Levi's system: the type of relationship can only be specified in a very loose and ambiguous way. In addition, the only reason the slots would be in the schema is so that noun-noun combinations could be modelled. On the other hand, the TELIC and AGENTIVE features discussed in earlier chapters could also be regarded as instances of "relational" properties, but instead of *being* types of predicates, the slots *contain* predicates which specify arguments, with the type of the argument being given in ARGSTR. They would cover many of the relations that, in Levi's system, would be subsumed under such categories as USE, FOR, CAUSE MAKE and FROM. However, because the fillers of TELIC and AGENTIVE vary with the head noun, extremely specific types of relationships can be represented.

This allows a model in which a schematic representation can cope with relational noun-noun combinations, as well as property-mapping, is some detail. Rather than a part of the modifier's schema being mapped into the head noun schema, we can instead imagine that the type specification for the modifying noun is checked against the type specifications listed in ARGSTR. For example, let us say that the noun *driver* contains in its schema TELIC = $drive(e, x, y)$, and therefore, as part of ARGSTR, a specification of argument type *y: vehicle.* When *driver* is modified by *train, bus, car, lorry*, etc., the match of the type of the modifying noun to the type specified in ARGSTR would allow the correct interpretation of the combination. Generally, there would not be a direct match of types: this would be simply dealt with by looking for matches in ARGSTR for the type specification of the modifier, followed by superordinates of that type, and so on up the hierarchy of types. Thus, if *train* is used as a modifier, then a match for *x: train* is looked for first, followed by *x: vehicle*, *x: artifact*, *x: physical-object*, and so on to the top of the hierarchy. If a match is found, the matched type specification is simply replaced by the more specific type of the modifier (e.g. *y: vehicle* becomes replaced by *y: train*). Using this method, *train driver* will be represented as "someone who drives a train", rather than having a vague specification such as "driver who uses a train" or "driver for a train".[7]

[6]It is also possible to account for noun-noun combinations that we have analysed as examples of property mapping in terms of thematic relations: for example, many of the examples we considered in previous chapters could be regarded as particular examples of a predicate RESEMBLES, although this would provide only a vague description of the meaning of the combination, in contrast to the more detailed accounts given by the schematic account. A separate means of modelling would be required for adjectives.

[7]Constructions such as *bus driver*, with a noun modifier and a deverbal head, have recently been given much attention in linguistic theory under the description of **synthetic compounds** (see Carstairs-McCarthy (1992), pp108–119; also Roeper and Siegel (1978), Selkirk (1982) and Lieber (1992)). The

In other words, default specifications of type for arguments within the head noun schema will provide constraints on the relationships that can be attributed to the combination. This approach would be very much like the theories of Lees and Vendler. Those theories ran into the problem that they could not provide a clear method of deducing what the predicate relation between head and modifier should be, primarily because transformational theory is a syntactic theory: transformations should be carried out without reference to the meaning of the words involved. However, the argument typing specified for features such as TELIC and AGENTIVE do supply a basis for a deduction of relationships to be made. No transformation is required; just a method to combine the meanings.

5.2.2 Relational Features

As already noted, TELIC and AGENTIVE can contain a variety of different predicates. However, these will only account for a portion of the different kinds of relationships that have been noted in previous corpus studies. A number of other relational features are required in order for the full range of thematic relations to be modelled schematically.

Two relationships that are commonplace are the whole-part relation, as in *duck foot*, in which the head noun is indicating a constituent element of the whole; and the part-whole relation, as in *plastic box*, in which the modifier indicates the material which composes the object (in whole or part). These relations roughly correspond to Levi's categories HAVE and MAKE.

Pustejovsky (1995) describes a CONSTITUTIVE slot (or CONST for short) that would contain information about part-of and made-of relations, and this is the approach adopted here. The CONST|PART slot will contain an argument that specifies the whole of which the referent is/was/will be a part. For example, the combination *duck foot* indicates that the referent is the subpart of a duck; similarly *sand grains* are the subparts of sand. There is, however, no guarantee that subparts are, in fact, attached to any larger object: they may be detached from the whole. (By the same token, in some cases the subpart may never have been part of such an object). Nevertheless, the

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head noun in a synthetic compound is taken to inherit the role-assigning abilities of the verb it is derived from: the modifier acts like an argument of the verb. The different argument positioning in verb phrase and synthetic compound is explained in terms of transformational theories that describe the derivation of synthetic compounds from an underlying verbal form. These are morpho-syntactic theories rather than semantic theories: they attempt to explain the constraints on the production of such structures, rather than explaining how the meanings of words are combined. They have nothing to say about combinations where the head noun is a telological but non-deverbal noun, such as *book shop*, which clearly are similar, in that the modifier is specifying the type of an argument for the head noun.

$$\begin{bmatrix} \text{ARGSTR} & \begin{bmatrix} \text{ARG1} & x : information \\ \text{ARG2} & y : physicalobject \end{bmatrix} \\ \text{QUALIA} & \begin{bmatrix} \text{FORMAL} & holds(y,x) \end{bmatrix} \end{bmatrix}$$

Figure 5.1: Representation of *book*

predicate $part-of(x,y)$ is used to represent this relation type; more specific predicates could be used to indicate the precise nature of the relationship. The CONST|MADE slot contains fillers that specify the material that something is composed from. If the head noun refers to a concrete object, this is typically going to require a mass noun for an argument (e.g. CONST|MADE $= made-of(x, y : mass)$), but the argument y could also be a count noun if the head can refer to a multiplex (i.e. a grouping of similar separable objects; see Talmy (1988)), as in combinations such as *seal herd, diamond cluster, art collection, video collection.*[8]

Levi's category IN is supposed to cover relations that can be expressed by a variety of prepositions (Levi cites *in*, *on* and *at*). The category is constructed "by positing a single predicate IN for both spatial and temporal, both concrete and abstract location". As noted above, the broadness of the predicate can lead to ambiguity in its interpretation. A LOCATIVE slot in the noun schema could contain a non-specific predicate such as $location(x,y)$, but would also include the possibility of more specific prepositional predicates (e.g. $in(x,y)$, $at(x,y)$, $under(x,y)$) or even predicates indicating the very specific types of location suggested by Herkovits (1988) and others.

Levi's category ABOUT provides a way of specifying the relationship of content or topic for head nouns that can hold pieces of information: e.g. a *music magazine* is "a magazine about music". In Pustejovsky (1995) the schema for *book* contains the slots and fillers shown in Figure 5.1 in order to specify that the physical object, the book, contains information (which can also be referred to with the word *book*. This provides a general method for modelling objects that can contain information. [9]

[8]There are also other ways in which an object can be said to be made of something: in Figure 3.13, periods of time were modelled as being composed of the subjective experience of a person.

[9]Pustejovsky also models nouns that have systematically related senses as possessing composite types: from this, the other senses can be derived, e.g. *book* can be taken as having the type *physical object*, the type *information*, or having the composite type of being both.

5.2.3 Summary

Theories that use thematic relations to represent the meaning of noun-noun combinations can be represented in schematic terms. The relationship types could be incorporated into schemata as slots, but such a model suffers from the same problems as theories that classify relations together: the resulting categories are imprecise, giving only a vague impression of the relationship in question. However, a model of schemata that uses relational features such as TELIC and AGENTIVE that contain predicates, offers an alternative approach. The type-specifications given in ARGSTR offer a means of constraining the possible relations for a combination, whereas the specific predicates found for a particular head noun allow the thematic relation to be specified in much greater detail.

5.3 Corpus-Based Analysis of Noun-Noun Combinations

5.3.1 Introduction

Wisniewski and Gentner (1991) investigated how noun-noun combinations are interpreted. In their study, 400 noun-noun combinations were generated by taking 10 count nouns (*frog, moose, robin, skunk, tiger, box, chair, pan, rake, vase*) and 10 mass nouns (*clay, copper, sand, stone, sugar, candy, chocolate, glass, paper, plastic*) and combining them as modifiers with 10 more count nouns (*elephant, fish, pony, snake, squirrel, book, car, clock, ladder, pencil*); this created 200 compounds, the reverses of which were also used. Each of the groups of 10 contained 5 'natural kind' words and 5 'artifact' words. The process of interpretation was investigated by presenting subjects with examples and asking for freely-generated descriptions of meaning: their analysis revealed that relational interpretations were frequent, but also that property-mapping interpretations were not uncommon.

Later studies (e.g. Wisniewski (1996), Wisniewski and Love (1998)) investigated the property-mapping and relational interpretations of noun-noun combinations in more detail, finding that varying proportions of the combinations received property-mapping interpretations, depending of the types of nouns involved, and also finding evidence of other processes involved in interpretation (e.g. construal). The problem with these studies is that they are carried out using only artificially generated combinations: there is no guarantee that the materials examined reflect the kind of structures that occur in natural language (an exception to this is Experiment 3 in Wisniewski and Love (1998): this will be discussed in Section 5.7.2).

However, the existence of our computer-searchable corpus allows for the counter-

part of such a study to be undertaken: one can examine what noun-noun combinations are actually entered into by particular words across a large, broad sample of real world language use. Thus, a study of the 30 words used by Wisniewski and Gentner (1991) was undertaken, in order to see what range of noun-noun combinations these words really appear in; what types of nouns they modify and are modified by; what sorts of relationships and property mappings are encountered; and their interpretability when examined out of context. While there are a number of previous studies which examine corpora of noun-noun combinations (e.g. Levi (1978), Warren (1978), Gagne and Shoben (1997)), I am aware of no study which provides such a detailed survey of the real types of combination entered into by specific words across a very large sample of text.

5.3.2 Materials

The 30 nouns fall into three groups: there are 10 mass nouns (*clay, copper, sand, stone, sugar, candy, chocolate, glass, paper, plastic*), 10 count nouns referring to artifacts (*box, chair, pan, rake, vase, book, car, clock, ladder, pencil*), and 10 count nouns referring to animals (*frog, moose, robin, skunk, tiger, elephant, fish, pony, snake, squirrel*).

All the noun-noun strings in the BNC corpus sample containing one of the 30 nouns were examined. There are 2392 such examples in total, providing a very large sample. However, a breakdown of combinations by type of word reveals a large frequency imbalance: 1027 combinations included the mass nouns; 1072 included the artifact nouns; but only 293 included the animate nouns (and the majority of these combinations were with the word *fish*). This imbalance, however, is not an artifact of the corpus, but simply reflects the lower average frequency of these animal nouns across the language. The mean word frequency values for each class, calculated from the lemma frequency measures given in Francis and Kucera (1982) are 98 for the artifact nouns, 65.9 for the mass nouns, and 15.2 for the animate nouns. For individual words, the number of combinations ranges from the single examples containing *squirrel* or *rake*, to the 324 involving *car*.

5.3.3 Procedure

Each combination was analysed as being either: a) a case in which the modifying noun could act as an argument for a relational property; b) an example of property mapping; or c) requiring some other strategy for interpretation.

All interpretations were those thought to be the most plausible by the author. However, notable ambiguities and problems of interpretation are also discussed. Naturally,

some combinations proved difficult to interpret when presented out of context. Where no obvious interpretation was available, I used the internet search engine *Altavista* to look for examples of the combination in actual use. This provided some concrete examples of the use of some obscure words and combinations, although there were not always examples to be found, so some combinations remained uninterpreted. In some cases, an *Altavista* search led to alternative possibilities of interpretation for a combination being found, and/or the suggestion that the example arose due to some form of apposition rather than being a genuine complex concept.

The concept of combinations having "obvious" interpretations could be argued against: all combinations potentially have an unlimited number of readings (e.g. as suggested in Lieber (1992), the phrase *truck driver* could, possibly, refer to "drivers with a picture of a truck on their t-shirt"). However, in many cases it would take a strongly prebiasing context to make certain interpretations viable. It seems that the *potential* ambiguity of combinations is often not reflected in people's understanding of them: there often is only one "obvious" interpretation. For example, in the normal course of things we would not interpret *headache pills* as "pills causing a headache"; we would not interpret *slave trade* as "a trade run by slaves"; we would not interpret *banana tree* as "a tree that is shaped like a banana", *river valley* as a "valley inside a river", or *bank customers* as "customers of a river bank".

Thus, the types of interpretations that we actually ascribe to combinations do not reflect the whole range of possible interpretations that could be made. It also appears from psychological studies such as those of Gagne and Shoben (1997) and Wisniewski and Love (1998) that there is generally a high degree of agreement between individuals about how particular combinations should be analysed.

5.3.4 Summary

A corpus-based survey of noun-noun combinations was undertaken, in order to look at the types of combination entered into by 30 specific words, of 3 different types. This will provide evidence about the kinds of combination these words enter into in a sample of actual language; analysis of the types of combination will show what strategies of interpretation are required in order to understand such combinations. The study uses a broad sample of language: being drawn from the BNC, there is a wide range of different source material. The next three sections examine the combinations that these groups of nouns enter into.

Noun	Total Number
chocolate	86
clay	27
sand	47
stone	154
sugar	64
glass	167
paper	283
plastic	186
copper	10
candy	3

Table 5.1: Number of Noun-Noun Combinations

5.4 Mass Nouns

5.4.1 Introduction

The ten mass nouns examined were *chocolate, clay, sand, stone, sugar, glass, paper, plastic, copper* and *candy.*[10] The number of unique noun-noun combinations which each was found in are presented in Table 5.1. A more detailed breakdown of the types of combination that are entered into by these words is given in Section 5.4.12.

5.4.2 Uses of *chocolate*

Head Noun

There are only a few uses of *chocolate* as a head noun. Two examples involve a CONST|MADE relationship, the modifiers specifying ingredients as in *milk chocolate, nut chocolate.*

Two other modifiers specify the *predicate* for TELIC: *drinking chocolate, cooking chocolate.* The ability of noun modifiers to express relational predicates rather than simply the arguments was not considered above: however, it seems that event nouns used as modifiers can specify the process that the head noun is used in.

The combination *school chocolate* has no obvious interpretation.

[10]It should be noted that *chocolate, stone, glass* and *paper* also have count noun interpretations: sometimes the count noun sense must be used to make sense of the combinations, as we will see below.

Compositional Relationship with Foodstuff Nouns
biscuit(s), blancmange, brazils, cake(s), choc-ice, coconut, crumb, digestives, drink, eclair(s), fudge(s), gateau, icing, liqueur, lollipops, meringue, milks, milkshake, morsels, mousse, orange, peanuts, pie(s), products, pudding, raisins, sauce, sponge, spread, sweets, teacake
Compositional Relationship with Non-Foodstuff Nouns
bar(s), buttons, drops, dots, dust, eggs, gunge, gunk, log, mice, miniatures, mouse, soldier

Table 5.2: Nouns modified by *chocolate*

Modifier Noun

Const The most common use of *chocolate* as a modifier is in relationships involving CONST|MADE. It indicates that referents are either wholly or partially made from chocolate. Examples can be seen in Table 5.2. The majority of the head nouns involved in compositional relationships are generally used to refer to foodstuffs. There are several cases of privation (e.g. with *eggs, mice, soldier*) which are included with the non-foodstuffs group.

Telic and Agentive There are also a number of teleological head nouns: the obvious interpretations of these combinations is in terms of *chocolate* specifying an argument of TELIC. The head nouns involved here are *eater, factory, lovers, magnate, shops, workers* with the relevant predicate fillers for TELIC being, respectively, something akin to *eat, make, love, sell, sell, make.* Possibly *chocolate chain* should also be included here (if *chain* is interpreted to mean a chain of shops). In addition, combinations with the head nouns *box(es)* and *tin* are best interpreted by taking *chocolate* to be an argument for a TELIC relationship of containment. There are also a couple of examples in which chocolate can be taken as an argument for AGENTIVE: the head nouns are *addiction, decadence.*

Property Mapping As noted in Chapter 2, COLOUR properties may sometimes be mapped from *chocolate*; probable examples of this are the cases where it modifies *compartment, ground, paint, sweater*, and *strip* (as in football strip, etc.). It should be noted that an interpretation in terms of CONST|MADE can also be made in each case here. However, one definite case of colour mapping is *chocolate gourami* (a gourami being a type of fish commonly kept in aquariums).

Others The combination *chocolate size* refers to a property of a particular piece of chocolate.

Ambiguity sometimes arises: it is not clear if a *chocolate diet* is a diet of chocolate or a diet in which chocolate is particularly avoided; similarly, the combination *chocolate kiss* does not have one single obvious interpretation.

In addition, there are some head nouns which are so vague, that a specification of the precise relationship involved is not possible: these are *experience, machine, stuff, things.*

5.4.3 Uses of *clay*

Head Noun

Special types of clay are specified by the modifiers *boulder, china.*[11] However, most of the examples are not straightforward: combinations with the modifiers *christmas, lobbyist, mirrors, story, word* do not have obvious interpretations.

Modifier Noun

Const Many combinations with *clay* as modifier are best interpreted as a compositional relationship, the modifier specifying an argument of CONST|MADE. This occurs for combinations with the head nouns *effigies, figures, floor, lips, lump, oven, pellets, pipe(s), soil, tablets* and *tubs.* The combination *clay mineral(s)* involves a relation of CONST|PART as opposed to composition.

Telic and Agentive A few combinations can be interpreted in terms of a relationship involving the filler of TELIC: the combination *clay mine* would seem to be one such. Combinations with *pits, seam* might also be analysed in this way, but in these cases, a compositional relationship would also be accurate.

Other The interpretation of *clay trial* is unclear.

[11] Where the modifier acts taxonomically, i.e. as a name for a subtype of the head noun, the modifier can be used to specify the type of the ARGSTR feature that corresponds to the referent of the head noun itself.

5.4.4 Uses of *sand*

Head Noun

There were few uses as a head noun. The nouns used were *aquarium, desert, river*, which seem to imply a CONST|PART relationship, and *auchlochan* which possibly indicates provenance (origin). The combination *granite sand* refers to sand created through the pulverisation of granite.

Modifier Noun

Const Head nouns in combinations involving a relationship of composition (*sand* specifying an argument for CONST|MADE) are *banks, bunkers, dunes, flats, pits, sheets, substrate, traps.*[12] The privative *sand castles* also belongs in this group.

Others that might be interpreted in this way are *sand storm* (which fits into a systematic pattern with *rain storm, snow storm*, etc.), and *sand drawings*, which is ambiguous: it could mean patterns created by pouring sand in some design; or a pattern created by scratching lines in wet sand. In addition, we also find the more idiomatic *sand paper*; originally this was paper with a layer of sand attached to it, but paper with other abrasives attached is also known as sandpaper.

The combination *sand grains* is best interpreted in terms of a CONST|PART relationship: grains are what sand is composed of.

Telic and Agentive In some cases, interpretation of the modifier as specifying a TELIC argument is possible. For example, where it modifies *bag, box*, the relationship is $contains(e, x, y)$; where it modifies *seeker*, the relationship is $seek(e, x, y)$. In addition, we find *pipeline, pipes*, which are used to pump sand, preventing loss of sand from beaches, *traps*, which has an interpretation as something that traps sand, and *store*, which could either be a store of sand (e.g. for gritting), or a shop that sells sand. One case in which AGENTIVE is the most important slot is *sand encroachment*: the head noun here is an event noun.

Others Another systematic use of *sand* is a modifier is to indicate a kind of habitat, when used with *eel(s), flea, lizards, martin(s).* The subtype INHABITS was one of the subgroups of Levi's category IN: to model this in schematic terms, we could assume animal nouns contain LOCATIVE = $inhabits(x, y : terrain)$, where *terrain* is a superordinate type for words such as *sand, grass, tree, jungle, sea*, etc.

[12]The right of the combinations with *bunkers, pits, traps* to be in this group could be disputed: after all, they are not made from sand, they are created by the shape of the sand.

A few other examples are found. The combination *sand heat* presumably refers to a property of sand (temperature). The combination *sand plunge* refers to a particular kind of soil arrangement used for growing plants. Also found is *sand religion*: it could be taken literally, although this seems unlikely; possibly, like *sun worshippers* it is a joking way of referring to holidays and holidaymakers. In addition, *sand* modifies the head nouns *thing* and *things*, combinations which are too vague in meaning for interpretation.

5.4.5 Uses of *stone*

Head Noun

There are relatively few uses of *stone* as a head noun.

A number of combinations are best described in terms of the modifier specifying an argument type for the CONST|PART slot: the modifiers *building, foundation, memorial, paving, road, seating* all indicate the object that the stone is/was/will be a part of. The same interpretation would apply for combinations in which the modifier is *cherry, fruit, plum*, although in these cases *stone* will be understood in a different sense, as referring to the hard centre of fruits.

There are a variety of other types of combination. Specific subtypes of stone are indicated by the modifiers *carborundum, marble, pudding.*[13] The modifier in *grind stone* specifies a predicate for the TELIC slot; *commutator stone* is a technical term, referring to equipment for cleaning a commutator; an *air stone* is a device used for aerating water in aquaria; and *quarter stone* refers to a measure of weight. There are also combinations that are not easily interpreted, with the modifiers *chance, risks.*

Modifier Noun

Const As can be seen in Table 5.3 a large number of modifying uses of *stone* are best interpreted in terms of it specifying an argument for CONST|MADE; there are some uncommon architectural terms, such as *mullions* (vertical bars dividing a window), *finials* (decorative urns), and *voussioirs* (wedge-shaped stones used for building an arch).

Telic and Agentive Straightforward examples in which *stone* will act to specify argument of TELIC are the combinations with examples are *masons, thrower(s).* Other cases are more ambiguous. For example, *stone shop* could be interpreted in terms of

[13]The combination *pudding stone* refers to a composite made of particles of varying size.

Compositional Relationship
axe, angel, arch(es), axe, balusters, bands, barn, base, beds, bell, bench, block, bollard, bolt, bottle, bowl, bridge, building(s), castle, cave, circle(s), coating, coping, cottages, courses, facade, facing, figures, floor(s), footbridge, formation, fortresses, foundations, gateway, hearth, hot-water-bottle, house, implements, jetty, mill-hut, monoliths, monument, mortar, necklace, panels, part, pendant, piers, pillar, plinth, porch, pots, ring(s), sculpture, sheds, shelves, shutters, sink, slab(s), slats, stair, staircase, stairway, statues, steps, surround, table, tablets, terrace, throne, tool(s), undercoat, urns, vault, wall(s)
Privative Composition
buttocks, elephants, god, groin, lioness, man, roses, tern, toadstool, trees, vertebrae, woman

Table 5.3: Nouns modified by *stone*

TELIC[14], but a CONST|MADE relation seems more plausible; *stone bags* also is ambiguous (but the compositional reading seems unlikely). A *stone attack* could be an attack made by using a stone, or one made upon a stone.

There are also several head nouns referring to events/processes, which are best interpreted in terms of *stone* acting as an argument of AGENTIVE: the nouns are *breaking, clearance, conservation, decay, extraction, fragmentation, removal, robbing.* The combination *stone painting* could also be interpreted as involving an AGENTIVE relation (it being created by painting stone).

Other There are a few other combinations. A locative relationship is suggested by *stone garden*, but this could also be regarded as specifying an argument of CONST|MADE. We also find: *stone age*, an idiom denoting a certain period of history; cases involving modification of nouns indicative of properties (*size, status*); and some vague head nouns (*things, version*).

There are also some combinations which are not easily interpreted: these are *stone recurrence(s), stone relief, stone shot* and *stone subjects.*

5.4.6 Uses of *sugar*

Head Noun

There are only a few uses of *sugar* as the head noun. Subtypes of sugar are indicated with the modifiers *caster, castor, demerara*; *blood sugar* involves a CONST|PART rela-

[14]The combination referring to a shop that sells stones; similar to a *fossil shop.*

tionship, the sugar here being a component of the blood; and *beet sugar* involves an AGENTIVE relationship (i.e. it is "sugar made from beets").

Modifier Noun

Const A number of examples involve relations of composition: *coating, cube(s), lump(s), paste, mixture*; in these cases *sugar* specifies an argument for CONST|MADE. A less familiar example is *sugar glass*, an easily breakable glass substitute made of sugar (used in movie making).

Telic and Agentive Combinations with teleological nouns derived from verbs such as *planter, workers* have an obvious interpretation, *sugar* specifying an argument of the TELIC filler. The same relationship holds in other cases: *barons, companies, industries, market* have a TELIC filler roughly corresponding to the predicate "sell"; the tools *sugar bowl* and *sugar spoon* are used to contain or spoon sugar, respectively. The most likely interpretation of *sugar train* also seems to be in terms of a TELIC relationship involving transportation.

For combinations with the head nouns *beet, cane, crop plants*, the relevant interpretation is that they are used to make sugar. In order for a TELIC feature to be specified, the head nouns must be understood as referring to crops, plants having no *inherent* use. Such an interpretation is made reasonably regularly for *plant*: the corpus contains combinations such as *banana plant, coffee plant, linen plant, tobacco plant.*[15]

Events and processes involving *sugar* as an argument of AGENTIVE are *production, rationing, trade.* Also involved in an AGENTIVE relationship are *sugar alcohol* and *sugar phosphates*, which refer to a group of chemicals derived from sugars (monosaccharides).

Other The combinations *sugar pipeline* and *sugar case* might also be regarded as involving a TELIC relationship (the relations being of transport or containment). However, *pipeline* would probably require interpretation in a metaphorical sense, and *case* could also have the meaning of an "instance", or "example".

A number of more idiosyncratic relationship types are also found: the term *sugar diabetes* is another name for diabetes mellitus, the common form of diabetes, caused by poor regulation of insulin. In this case, sugar is involved because the result is incorrect balance of blood sugar levels; *sugar puffs* is the name of a breakfast cereal; *sugar plum* is an archaic term for a kind of boiled sweet; *sugar paper* is a highly absorbent, grainy

[15] Examination of noun-noun combinations involving *plant* also suggests an alternative interpretation of *sugar plant* as an industrial sugar-processing factory, by analogy with *alumina plant, car plant, pesticide plant, power plant, sewage plant*, etc.

paper that comes in many colours (I am unsure whether sugar is actually used in its manufacture). The combination *sugar concepts* does not have an obvious interpretation.

Further combinations were with *level(s)*, which I take to be a refer to a property of sugar in solution; with *stuff* and *women*, producing combinations too vague for a precise relationship to be specified; and with *place* and *sector*, which suggest a locative relationship.

5.4.7 Uses of *glass*

As Head Noun

A few combinations are examples of relationships involving the CONST|PART slot: *glass* is used as a constituent of *aquarium, bottle, door, mirror, tank, window.* The combination *sheet glass* can also be interpreted in this way. On the other hand, *sugar glass, lead glass* involve CONST|MADE relationships.

The modifier in *viewing glass* specifies a predicate filler for TELIC (rather than an argument). We also find *ground glass*, glass which has been ground up into small particles. In this case, the modifier seems to specify a predicate filler for AGENTIVE.

Of course, *glass* is also used to refer to a drinking instrument, as in the combinations with *champagne, water, whisky, wine*, the modifier referring to what is typically drunk from that type of glass. These would then involve a TELIC relationship. We also find the combination *pint glass*, which specifies a volume rather than a type of drink. In addition, *balloon glass* refers to a drinking glass used for holding brandy or beer: the combination involves a mapping of SHAPE characteristics from the modifier.

We also find modifiers that specify particular subtypes of glass, these being *fibre, plate* and *safety*, and the combination *colour glass* (equivalent to *coloured glass*).

Combinations with the modifiers *peacock, corrosion, potter, pretzel* have no obvious interpretation.

Modifier Noun

Const Many examples of combinations with *glass* as the modifier involve straightforward CONST|MADE relationships, as can be seen in Table 5.4. In some examples only a part of the object is made of glass, as for *glass showers*, which refers to the shower enclosure. There are a few other, less obvious, combinations of this type: *glass slides* and *glass negatives* are glass items commonly used in the early days of photography; the head nouns *case(s), cabinet(s), cupboard, vitrines* all refer to types of cabinet, which could either be made of glass, or could be used for containing/exhibiting a collection of glass; *glass rovings* are a form of filament made with glass; and there are also a couple

Compositional Relationship
ashtrays, ball(s), bead(s), bookcase, bottle, bowl(s), box, bulb, cage, cannula, capillary, chips, collection, containers, cover, coverslip, cup, cupolas, decanter, dish(es), dome(s), door(s), door-top, end, fibre, fragments, house(s), jar(s), jug, key, lid, lift, mirror, mosaic, office, ornament, panel(s), paperweights, partition, pipette, plate(s), platter, pots, present, roof, room, screen, sculptures, shades, shafts, slipper, stopper, surface, tank(s), top, tower(s), tube, urns, vase, vessels, vial, walls, wares, work, window(s)

Table 5.4: Nouns modified by *glass*

of privative compositional relationships, with *eye(s), phallus* (and possibly also *glass armchairs*).

Telic and Agentive Examples of combinations for which a relationship involving TELIC is possible involve the head nouns *cleaner, cutter, collector, washer, worker* (although *washer* could also be interpreted as being akin to nuts, bolts, etc.).

Non-deverbal head nouns for which a TELIC relationship is suggested are *artists, furnace, industry, kiln* and possibly *works* (if this is read in the sense of "factory", rather than as referring to items made out of glass).

Combinations with *manufacture, repair* are related through the AGENTIVE quale (the relevant fillers being roughly "make, repair", respectively.

Other There are several head nouns which refer to properties of glass: these are *colours, fragility, matrix, phase(s), size.*

There are also some more specialised meanings: while *glass ceiling* can be used literally, it also has the common idiomatic meaning of "a level above which promotion is blocked"; a *glass coach* is a particular type of coach (similar to a hackney coach), used for important ceremonial occasions: glass does not play any important role in its construction; *glass ionomers* are powders used as filling material in dental work.

The meaning of *glass blitz* presumably involves breaking of glass, although other interpretations are possible; *glass target* could be a target made of glass, or a target for the production of glass, etc; *glass polymers* probably involves a CONST|PART relationship, although this is unclear.

In a couple of cases (*advice, mystery*), the head nouns refer to types of information-holding entities, suggesting that glass is in these cases the topic of the information: the topic relationship is discussed in more detail in Section 5.4.8.

5.4.8 Uses of *paper*

The word *paper* is the most frequent of the ten mass nouns. It also seemingly has the greatest number of meanings: it does not just refer to paper in the mass sense, but also has uses as a count noun, referring to publications and newspapers. The count noun uses also allow it to refer to information, as in Figure 5.1, and also to organisations (e.g. it can refer to a newspaper organisation, as in: "The paper employs 10 different editors"). This means that interpretation of the combinations it enters into is more complicated than in the preceding cases.

Head Noun

Const In combination with the head noun *paper*, the modifiers *tissue, vinyl, wax* specify arguments for CONST|MADE, while the modifiers *backing, book, manuscript, map, flipchart, pad, scrap* and *waste* specify arguments for CONST|PART. In all these cases, *paper* is interpreted as a mass noun.

Telic and Agentive A standard use for paper is for printing something on. The modifiers *computer* and *fax* specify the printing device, assuming the schematic feature TELIC = $print(e, v, x)$, with v referring to a printing device and x specifying the information that they write. However, this is not the only possible predicate for TELIC. Another common use for paper is covering or wrapping objects, as we find with the modifiers *chip, toffee, wall.* This would require the schematic feature TELIC = $cover(e, w, y)$, with w indicating the type of object that is covered, and y specifying the physical piece of paper.

The deverbal modifiers *copy, filter, plot, print, wrapping, writing* also seemingly operate on TELIC, this time specifying different predicate fillers.

There is a set of modifiers which I presume are names: *auguste, co-op, cprs, derby, gsm, hickman, kami, labour, nus.* These suggest the interpretation that the paper originates from these entities, possibly being manufactured by them, but more likely simply being created for them (e.g. headed writing paper). The same interpretation seems likely for the common noun modifiers *army, council* and *hotel.* These combinations might thus be taken to exhibit a relationship involving AGENTIVE. However, each case could also be interpreted as referring to a paper (e.g. a report or newspaper) written by the organisation, in which case, a TELIC relation would be the correct interpretation.

Subtypes A number of modifiers specify subtypes of paper: that is, the head noun may be interpreted as specifying the particular subtype of information which the paper

holds. Examples of this are *audit, draft, exam(ination), question, results, test, tutorial*: the specify the type of the argument y for the head noun schema slot QUALIA|FORMAL = holds(y,x). In particular, the modifiers *graph, music, watercolour* are frequently used to refer to paper of a type especially designed for holding a certain kind of information; similarly, we find *projection paper*, a special sensitised paper for recording a projected image.

Topic A number of modifiers indicate not the type of information stored on/in a paper, but describe the **topic** of that information. For example, combinations of *paper* with the modifiers *business, chemistry, maths, pop, research, science, sport* will be interpreted as referring to papers that discuss particular subject areas. In fact, the topic of an information-bearing entity such as a paper is unrestricted: a paper can be about practically anything. Thus, the relationship in practically every case of noun-noun combination in which *paper* is the head *could* be one of topic. Other modifiers probably related in this way are *budget, census, design, election, process, work.* The occurrence of topic relations between modifier and head can be modelled with a schematic feature QUALIA|FORMAL = $holds(y, x) \wedge subject(z, y)$ (as opposed to that given in Figure 5.1); the argument z could be of any type at all.

Less obvious in meaning, but still involving a topic relationship are the combinations: *background paper*, which gives background information on a topic; *position paper*, which states an entity's position on a topic; and *working paper*, discussing current work.

Other Academic and governmental systems use specific kinds of documents, which are referred to using modifiers that are often not immediately interpretable: a *class paper* is a paper written as a requirement of taking a class; a *revision paper* is a mock-up of an exam-paper, used in revision (as is a *specimen paper*); a *merit paper* is (probably) a paper given an award for merit; an *order paper* is a document which describes the coming day's business in parliament; and the modifiers in *consultation paper, discussion paper* refer to what the paper is supposed to elicit. There are also a number of modifiers referring to events that cannot occur without some kind of documentation being used. For example, a *nomination paper* must be submitted for a candidate for election to be nominated; a *travel paper* is a document required for travel; and a *ballot paper* is necessary for voting to take place.

A number of combinations suggest interpretations specifically concerned with newspaper organisations. For example *sister paper* of a newspaper, means "owned by same company as another paper"; the modifiers *evening, midday, morning, weekend* suggest the time when a newspaper is issued; *colour paper* perhaps suggests a newspaper

containing colour photographs (but might simply be used to refer to coloured paper).

Another set of modifiers indicates particular types of paper that are used in specific locations: *kitchen, lavatory, loo, toilet.*

Ambiguity is apparent for *salmon paper*, which suggests a mapping of COLOUR values, but might simply be a relation of topic, and *colouring paper* which could be a misclassified adjective-noun combination (meaning "paper that is changing colour"), but could also involve a TELIC relationship (like that of *colouring book*), or a relationship of topic.

Other combinations are *christmas paper* (paper used specifically for wrapping christmas presents), *cartridge paper* (thick, general purpose paper used for printing and drawing), *acid paper* (paper bleached with acid), *semi-log paper* (a type of graph paper with a particular arrangement of lines), and *sugar paper, sand paper* (both mentioned above in the relevant sections). The combination *centre paper* is difficult to interpret: seemingly it refers to position (which could be either physical or political position).

Modifier Noun

Const When *paper* occurs as a modifier, it frequently specifies an argument of CONST|MADE. Many objects such as *bag(s), balls, cup(s), handkerchief, hankies, hat(s), money, napkin(s), overalls, plate(s), streamer, strip, tissues, top, towel(s)*, as well as items such as *cuttings, debris, inside, offcuts, products, pulp, resources, sculpture, slips, tape, wrapping* are physically made of paper: the relationship is a compositional one. This relationship could also be attributed to a number of privative combinations, examples being combinations with head nouns *aeroplane(s), crown, holly, logs, man, people, rope, rose(s), star, tie, tongue, veils* and *wasps* (although some of these seem slightly odd; other interpretations might also apply).

In addition to these, there are also information-containing documents which are physically made out of paper: head nouns in these combinations include *article, back-up, copies, copy, document(s), documentation, file(s), form, journals, mail, news, newspaper, pad, questionnaire, records, receipts, series, version*, as well as pieces of information that are recorded on paper, suggested by the modifiers *agreement, deals, information, transactions.*

There are also a couple of cases in which the head nouns suggest parts of the information contained within the paper (i.e. combinations with *comments, details*) which suggest a relationship involving CONST|PART, referring to the informational structure of the paper.

Telic and Agentive In a number of cases, *paper* will act as an argument of TELIC. For *cutters, fastener, slider, sniffer* the relevant TELIC predicate is determined by the base verb. For the head nouns *factory, industries, industry, manufacture, mill(s)*, the default TELIC predicate roughly corresponds to "make", and for *shop, stores, sources* it will be akin to "sell" or "supply".

Other examples which I take to exhibit a TELIC relationship are *paper gallery* (a display of different paper types), *paper show* (a trade exhibition, i.e. to show paper), as well as *paper clip(s)* and *paper round.*

Head nouns specifying events or processes may take *paper* as an argument of AGENTIVE, examples being: *allocations, exhibition, fall, folding, planning, needs, output(s), record-keeping, shortage, spills.* Combinations with head nouns *print, paintings* might also be interpreted in terms of AGENTIVE, being created by printing or painting on paper.

The combinations *paper cut* (caused by paper) and *paper tears* (created in paper) are other cases in which AGENTIVE is relevant.

Other Another use of *paper* as a modifier is to indicate the "theoretical" nature of something: *paper profits*, for example are theoretical profits (e.g. they could be realised if holdings are sold); *paper debts* is presumably similar; possibly *paper freeholders, paper qualifications* should also be interpreted in this sense.

The head nouns *size, force, strength* refer to properties of paper. Properties of a paper can also be referred to: *design, pattern*, for example, indicate properties of physical layout (and could also possibly refer to paper as a bulk object); the informational properties can be referred to using head nouns such as *area, focus.* Paper is referred to as an information medium in combination with *format, media, medium.* In *paper talk*, it seems that the topic of the talk is paper (as a mass) or a particular paper.

Ambiguity is found for a number of combinations: *paper planning*, which could involve planning of a paper, about paper, or on paper; *paper match* could be a match made of paper (as contained in a matchbook), or something that is matched to a paper; *paper mark* could mean a physical mark on a piece of paper, or a grade for the content of a paper; *paper mountain(s)* could involve a privative compositional relationship, or simply refer to "lots of paperwork"; *paper stamps* could refer to either stamps made out of paper, or objects for stamping paper. The combination *paper games* can refer to both paper-using activities such as origami, and writing games such as crosswords, logic puzzles, etc. Similarly, *paper exercise* could be an exercise written on paper, or carried out with a paper.

More idiosyncratic/idiomatic combinations are: *paper back*, a type of book; *paper*

Compositional Relationship
back, bag(s), ball, bangles, bars, basin, baths, beaker(s), blinds, bottle(s), bowl, box(es), briefcase, bucket(s), card(s), carrier-bags, cases, casing, chair(s), circles, cistern(s), clips, container(s), cover(s), crates, cruets, cupboard, cups, cutlery, dash, deckchair, decorations, discs, doors, draught-strip, drums, edging, envelopes, eraser(s), fenders, fitting(s), folder, glasses, grid(s), guttering, gutters, handcuffs, handle(s), holders, interior, letters, materials, models, moulding, mugs, p-traps, packet, pan, panelling, pass, peg, pen, pipe(s), plate, pot(s), probe, rack, rails, raincoat(s), reel, rings, roadway, roofing, sacks, sail, sandals, seat(s), sheet(s), sheeting, skylight, sleeve, slopes, socket, spoon(s), stamp, stool, straw, surface(s), symbols, table, tape, tip, toy, traps, tray(s), trough, tube, tubs, tumbler, wallet(s), wendy-house, wrapper, wrapping(s), waste
Privative Composition
bats, boulders, child, diamond, ducks, eye, flowers, grass, gums, heads, heron, holly, leg(s), lemon, men, pitch, plants, seagulls, skin, snake, snowball, trees, weed

Table 5.5: Nouns modified by *plastic*

boy, a boy who delivers newspapers; *paper bank(s)*, stores for paper to be recycled; *paper moon*, a paragon of artificiality; *paper tiger*, an apparently threatening but actually harmless entity; *paper trail*, meaning a collection of pieces of paper that can be followed; *paper train*, commonly used to refer to one process involved in housetraining a dog; *paper unions*, unions for workers on newspaper/in paper businesses; *paper weight*, a heavy object used to hold down piles of paper; and *paper work*, clerical and administrative work.

The combinations *paper day, paper light, paper family, paper hero* are difficult to interpret. It is also difficult to interpret combination of *paper* with head nouns *context, operations, system(s)* and *trials.*

5.4.9 Uses of *plastic*

Head Noun

There are very few uses of *plastic* as a head noun. Only two are interpretable: *foam plastic*, an intersective combination, and *side plastic* (presumably plastic on the side of some object.

Modifier Noun

Const Practically all the uses of *plastic* as a modifier can be interpreted as a relationship involving CONST|MADE. As can be seen in Table 5.5, most of there are

straightforward cases, but there are also a substantial number of cases in which it is operating privatively.

Telic and Agentive Combinations with *adjuster, dispensers* and *washer(s)* could be interpreted in terms of *plastic* specifying an argument of TELIC: however, in each case a CONST|MADE reading is also plausible. The combination *plastic recycling* can only be interpreted as a relationship involving an argument of AGENTIVE.

Other As a modifier, *plastic* has two obvious uses: firstly, as a noun indicating a type of material; secondly, as an adjective implying that something is "easily adjusted" or "flexible". Combinations with the head nouns *design, flow, job* and *systems* could be interpreted in terms of *plastic* specifying an argument of CONST|MADE, or in terms of the adjective reading. It definitely has the adjectival meaning in the combination *plastic explosives.*

Another use of *plastic* is as a shorthand for "credit card". Thus, there are combinations such as *plastic credit, plastic money* and *plastic purchase.*

In addition, we find combinations with some non-specific head nouns (*bit, condition, ones, stuff, sort*) and a number of idiomatic combinations (*plastic arts, plastic surgeon(s), plastic surgery*). I am unclear what a *plastic push-fit* or a *plastic overtop* are precisely, but most likely they are objects made from plastic. Finally, the combination *plastic polypropylene* seems to be a case in which a subtype is being specified through postmodification (e.g. it could occur in a sentence such as: "The plastic polypropelene has many uses").

5.4.10 Uses of *candy* and *copper*

There are only 3 uses of *candy*: this is not a common noun in British English. All its uses are as a modifier: *candy bars* and *candy peel* are straightforwardly compositional. The other combination, *candy flip* is a cocktail name, a pop group name, and also drug slang. 10 combinations containing *copper* were found, but most of these were not easily interpretable (see Section 5.4.11). However, two combinations (*copper pipe, copper thistle*) seem to involve *copper* specifying an argument of CONST|MADE.

5.4.11 Other Combinations

A number of other corpus items were not included in the interpretations given above. These are cases which I judged were unlikely to be genuine examples of noun-noun combinations. These word sequences may arise for a number of reasons: firstly, the

Co-Taxonym Pairs
alloy clay, cake chocolate, brick stone, chalk sand, grit sand, mud sand, wood sand, sun sand, sand surf, oranges chocolate, clay straw, nickel copper, cement copper, copper aluminium, copper lead, aluminium plastic, plywood plastic, glass water, coffee sugar, loaf sugar, salt sugar, tea sugar, wheat sugar

Table 5.6: Uninterpreted pairs of co-taxonyms

words may be in apposition simply by being part of a list; they may be subparts of larger structures; or they may arise through the parser assigning words to the wrong syntactic category. The examples of uninterpreted pairs are given below, in order to demonstrate why they are not easily interpreted as being genuine examples of complex concepts.

Co-taxonyms and Repetition

Table 5.6 displays pairs of co-taxonyms found in the corpus (i.e. pairs of words that label similar entities within a category). Wisniewski's property mapping model would suggest that such combinations be interpreted in terms of a hybrid relationship, the combination referring to an entity that combines characteristics of the two classes. Such interpretations are not easy to place on some of the combinations here (e.g. *sun sand* or *glass water*), but some of the others do indicate mixtures of materials when combined into modifiers (e.g. *Altavista* searches turn up such phrases as *mud/sand mixtures, clay-straw technology* and *nickel-copper alloy*). In this sense these modifiers are hybrids, but it is unclear if any of these form noun-noun combinations that stand alone rather than just being used as hybrid modifiers. In addition, we find pairs of nouns that seem to arise because both materials can be described as recyclable: these are *bottles paper, glass paper, glass steel, glass tin, paper cardboard, paper cans, paper foil, paper glass, card glass.* There are also a number of cases in which nouns are repeated: *sugar sugar, sand sand, stone stone, paper paper.*

Syntactic Misclassification

There are a number of cases in which words have been syntactically misclassified. For example, the modifier is actually an adjective in the combinations *swiss chocolate, stiffish paper* and *supertough plastic*; similarly, *stone cold* is a compound adjective rather than a noun-noun combination.

Other examples seem to contain misclassified verbs as the modifier: *break glass,*

Modifier Noun	Modified Words
chocolate	emerges
glass	belongs, breaks, gleaming, melts, fall, plummet
plastic	stretches
paper	burns, calls, decreases, pokes, skips, presents
sugar	approach, burns, starts, standing

Table 5.7: Possible Modified Verbs

Modifier Noun	Modified Words
chocolate	mum
glass	ditto
paper	mother, mum, sir
sugar	baby, cath, dougy, eileen, love, thanks
stone	duckie

Table 5.8: Pairs Containing Names, Titles, Exclamations

knead sand, grease paper, use paper, circulate paper, love copper, love paper. Some examples (ending *-ing*) are possibly specifying TELIC predicates: *etching copper, heading paper, happening paper, saving paper*, but this is unclear. There are also a number of cases in which the second word seems to be a misclassified verb: these are presented in Table 5.7. Some of these words have interpretations as nouns (e.g. *plastic stretches* could be "events that involve stretching plastic" or "stretches (i.e. portions) made out of plastic"; *sugar burns* could be "burnings of sugar"). In many cases, interpretation is possible because the head noun could be an event noun, and thus these might be interpreted in terms of the modifier specifying an argument for AGENTIVE. However, *Altavista* searches reveal no obvious uses of these combinations as complex concepts.

There is a third kind of misclassification. The process of extracting examples from the BNC should have excluded proper nouns. However, some items were not classified as common nouns (see also the section of *paper*); also included were titles, other words used like names, and exclamations (e.g. *dad, duckie, thanks, sir*). Thus, pairs such as *grandad glass* and *philip glass* were found: other examples are given in Table 5.8.

Further Examples

Some examples, difficult to interpret, become clearer if we hypothesise additional non-noun modifiers.[16] The following list shows examples which are much more easily interpreted if a numeral is preposed (the numeral being indicated in brackets): (30) percent copper; (8) stone jockey; (3) stone lighter; (9) stone load; (2) parts sugar; (12) shilling paper; (13th) century glass; (17th) century stone; (30 degrees) centigrade sand; (30) minutes paper.

In other cases, another word or a phrase preposed (or occasionally postposed) to the sequence makes the combination easier to interpret: (high) quality paper; (high) resolution paper; (medium) size paper; (good) luck chocolate; (stained) glass image; (stained) glass portraits; (head in the) sand mentality; (sly and the) family stone; (corporate financial) statements paper; (onto) paper years (ago); hand paper (making).

Another group of uninterpreted combinations include nouns in apposition with measurements: *stone 10lb, stone 8lb, paper £4.99, paper 8cm, paper a., 80g sugar, pack sugar, ream paper.* In addition we find *glass fulls*, presumably also a measure of quantity (e.g. 3 glassfulls of wine).

Finally, a number of other cases occur in which one of the items is unusual, giving no basis for interpretation: *as-size paper, auto paper, lme copper, glass bleech, glass gearoid, glass petrova, sand hutton, plastic stents, paper lasmo, stone coade, stone com, paper mâ.*

5.4.12 Discussion of Mass Noun Combinations

Uses of Mass Nouns

The simple frequency of occurrence for these nouns in different kinds of construction reveals an interesting pattern: in Table 5.9 we can see for each noun: the total number of examples in the corpus; the number analysed as complex concepts; the number of complex concepts in which the noun appeared as a head noun; the number of complex concepts in which it appears as a modifier; and the number of uses as a modifier that were interpreted in terms of a compositional relationship (i.e. the noun specifying an argument of CONST|MADE).

It is immediately apparent that these words are all used much more frequently as modifiers than as head nouns: in total, there are 158 uses as head nouns as opposed to 747 uses as modifiers; over 80% of the combinations with mass nouns featured them as

[16] This was suggested by the results of *Altavista* searches.

Noun	Total Number	Complex Concepts	Head	Modifier	Const Made
chocolate	86	81	5	76	50
clay	27	25	7	18	12
sand	47	34	5	29	12
stone	154	142	18	124	97
sugar	64	46	5	41	8
glass	167	144	25	119	93
paper	283	246	91	155	71
plastic	186	182	2	180	152
copper	10	2	0	2	2
candy	3	3	0	3	2

Table 5.9: Frequencies of Combination Types

modifiers.[17] Furthermore, as modifiers, these nouns are overwhelmingly used to specify the composition of objects: this interpretation was made for 499 out of 747 cases, more than two-thirds of the total.

Overall, there were very few cases of property-mapping. A few cases were noted for *chocolate*; the only other obvious case was *balloon glass*. A few other cases were possible where co-taxonyms were paired. This finding agrees with the conclusions of Downing (1977) and Shoben and Gagne (1997); property mappings are generally scarce in real language. That this finding is reached by sampling a wide variety of uses for particular nouns over a very large sample of real world language tends to strengthen this conclusion.

The lack of property mappings may simply occur because the strategy is not applied to mass nouns. However, as we saw in Table 2.7, there certainly are some mass nouns from which property mapping is carried out: minerals with distinct colour values. However, the corpus analysis above suggests that this may not be a strategy applied only to very specific types of mass noun, rather than being used across a wide range of combinations.

Head Noun Uses

These items tend not to occur as head nouns precisely because there is little possibility of relationship. Naturally, COMP|MADE will already be well specified, although a few

[17] It should be noted that the data we are examining here is for *unique* pairs of nouns; thus, this reflects the range of types found in the language, rather than the frequency with which particular patterns of combination occur.

examples appear where the modifier specifies an "ingredient". Specification of an argument type for COMP|PART is generally possible, however, and several examples of this pattern appear.

Generally there will be no TELIC filler specified, as most of these nouns don't refer to objects with inherent functions. Exceptions are *chocolate, sugar, candy*, which are produced for eating, but the type of being that eats it is not specified anywhere by a modifier noun. The two mass nouns most frequently occurring as head nouns, *glass* and *paper*, both have count noun interpretations for which TELIC is well-specified; *paper*, in addition, also allows for modifier nouns to specify a topic. In some cases, deverbal modifiers actually specify a predicate filler for TELIC.

Although AGENTIVE would generally be available, modifiers seem not to specify the type of creating entity; nor is place of origin usually specified.[18]

Other modifiers indicate a particular subtyping for the class (e.g. *boulder clay, marble stone, demerara sugar*); in the case of *paper*, a wide variety of subtypes of information were specified.

Modifier Noun Uses

Wisniewski and Gentner (1991) found that subjects tend to interpret modifying mass nouns as indicating a compositional relationship to the extent that they are frequently interpreted as being privative when modifying animate count nouns (e.g. *chocolate snake* is likely to be interpreted as chocolate in a snake-like shape, rather than as "a snake that eats chocolate", "a snake coloured like chocolate", etc.). This study of corpus examples confirms this on the basis of real-language sources: however, it also shows that a compositional relationship is overwhelmingly adopted across *all* the types of nouns that these mass nouns are used to modify in the language. Privative composition uses of the nouns are found to be relatively infrequent; they generally only occur with head nouns referring to animate objects or bodyparts (although there are a few other cases, e.g. *paper aeroplane, plastic boulders*).

More than two thirds of the uses of these mass nouns as modifiers is to specify an argument type for CONST|MADE. Basically, it seems as though any case in which the head noun can refer to a type of concrete object, these mass nouns can specify the type for CONST|MADE = (x, y: mass). In fact, there is a distinction between the words that can indicate a **solid** mass, which are good candidates for indicating composition, and the **granulated** masses generally indicated by *sand, sugar* and, to a lesser extent,

[18] Possibly this picture would change if proper nouns had been included in the corpus; as it is, company names and place names are generally excluded.

paper: for these three nouns, less than half of their modifier uses are specifying object composition. In the case of *sand*, several of the nouns it modified indicated objects outlined by the shape of the sand, rather than being solid objects composed out of sand.

The other kinds of relationships frequently found were cases in which the head noun was a teleological noun, in which case the modifier could specify the type of an argument for TELIC (this frequently being a relationship of selling, manufacturing, or containment), and cases in which the head noun was an event noun, in which case the modifier acted to specify the type of an argument for AGENTIVE.

There are also other, specific uses which particular modifiers have. For example, we found several uses of *sand* in which it indicated the habitat for a class of animal (suggesting that *sand* might be classified as a type of *terrain*; another example is the use of *paper* to indicate the "theoretical" nature of the head noun. There was also a wide variety of more idiomatic combination types.

Ambiguity of Combinations

Many of the ambiguities found for combinations fall into systematic patterns, arising simply because particular arguments have different scopes. For example, *paper*, used as a head noun, allows for a relationship in which the modifier specifies a topic; however, the scope of this argument is so wide that literally any noun can specify a topic. Thus, any combination involving *paper* as a head noun could be interpreted as having this relationship. Similarly, any concrete object can take a mass noun as specifying argument type for CONST|MADE; this leads to ambiguity for some teleological head nouns that can refer to artifacts, *stone shop* being an example.

However, even though alternative interpretations may be possible, there generally seems to be a particular reading which is preferable. For a noun like *paper*, the match would seemingly be to the most specific type of feature in the schema (i.e. if the noun can be taken to specify an argument of a type more specific than the all-encompassing topic, this reading seems more plausible). In other cases, the selection of the argument would basically seem to be due to the fact that, as argued in Section 3.2.6, teleological nouns are adequately defined in terms of TELIC alone, and event nouns in terms of AGENTIVE (these features are, at least, highly diagnostic for class membership in these cases; clearly, other arguments must be present in ARGSTR, or there would be no potential for ambiguity).

Other cases of ambiguity were noted where the head noun was susceptible to different interpretations. For example, a *plastic washer* could be either "something that

washes plastic", or could refer to "a washer made out of plastic" (where *washer* refers to a piece of hardware, akin to a nut or bolt).[19] The ambiguity in such cases can only be resolved by the influence of the wider context in which the combination occurs. As we saw, there are also lots of examples in which the head noun was too non-specific/vague for the meaning of the combination to be resolved: these cases would again rely on context for disambiguation.

Finally, it was unclear whether some of the word pairs analysed were really examples of complex concepts, or whether the words are apposed for other reasons: e.g. where cotaxonyms were brought together, or where one word in the combination could be either verb or noun.

Summary

The types of combinations that these ten mass nouns enter into support the idea that the primary method for interpreting noun-noun combinations is the deduction of thematic relations: very few combinations involving property-mapping were found.

In fact, there is an overwhelming propensity for these modifiers to occur in the modifier position, where they generally act to specify object composition: this one specific use accounts for over 55% of these words' appearances in complex concepts.

5.5 Inanimate Count Nouns

The inanimate count nouns examined were *box, chair, pan, rake, vase, book, car, clock, ladder, pencil.* The number of unique noun-noun combinations which each was found in is presented in Table 5.10. A more detailed breakdown of the types of combination that are entered into by these words is given in Section 5.5.10.

5.5.1 Uses of *box*

Head Noun

Telic and Agentive For *box*, I suggest that TELIC = $contain(e, y, x)$. There are many modifying nouns that are used to specify the type of the argument y, and some of these are listed in Table 5.11.[20]

[19] Note that scope ambiguity also allows for the reading "something plastic that washes (something else)".

[20] As noted in the discussion of event predicates, Section 3.2.6, the argument of the TELIC slot is implicitly understood as possibly applying: thus, an *egg box* doesn't necessarily contain eggs; a *video box* doesn't necessarily contain videos, and so on.

Noun	**Total Number**
box	193
chair	110
book	313
car	324
clock	56
ladder	21
pencil	24
pan	19
vase	11
rake	1

Table 5.10: Number of Noun-Noun Combinations

TELIC (contains) Relationship
ammunition, ballot, biscuit, cash, cheese, choc(olate), cigar, cigarette, coin, collage, compost, contribution, deposit, egg, engine, flower, fuse, gateau, gear, hat, horse, indicator, jewel, jewellery, junction, laser, laundry, lunch, mail, match, modem, money, needle, needlework, phone, post, provision, reject(s), remnants, sand, sandwich(es), sewing, shoe, snack, snuff, soap, tape, telephone, tinder, tissue(s), tobacco, tomato, tool, trinket, video, wine

Table 5.11: Nouns modifying *box*

Other relations of containment are less obvious: a *bell box* may be part of a burglar alarm or an early telephone; a *fish box* can be used for transporting aquarium fish; a *poster box* may contain advertising posters (e.g. on a bus shelter); *car box* is often used to refer to a container for toy cars; and *word box* can refer to an element of a computer program, a place where a word is entered on screen.

Information may also be contained in a box, either written on a piece of paper which is then placed in a box, as in *comment, despatch, dispatch, suggestion(s)*, written within a 2D box drawn on a piece of paper, as for *score, tick, wages*, or written on a computer screen, as in *dialog box.*

There are also some cases in which humans are found within a particular kind of box (*press, vip, witness*), and it can also act as a home for certain animals (e.g. *bird box*).

In other cases, the box is simply a location where a certain event may occur, as in *call, penalty, tee(s)*

There are also some modifiers which specify an alternative TELIC predicate: these are *filter, signal, switch, control.*

In a few examples the referent will be produced by the box, suggesting an AGENTIVE relationship, the modifiers in these cases being *ice, music, smoke, voice.* In some cases, the box might also contain the product, but this is not true for all of these examples (some objects are of the wrong type to be contained).

Const Several combinations in which the modifier is a mass noun are best interpreted in terms of a CONST|MADE relationship: these are combinations with the modifiers *brass, cardboard, enamel, glass, horn, metal, iron, ivory, plastic, plexiglass, polystyrene, tortoiseshell, tupperware, wicker, wire*, although there is a degree of ambiguity here: it is possible to interpret all of these in terms of a box containing some of the material, rather than being composed of the material.

Others Some modifiers seem to require interpretation in terms of a LOCATIVE relationship, these being *end, mid-range, window.*

A number of more indirect relationships also occur: a *charity box* contains money donated to charity; a *swear box* contains money placed in by people who swear; a *collector box* may contain "collector" products, but there are also some people who collect boxes, and a collector's item in this field may be called a *collector box*); a *fishing box* contains gear used in fishing; a *kitchen box* contains cooking utensils and equipment e.g. for camping; a *christmas box* and a *presentation box* are special ornamental boxes, suitable for holding gifts; a *selection box* contains a variety of objects (e.g. different

types of chocolates).

Computers are also occasionally referred to as boxes, the modifier indicating the type of system: *dos, supersparc, unix.*

Several idiomatic combinations are also found. These are: *bankers box*, a file storage box; *brain box*, a clever person; *dairy box*, the name of a chocolate product; *glove box*, storage compartment in a car; *juke box*, which term is motivated by its original location in "juke joints"; *letter box*, for letters to be put through, rather than contained in; *pillar box*, another term for post box (the term is motivated by the shape of the box); *sinner box*, the area where sports players who have committed a foul have to wait; *skinner box*, a piece of equipment used in conditioning experiments with animals; *shit box*, crude slang for toilet; *sweat box*, an excessively hot place; and *time box*, which is a term used in the stock market, in "iterative processing" manufacture, and also refers to a box with the time in it (e.g. to be displayed on a web page).

While *tuxedo box* and *snow box* could be interpreted in terms of containment, they also have more specific uses: the former can refer to a box that resembles a tuxedo (used at weddings), and the latter can refer to a box covered with snow. Combinations difficult to interpret are *campus box, derby box, line box.*

Modifier Noun

As discussed in Section 2.2.3, *box* as a modifier can be interpreted in terms of mappings of SHAPE properties: as when modifying *bed, bedroom, camera, car, file(s), frames, hat, hedges, kite(s), lamp(s), room, seat, shape, ships.*

There are a variety of other uses. Subparts are specified by the head nouns *back, lid, section*, implying a relationship involving CONST|PART. We find *box* as a possible argument of the TELIC quale in combinations with *coolers, shop.*

A number of idiomatic combinations are also found: *box thorn* is one of the common names of the plant *Lycium* spp.; a *box office(s)* sells tickets; a *box filter* is an image processing tool; and *box populi* is either a pun or mis-spelling.

Combination with *bud* and *cuttings* suggests that *box* may have some use as gardening terminology: however, it may instead be being used as a verb in these case. Other combinations difficult to interpret are those with *brainchild, comment, extension, head, home, joy*; there are also combinations with the nouns *system, thing*, which are too vague for a relationship to be specified. The combinations with the head nouns *form, height, type* refer to properties of a box.

5.5.2 Uses of *chair*

Interpretation of these combinations is complicated by the fact that *chair* is not only used to label furniture, but is also a title (e.g. the chair of the meeting) as well as a position in academia.

Head Noun

Telic and Agentive The modifiers *guest, members* seem to indicate who is supposed to sit on the chair, and thus specify an argument of TELIC. The modifiers *dining, exercise, writing* indicate an activity engaged in while sitting on the chair: they should thus specify an additional TELIC predicate.

Combinations with the event nouns *count, increase* involve an AGENTIVE relationship.

Const There are several modifiers which seem to clearly be related in terms of what the chair is made of, a relationship involving an argument of CONST|MADE: these are *cane, canvas, leather, mahogany, metal, plastic.* The modifiers *gilt, tapestry* are similar, but indicate details of the chair's ornamentation rather than its basic structure.

Subtype Some modifiers act to indicate specific, familiar types of chair, in the furniture sense: *arm, deck, wheel* are familiar examples, but there are also other specific types which may be more or less familiar. Modifiers of this type are *balance, empire, saddle, sedan, nappy, stool, swivel.* Often the use of these modifiers is motivated (e.g. by shape), but unpredictable. Similarly, some of the modifiers indicate specific brands/types of chair for the handicapped (e.g. *cycle, mobility, roamer*).

Other Some modifiers imply a locative relationship: *bedside, fireside, garden, kitchen, office.* A *university chair* is an academic position; *bible chair* indicates a topic of study; and *deputy chair, madam chair* are titles. Examples difficult to interpret are: *roses-and-castles chair, page chair, things chair.*

The word *chair* does not only refer to furniture: it is also widely used to refer to the "chairs" of meetings, committees or other groups. The modifiers *campaign, conference, party* provide familiar examples of this kind: combinations with modifiers such as *chamber, community, credit, education, migration* probably also refer to the "chair" of a particular type of committee. Practically anything could be a topic of discussion for a committee; for example *firewood chair* was found to be used as a title

in the context of a forestry club. A large number of cases of apposition also occur because *chair* can be used as a title: see Section 5.5.9 below.

Modifier Noun

Straightforward "furniture" uses of *chair* are infrequent when it occurs as the modifier. We find CONST|PART relationships with the head nouns *arm(s), back, cover(s), leg(s).* For head nouns *industry, user* a relationship involving TELIC seems most likely; the same relation is possible for combinations with *work, workers*, but they could also be interpreted as meaning "work done while sitting on a chair" and "those who work while sitting on a chair".

Combinations of *chair* with the informational nouns *apology, issue, paragraph, proofs* could be interpreted in terms of *chair* specifying a topic. Similarly, the combinations *chair committee* and *chair conference* could be take as TELIC relationships, in both cases the relevant predicate being "discuss" (i.e. a committee or conference discussing chairs). However, it seems unlikely that chairs are discussed as much as this would imply: again, see Section 5.5.9; these are possibly cases of apposition rather than complex concepts.

Idiosyncratic/idiomatic combinations include *chair lift*, a device allowing the disabled to get up stairways, *chair rail(s)*, which are wooden strips installed on walls to prevent chair backs from scuffing them, and the compound, *chair person.*

No obvious interpretations are available for a number of combinations such as *chair attendance, chair boy, chair cigar, chair courtesy, chair home, chair lips, chair sin.*

5.5.3 Uses of *book*

Head Noun

Telic and Agentive The modifiers *reading, colouring* indicate activities that the book is used in: they specify TELIC predicates.

There are several cases in which the book is modified by a name: these presumably correspond to the name of the publisher or author or the book, in which case the modifier will specifying an argument for AGENTIVE. Modifiers of this type are *boece, duxbody, guin(n)ess, haig, jungle, kingwood, ladybird, maitlin, penguin, strachey, whitbread, wisden.* The only other case in which authorship is indicated is *class book* (a book written by pupils in a class).

Const A couple of modifiers indicate objects that are *physically* contained within the referent e.g. *cheque book, ticket book*: these act to specify an argument of CONST|MADE.

Subtype A large number of modifiers indicate the type of information that the book contains, these being *address, appointment(s), autograph, code, comments, complaint, enquiry, hymn, index, instruction, joke, log, name, note, observation, order, pattern, photograph, picture, poem, poetry, prayer, préludes, price, problem, programme, prose, puzzle, recipe, record, request, research, rule, score, sketch, song, statement, statute, story.*[21] As was the case for *paper*, these will act to specify y for QUALIA|FORMAL = holds(y,x).

In addition, there are modifiers indicating specific types of book (i.e. specific physical types), these being *hand, pocket, paperback.*

Topic Many modifiers for *book* specify a topic: that is, they indicate the type for z in QUALIA|FORMAL = $holds(y, x) \wedge subject(z, y)$. As for paper, it should be noted that the scope of topics for a book is so great that any modifying noun could be interpreted as specifying a topic.

Straightforward specifications of topic are given by the modifiers *accident, action, advertising, bird, cat, cook, cookery, cycle, detective, dream, fern, gardening, ghost, herb, history, horror, law, maths, physiology, policy, procedure, tank, television, travel* and *wildlife.* However, some topic modifiers are perhaps less easy to interpret: an *activity book* details "activities" i.e. things-to-do; a *contact book* contains a list of "contacts"; a *drill book* contains information about the "drill" to follow (e.g. for sports coaching); an *issues book* deals with "issues"; a *rate book* lists rates (i.e. charges) for something; a *remembrance book* contains remembrances about a deceased person; a *resource book* gives information on available resources; a *service book* may be either for a church service, or contain information for technicians about how to service a machine; a *type book* contains information about typography. The modifiers *account(s), bank, budget, cash, levy, loan, rent, wages* indicate that the book contains a record of financial details of money received, paid out, etc.

A couple of other combinations also indicate what the book's contents are: a *dialect book* is written in dialect, the modifier being akin to adjectives such as *English, French, German*; *gospel book* and *revelation book* presumably refer to parts of the bible.

Other A variety of other relationships are found: the modifiers *copy, exam, exercise, work* indicate a book specifically for writing out work in; the modifiers *ration, pension* indicate books that record eligibility for either rations or pension money; a few modifiers suggest the ownership of the book (*club, lab, library, school*); a *sample book* may either

[21] An *index book* is a book which is itself an index (e.g. a guide to a photo library).

contain samples, or may itself be a sample of a type of book; the modifiers *doom, domesday, spycatcher* seem to be giving the book's title.

There are a variety of idiosyncratic relationships, many acting to specify a book's topic or contents in an indirect manner. For example: a *christmas book* might be a book about christmas, or a book recommended to buy as a christmas present; a *form book* details the "form" of horses; a *guide book* is a guide to some specific place; a *leave book* is a book to sign when going on leave; a *reference book* is a collection of factual information on a specific topic; a *scrap book* is used for collecting miscellaneous documents related to some subject; a *source book* is a source of reference information on some topic; a *starter book* is a book to introduce a novice (i.e. a starter) to a topic; a *(tele)phone book* is generally a book of phone numbers; a *text book* is a specific kind of non-fiction book; a *visitors book* is for visitors to sign; and a *year book* is a book compiled by the members of a group at the end of the year, giving details of themselves.

Combinations with the modifiers *capital, fragments, people, ribbon, rails, shopping, spender, task, trouble, village* are not immediately interpretable (but a topic relation is always possible).

Modifier Noun

Telic and Agentive Various TELIC relationships are found: *case, ends, shelf* are used for containing books; *business(es), companies, publisher(s), seller(s), shop(s), store(s), supplier, trade* are concerned with making and selling books; we also find the head nouns *illustrator, writer* and *mark(s), marker, token(s).*

The most obvious AGENTIVE relationships are for the *-ing* nouns *burnings, collecting, publishing, reading, signings.* There are a number of other events and processes, such as *sales, orders, production, provision, purchases, manufacture* concerning production and selling, and also *acceptance, deal(s), delivery, display, donation(s), entertainment, launches, show(s).* Other possible examples of AGENTIVE relationships are *book debt(s), book profits*, which may arise from the buying and selling of books, and *book contributions*, which are either contributions to a book, or contributions of a book to something else (e.g. a sale).

Const Subpart (CONST|PART) relationships are found with *chapter, cover(s), jacket(s), paper, staple, title, illustration(s)*, and possibly also *back, side.* On the other hand, there are also some CONST|MADE relationships, with *collection, series.*

Other There are a variety of other relations.

Firstly, there are a number of informational head nouns, for which *book* will itself be the topic. These are *agreement, list(s), news, policies, policy, review(s).*

Some head nouns indicate qualities of a book, these being *condition, number, value.* Although seemingly similar, it is less clear what *book polarity* might be.

There are a number of indirect relationships. The head nouns *club, society* imply a complex relationship; the referent of the combination will be composed by people who appreciate books. The combinations in *book room(s)* suggest a place for reading or storing books in. The combinations *book research, book work* describe activities that are done with the use of books.

Other combinations include: *book form*, which is likely to be the realisation of some idea in book form; *book action*, which could either be the action described within a book, or some action involving a book; *book day*, which might be a day on which people are requested to read books; *book world*, which is a term to describe everything associated with books; and *book thing(s)*, too vague for interpretation.

There are also a large number of combinations for which interpretation is difficult. It is possible to come up with interpretations for many of these: for example *book religion* can mean a religion with written scriptures; a *book war* may be a commercial dispute, or some argument over a book; *book nations* might mean countries in which a lot of books are sold; *book deserters* might be people who give up reading; *book innocents* might be people who never read, and so on. However, these interpretations are not "obvious", and there are other cases in which a plausible meaning for the combination is harder to find. One reason for this could be that such combinations arise out of a form of apposition, rather than them being true examples of noun-noun combinations: the head noun may simply be the first word of a book's title appended to the word *book*, e.g. "Joe Bloggs' book Annihilation". Examples from *Altavista* of this type of structure were found for combinations with the head nouns *evolution, victims* and *diagnosis*; the existence of such structures probably also explains combinations with *awakenings, chronicles, christianity, kings, lamentations, mindstorm.*

Other combinations for which interpretation is unclear are *book address(es), book button, book home, book nudes, book records.*

Finally, *book keeping* is an idiomatic compound.

5.5.4 Uses of *car*

Head Noun

Telic and Agentive Given a feature TELIC = $transport(e, x, y)$ for *car*, then the modifiers *executive, family, police, squad, staff* can specify the type for y; the nouns

coffin, ganga, radio also suggest a relationship of containment or transportation. The combinations *hire car, lease car* have modifiers that indicate additional possible predicates for TELIC.

A feature AGENTIVE = $build(e, z, x)$ would allow the modifiers *allegro, bmw, jaguar, lada, rover, skoda, volvo, yugo*, names of manufacturers, to specify the argument z.

Subtype Specific nouns act as indicators of the car's particular type, examples being *estate, panda, saloon, sports, stock*; similarly, *sierra* indicates the brand of the car. Only in combination with *car* do they take on the particular senses they have here.

Other A number of modifiers indicate who the owner of the vehicle is: *avis, business, company, hospital, mummies, mums, office.*

A variety of other relationships are also found. A relationship of composition is indicated by *convoy car*; the modifiers *pedal, petrol* indicate the power source of the car; events in which the referent plays an integral part are specified by *funeral, getaway, patrol, rally, wedding*; *replacement* indicates that the car is standing in for another car.

More specialised meanings are: *courtesy car*, a car leant as a temporary replacement while repairs are carried out; *kit car*, a car built from a kit; *concept car*, built as a demonstration of cutting-edge technology (i.e. it uses new concepts); and *lead car*, which is ambiguous, meaning either a car that is leading (e.g. a race), or a car that runs on leaded petrol, or even a car made out of lead.

Cars can also be subparts of trains or other vehicles, of a variety of types.[22] This is suggested by combinations with *box, breakfast, buffet, cable, coach, pullman*, indicating types of railway carriage, and *cable, tram* indicating types of vehicles. In addition, there is *support car*, a special vehicle used to support cranes.

In addition, there are the modifiers *dream, duff*, which seem to be used more like adjectives than nouns in these combinations.

Combinations containing the modifiers *input, name, room, volt, village* and *years* are difficult to interpret.

Modifier Noun

Telic and Agentive A large number of combinations are interpretable in terms of *car* specifying an argument for TELIC or AGENTIVE.

For example, there are a lot of obvious TELIC relations, with head nouns such as: *ads, auction, bomb(s), business, buyers, company, dealership, distributors, dealer(s),*

[22] Automobiles can be specified with the phrase *motor car*, although this does not occur in the corpus.

Constitutive Relationship
alarm(s), batteries, battery, bodies, body, bonnet, boot(s), brakes, bumper, clock, dashboard, door(s), exhaust(s), engine(s), headlights, horn, lights, mat(s), mirror, panel, parts, phone(s), radio(s), roof, seat(s), stereo, suspension, telephones, tyres, window(s), windscreen(s)

Table 5.12: Nouns modified by *car*

driver(s), enthusiasts, factory, firms, fitters, ferry, hirers, industry, insurance, maker(s), manufacturers, market, mechanics, owner(s), plant(s), repairer, salesman, salesmen, salesroom, showrooms(s), sprayer, swindler, tax, thief, transporter(s), worker(s). Other relations of this type are available with nouns referring to tools (*heaters, hoover, jack, key(s), trailer, sticker(s), wash(es)*) or to areas for storage, either parking or impounding (*lot, park(s), port(s), pound*).

There are also many cases in which an AGENTIVE relationship is present. The most obvious are those involving modification of event nouns ending with *-ing*: *bombing, cleaning, driving, hunting, racing, reversing, shopping, travelling, washing.* Other event nouns include ones concerned with types of motion (*chase, drive(s), driving, journey(s), transport, travel, trips*), those concerned with crashes (*accident(s), crash(es), pile-up*), and a variety of others (*assembly, care, hire, lease, leasing, maintenance, repairs, production, sale(s), theft, trade, usage(s), use*). States that a car can induce are *dependency, love, ownership, sick(ness)*, and physical objects that a car can produce are *fumes, tracks.*

Const There are head nouns for which *car* specifies an argument of CONST|PART: these are listed in Table 5.12. Possibly this list should also include *number(s), registrations*, and maybe also *car tank* (if this refers to the petrol tank) and *car back.* In addition, the combination *car boiler* refers to a subpart of a train (rather than a motor car).

We also find a few examples of CONST|MADE relationships, with the nouns *fleet, pile, traffic.*

Other Various qualities of the car are given by some head nouns, both physical properties (*length, speed, location*) and more abstract properties, such as *aesthetics, appeal, cost, prices, safety, security*, and also the nouns *edition, sort*, referring to the property of the car being a particular type.

Other combinations in which the modifier has a more indirect or idiosyncratic re-

lation with *car* are: *car people, car person*, which may be indicative of people who like cars; *car account*, which is an account for (e.g.) rented cars; *car allowance* which is an allowance given for maintaining a car; *car expenses*, which are expenses associated with running a car; *car rally* and *car rallies*, referring to a particular type of race; *car culture*, which generally refers to a culture dependent on cars; *car classics*, which refer to the range of "classic" cars; *car council*, a body which has some authority in car-related matters; *car box*, which, as discussed above, may be a box to hold a toy car in; *car capital*, generally used to label a town strongly associated with cars in some way; *car keyring*, which is presumably a keyring holding car keys on it; *car station*, which can refer to the part of an elevator used by passengers, but also occurs in combinations such as "cable car station"; *car trouble*, which means a problem with the car such as a mechanical fault; and *car shares*, which I take to refer to shares in a car manufacturing company.

Ambiguities arise with combinations such as *car parking*, which can be an activity, or an object (a place to park cars); *car loan*, which could either be a loan to buy a car, or a loan of a car.

Two informational nouns can take *car* as their topic: these are *conversation, magazine.*

The head nouns *levels, situation, system, thing(s)* are too vague for any direct interpretation to be made. The head nouns *crime, jobs, work* seem to involve a TELIC relationship, but because the nouns are fairly vague, the actual processes involved cannot be specified in precise terms. Combinations with *mascot, oil, rubber, t-cut* suggest a relationship such that the referent is used with a car in some way, but a direct TELIC specification is unlikely here.

Combinations which are not easily interpretable are: *car button, car clothes, car coats, car drunks, car hundreds, car runway.*

5.5.5 Uses of *clock*

Head Noun

Subtypes Specific types of clock are described with the modifiers *carriage, grandfather.* The modifiers *alarm, cuckoo, pendulum* could also be said to specify particular types of clock, but the modifiers are doing so by referring to particular subparts of the clock (the modifier and head are in the opposite order to examples of CONST|PART relationships that we have already seen). Similarly, *alarm clock* and *travel clock* refer to particular type of clock, but the modifier also indicates a particular use of the clock.

Const/Locative Modifiers indicating the location of the clock are commonplace: *car, church, dashboard, hall, home, kitchen, laboratory, library, mantel, mantelpiece, microwave, tower, wall.* Some of these could be interpreted as examples of CONST|PART relationships: however, in several cases the clock will not be a part of the structure of the referent. The modifier *town* might also be included as specifying location, although the combination *town clock* more specifically refers to a clock centrally visible within a town, rather than just any clock in a town.

Others The modifiers *computer, system* refer to a timing device used in computer operation; the *guinness clock* is a famous device[23]; *cunard clock* might be similar to *guinness clock*, or could more simply be a clock on the Cunard building, or one displaying the Cunard logo; a *detention clock* is a clock timing how long someone has been held in detention; *body clock* refers to the biological systems that regulate the sensation of time. The combination *money clock* is difficult to interpret.

Modifier Noun

Telic and Agentive Combinations involving TELIC relations are suggested by head nouns *collector, manufacturer* and *shop.* The combination *clock timer* also involves a TELIC relationship; it is a device to check the accuracy of a clock, for repairs, etc.

It seems that *clock* can specify an argument of AGENTIVE relationship for *clock making.* The same might be suggested for *clock stopping* (if interpreted as being an activity) and also *clock strikes, clock ticking* (kinds of sound).

Const Relations in which *clock* specifies an argument for the feature CONST|PART are suggested by the head nouns *back, bit, face, number.*

Other The terms *clock speed, clock frequency* refer to a clock's qualities: they particularly refer to computer clocks (which synchronise computational operations.

A variety of other relations exist: *clock time* is the time according to a clock; *clock radio* is intersective, a hybrid between the two categories; a *clock card* is a card stamped to show time of starting/ending work; *clock work* could either refer to clockwork (machinery), or work regulated by a clock, or work carried out on a clock; *clock tower* involves a locative relation; and in *clock spin*, clock is used as shorthand for clockwise.

[23]The Guinness company constructed an elaborate clock for the Festival of Britain, which was so popular, several duplicates were made for exhibition elsewhere; later another design was also constructed: it was a form of advertising.

The interpretation of *clock turn* is unclear: it could refer to a revolution of the hands. The combination with *thing* is too vague for interpretation.

5.5.6 Uses of *ladder*

Head Noun

Three modifiers imply a CONST|MADE relationship. These are *aluminium, iron, rope.*

Subtypes of ladder are specified by *distance, extension, step, trap* (the last three modifiers also possibly qualifying as labelling subparts). The modifier *library* indicates who owns it, the modifier *loft* where it leads to, and the modifier *inspection* what it is used for (thus specifying an addition predicate for TELIC).

However, it appears that *ladder* is also often used metaphorically. Modified by *career, fame, league, learning* and *property*, it implies a series of steps within a field of activity, leading upwards to "more" or "better" status within that field.

The combination *needles ladder* has no obvious interpretation.

Modifier Noun

There are only a few examples of *ladder* as modifier: a *ladder stile* is a hybrid of the two objects, and *ladder hooks* involves CONST|PART relationship. Not admitting of any obvious interpretation are *ladder league, ladder radio.*

5.5.7 Uses of *pencil*

Head Noun

Two modifiers indicate the medium that is drawn on, i.e. specify an argument of the TELIC predicate: *eyebrow, slate.*

A *precision pencil* has a thin lead; a *colour pencil* contains coloured lead; a *clutch pencil* is a type of mechanical pencil. The combination *time pencil* can label a pencil with a clock inbuilt, or be preceded by a word such as *fun.*

Modifier Noun

Telic and Agentive In several combinations, *pencil* is used as a modifier to specify an argument of AGENTIVE, i.e. a pencil is used in creating objects, such as *drawings, figure, mark(s), moustache, notes.*

There are also some combinations that can be interpreted in terms of TELIC. For example, *case(s), firm, sharpener* seem to involve relations of containing, making and sharpening pencils, respectively.

Other Other combinations include *pencil crayons*, where *pencil* simply specifies a particular type of crayon; *pencil grades*, which seems to refer to the quality of the hardness of the lead (e.g. 2B, HB, etc.); and, as usual, a couple of vague nouns also occur: *stuff, thing.*

5.5.8 Uses of *pan*, *vase*, and *rake*

Head Nouns

The only appearance of *rake* is in *hoe rake*, which seems to be referring to a hybrid tool, or reflects a case of apposition.

Examples of CONST|MADE relationships for *pan* are found with the modifiers *plastic, steel*; for *vase* with the modifiers *china, glass.*

Three other combinations are found with *vase*: *baluster vase*, a specific type (shape) of vase, *fa vase*, a football trophy; and *wedgewood vase*, indicating the manufacturer.

With *pan*, we find: combinations with *chip, stew* specifying an argument of TELIC, and *frying, grill* (sub)specifying the predicate; *wc pan*, involving a CONST|PART relationship; *bed pan, dust pan* referring to particular types of pan; and *skid pan*, referring to a place designed to allow skidding in a car to be safely carried out.

Modifier Nouns

As modifiers, the nouns specify arguments of TELIC in *pan scrubber* and *vase painters.*

The only other obvious relation for *pan* is in *pan bread*, which is cooked in a pan. In the remainder of cases, it is used differently: in *pan american*, it is used as a pre-adjectival modifier, meaning "spread across"; in *pan demon* and *pan books* it is used as a name (as it probably also is in *pan agency, pan spokeswoman*); and *pan butter* is probably appositional.

The combination *vase towers* is difficult to interpret.

5.5.9 Other Cases

As for mass nouns, a number of other corpus items were not included in the interpretations given above. Again, the examples of uninterpreted pairs are given below, in order to demonstrate why they are not easily interpreted as being genuine examples of complex concepts.

Co-Taxonym Pairs
car bus, car cars, car lorry, car rail, car van, chair chairman, chair chairs, chair colleagues, chair delegates, chair wheelchair, case bottle, pencil watercolour, book computer, book graph, vase cup

Table 5.13: Uninterpreted pairs of co-taxonyms

Co-taxonyms and Repetition

Cotaxonym pairs are presented in Table 5.13. There are fewer such pairs than there were for the mass nouns. A number of cases of repetition were also found: *box box, book book, car car, chair chair.*

Syntactic Misclassification

A number of cases of syntactic misclassification: *lit box* and *dinky car* are examples of adjective-noun combination; *chair opposite, car anytime, car outside* contain prepositions (some of which do have functions as nouns).

We also find cases in which the first word seems to be a misclassified verb, such as *being chair, effect chair, insures car*; in addition, there also appear to be cases where *book* should have been classified as verb, being used in the sense of a ticket being booked. Uses of this type are suggested when *book* modifies nouns such as *acts, air, bands, courts, gigs, holidays, places, seats*; probably the word is also being used as a verb in *book weekdays* (specifying when to book) and *book air* (e.g. tickets, or time). Similarly, in *clock speeders*, it seems as though *clock* is used as a verb, in the sense of registering or measuring.

Table 5.14 presents examples of combinations in which the second word might be a misclassified verb. In some cases, the word may be read as a noun, and thus the combination may be taken to form a complex concept: e.g. *book falls* could be interpreted as "falls of books", *book advocates* as "people advocating books". Again, as for mass nouns, some combinations could be interpreted as being noun-noun combinations; in these cases that reading generally seems unlikely.

There are also examples in which the combinations contained proper nouns, titles and exclamations: these are given in Table 5.15. For the noun *chair*, there are a large number of cases in which the modifier refers to a kind of linguistic or informational entity, the modifiers being *advice, answer, debate, issue, questions, reason(s), recommendations, request, thanks.* These might possibly indicate types of committee structures, or examples of discussion about chairs, but it seems more likely that these

Modifier Noun	Modified Words
book	advocates, argues, disappoints, draws, finishes, focuses, partakes, relates, falls, jumps, leaps, lies, points, slips, sounds, run, skip, squeal, turn, saying, look
box	belongs, falls, ships, look
car	accelerates, belongs, cuts, fits, leaves, moves, needs, soars, stops, swerves, pull, push, slide, jump, start, stay, reflect, resign, beginning, waiting
chair	reasons, tilts, look
pencil	runs
vase	holding

Table 5.14: Possible Modified Verbs

Modifier Noun	Modified Words
box	cody, dear
chair	daddy, jessie
book	daughter, deighton, diana, granddad, freud, johanson, love, mum, sir, spycatcher
car	daddy, hank, kids, mum, mummy, shelley, sir
clock	daddy
ladder	thanks
vase	mum

Table 5.15: Pairs Containing Names, Titles, Exclamations

are cases of apposition in which *chair* is being used as a title. Probably *chair* is also being used as a title in combination with modifiers such as *basis, behalf, case, morning, respect, point, position, wonder.*

Further Examples

Again, there are examples that become easier to interpret if we hypothesise additional elements in the sequence. The following list shows examples which are much more easily interpreted if a numeral is preposed (the numeral being indicated in brackets): (24) hour clock; (31) day clock; (5) door car; (2nd) hand car; (3) litre car; (3) wheeler car; (2) car family; (2) car driveway; (10) pound book; (20) yard box; (10) centimetre box; (10) pound box; (10) tonnes box.

In other cases, another word or a phrase preposed (or occasionally postposed) to

Noun	Total Number	Complex Concepts	Head	Modifier
box	193	173	133	40
chair	110	77	49	28
book	313	251	143	108
car	324	267	62	205
clock	56	49	27	22
ladder	21	20	16	4
pencil	24	20	6	14
pan	19	18	10	8
vase	11	7	5	2
rake	1	1	1	0

Table 5.16: Frequencies of Combination Types

the sequence makes the combination easier to interpret: (4 wheel) drive car; (P) reg car; (top) quality car; (top of the) range car; (remote) control car; (around the) clock shifts; (first) aid book; (first) aid box; (3 o') clock knock (off); (7 o') clock point (like *compass point*); (oil) pan dampers (mechanical component for engines); (scientific, spatial) reasoning book; (chinese, legal) word book; (in) car recorder (camera for recording e.g. racing footage); (second) stage chair ; (remote) control chair; car steam (cleaned).

We find other uninterpreted combinations which involve measurements of various sorts: *£11,000 car, £6,200 car, 87bhp car, box chocolates, box smellies, box suet.* In addition we find *car load(s)*, also a measure of quantity (e.g. 3 car loads of furniture).

A number of other cases occur in which one of the items is unknown, giving no basis for interpretation: *prémin box, leah car, interpet book, book co, book ht*; we also find *book* as the first word in combinations with the words *acetaria, celie, eikonoklastes, holden, leapor, zendavesta*, which look to be proper nouns.

Finally, there are a few other miscellaneous uninterpreted combinations. We find combinations of *book* with the head nouns *black, hardback, paperback, threadbear*, which seem to be specifying properties of the book (postnominal modification). The combination *car vehicle* involves a subordinate-superordinate pairing; *car home* is possibly a case of apposition (e.g. "drive the car home"); *box villa* probably occurs in the context of football.

5.5.10 Discussion of Inanimate Count noun Combinations

Uses of Inanimate Count Nouns

The frequency of occurrence for these nouns in different positions is displayed in Table 5.16. The columns indicate: the total number of examples in the corpus; the number analysed as complex concepts; the number of complex concepts in which the noun appeared as a head noun; and the number of complex concepts in which it appears as a modifier.

Unlike the mass nouns, there is no overall bias in the positions in which these words appear: there are 452 uses as head nouns, and 431 as modifiers. However, certain of the words do appear preferentially in either one position or the other: for example, *box* overwhelmingly occurs as a head noun, while *car* overwhelmingly appears as a modifier. Nor is there any overall bias in the types of relations that the words are involved in, but again, there are distinct biases for certain words.

Once again, few cases of property-mapping were found. There were some cases in which SHAPE values for *box*, a couple of possible SHAPE mappings for *chair* (e.g. *nappy chair, saddle chair*), a couple of hybrids (e.g. *ladder stile*): again, it seems that the property mapping strategy is only rarely applicable to noun-noun combinations in samples of real world language.

Head Noun Uses

The set of artifact nouns are less semantically homogenous than the group of mass nouns, and this is reflected in the fact that when these nouns appear as combination heads, there are sometimes strong biases in the types of relationships that occur, but there does not seem to be a distinct bias for the group overall.

In every case, we are looking at artifact nouns which refer to objects manufactured for some specific purpose. This might suggest that, when these nouns are used as heads, the modifying nouns would often operate to specify arguments for the TELIC slot. However, there are distinct differences between the words. For example, while objects in the category of *box* can be used to contain a whole range of different objects, the purpose of objects in the category of *clock* is simply to measure time: the TELIC predicate here will have no arguments that *can* be specified by modifiers, because TELIC does not specify a relationship with other types of object: there are no subtypes of time that an argument can specify. Similarly, while the function of a *ladder* is to allow someone to ascend, there generally are not different types of ladder for ascending to specific kinds of places: the types of ladders that exist are distinguished in other ways, by modifiers indicating specific subtypes of ladders. Several nouns from the group

took modifiers which specified a TELIC predicate (rather than argument), pinpointing a specific function for the referent.

When these artifact nouns are used as head nouns, modifiers should be able to specify arguments for the AGENTIVE slot (as these are artifacts, the filler for this slot should indicate the manufacturing process). However, such relationships seem relatively rare. As for mass nouns, this may be because proper nouns are generally excluded from the corpus; however, some still remain, and in combination with *car* and *book* especially, they did often suggest AGENTIVE relationships.

Some of the nouns refer to objects that can be made of a range of different materials, while others refer to objects that tend to have a fixed type of composition: for example, *box* took a number of modifying mass nouns that specified an argument for CONST|MADE, while a *book* is generally composed of paper pages (modifiers suggesting special types of page being *cheque, ticket*). On the other hand, modifiers of *book* usually specified either a type of information or the topic of the information: while some kinds of box can contain information, we would not interpret any kind of box as being about a topic.

There were smaller patterns revealing specific kinds of relation available for each noun. Both *book* and *car* are modified by nouns that specify the owner of the object. Some combinations with *chair* and *clock* displayed locative relationships, the head nouns being types of furniture or architecture that occur in specific places. We found that *car* could be modified by nouns indicating what kind of fuel it uses. We also saw a number of indirect relations (e.g. a *fishing box* is a box containing equipment used in fishing; a *telephone book* is a book containing telephone numbers), as well as specifications of subtype (by modifiers that have a particular use as a subtype specifier for the head noun) and idiomatic combinations.

Thus, the patterns of relationships observed do not reflect similarities within the group: rather, there are a range of different patterns, reflecting the varied natures of the words within the group.

Modifier Noun Uses

As modifiers, these nouns could be used to specify arguments for TELIC, where the head noun was a teleological noun, and also for AGENTIVE, where the head noun was an event noun. Relationships of this kind were particularly common with *car* and *book*.

As the nouns in the group are all count nouns, they generally cannot be used as a modifier to specify an argument type for CONST|MADE, except for a few occasions where the head noun refers to a multiplex. However, they were often used to specify

a type for CONST|PART, with the head noun referring to some specific subpart of the object.

A variety of other relationships were also found. There were some regular patterns, such as the occurrence of combinations in which the head noun referred to a type of property, but there were also a large number of combinations which involved relationship types that didn't fall into any of the general patterns we have identified (e.g. *car capital*), or were idiomatic (e.g. *clock card*).

Ambiguity of Combinations

As for mass nouns, ambiguity for the combinations sometimes arises because the arguments for particular features have different scopes. For *book*, as for *paper*, any modifying noun could be interpreted as specifying a topic.

Ambiguity also arises because the word can be interpreted in different senses. This was particularly noticeable for *chair*, which can be used as a title as well as referring to a piece of furniture. Many cases of word pairs were found in which *chair* seemed to be used as a title were not genuine complex concepts; the same was true for *book*, which can be used as a verb as well as a noun.

Summary

The combinations that these inanimate count nouns enter into must generally be interpreted in terms of thematic relations describing the connection between head and modifier: there are very few combinations involving property-mapping.

The relative frequency with which particular words occur as head or modifier can only be explained in terms of specific factors relevant for the different words: whereas a car is a complex and valuable object, having an elaborate structure and requiring maintenance to keep it operational, a box is a simple structure upon which few or no operations are carried out. This is reflected in the occurrence of *car* primarily as a modifier (specifying an argument), and *box* primarily as a head (having the type of its contents specified).

A broad range of different types of relation were found for combinations containing these inanimate count nouns. There were specific biases in the types of relation entered into for particular words, and a large number of indirect/idiomatic relationships between head and modifier. Regular patterns of relationship were identified, such as the likelihood of the noun specifying an argument type for TELIC if the head is a teleological noun.

5.6 Animate Count Nouns

The nouns examined in this section are *elephant, frog, moose, pony, robin, skunk, squirrel, snake, tiger* and *fish.* These animate nouns are far less frequently used in noun-noun combinations than most of the nouns considered above, with the exception of *fish.* In fact, there are only 86 examples of noun-noun combinations involving the first nine in total (whereas there are 207 combinations containing *fish*). The combination frequencies for each word are: elephant, 23; frog, 5; moose, 2; pony, 15; robin, 4; skunk, 2; squirrel, 1; snake, 16; tiger, 18. For this reason, I will examine combinations involving the nine infrequent modifiers together; *fish* will be examined separately.

5.6.1 Uses of animal nouns

As Head Nouns

Because there are so few examples, there is little to be found in the way of systematic combination patterns.

Combinations in which the modifier labels an occupation are *delivery pony, guardian snake, warrior pony*: a TELIC predicate will be indirectly suggested by these combinations. Similar, but still less direct, are those cases in which the modifier simply indicates an event that the animal somehow participates in, as in *circus pony, polo pony, war elephant.*

The combinations *baby elephant, infant elephant, mother elephant* and *rogue elephant* are intersective, indicating either age or family status (*rogue* being used to indicate an animal of fierce temper living away from the herd).

Two combinations are examples of privative compositional relationships, these being *plastic snake, jelly snake.* Two combinations, *jungle snake, tree frog* suggest an INHABITS relationship (only previously found with *sand* as a modifier).

There are a number of idiomatic combinations, listed in Table 5.17. Other combinations are: *son robin* and *chemicals robin*, which seem to be cases of apposition, *robin* being used as a name; *moose carton* and *strawberry moose*, both of which seem to be mis-spelt versions of *mousse*; and *liberty pony, hippie frog, time frog*, for which I could find no obvious interpretation.

Combination	Meaning
currency snake	1970s system of regulating EC currency exchange rates
esso tiger	advertising emblem
paper tiger	apparently threatening but ineffectual person or thing
project tiger	name of project to preserve India's tiger population
rainbow snake	a figure in Australian aboriginal mythology
snake cable	a particular kind of cable
thirst snake	common name of *Dipsas variegata variegata*
triumph tiger	a make of motorcycle

Table 5.17: Idiomatic combinations involving animal nouns

As Modifiers

Property Mapping Property mapping is found in several cases in which *tiger* is the modifier: the head nouns are *beetles, flower, lily, moth.*[24] This generally involves a very loose mapping, implying some kind of orange/black or red/black patterning, perhaps in stripes. However, it should be noted that *tiger sharks* are not coloured in this way (possibly the mapping implied here is one of ferocity). General visual resemblance is implied in *elephant man, elephant seals.* Both property mapping and construal are both necessary for interpretation of the combinations *elephant mask, tiger mask.*

Telic and Agentive Straightforward TELIC relationships explain the meanings of combinations with teleological head nouns indicating occupations: *pony owners, elephant keeper, tiger trainer, snake charmer.* In addition, there are also objects whose functions are fulfilled by processes involving animals: *pony cart, elephant stables.*

In the combinations *elephant dropping, frog spawn, snake bites* the modifier specifies an argument of AGENTIVE, the combination referring to an object produced by an animal; *frog music* and *snake hole* can be similarly interpreted.

An AGENTIVE relationship is present for a number of combinations in which the head noun is an event noun: these are *elephant fights, elephant hunts, elephant tug-of-war, pony rides, pony trekking, tiger prowl, tiger trouble*, and possibly also *tiger traverse.* The combination *elephant losses* also involves AGENTIVE, elephant losses being created through the process of losing elephants.

[24]The combination *tiger moth* is also the name of a type of plane.

Const A number of relationships involving CONST|MADE are found, with *elephant steak, snake pie, snake soup* and *elephant family, elephant populations, pony lines*; several CONST|PART relationships are also found, with *elephant ears, elephant tusks, pony tail, tiger bone, tiger skin.* The combination *tiger products* is more ambiguous (they could be either produced by, or produced from a tiger).

Others

A variety of other relationships are found. An *elephant analogy* is an analogy whose topic is the elephant; *snake forms* seems to label a property of snakes; *snake monster* requires a hybrid interpretation; a *pony club* is a club for people who ride ponies; *elephant numbers* is a property of elephants en masse; the modifier in *squirrel monkeys* names a species of monkey; the interpretation of *skunk kilo* is unclear, although possibly involves reference to drugs; *snake thing* is too vague for interpretation.

Repetition and apposition of animal nouns with exclamations account for *pony pony, pony quiet, elephant wooh.* The combinations *pony going, snake gliding* seem to contain misclassified verbs.

A number of combinations form names: *tiger club* is commonly used to name a club supporting a sports team named the "Tigers"; *robin prince* may be a name (possibly part of "Robin Prince of Sherwood"); *robin redbreast* is sometimes used as a name for the common robin; *skunk works* is used as a name by a variety of organisations.

5.6.2 Uses of *fish*

Head Noun

Subtypes/Property Mapping There are several modifiers that indicate the type of the fish (i.e. the combination is the common name for a species of fish). These include *angel, angler, archer, cat, gold, pilot, piranha, tuna, salmon*, as well as modifiers indicating lesser known fish types such as: the *blood fish* (Phractlaemso ansorgei); the *penny fish* (Denariusa bandata); the *pineapple fish* (Monocentris japonicus); the *x-ray fish* (Pristella riddlei); the *knife fish* (there are various types, e.g. clown knife, royal knife, african knife); the *butterfly fish* (also of various types); the *rattail fish* (a very deep sea fish); and also the privative combinations *jelly fish* and *silver fish* (although this latter also has an obvious literal meaning in terms of colour).

Some of these modifiers involve property mapping: for example, *angler fish* catch their prey using a lure placed on the end of a line; *archer fish* catch their prey by "shooting" at it; *pineapple fish* have a yellow and brown patterning reminiscent of a

pineapple; and the internal structure of *x-ray fish* can clearly be seen, making it seem as if they are lit by x-rays.

Telic and Agentive The modifiers *host, killer, prey* are intersective, but being defined purely in terms of a TELIC predicate, they act to specify such a predicate for the combination. Similarly, the modifiers in *breeding fish, schooling fish* indicate the activity that the fish are taking part in. Less direct specification of a TELIC predicate is found in the combinations *brood fish* (fish used for breeding from) and *show fish* (fish for exhibiting in fish shows).

Others A number of modifiers indicate the habitat of the fish: *aquarium, coldwater, deepsea, farm, harbour, mid-water, pond, sea.*

Intersective modifiers indicating family status or age are found (*adult, children, father, mother*), as well as the intersective word *albino.*

More idiosyncratic/idiomatic are the modifiers: *gefillte*, a jewish cooking style; *salt*, indicating the fish has been treated with the preservation method of salting; *community*, which implies that these fish can safely be placed in a tank with other species; and *record*, which possibly indicates that the fish breaks a record in some way (e.g. has the highest weight recorded).

Combinations with modifiers *bag, crossword, crops, disco, fire, priming, problems. repair, toggle, tower, years* are difficult to interpret.

Modifier Noun

Telic and Agentive Where *fish* occurs as modifier, we find it specifying an argument for TELIC when combined with the deverbal head nouns *farmer, finder* and *photographer.* In addition, TELIC relationships occur for head nouns referring to: places where fish is sold (*markets, shop(s), stall(s), stand, van*); entities that produce or process it (*farm(s), industry*); and a variety of tools (*crates, knives, nets*, as well as *fish box* (for transporting aquarium stock) and the idiomatic *fish slice*). Finally, there are *fish food(s)*, used to feed fish.

For many combinations with deverbal head nouns, *fish* specifies an argument for AGENTIVE: the nouns are *catches, collection, death(s), decline, exports, kills, loss(es), life, lives, moves, movement, sales, transfer, transport, waste.* In addition, there is the combination *fish falls*, used to describe the phenomenon of fish falling from the sky. Non-deverbals head nouns also involved in this type of relationship are: *husbandry*, an activity; *ailments* and *diseases*, processes affecting fish; and *eggs, roe*, concrete objects produced by fish.

Const There are a number of compositional (CONST|MADE) relationships in which *fish* is treated as a mass noun, making types of food product such as *ball, cakes, finger(s), oil, paste, pie, sauce, soup, steaks, stew*, as well as less specific items such as *bits, course(s), dishes, meal, portions, product.*

Other compositional relationships involve the fish as a multiplex, these being *fish individuals, fish populations, fish species, fish stock(s).*

In addition, constitutive (CONST|PART) relations are present in combinations with *bladders, blood, bone, scales.*

Others A number of other relationships are found.

Locative relationships are found with head nouns *dock, home, house, room*; there are also some combinations that describe habitats, with head nouns *bowl, lakes, niche, tank(s), pond(s).*

Indirect relationships are those for *fish agents* (agents for buying and selling fish), *fish association* (e.g. an association for discussing fish-related topics, and *fish nutritionist*, someone who studies fish nutrition.

Also, a number of cases in which construal is involved are found: *fish cards* probably refers to a card with images of fish on it. Similar interpretations are possible for *fish invitation* and *fish shade*, meaning a lampshade with images of fish on it. A similar interpretation might also be give to *fish greeting*, a greeting associated with the symbol of a fish (e.g. early christians might have given such a greeting).

There are a number of ambiguities for combinations. Examples of this are: *fish fry*, which can refer either to the activity of frying fish, or to the young of fish; *fish feed(s)*, which can refer to material to feed fish with, or to occasions of feeding fish; *fish diets*, which might be diets for fish, or diets made of fish; *fish prey*, which could be either the prey of fish, or prey that is fish; *fish flick*, which can refer to a film about a fish, or possibly a motion; and finally the head noun in *fish nutrition* can be either a process, foodstuff itself, or the study of the field.

The head nouns *cost, length, prices* refer to properties of fish. The combination *fish wife* is idiomatic, and *fish thing* is too vague to interpret. Combinations with head nouns *grief, handles, patience, present, rainbows, trespasses* are difficult to interpret.

Other Cases

As in previous sections, there are a number of combinations which seem to not belong in the examples of noun-noun combination given above: those arising from apposition.

Examples of apposition involve fish combining with other nouns labelling foodstuffs (*chips fish, meat fish, tea fish, chicken(s) fish, fish chips, fish wine*) or with other nouns

labelling organisms (*fish crabs, fish fishes, fish frogs, fish insects, fish lice*).

There are also cases where *fish* combines with titles or exclamations: *fish darling, fish papa, fish right, mister fish.*

There also seem to be many cases in which verbs are misclassified as nouns. Where *fish* appears as the first word, the second nouns *affects, behave, choke, cook, dither, flaps, handle, look, meaning, need, pursue, swim(s), steam, use* seem to be of this type. Some of these can, in fact, be read as nouns, but there seems to be no obvious natural interpretation of the combination if they are so used in this context. Several examples also exist where *fish* is the second noun, and the modifier ends with *ing*: *cooking fish, farming fish, feeding fish, keeping fish, rising fish, spotting fish, stocking fish, swimming fish*, although some of these modifiers can be interpreted as adjectives as well as verbs.

A few combinations are more easily interpreted if placed in a larger context. These examples with hypothetical extra context placed in parentheses are: (on some) days fish; (big) game fish; and (high) quality fish. In addition, there are a number of cases of combination with units of measurement: *£175 fish, £50 fish, cm fish, pound fish, fish £50, fish p.*

5.6.3 Discussion of Animate Count Noun Combinations

Uses of Animate Nouns

The number of combinations involving animate count nouns was substantially lower than the number of mass noun and inanimate count noun combinations. To some extent, this reflects the particular set of words examined: we are less likely to find discussion in British English of unfamiliar animals such as the *skunk* or *moose*. Other animate count nouns enter into a greater range of combinations (e.g. *dog* appears in 151 combinations, and *horse* in 107, although these were the only two nouns referring to types of animal we found that had combination-frequencies over 100). The word *fish* was much more frequent than the other words. This seems to reflect the fact that this word is at a higher taxonymic level than the other words in the group, being cotaxonymic with words such as *animal*, which occurs in 174 unique noun-noun combinations, and *bird*, which occurs in 74.

The relative paucity of examples makes it difficult to discern systematic patterns in the types of relations that are found for words of this type. However, the number of uses that these nouns have as modifiers in complex concepts is roughly double the number of uses they have as heads (this is true for both the group of nine animal nouns, and for *fish*). This is probably because, like mass nouns, there are few slots for which modifiers can specify an argument type: see below.

Several cases of property mapping were found: for example, we found property mapping from the modifiers *tiger* and *elephant*, and property mapping to the head noun *fish*, in cases where subtypes were being specified. Although relatively more frequent than for mass or inanimate count nouns, combinations involving property mapping were still vastly outnumbered by the number interpreted in terms of a thematic relation.

Uses as Head Nouns

Given the number of examples found for animate nouns, it is difficult to generalise about the types of relations that characterise the combinations they enter into. However, some patterns are suggested by the data.

Firstly, where these nouns occur as head nouns, mass noun modifiers indicating composition will invariably be privative. Living creatures cannot be composed of an inanimate mass. Privative modifying nouns were discussed in Section 4.4.6.

Secondly, because animals do not usually have particular functions associated with them, we would not expect a TELIC filler to be specified in the head noun. Out of the words considered, only *elephant* and *pony* refer to domesticated animals, so only these are trained to carry out specific tasks: however, they can carry out a variety of different functions. Where a modifying noun has been analysed as associated with the TELIC quale, it therefore specifies either the predicate filler, or indirectly suggests a predicate by indicating the field of activity within which the animal is being used, as in *circus pony, war elephant.*

Thirdly, we also find that combinations referring to a subtype of the head noun often involve property mapping: as well as cases in which properties are mapped in combinations with *fish*, we also find property mapping from the modifiers *tiger* and *elephant* to other animate count nouns (and to *masks*).

Fourthly, we find modifiers that indicate the habitat for the animal in question, as in *jungle snake, sea fish*: such a relationship is likely to be quite common when animate nouns are used as heads.

Uses as Modifier Nouns

As modifier nouns, these words acts to specify arguments for both TELIC and AGENTIVE features of the head noun schema. As we would expect, these relationships frequently arise when the head noun is a teleological or event noun, but there are also other cases, such as objects which are used by/in conjunction with animals, and physical objects that are produced by an animal.

Several CONST|PART relationships were found. We also found quite a number of

CONST|MADE relationships. In these cases, we found that the modifying animate nouns can be treated either as count nouns, where the head refers to a multiplex, or as mass nouns, where the head noun refers to a kind of foodstuff or other mass-composed objects (e.g. *paste* and *portion*): meat produced from the animal is an ingredient. The interpretation of animal nouns as mass nouns is not restricted to cases where they appear as modifiers in complex concepts: Copestake and Briscoe (1995) discuss uses of animal nouns to refer to meat, as well as fur, and describe a "grinding" operator, which can be used to systematically produce these mass noun senses from the count noun schema. A method for quick matching of argument types where such alternatives are possible for the modifier would be to specify for the modifier not just a single type, but a range of different possible types it could take (i.e. all the types that could result from the application of such operators): Pustejovsky (1995) uses composite type spefications (dot objects) which are similar in concept.

Ambiguity of Combinations

We find fewer ambiguities resulting from the scope of arguments: obviously, none of the head nouns can refer to types of information, so there are no broad-ranging topic relationships to consider, and although, as we have seen, as modifiers these nouns can be interpreted as mass nouns, they are less likely to be interpreted this way: while a *stone shop* may either sell, or be made out of stone, the combination *fish shop* will never be interpreted in terms of the shop being made out of fish.[25]

There were several examples of ambiguity arising from there being alternative interpretations of the head noun: examples were *fish fry* and *fish prey.*

Summary

Although relatively infrequent, the combinations involving animate count nouns revealed a number of distinctive patterns. Although the vast majority of combinations were interpreted in terms of thematic relations, there were several cases of property-mapping, suggesting a relatively greater importance for this mechanism.

Like mass nouns, these words are much more frequently found as modifiers than as head nouns, presumably because there are less relational features for which a modifier can specify an argument. As modifiers they have the interesting ability to operate either as count or mass nouns; however, their interpretation as mass noun modifiers

[25]Copestake and Briscoe (1995) suggest that the grinding operator produces a particular kind of mass noun type: the comestible mass. The CONST|MADE feature will presumably specify different kinds of mass arguments in different noun schemata.

seems restricted to cases where the head noun refers to particular kinds of objects, either foodstuffs or non-specific (vaguely described) types of mass.

5.7 Discussion

5.7.1 Combination Structure

A large number of noun-noun combinations were considered in the course of this corpus analysis. In general, the patterns of interpretation for combinations that were analysed suggests that the type of study carried out on artificially generated combinations may be extremely misleading; such studies are working with materials that do not accurately reflect the range or types of combination that are found in real world language.

In Wisniewski and Gentner (1991), for example, 400 combinations were produced from 30 words: in our sample, extracted from over 20 million words, only 17 combinations were found in which both nouns were from this set of thirty.[26] Naturally, the absence of other specific combinations in any sample does not show that they cannot exist. However, it is at least clear that it is not common for these words to appear as pairs in noun-noun combinations.

In addition, the corpus data reveals that there are biases in the kinds of combination that are found in real world data which are not reflected in studies using artificial combinations. For example, both the mass nouns and the animate count nouns were found far more frequently as modifiers than as head nouns: this seems to be due to the lack of relational feature arguments specified in their schemata: there are few plausible types of relationship that modifiers can specify.

A quick look at relative positions for a few teleological nouns, which will have well-specified relational arguments reveals the reverse pattern, these generally being used as the head noun. For example, across all the noun pairs[27] they appear in: *shop* has 179 occurrences as the head noun, and 79 as the modifier; *worker* has 46 as the head and 20 as the modifier; *manufacturer* has 17 as the head and 4 as the modifier. Although we found the same pattern for *box*, generally this distribution did not hold for the artifact nouns we examined; this seems to be because certain of them have arguments that are already well specified.

Thus, this corpus study shows that there are important distributional patterns in the language: the likelihood of a word occurring either as modifier or head will vary,

[26] These were *book paper, box car, car box, car clock, chocolate box, fish box, glass paper, glass vase, paper tiger, plastic box, plastic chair, plastic pan, plastic snake, sand box, sand paper, sugar glass, sugar paper*; this does not count cases where one word was repeated.

[27] No attempt has been made to look at complex concept pairs only.

depending on the type of the word: while we cannot say that any particular combination is impossible, it is certainly the case that certain patterns are much more frequent than others.

5.7.2 Combination Mechanisms

Property Mapping

Analysis of the corpus data revealed very few cases of property mapping. This does not fit with the findings of Experiment 3 of Wisniewski and Love (1998): this is a study of corpus material which finds that a large proportion of noun-noun combinations are interpreted through property-mapping. They suggested that previous studies of noun-noun combinations, such as Downing (1977), which found little evidence for property-mapping, may be flawed because of the small size and unusual nature of the corpus material examined. Thus, they carried out a large scale study, allowing for the broad, systematic sampling of particular phrase types.

They examined 1401 noun-noun combinations, finding property mapping in approximately 40% of combinations involving animals or plant nouns, and about 15% in combinations involving artifact nouns; the study presented above was of a large scale, examining 2398 noun-noun pairs, and again systematically sampled particular kinds of phrase (in this case, focussing on specific nouns), but found property-mapping only in an extremely limited number of cases.[28] The disagreement between the findings is severe: for example, Wisniewski and Love (1998) suggest that of the 63 combinations they examine that refer to fish, 73% involve property mapping.

However, there does not seem to be any fundamental disagreement about the *types* of combination that qualify as cases of property mapping: examples of combinations using property mapping Wisniewski and Love (1998) cite for animal and plant nouns are *pig's ear fungus, fence lizard, snowshoe hare, porcupine fish, leopard lizard, fox grape, salmon entolomoa, guitar fish, mole salamander* and *kangaroo rat.* These are exactly the kinds of examples we found above for property-mapping with animate nouns: subtypes (species of animals) are named by these combinations, and referents of the combination have some property suggested by the modifier.

The discrepancy between these two studies seems to largely lie with the choice of corpus material. While the BNC is a very large corpus, containing a wide variety of spoken and written material, the sources used by Wisniewski and Love (1998) were of a very specific type of text: this would have introduced a severe bias into the types of

[28] It should be noted that Wisniewski and Love (1998) consider only *combinations* referring to animal and artifacts; they are not looking at animal and artifact nouns specifically.

combination they looked at. The combinations they examined were extracted in the main from three sources: combinations involving plant and animal nouns were taken from the book *Reader's Digest North American Wildlife*; combinations involving artifact nouns were taken from the books *Office Stores Program Catalog* and *The Facts On File Visual Dictionary*. They also examined 200 more combinations randomly selected from another dictionary. These sources are basically taxonomic guides, designed to describe particular subtypes of objects: a wildlife guide, naming a variety of different species; a catalogue of office equipment, distinguishing between variants of the same articles (e.g. styles of furniture, or types of paperclip); and two dictionaries (any noun-noun combination that is in a dictionary probably does not have a systematically deducible meaning).

Thus, a whole range of combination types are likely to be missing from the corpus: a wildlife guide is not likely to include combinations in which animals are described in terms of the fields of activity in which they can be put to use (*polo pony, war elephant*, etc.). The proportion of the combinations in the corpus that involve property mapping is thus greatly exaggerated above the proportion found in more balanced samples of the language.

One possible interpretation is that Wisniewski and Love (1998) show that the property mapping strategy is frequently used with specific types of combinations. As we saw in Section 2.3.4, there do seem to be systematic mapping patterns for colour, both in the types of nouns it is mapped from and to: it is interesting that Wisniewski and Love (1998) find that the highest proportion of property mapping for artifacts is, by far, for combinations referring to clothing; many of the property mapping examples found in Section 2.3.4 were for combinations referring to clothing.

However, it is unclear to what extent property mapping is used as a strategy for interpreting combinations that refer to particular species or specific types of artifact, simply because the combination is often *not* part of a productive pattern: one cannot generate new examples of the same type, because the combination is actually the *name* of a species or type of artifact. It could be argued that property mapping arises in these cases not because it is a common strategy for interpretation, but because it motivates the *naming* of these species: although we find property mapping from *tiger* used as a modifier, the property mapped is different for *tiger moth* and *tiger shark*, and there is no way we could predict which property is mapped without knowledge of referents of the combination (i.e. extensional feedback is required to understand what property is mapped). Similarly, with a combination such as *x-ray fish*, familiarity with an exemplar of the category makes obvious the motivation for the name, but it is not obvious that the meaning of the combination could be deduced without this knowledge (compare

electric eel). Again, it is unclear whether *blood fish* is thus named due to it being a red colour, or whether there is another connection with blood that this species has. Nevertheless, it does seem that property mapping does account for a wide variety of species names (and probably also specific categories of artifacts); it remains to be shown where and when it is a viable strategy for the interpretation of real-world language.

Thematic Relations

The majority of the combinations analysed were interpreted in terms of thematic relations: however, the modifier was described as specifying the type of an argument of a relational feature in the head noun's schema. In particular, arguments for the predicate fillers of the slots TELIC, AGENTIVE, CONST|MADE and CONST|PART were frequently found to be type-specified by the modifier. The advantage of describing thematic relations in these terms is that there is a means of constraining how the modifier relates to the head, simply because there are only a few relational features; at the same time, the type of relationship between the two can be a very specific one, due to the fact that certain of the slots can be filled by different predicates. Instead of assigning combinations to vaguely specified categories of relationship such as IN, FOR, CAUSE, or MAKE, the combinations can be interpreted in terms of specific relationships such as $sell(e, x, y)$ or $eat(e, x, y)$. Specifying argument subtypes in this way allows for the thematic relation to be described in precise terms, retaining the semantic detail that is specified in the head noun's schema: it gives a means of accounting for the detailed relation that we understand for each combination. This allows for an account even of the specificity of the relationships in combinations such as *headache pill* and *fertility pill*: given that the schema for *pill* contains TELIC $= cure(e, x, y : illness) \vee increase(e, x, z : property)$ (the argument types here being displayed as part of the predicate), combination with both modifiers can be accurately modelled.

This type-specifying analysis accounts for a significant proportion of the combinations found: in particular, an overall majority of the combinations involving mass nouns involved the noun acting as a modifier, to specify an argument type for CONST|MADE. Particular types of head nouns also implied specific kinds of relations: combinations containing teleological nouns in the head position tended to be interpreted in terms of a TELIC relation; combinations containing event nouns as the head were mostly interpreted in terms of an AGENTIVE relation.

There were a range of other relationships that were not accounted for by the modifier specifying an argument type for one of the four relational features mentioned above.

Firstly, there were a number of specific types of relationship relevant only with

certain kinds of words. For example, nouns that can refer to information as well as a physical object (e.g. *book* or *paper*) took many modifiers that acted to specify the topic of the information the object contains.

Secondly, there were a large number of modifiers that indicated the subtype of the head noun itself, rather than of an argument. For example, *pudding stone* is a subtype of *stone*; *demerera sugar* is a subtype of *sugar*; and *estate car* is a subtype of car. Modifiers indicating subtyping do so in a specific way for the particular noun they are modifying; there is no general pattern that allows deduction of what the subtype is like from the modifier.

Thirdly, some modifiers specified the type of habitat that an animal lives in or the location an object is found in. Purely locative relationships were uncommon: generally, a relation that involves position also involves structure (e.g. the head specifies a subpart of the referent).

Fourthly, some modifiers specify a predicate filler for TELIC or AGENTIVE: in particular, deverbal nouns ending in *-ing* often specified a function of the object.

Finally, there were a number of other relationships involving indirect relationships between head and modifier. For example, there are combinations in which the modifier indicates an object or activity in which the referent is somehow involved without the nature of the connection being transparent from the meaning of the words (e.g. *war elephant, swear box, consultation paper*). In some cases the connection might be deduced, in others the relation is less transparent, up to the point where the meaning of the combination must be regarded as idiomatic.

5.8 Conclusions

Research Contribution

This chapter presented a corpus-based study of noun-noun combinations. It specifically focussed on the combinations entered into by particular words. 30 words were examined, 10 being mass nouns, 10 being inanimate count nouns, and 10 being animate count nouns.

The corpus data showed the range of combination types into which these words entered. Analysis of the data revealed a number of interesting patterns, including the propensity of mass and animate nouns to act as modifiers rather than heads: there are clearly some strong constraints on the positions within complex concepts in which particular words are found.

Little support was found for the frequent use of property mapping as a strategy for

interpreting noun-noun combinations. However, the nouns *chocolate* and *box* both had some uses as modifiers for which property mapping provided the best interpretation; there were also a number of cases involving property mapping for animate nouns (which were similar in construction to those found in the study of Wisniewski and Love (1998)), but it was suggested that this pattern arises because property mapping is used as a strategy for naming species, rather than being a strategy for interpretation.

The majority of combinations were interpreted in terms of thematic relations holding between head and modifier. However, thematic relations were described not in terms of a set of pre-specified predicates such as those discussed in Levi (1978), but in terms of the modifier specifying the type of an argument, as represented in the ARGSTR features of the head noun's schema. The relationship between head and modifier can thus be described in specific terms, rather than being an example of a broadly applicable, underspecified type of predicate. Not all combinations can be interpreted as specifying an argument type in this straightforward way, but the mechanism does give an account of a substantial proportion of the combinations examined.

Chapter 6

Corpus Statistics

6.1 Introduction

6.1.1 Quantitative Corpus Analysis

In previous chapters we have been looking directly at individual examples of complex concepts extracted from a large corpus of language: detailed schematic structures have been proposed for modelling the meaning of combinations. The use of corpus material provided a wide range of data with which to evaluate particular theories of combination, and this allowed a detailed, qualitative analysis of the types of representational structures and combinatorial processes required to model the semantics of complex concepts.

However, the existence of large corpora of language also offers the opportunity to investigate these structures in a more quantitative manner: a large amount of material allows empirical measurement of properties such as a word's distribution through the language. The best known example in the psychological literature of a corpus-derived statistical measure that is relevant to language processing is word frequency (or, more accurately, the log of word frequency). The finding that word frequency measures predict the speed with which words are recognised is one of the most robust findings of psycholinguistics.

However, the recent availability of large-scale corpora together with increases in computing power allows a variety of other statistical measurements to be made, including measures of patterns of word distribution, which may be thought of as characterising the combinatorial possibilities available for particular words. This chapter explores how such measurements can be used in describing and analysing complex concept structures.

6.1.2 Measuring Meaning

The Semantic Differential

A construct known as the **semantic differential** was created by Osgood (1952). It simply consists of a number of scales, corresponding to pairs of opposing adjectives, these being *angular, rounded; weak, strong; rough, smooth; active, passive; small, large; cold, hot; good, bad; tense, relaxed; wet, dry; fresh, stale.* Given a word, subjects were asked to judge where on each scale a particular word should be. Osgood was thus able to "measure" a word's meaning in terms of how strongly people associate particular words. Although no longer widely used in cognitive psychological work, the semantic differential is, apparently, still used as a tool in market research.

Work using the semantic differential, and later cognitive psychological work in which meaning is modelled by asking subjects to generate features for particular words (e.g. McRae and Seidenberg (1993)) assume that the information generated is somehow related to or correlated with mental structures used to represent word meaning. The subjective judgments that these models are based on may vary widely from case to case. This may not be a problem if, *en masse*, the results can be reliably produced. However, constructing representations by this method is laborious: only a small amount of data can be generated and evaluated (e.g. the scores for a dozen or so scales).

The availability of large computerised corpora of language, and the computing power to process them, offer an alternative method to generate such representations, and to do so using objective measurements rather than asking for subject judgments.

Co-Occurrence Vectors

The contemporary equivalent of the semantic differential is found within the field of quantitative corpus linguistics: statistical analysis of corpus data can give an objective measurement of the strengths with which particular words are associated across a language. Instead of asking subjects to generate word association strengths, the number of **co-occurrences** of particular words can simply be measured over a sample of text (typically millions of words). Statistical measurement of corpus data allows measures of word association to be comprehensively taken across a very large sample of language: every token of the word in the sample can be examined, which gives hundreds or even thousands of data points for a single word: its degree of association with a large number of other words can be recorded, giving a picture of its overall pattern of distribution within the language.

The method for doing this is quite simple. Two sets of words are used. Firstly, there is a set of target words $(t_1, ..., t_n)$, these being the words whose co-occurrence

	c1	c2	c3	c4	c5	c6
t1	0	0	2	1	1	0
t2	1	1	0	0	1	1
t3	0	0	0	2	0	0

Table 6.1: Co-occurrence vectors

patterns we are interested in. Secondly, there is a set of context words $(c_1, ..., c_n)$ that define elements of a vector: co-occurrences of the target words with the context words are recorded.

An occurrence of a token of c_1 near to a token of t_1 will add one to the first element of the vector for t_1; if there are 200 such occurrences in total across the corpus, then the first element of the co-occurrence vector will be 200. The distance in words that is used to define whether a co-occurrence is recorded or not is known as the "window" for co-occurrence.

Taking a window size of two words to either side of a target, a set of target words t_1, t_2, t_3, and a set of context words $c_1..c_6$, then the samples of language "c4 c3 t1 c3 c5", "c1 c2 t2 c5 c6" and "c4 x1 t3 x2 c4" will give us the co-occurrence vectors shown in Table 6.1. The use of large corpora of language allows co-occurrence vectors to be constructed using target and context sets that contain thousands of members.

6.1.3 Uses Of Co-Occurrence Data

Given a set of co-occurrence vectors, it is possible to investigate the relatedness of the target words in terms of how similar their vectors are. Examples of this kind of research are found in Pereira et al. (1993), Finch and Chater (1993), Schütze and Pedersen (1993) and Resnik (1993). The method used is to take the similarity of the vectors as a basis for clustering words together, thus discovering groups of words that have similar syntactic or semantic properties.

Alternatively, statistical measures can be derived from the co-occurrence vectors, and these used to predict performance in psycholinguistic tasks. One corpus-derived statistical measure, that of word frequency, is well-established as a predictor of performance in tasks such as word recognition (Howes and Solomon (1951), Whaley (1978), Monsell (1991)). However, a frequency measure gives no information about the pattern of word distribution, but the distributional pattern may also affect the way in which words are processed, particularly where the task involves processing words in context. For example, in Lund et al. (1995), measurements of the relatedness of co-occurrence

vectors are shown to predict word priming effects. Such measures could also be of value in predicting performance in tasks involving complex concept interpretation.

Both clustering and distribution-measure analyses of language data are used in this chapter, showing how corpus-based data may be used in a quantitative way in order to explore the structure and processing of complex concepts.

Firstly, co-occurrence vectors are used to construct clusters of adjectives and nouns, the aim being to explore whether groups of semantically similar adjectives can indeed be found using a simple clustering method: for example, whether groups of colour adjectives, size adjectives, and so on, emerge from a simple measure of similarity in the way they are used in combination with nouns and other words. This shows the extent to which simple quantitative measurements can be used to characterise semantic similarity.

Secondly, a measure characterising word distribution is derived from co-occurrence vectors. Its usefulness as a predictor of response time in a task requiring the interpretation of noun-noun combinations is then investigated.

6.2 Clustering

6.2.1 Introduction

Overview

This chapter begins with reports of clustering studies, in which the meanings of words in the British National Corpus are defined by the contexts in which the words occur. The proximity of words in this semantic space is represented by the creation of dendrograms.

Defining words in terms of their contexts is an approach with its roots in the standard substitutability criterion employed by linguists; if two words are exchangeable in a certain context, then they are equivalent in some respect, such as syntactic category. Although this approach was established some time ago, it has only been possible to employ very large corpora and very large contexts in solving the problem in recent years, and this factor of scale constitutes a qualitative advance.

In this chapter, this approach is used to explore the relationship between adjectives and nouns, in order to explicate their relationship in complex concepts. Adjectives and nouns are employed as the contexts for the construction of the semantic space. This focus is novel: previously the approach has been almost exclusively applied to the relationship between nouns and verbs and the issue of subcategorization and selectional restrictions (thus, the role of adjectives is not explored in Resnik's thesis (Resnik (1993)), for instance).

The exploration of clustering provides (a) an existence proof of the mutual constraints that exist between adjectives and nouns, (b) a demonstration that involving all categories of words in the definition of the space gives superior results, (c) even though interpretable small-scale groupings of adjectives emerge, there is no clear larger scale structure, (d) a motivation for the exploration of a corpus-based measure in the rest of the thesis.

Patterns of Adjective Occurrence

While verbs and nouns are standardly modelled in terms of patterns of constraint (e.g. verbs take particular argument types; nouns provide arguments of particular types), the range of constraint involved in adjective-noun combination is less well investigated. It is obvious that the range of nouns that can serve as a head for an adjective will vary from case to case. For example, shape, size and colour adjectives can be expected to modify an extremely wide range of head nouns. Where adjectives are polysemous, e.g. *fast, healthy, heavy* they may modify an even broader selection of nouns. On the other hand, there are adjectives that appear only in very specific contexts; examples are *ovine, ursine* and *lupine*. It is unclear whether these patterns of co-occurrence constraint translate into patterns of semantic similarity when clustering methods are applied. This section investigates what patterns of clustering are found through simple measurement of co-occurrence.

It should be noted that the types of adjective-noun combination we have examined in previous chapters are all cases of attributive modification: the adjective appears immediately preceding the head noun. However, there are a range of other positions in which adjectives may occur, both pre- and postnominally.

For example, strings of adjectives may be used prenominally. Vendler (1968) investigated the patterning of these strings in some detail. There are fairly rigid constraints on their ordering (there are, however, exceptions for reason of style, focus or idiomaticity). For example, colour words typically follow those for size and shape: while *big red car* is acceptable, *red big car* is not. Ordering constraints may be important in indicating semantic similarities between adjectives.

In addition, complex concepts can themselves be modified and modify in the same manner as nouns to give larger structures, in which there are a string of modifiers, both adjective and noun. Examples are:

- mammoth new medical care program
- modern American nuclear submarine Skipjack

- weak isotropic hyperfine contact interaction
- Young Democratic Club cocktail party
- senior high school teaching certificate
- annual co-operative fire prevention program
- sixth straight spring exhibition decision
- minor league professional football team
- liquid phase thermal reaction studies
- Hospital outpatient clinic diagnostic service
- State Highway Department public relations director

Adjectives also occur in the postnominal position: where they do, arguments may be added after the adjective to specify the precise circumstances where or in what terms it is applicable (see Bolinger (1967)). Examples are:

- the stars visible through this telescope
- the stars visible in the southern hemisphere
- the stars visible last night
- the stars visible in the southern hemisphere last night
- the rivers navigable after the drought
- people guilty of theft
- the man running for a bus
- eyes wide with astonishment
- data similar to my own

However, post-nominal occurrence does not obligate the use of complements: the circumstances of applicability may be suggested by extralinguistic context e.g. *the stars visible* might be used to indicate the stars visible at the time of utterance (*the visible stars* can be used in a more generic manner, indicating the stars that are visible in principle).

Adjectives may also occur postnominally as the object complement in a sentence. For example, there are sentences in which the adjective expresses the result of an action upon an object; sentences in which it expresses someone's opinion about the object's qualities; and also other uses simply indicating an object's status. Thus, like the above examples of post-nominal occurrence, they explicitly indicate that the modifier is not describing a generic quality of the referent: the sentence context makes clear the circumstance or opinion that assigns this quality to the object in question. Examples are:

- He made his wife happy.
- 'Make my pilots good,' he prayed.
- Ali rubbed the lamp clean.
- She considers the prosecution case hopeless.
- He thought the painting ugly.
- He brought his gun loaded.

Adjectives also occur post-nominally after measurement nouns as in *hundred yards wide, ten feet tall, five miles southwest*; and in certain idiomatic phrases such as *light fantastic, body politic* and *blood royal, princess royal, battle royal.*

They do not have to be immediately postnominal: they can also be related in terms of a copula. The most obvious example is in terms of the verb *to be*, as in *daughter who is pretty*, but there are a variety of verbs that can be used in this manner, especially those that designate change of state or types of perception (e.g. *look, seem, sound, smell, taste, feel, remain, become, turn, make*, etc.). Some examples of this use are:

- the man (who) could be dangerous
- the tree (which) grew taller
- the crowd (that) remained angry
- the man (who) seemed old

Adjectives given after a copula can also take additional arguments, as in other cases of postnominal modification.

As we see, there are a variety of different patterns in which adjectives can occur: they are not always close to the head noun in a phrase, and they also occur in conjunction

with a range of other items (copulas, arguments, and so on). Thus, a wide variety of syntagmatic relations are available for these words. It is unclear, then, how well co-occurrence patterns will serve to characterise the semantic similarity between different adjectives.

6.2.2 Adjective Clustering: Method

A set of potential target adjectives was found on the basis of the part-of-speech tagging in the BNC corpus: any word that could be classified as an adjective was part of the potential set. This set was then reduced by including only the words that had a frequency of over 500 in the spoken word portion of the BNC. This gives a set of 172 adjectives as the target words (these are listed in Appendix A).

Two different sets of context words were used to produce vectors. The first set included all the nouns with a frequency of over 500 in the spoken part of the corpus: there were 555 of these. The second set simply consisted of the 2000 most frequent words in the corpus. Both sets are listed in Appendix A.[1]

Vectors were produced by counting co-occurrence across the whole of the spoken word portion of the BNC (approximately 10 million words), using a window of two words in order to capture the structure to both sides of the adjective. Once the vectors were calculated, using software written by Scott McDonald (scottm@cogsci.ed.ac.uk), a Hierarchical Cluster Analysis was carried out on the data using the Unix *clusters* program[2] This program works by finding the two most similar vectors from the set and grouping them together. The two vectors thus grouped are removed from the set and replaced by a single vector that is the average of the two (and thus corresponds to the cluster of two words). Thus, the set contains one less vector. The process is then repeated over and over, the two most similar vectors being grouped: this may involve vectors for two words, a vector for a word and a vector corresponding to a cluster, or two vectors corresponding to clusters. In every step, the number of vectors is reduced by one, the process being continued until only one vector remains. Thus, all words and clusters of words are related in terms of their similarity.

The pattern of relationships this reveals was drawn as a dendrogram, a tree-like structure in which the branches correspond either to clusters of words, or to individual words (positioned at the ends of the branches). This allowed the patterns of relation-

[1] There are some odd inclusions in 2000-word list, such as "a little bit" being taken as a single word. This is due to the way in which the corpus is originally encoded; these words are regarded as a single lexical unit.

[2] Originally written by Yoshiro Miyata (miyata@boulder.colorado.edu); similarity was measured in terms of the cosine of the angle between the two vectors, an option added by Paul Cairns.

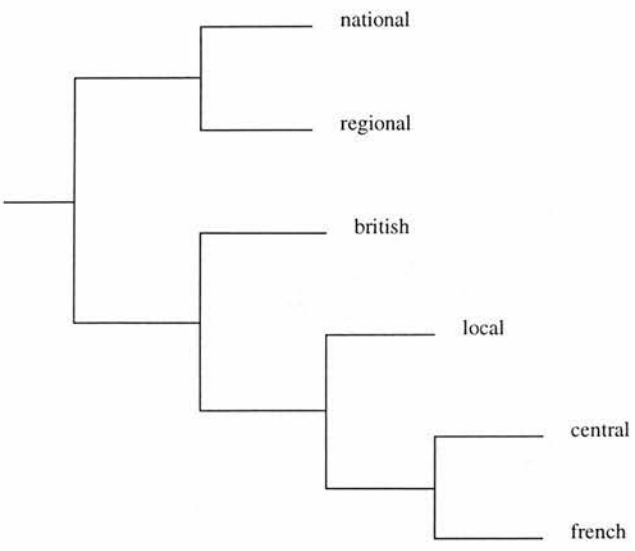

Figure 6.1: "Place" Adjectives: 555-noun clustering

ships to be inspected visually.

6.2.3 Adjective Clustering: Results

Figure 6.1 shows that small scale clusters do contain semantically related adjectives. In this case, we see that six adjectives indicating "place" (*national, regional, british, local, central, french* are grouped together in the clustering based on vectors indicating co-occurrence with 555 nouns. This indicates that adjectives with similar meanings have similar patterns of co-occurrence with nouns.

Figure 6.2 illustrates a larger cluster produced using the 555-noun vectors. Within it, we see several small groups of related adjectives: the three colour adjectives *yellow, blue, red* are together, as are the evaluative adjectives *bad, brilliant, excellent, good.* There is also a collection of adjectives such as *well, alright, dear, right, okay, fine* which are used as exclamations as well as adjectives; some of these adjectives are unlikely to be used in the attributive position (*okay, alright, well*). In this section of the dendrogram we thus find small groups of semantically related adjectives, but the overall connection between the colour adjectives and the others is not obvious: they must have similar patterns of co-occurrence with nouns, but it is not clear if this reflects any broader similarity between the groups. However, there is an element of similarity between the evaluative and the exclamatory adjectives, in that objects are "rated" by both groups (e.g. *bad, good, okay, alright*).

Figure 6.3 shows a cluster consisting mainly of colour adjectives, reflecting the

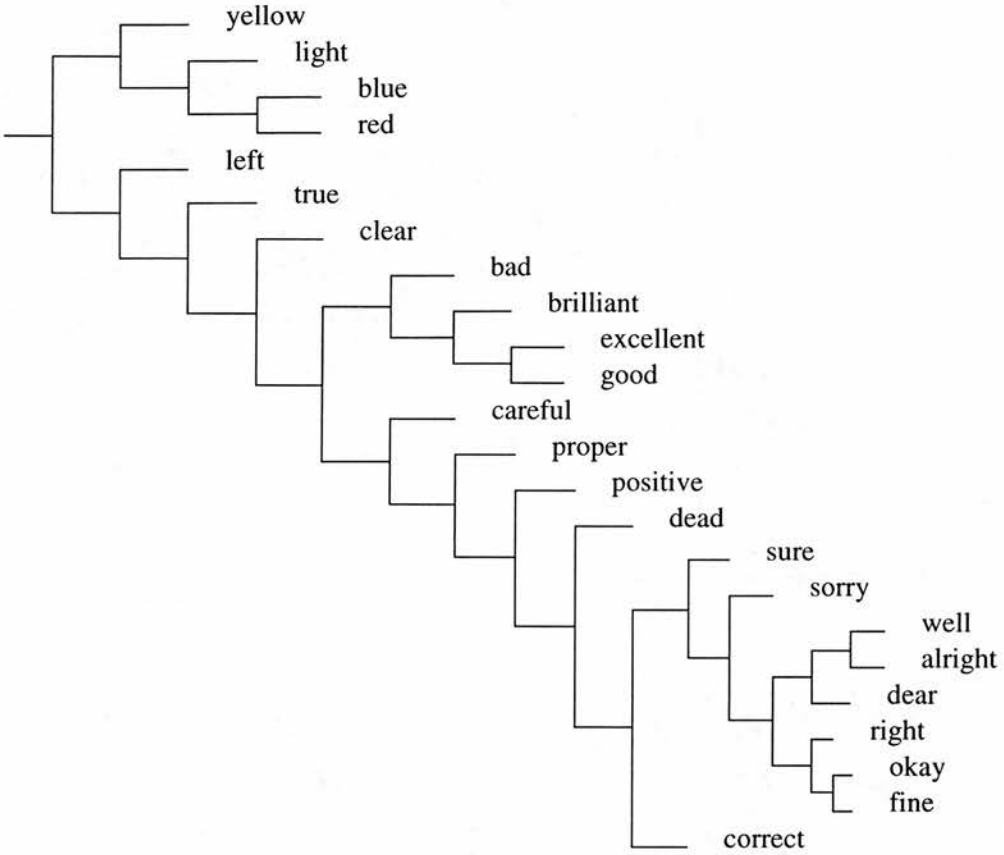

Figure 6.2: Colour and Other Adjectives: 555-noun clustering

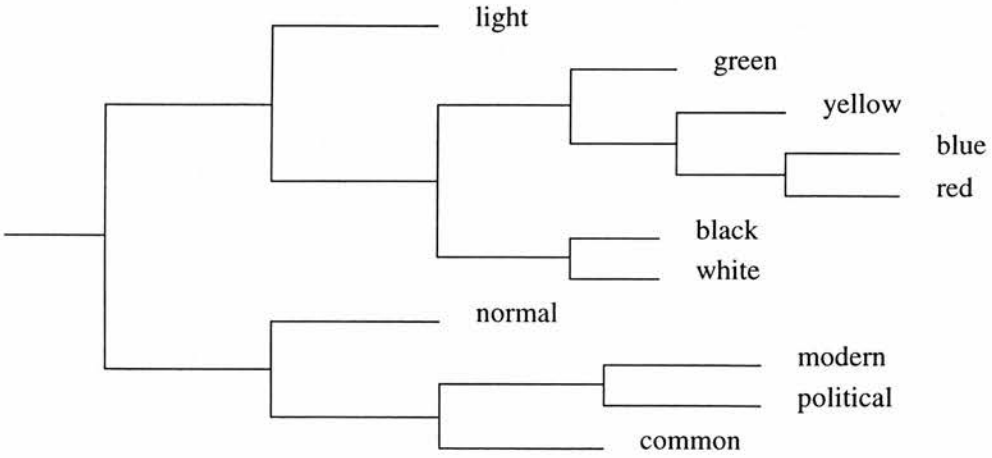

Figure 6.3: Colours: 2000-element clustering

clustering produced when the co-occurrence vectors is constructed using the context set of the 2000 most frequent words. We see that the increased vector size (or perhaps simply the wider range of element types in the context set) creates a better cluster in this case: *all* the colour adjectives in the target set are found together. The position of this cluster within the dendrogram is dissimilar to that produced by clustering with the 555-noun vectors: colour adjectives are not found to be similar to evaluative or exclamatory adjectives in this clustering. However, as can be seen in Figure 6.3, the colours are now grouped with *normal, modern, political, common*; again, there is no obvious similarity between the two sets.

It is unclear whether the larger scale clusters (i.e. which groups are related to which) bear any significance at all, whether defined by the 555-noun or 2000-element vectors. No intuitive importance seems to be present in the large scale patterns: generally, only small local groupings display obvious patterns of semantic relation.

The 2000-element vector clustering displays other small scale similarities to the 555-noun clustering. For example, in Figure 6.4, a group of adjectives sometimes used as exclamations is shown. Most of the same words found in Figure 6.2 are found again (e.g. *well, alright, dear, right, okay, fine*), but this cluster also contains a couple of expletives, and words such as *left, wrong* which are related to *right.* The exclamatory adjectives are not found to be similar to the evaluative adjectives *bad, brilliant, excellent, good* in this case; possibly this reflects the semantic difference that the exclamatory adjectives are non-gradable, unlike other evaluative adjectives.[3] In fact, there is no cluster defined by the 2000-element vectors that contains the evaluative adjectives *bad, brilliant, excellent, good*: these are all found in separate clusters.

Two more clusters that show roughly comparable results are displayed in Figures 6.5 and 6.6. These also contain evaluative adjectives, and there are several features shared by each clustering: for example, the pairing of *important, interesting* and the inclusion of *easy, difficult, funny, silly, horrible, terrible, useful.* However, the structure within the groups is generally very different. While in Figure 6.5 the pair *easy, easier* are together, in Figure 6.6, *easy, difficult, hard* are grouped. Neither clustering could be said to be a "better" display of the relatedness of the words: both show important kinds of connection between adjectives.

[3]If gradability is solely defined in terms of the possibility of the modifier being preceded by degree adverbs such as *very, extremely*, then there is no way this distinction could have been found on the basis of clustering using the 555-noun vector.

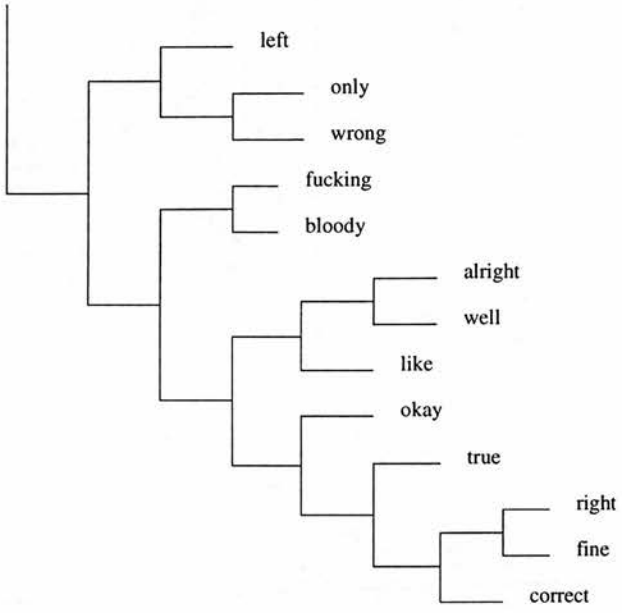

Figure 6.4: "Exclamation" Adjectives: 2000-element clustering

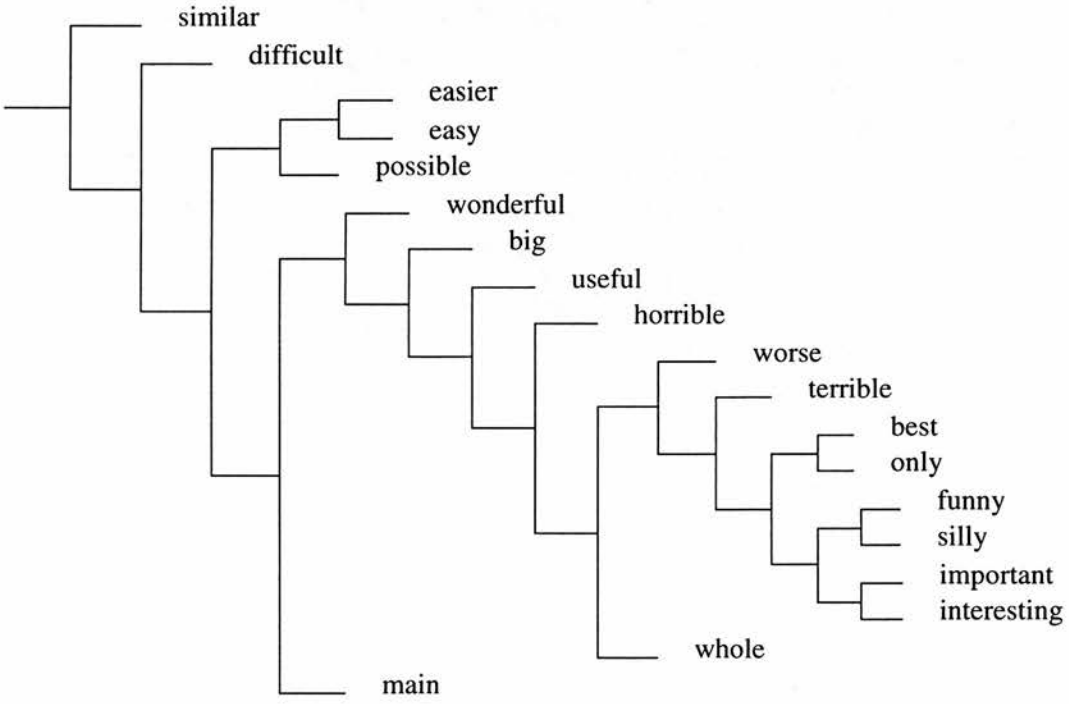

Figure 6.5: Evaluation Adjectives: 555-noun clustering

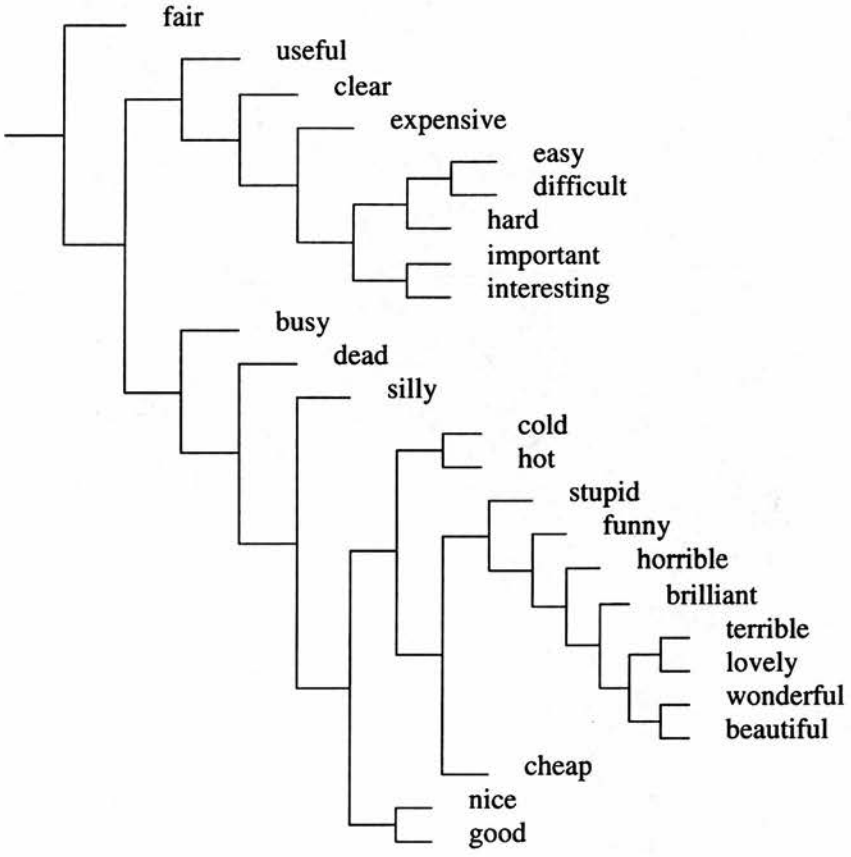

Figure 6.6: Evaluation Adjectives: 2000-element clustering

6.2.4 Adjective Clustering: Discussion

Finch and Chater (1993) showed that simple statistical methods can be used to produce categories that correspond to traditional syntactic categories: the examples of clustering given above show that when this method is extended to apply only to target words within the single grammatical category of adjectives, semantically related adjectives are grouped together, regardless of whether co-occurrence with frequent nouns or simply frequent words is used as the measure.

It is perhaps counter-intuitive that such a simple approach serves well to characterise adjectives: as we saw above, there are a range of different syntactic contexts in which adjectives can occur, but the measurement of co-occurrences was carried out using only a small, two-word window around tokens of the target words, taking no account at all of the syntactic structure of the material being considered. Thus, information solely about very locally co-occurring context words served to produce clusters of semantically related words: even a vector using only nouns in the target set was sufficient to find similarities between related adjectives.

When the detail of clustering is observed, the semantic groupings are obvious: however, it is not clear that there is any significance to the larger scale groupings produced (i.e. the clustering of clusters). In addition, it should be noted that clustering of this kind cannot bring together all words that are related: for example, *hard* is related to both *easy* and *soft*, but *easy* and *soft* do not have any close semantic relationship. There can be no single satisfactory grouping encompassing all adjectives; to cope with problems of ambiguity, more sophisticated clustering methods must be used to separate out different senses of a word, and produce co-occurrence vectors corresponding to each (e.g. Fukumoto and Tsuji (1994)). Such approaches would necessarily assume that clearly defined separate senses can be identified.

However, the patterning of small-scale clusters is suggestive of the idea that co-occurrence vectors do, in some sense, "measure" meaning. More examples of clustering could be given, showing that, in general, the sets of co-occurrence vectors we considered do produce small-scale clusters of adjectives that are intuitively semantically related. The constraints that exist on the way adjectives are distributed are strong enough to reflect similarities of meaning between the words. However, clustering patterns do not tell us directly about the meaning of words; there is no direct way to connect the vector representation with any kind of schematic structure that describes what an adjective *does*, semantically, when it combines with other words. What the clustering patterns do indicate is that the meaning of adjectives very tightly constrains the patterns of combination they enter into: semantically related groups operate in specific ways, on

specific classes of nouns (and in other constructions).

6.2.5 Noun Clustering

Following the examination of adjective clustering, a corresponding study was carried out on nouns. In this case, the target words were the 555 nouns used in the previous study as a context word set; two clusterings were carried out using as context words sets the 172 adjectives and the 2000 most frequent words in the corpus (all listed in Appendix A.

The clustering produced by using 172 adjectives as the context vector was much "noisier" than the clustering produced using the 2000 most frequent words. For example, if we compare clusters of "people" nouns produced, displayed in Figures 6.7 and 6.8, we see that the adjective-based clustering contains more extraneous elements: as well as nouns referring to people, we also find days of the week, and a variety of other elements (e.g. *yorkshire, play, food, mind, course, others, saying, past, rest, back, pence.* In the 2000-word clustering, on the other hand, the patterning is very much neater: there are fewer elements in the cluster that could be described as noise (*saying, rubbish, right, birthday, hair*). Furthermore, the people nouns fall into three clear groups: terms of kinship (e.g. *mother, father, sister*); titles (e.g. *chairman, mr, love, darling, mate*); and proper nouns (e.g. *michael, paul, david*). This is repeated throughout the dendrogram: the 2000 word clustering contains neat groups of (e.g.) bodypart nouns, weekdays, place nouns, event nouns, and so on, whereas the adjective-based clustering contains smaller groups of related words, with much more noise.

This reflects, in part, the fact that there are few adjectives acting as context words: the constraints that the co-occurrence vector can indicate will be weaker, and thus less likely to capture semantic similarities. Nevertheless, both clusterings do capture a range of small-scale semantic similarities within the set of nouns: co-occurrence vectors also seem to provide a method for characterising relatedness within the class of nouns.

6.2.6 Summary

Corpus-derived co-occurrence data can be used to cluster together words, on the basis of similarity of patterns of distribution. This clustering produces groups of words that are semantically similar, according to intuition, and thus co-occurrence vectors, in some sense, act to "measure" meaning. The success of clustering in capturing semantic relatedness suggests that there are strong constraints within language on the allowable patterns that can occur. Like the semantic differential, the co-occurrence vector indicates the range of combinatorial possibilities that are open to a word.

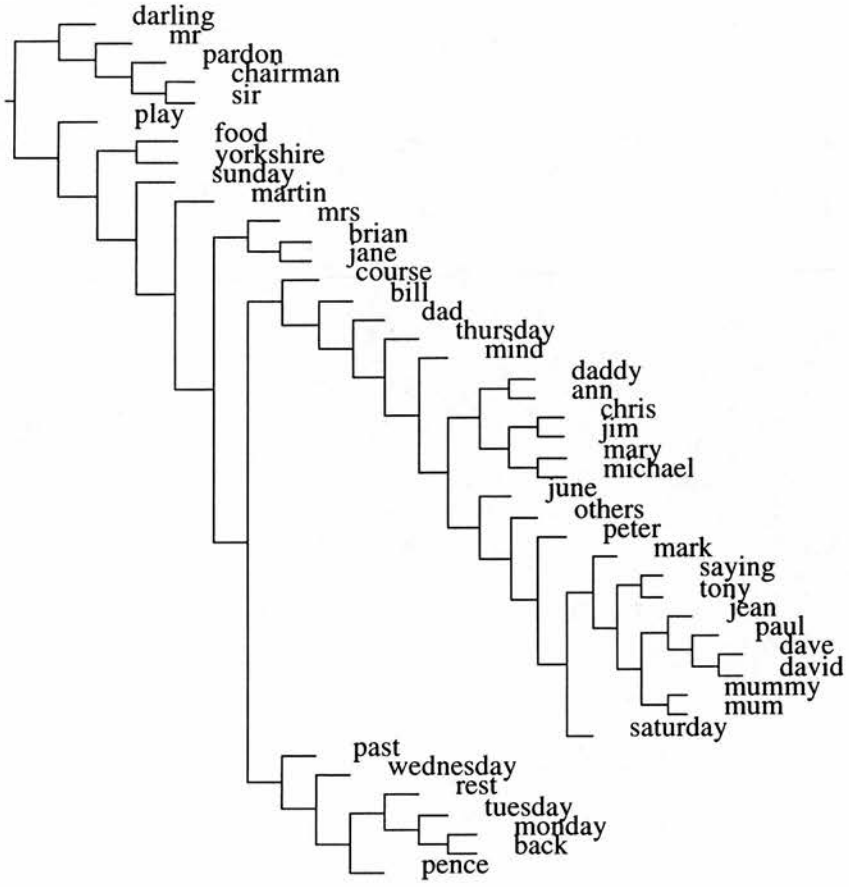

Figure 6.7: Person Nouns: 172-adjective clustering

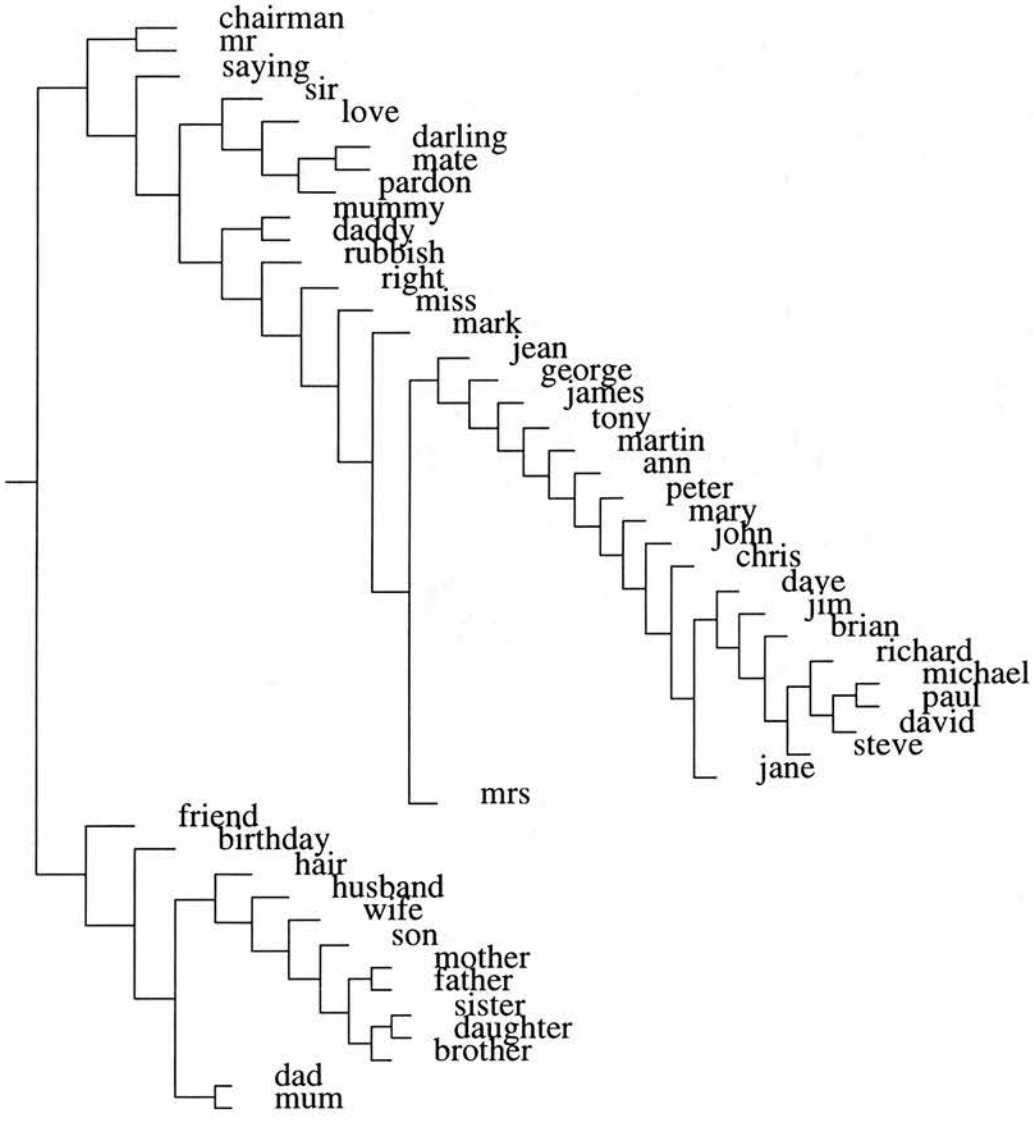

Figure 6.8: Person Nouns: 2000-element

As we saw, some of these groupings are produced simply by measuring co-occurrence with a context set consisting of frequent nouns or adjectives. The fact that measuring co-occurrence with only a few hundred words does capture some patterns of the semantic relatedness of words shows that even a fraction of the overall context in which a word appears strongly reflects the constraints which affect the word's distribution.

The fact that groups of related words can be found using such simple statistical methods has interesting implications for the acquisition of language: it suggests that syntactic and/or semantic similarities between words can be deduced without any elaborate processing of language being required. Thus, it might be possible for a language learner to construct grammatical and semantic categories without reference to innate linguistic knowledge: linguistic categories would be constructed by "bootstrapping" from raw data, and these categories then used to construct more elaborate theories of language structure. Similarly, the meaning of a word such as an adjective can be partly deduced through examining the pattern of combination it enters into: the operation it carries out on a head noun is likely to be similar to that of the adjectives it is clustered with, i.e. those that have a similar co-occurrence pattern.

There are, however, other ways than clustering in which these simple co-occurrence vectors can be used: in the next section, we investigate whether a measure of the degree of constraint on the range of combinations that a word enters into is predictive of the way in which words are actually processed, both in isolation and in complex concepts.

6.3 Psycholinguistic Experiments

6.3.1 Introduction

This section investigates whether a corpus-derived measure of word distribution is predictive of the speed with which noun-noun combinations can be interpreted. Clearly, however, the process of interpreting a noun-noun combination will involve both word recognition (lexical access), and the task of combining the meanings of the two words.

Therefore, two experiments were undertaken. The first experiment was a visual lexical decision experiment, measuring the speed with which words are recognised; the second measured the speed with which noun-noun combinations were interpreted as making sense or not.

In both experiments, the predictive value of three measures were investigated: word frequency, polysemy, and relative entropy (a measure of how sharply a word's observed distribution pattern diverges from a hypothetical random distribution).

Frequency was chosen because it is the best known predictor of response time (RT)

in word recognition tasks (as mentioned in Section 6.1.3).[4]

Polysemy was chosen as a predictor in contrast to frequency, being a measure of range of meaning, thus capturing aspects of the word that are not covered by a simple frequency measure, but may affect processing tasks (especially where interpretation is required).

The third measure investigated was Relative Entropy (RE), which is a measurement of how constrained/random the distribution of a word is in a sample of text: RE is calculated by finding the difference between the co-occurrence vector as measured, and the co-occurrence vector that would be found if the word distribution were random, i.e. the co-occurrence pattern if all the words in the corpus sample were jumbled into a random order.

Frequency

Frequency measures are robust predictors of the speed with which words are recognised. The log of the frequency count for a word is the best predictor of response times (distribution of word frequencies is non-linear): log values were used at all times. Word frequency was measured across a lemmatised version of the spoken word part of the BNC. Lemmatised forms for the BNC corpus are available as part of the CELEX database.[5] Using the lemma frequency rather than the frequency of a particular token is standardly done when frequency measures are taken from a listing of values such as Francis and Kucera (1982); this is the best predictor of response time (see Bradley (1978)).

Polysemy

There is no direct way to measure polysemy from the corpus. However, polysemy could well be an important factor in predicting the speed of response in both tasks: its value in predicting lexical decision speeds is argued for by Jastrzembski (1981), and in noun-noun combinations, it would seem that the greater the number of senses a noun has, the greater the potential ambiguity of any combination.

Polysemy values were found for the words in the following experiments by following the method of Jastrzembski (1981): using a dictionary (in this case, the Concise English

[4]Other factors that have been investigated as predictors for processing effects involving single words include Age of Acquisition (Gilhooly and Logie (1982), Gilhooly (1984)), Ease of Predication (Jones (1985)), Familiarity (Gernsbacher (1984)), Concreteness (Paivio et al. (1968), Paivio (1971), James (1975)), and Stand-aloneness (Taft (1990)); frequency is, however, better investigated than these other factors: in addition, it is a simple corpus-derived statistic which can be objectively measured.

[5]CELEX Lexical Database of English, Dutch Centre for Lexical Information, Nijmegen. The measurements were supplied by Scott McDonald.

Dictionary, Allen (1990)) that contains numbered entries for the different senses. The largest number in the entry is taken as the polysemy value for that word. The polysemy measure is a rather informal one; the criteria that lexicographers use in breaking down the meaning of a word into separate senses are not formally specified. This, however, provides a rough and ready means of estimating the range of meanings which a word can have.

Relative Entropy

Relative Entropy (RE), or Kullback-Leibler distance (as described in Resnik (1993)) indicates the randomness of a word's distribution (i.e. the degree of constraint there is on the type of contexts in which it appears). RE measures the difference between the distribution of context words actually observed as occurring around the word (the posterior distribution), and the distribution of context words expected simply from the word frequencies (the prior distribution).

The prior distribution C is defined as ranging over an alphabet of symbols $c_1, ..., c_n$ with probability mass function $p(c)$. The alphabet here is simply the set of context words used to define the co-occurrence vector; values of $p(c)$ are obtained using the maximum likelihood estimate:

$$p(c_i) = \frac{f(c_i)}{\sum_{j=1}^{n} f(c_j)}$$

In this equation, $f(c_i)$ is the frequency of c_i in the corpus, and the denominator of the fraction is the total number of context word occurrences in the corpus. Thus, the prior distribution is a vector containing elements expressing co-occurrence probabilities, which simply express the expected probability of co-occurrence with each of the context words (i.e. if the words in the corpus were simply randomly ordered).

The posterior distribution, i.e. the distribution of context words observed given that the target word t appears, is based on the probability mass function $p(c|t)$. Values for $p(c_i|t)$ are derived from the co-occurrence frequency of target word t with the context word c_i, normalised by the total occurrence of t with each possible symbol c (i.e. each element of the co-occurrence vector is divided by the sum of all the elements of the vector). This is expressed by the equation:

$$p(c_i|t) = \frac{f(c_i, t)}{\sum_{j=1}^{n} f(c_j, t)}$$

The relative entropy between these two distributions is defined as:

$$D(p(c)||p(c|t)) = \sum_i p(c_i|t) log_2 \frac{p(c_i|t)}{p(c_i)}$$

This assumes the convention that 0 log 0 = 0. The use of log_2 means that this value is the quantity of information in bits provided about a random variable (the contexts in which the word appears) by an event (the occurrence of the word). Thus, RE measures the difference between the actual pattern of co-occurrences of a word, and a hypothetical random pattern of co-occurrences based on the frequencies with which words occur. The higher the RE value is, the less random its pattern of co-occurrence, and the more specific the range of contexts in which it appears.

RE scores were calculated using the same lemmatised corpus that frequency measures were taken from. The context words for the co-occurrence vector were the 2000 most frequent content words (selected by hand). Content words were chosen as these are important in disambiguating other content words, whereas function words (e.g. *the, a*) are primarily important in syntactic terms: they tend not to co-occur with specific words, but rather specific word classes; their extremely high frequency would act to "swamp" the specific patterns of co-occurrence that are entered into with particular content words. The set of context words is listed in Appendix D.

6.4 Experiment 1: Lexical Decision

6.4.1 Introduction

This experiment was undertaken in order to examine the predictive value that the three measures described above have for speed of word recognition. This is necessary in order to separate out the process of word recognition from that of semantic composition that occurs in the noun-noun interpretation task.

One of the most robust findings in psycholinguistic research is that frequency measures predict the speed of response in visual lexical decision tasks (VLDT), and we therefore expected the frequency measure to be a good predictor of RT.

An effect of polysemy was demonstrated by Jastrzembski (1981) for word recognition: the more meanings a word is, the faster it is to be recognised. Interpretations of this effect (see Balota et al. (1991)) suggest it is due to the level of activity in the "semantic system"; either the number of candidate meanings activated, or the overall level of activation, acts to increase the speed with which a word is recognised, all else being equal.

As a measure of distribution randomness, the relative entropy measure would, according to standard accounts of the VLDT, have no predictive role to play: the task measures speed of word recognition in a neutral context. Words are presented in isolation, not within a context.

6.4.2 Method

Subjects and Equipment

There were 18 subjects, all of who were native speakers of English, with no known language difficulties and normal or corrected vision.

The experiment was run on an Apple Macintosh using Psyscope software version 1.2. Response times were recorded from a button box, supplied with Psyscope, which is specifically designed for this purpose.

Materials

150 words were chosen with a frequency of greater than 250 across the lemmatised version of the spoken portion of the BNC. An additional 15 items were chosen that had a lemma frequency of over 25 but below 250, in order to ensure a good spread of frequencies overall. The words selected were all between 4 and 7 letters in length, allowing them to be read with a single fixation

Non-words were generated by taking the words in the list and altering three letters in them. The resulting non-word was, however, orthographically close to English: every case was one letter away from at least one real word. This makes the discrimination task the subject undertakes more difficult than if non-words are random strings such as "mnxwg". The fact the non-words strings have properties like those of real words means that the subjects have to carry out the task on the basis of word recognition, rather than being able to rely on lower-level cues such as the appearance of letter bigrams unacceptable in English. The words and non-words used in the experiment are presented in Appendix B, Table B.1.

Procedure

Subjects were required to judge, as rapidly as possible, whether a string of letters constituted an English word or not. For each item, a fixation cross was presented for 500 msec. As the cross was removed, a string of letters then appeared, centred on the position of the fixation point.

Subjects responded using a button box. Positive responses were always made with the dominant hand. When the subject pressed a button, the string was removed, and the next fixation point presented.

Subjects were given 10 practice examples to acclimatise them to the task. Following this, they were then asked if they were comfortable with the procedure and understood the task. No subject expressed difficulty in understanding or performing the task.

Following this, all subjects worked through the items; in each case, the order of presentation was random. They were given a break after half of the items were presented, in order to minimise the effects of fatigue.

Instructions

The instructions given to the subjects were as follows:

This experiment is to determine how fast people can tell the difference between real English words and nonsense strings of characters. Examples of nonsense strings are "dort", "flink" and "greap": although they look like real words, they don't mean anything.

You will be using the red and green buttons on the box in front of you to respond. Throughout the experiment you should keep the index finger of your right hand lightly resting on the green button, and the index finger of your left hand on the red button.

When the experiment starts, you will see a cross at the centre of the screen: you should focus on this. After a short period, a string of characters will appear in the same position. When the string appears, you should decide as quickly as possible if it is a real word or not. If it is a real word, press the right (green) button. Press the left (red) button if it is nonsense. (If you are left handed, please do the opposite; inform the experimenter if this is the case).

Keep your eyes on the screen: do not look at the buttons. Your responses should be as fast as possible.

As soon as you press a button, the words will disappear, and the cross will come back into view, giving you the chance to prepare for the next string of characters.

If there is anything you do not understand about these instructions, please ask the experimenter to explain.

To get you used to the way this works, there will now be a short practice run. Press any button on the box to start.

Variables	1	2	3	4
1. RT	1.000			
2. FREQ	−.2019**	1.000		
3. RE	.2763***	−.7466***	1.000	
4. POLY	−.1380	.2297**	−.2157**	1.000
$* = p < .05, ** = p < .01, *** = p < .001$ two tailed				

Table 6.2: Correlations between measures for VLDT

6.4.3 Results

Errors

The mean number of errors that subjects made on the words was 5.333, the minimum being 1, and the maximum 14. For the items themselves, the average number of errors was 0.59, the minimum being 0 and the maximum 6. Where an error was made, the RT value was replaced by the average RT for the subject across all items.

Due to experimenter error, two words were included in the materials which should not have been. These were *days* (an inflected word) and *fumble* (which has a frequency of below 25 in the lemmatised corpus). These were excluded from the analysis below.

Correlation Analyses

The correlations between mean response time (RT), log frequency (FREQ), relative entropy (RE) and polysemy (POLY) were examined (descriptive statistics for these measures are found in Appendix B, Tabledescvldt). The results are displayed in Table 6.2. As can be seen from the table, both frequency and RE correlate significantly with RT, with RE having the strongest correlation.[6]

However, FREQ, RE and POLY are all significantly intercorrelated; RE and FREQ especially so. Thus, it is unclear whether these effects are independent of one another, or whether the measures all account for the same portion of the variance. Therefore, a partial correlation analysis was carried out, in order to determine the separate contribution of each measure to explaining the variance in RT.

Controlling for the effect of Log Frequency, Relative Entropy still correlated significantly with RT (r= .1927, p=.014). Polysemy, however, was not significantly correlated (r= -.0961, p=.224).

[6]For comparison, frequency measures were also taken from Francis and Kucera (1982). The correlation for these measures was extremely similar to that for FREQ; r=-.2076, p=.008.

Controlling for the effect of Relative Entropy, Log Frequency had a non-significant correlation with RT (r=.0069, p=.930); Polysemy was also non-significantly correlated with RT (r= -.0835, p=.291).

This suggests that RE accounts for all of the variance explained by FREQ, but also that it accounts for another portion which FREQ does not explain. The effect of holding POLY constant was thus also examined, in order to see whether this accounted for part of the variance attributable to FREQ or RE.

Controlling for the effect of Polysemy, both Log Frequency and Relative Entropy remained significantly correlated with RT (r= -.1765 and r=.2459, p=.025 and p=.001, respectively). If both Polysemy and Log Frequency were held constant, Relative Entropy still correlates significantly with RT (r=.1875, p=.017); if Polysemy and Relative Entropy are held constant, Log Frequency does not significantly correlate with RT (r=.0159, p=.842).

Thus, RE survives as a significant correlate of RT, even when the effect of both frequency and polysemy are taken into account. On the other hand, frequency is no longer significant when RE is taken into account.

6.4.4 Discussion

RE, although a novel kind of measure, is a good predictor of the speed with which words are recognised. In fact, it is a better predictor of RT than Log Frequency, although they are strongly correlated. The patterns of partial correlation suggest that RE accounts for the same variance as FREQ, but that it also contains an additional component, which is significant in its own right in predicting the speed with which words are recognised.

RE will tend to be correlated with frequency, simply because more frequent words are likely to co-occur with a greater range of words: this implies that their distribution is less constrained (or, in other words, more random; such words are generally likely to have low RE values, being relatively uninformative about the contexts they are likely to appear in). However, RE does not simply measure range: a high RE value indicates the degree to which the word's distribution is non-random. A word that can co-occur with a wide range of context words, but does so mainly with a small portion of them, will have a high RE value.

The question naturally arises as to why a measure of the randomness of a word's distribution should be predictive, over and above frequency, for a task in which words are presented in a completely neutral context.

One widely accepted explanation for the predictive value of frequency as a measure is simply that "less evidence" is needed for recognition of frequent words, either through

the biasing of a threshold for recognition, as in logogen-based theories (Morton (1969)) or by arranging a search space in a way such that more frequent words are examined earlier as potential matches to the evidence (Forster (1981)). Naturally, the more frequent a word is, the more likely it is to occur in general: thus, biasing the recognition process in this way leads to faster recognition speed in general (a classic example of a Hebbian learning process.)

Both of these models are straightforwardly "bottom up": that is, the only thing that drives the recognition process is perceptual evidence. In the visual lexical decision task, the only evidence available for word recognition is perceptual. However, in interactive activation models (see McClelland and Rumelhart (1981)) one of important sources of evidence for recognition of a stimulus is feedback from "higher levels", such as evidence about the context of occurrence for the stimulus.[7] It would be natural in an interactive activation model to structure the recognition process so that context has a "top down" effect, biasing the recognition of words that are most likely to occur in the context observed. Experiments such as Elman and McClelland (1988) show that such top down effects do exist in word recognition.

However, there is a more general principle that arises from consideration of the role context plays in recognition. For words that occur only in tightly constrained contexts (i.e. having a high RE value), the context of occurrence would be an important source of evidence. However, for words that are more randomly distributed (i.e. having a low RE value) context would play little role in the process of recognition. Randomly-distributed words should thus be set to be more easily recognised on the basis of their appearance alone ("lower level" evidence), making them more speedily recognised when the context is a neutral one. Words that appear in specific contexts would generally only be seen in those contexts: the "lower level" evidence would have to be good for them to be recognised when not in those contexts. Altering the criteria for recognition in this way would serve to make it less like that word are "recognised" in contexts where they would not normally occur, thus helping to prevent errors of recognition.

In effect, words that only occur in specific contexts should have thresholds for recognition that are set higher than words that can occur in a broad range of contexts. This provides an explanation as to why the RE value should be predictive of recognition speed which takes into account the factors that would come into play in the normal course of word recognition, in which words are not isolated from context. The recognition of words for which "top down" evidence will normally have little effect should

[7] The existence of lexical priming (Meyer and Schvaneveldt (1971)) is good evidence that contextual factors do play a big role in word recognition.

be more rapid that words for which "top down" evidence is important, all other things being equal. In the course of processing normal text, contextual effects may operate to counteract this pre-bias for recognition of "randomly" distributed words.

6.5 Experiment 2: Complex Concepts

6.5.1 Introduction

A task in which interpretation of words within context is required should provide another way of assessing the usefulness of a context-based measure such as RE. The task of interpreting modifier-noun combinations is a natural candidate for such an investigation: words are presented in a minimal but rich context for interpretation.

Previous psycholinguistic work on the time-course of the processing of modifier-noun combinations carried out by Murphy (1990) and also Gagne and Shoben (1997) suggests that: (a) when presented in isolation, the more plausible a combination is, the faster it is interpreted (also that adjective-noun combinations are interpreted faster than noun-noun combinations); (b) that the plausibility of the relationship for the modifier affects RT for the interpretation of noun-noun combinations, while the plausibility of the relationship for the head is less important. In general, the plausibility of the relationship for the combination affects interpretation speed, but the plausibility of the relationship for the modifier in particular seems to have the most impact on RT.

These experiments group the combinations on the basis of subjective analyses of the plausibility of particular combinations, involving normal, easily interpreted combinations, nonsensical combinations, and possible but unusual combinations such as *unsliced typewriter*, *fertile worm* or *mountain range* (this last being unusual because *mountain* is typically not used as a modifier to specify the composition of an object. The effects demonstrated arise because particular combinations which make sense are more or less "strange", i.e. contain unusual kinds of relations, and this can affect the speed of interpretation.

However, the experiment described below does not use these "strange" kinds of combinations. The aim is to see whether statistical measures of a word's frequency and/or distribution predict the speed with which combinations are understood, but the combinations used (that make sense) are taken from a sample of real-world natural language use, and thus the experiment should reflect closely the processing that occurs in normal situations of interpretation.

6.5.2 Method

Subjects and Equipment

There were 24 subjects, all of who were native speakers of English, with no known language difficulties and normal or corrected vision.

The experiment was run on an Apple Macintosh using Psyscope software version 1.2. Response times were recorded from a button box, supplied with Psyscope, which is specifically designed for this purpose.

Materials

The experiment used 100 noun-noun pairs. Every word used was five characters long; this constraint was introduced to eliminate any effects arising from asymmetry of word length within a pair, and length differences between pairs.

In addition, a frequency constraint was introduced. All words considered occurred 25 or more times in the lemmatised version of the spoken part of the BNC (the same corpus as used in Experiment 1). This excluded low-frequency (unfamiliar or unusual) items from the materials; the lemmatisation also ensured that none of the words was inflected.

Of the 100 pairs, 50 were selected from BNC data. Of the 123896 unique noun-noun pairs extracted from the BNC there are 3814 of which both pairs are of length 5 (approximately 3% of the whole). Within the 3814, there are 1133 unique pairs that match the frequency criterion: composing these, there are 314 unique nouns in the initial position, and 287 unique nouns in the final position; in *total* there are 346 unique nouns. Selection was made of 50 pairs that: (a) made sense in isolation, and are easy to interpret[8]; (b) did not duplicate words within the list (i.e. there were 100 different words in the 50 pairs).

These were therefore pairs used in real world language that could be easily understood in isolation. These are the SENSE items.

A further 50 NONSENSE items were then constructed from the same 100 words. New combinations were produced by swapping which words were combined: words that were modifiers in the SENSE items always remained modifiers; likewise for head nouns. The only constraint on production were that the combinations were judged to be practically impossible to interpret in any obvious way. These are the NONSENSE items.

A full list of all these items is given in Appendix C.

[8]The fact that these combinations were easy to interpret was decided on by two judges.

Procedure

Subjects were required to judge, as rapidly as possible, whether pairs of words made sense or not (could be easily interpreted or not). For each pair, a fixation cross was presented for 500 msec. A noun-noun pair then appeared, one noun on each side of the position of the fixation point (which was removed as the word pair appeared).

Subjects responded using a button box. Positive responses were always made with the dominant hand. When the subject pressed a button, the word pair was removed, and the next fixation point presented.

Subjects were given 10 practice examples to acclimatise them to the task. Following this, they were then asked if they were comfortable with the procedure and understood the task. No subject expressed difficulty in understanding or performing the task.

Following this, all subjects worked through all 100 combinations; in each case, the order of presentation was completely random.

Instructions

The instructions given to the subjects were as follows:

This experiment is to determine how fast people can tell the difference between pairs of English nouns that make sense, and pairs that do not. For example, pairs such as "drugs squad", "truth serum", and "white lines" make sense: they are easily recognised as describing objects. In contrast, "broom grape", "plant jumps", and "mince blank" cannot easily be understood as referring to anything.

You will be using the red and green buttons on the box in front of you to respond. Throughout the experiment you should keep the index finger of your right hand lightly resting on the green button, and the index finger of your left hand on the red button.

When the experiment starts, you will see a cross at the centre of the screen: you should focus on this. After a short period, two words will appear in the same position. When the words appear, you should decide as quickly as possible if the combination makes sense or not. If it makes sense, press the right (green) button. Press the left (red) button if the string is nonsense. (If you are left handed, please do the opposite; inform the experimenter if this is the case).

Keep your eyes on the screen: do not look at the buttons. Your responses should be as fast as possible.

As soon as you press a button, the words will disappear, and the cross will come back into view, giving you the chance to prepare for the next pair of words.

If there is anything you do not understand about these instructions, please ask the experimenter to explain.

To get you used to the way this works, there will now be a short practice run. Press any button on the box to start.

6.5.3 Results

Errors

Overall, the error rate was 13% (305/2400). For SENSE items the rate was also 13% (159/1200); it was 12% for NONSENSE items (146/1200). In every case where a mistake was made, the RT for that RT item was replaced in the data set by the mean RT over correct responses for that subject. No one made more than 27 errors overall.

The error rate for individual items was generally low, the mean number of errors per item being 3.16 for SENSE items, and 2.88 for NONSENSE items. Items that engendered a high error rate (defined as misinterpretation by more than 8 of the subjects) were excluded from the analyses. There were four such items: 3 SENSE items (*shirt front, radio staff, voice coach*, misinterpreted by 12/24, 12/24 and 9/24 subjects respectively), and 1 NONSENSE item (*floor clerk*, with 10/24 subjects interpreting it as making sense).

Response Times

The mean RT across the population was 874 msec; for SENSE items it was 793msec; for NONSENSE items, it was 952msec. An ANOVA analysis shows that the RT difference between SENSE and NONSENSE items is highly significant: $F(1, 95) = 106.667, p < 0.001$.

Correlations

Measures The measures considered as correlates of RT were: measures of log frequency, relative entropy and polysemy for each word (FREQ1, FREQ2, RE1, RE2, POLY1, POLY2); the means of each pair of values (MEANFREQ, MEANRE, MEANPOLY); the difference between the pairs of values, the value for the modifier being subtracted from the value for the head, (DIFFFREQ, DIFFRE, DIFFPOLY); and the absolute (unsigned) difference in values (ADIFFFREQ, ADIFFRE, ADIFFPOLY). Thus, measures existed which measured various characteristics of the individual words, the mean of the values for the two words, and the size of the difference of the values between the two words. Descriptive statistics for these measures can be found in Appendix C, Table C.1; the FREQ, POLY and RE measures for each pair are in Tables C.2 and C.3.

Sense Items Only three measures were significantly correlated with RT or approached significance for the SENSE items. The correlations for these are displayed in Table 6.3.

Variables	1	2	3	4
1. Response Time	1.000			
2. RE2	.2630	1.000		
3. MEANRE	.3279*	.6155***	1.000	
4. MEANFREQ	−.2543	−.4805**	−.7022***	1.000
$* = p < .05, ** = p < .01, *** = p < .001$,two tailed				

Table 6.3: Correlations between measures for SENSE items

MEANRE (r=.3279, p=.024) was significant at the 0.05 level: marginally significant are RE2 (r=0.2630, p=0.074), and MEANFREQ (r=-.2543, p=0.085).[9]

Once again, the measures are strongly intercorrelated. A partial correlation analysis was run to see whether these correlations correspond to different portions of the RT variance.

Controlling for the effect of MEANFREQ renders both the other measures non-significantly correlated with RT: for RE2, r=.1660, p=.270; for MEANRE r=.2169, p=.148.

Controlling for the effect of MEANRE leaves the two other measures non-significantly correlated with RT: for MEANFREQ, r=-.0357, p=.814; for RE2, p=.0822, p=.587.

Controlling for the effect of RE2 also leaves both other measures non-significant: for MEANRE, r=.2183, p=.145; for MEANFREQ, r=-.1512, p=.316.

Thus, separate contributions of the three variables to predicting RT variance cannot be distinguished.

Nonsense Items For NONSENSE items, there were four measures that predicted speed of response. These are RE1, FREQ1, POLY1, and MEANPOLY, and their correlations with MEANRT and each other are shown in Table 6.4. The correlations and significance levels are: RE1 (r=-.2980, p=.038), FREQ1 (r=.3192, p=.025), POLY1 (r=.3272. p=.022), MEANPOLY (r=.3515, p=.013).

Again, all the measures are significantly intercorrelated. A partial correlation analysis was carried out to determine if separate contributions to accounting for RT variance could be distinguished.

Controlling for the effect of RE1 renders FREQ1 non-significantly correlated with MEANRT (r=.1361, p=.356). However, MEANRT is still marginally significantly correlated with both POLY1 and MEANPOLY (r=.2471, p=.090 and r=.2820, p=.052,

[9]Neither RE1, FREQ1 or FREQ2 are approaching significance; the closest is FREQ2, with r=-.1781, p=.231.

Variables	1	2	3	4	5
1. Response Time	1.000				
2. RE1	−.2930*	1.000			
3. FREQ1	.3192*	−.8244***	1.000		
4. POLY1	.3272*	−.3598*	.3218*	1.000	
5. MEANPOLY	.3515*	−.3251*	.3050*	.6093***	1.000
$* = p < .05, ** = p < .01, *** = p < .001$,two tailed					

Table 6.4: Correlations for measures for NONSENSE items

respectively).

Controlling for for the effect of FREQ1 leaves RE1 non-significantly correlated with MEANRT (r=-.0649, p=.661). Again POLY1 and MEANPOLY are marginally significantly correlated with MEANRT (r=.2502, p=.086 and r=.2815, p=.053, respectively).

Controlling for POLY1 renders both RE1 and MEANPOLY non-significantly correlated with MEANRT (r=-.2045, p=.163 and r=.2030, p=.166, respectively). FREQ1 is not significantly correlated with MEANRT, the probability falling just below the 10 percent level (r=.2391, p=.102).

Controlling for MEANPOLY similarly leaves both RE1 and POLY1 non-significantly correlated with MEANRT (r=-.2076, p=.157 and r=.1523, p=.301, respectively). FREQ1 is again not significantly correlated with MEANRT, the probability falling just below the 10 percent level (r=.2378, p=.104).

6.5.4 Discussion

Processing Speed

As expected, the processing time for NONSENSE items is significantly slower than for SENSE items.

Although any strict comparison is impossible, it is worth noting that decisions in this experiment are made much more rapidly than those in Expt. 1 of Murphy (1990). Murphy used 4 different types of stimuli, 3 types of which were SENSE materials, but of these, 2 types involved novel or unusual combination types. In addition, the error rate here is much lower than that for Murphy's novel noun-noun pairs: whereas 65% of subjects on average make the expected response in Murphy's experiment, here 87% of subjects make the expected response.

Having to discriminate between merely implausible and completely nonsensical combinations may slow subjects down considerably, and perhaps produces an unrealistic

picture of the time course in which conceptual combination is carried out (as is also suggested by Murphy's Expt. 4, in which a biasing context evens out RT differences for implausible combinations).

Correlation Patterns

Response times for the two types of combinations correlate with different measures.

For the SENSE items, the fact that both MEANFREQ and MEANRE are good predictors reflects the results found in Experiment 1 for single words. It might simply be that these measures predict RT simply because they predict the time it takes to recognise the two component words: FREQ and RE were the measures found to be the best predictors for the visual lexical decision task. In this task, however, partial correlations do not reveal that any measure accounts for more of the RT variance.

However, it is clear that the predictive value of measures for the NONSENSE items does not simply reflect the activity of lower-level processes of recognition. If this was the case, we would expect the same pattern of results for both SENSE and NONSENSE pairs: the same variables would be predictive. The different patterns of correlation suggest that a different process is at work for these nonsense examples, one in which an interpretation is being sought without success.

It is notable that the correlations with MEANRT for measures of Frequency and RE for NONSENSE items are the reverse of those found in Experiment 1 and with the SENSE items in Experiment 2. It implies that words that are quickly recognised are slower to be rejected as potential members of a combination that makes sense.[10].

In addition, the pattern of correlation for NONSENSE items seems to indicate that the modifier is playing the primary role in the interpretation process: rejection of the item is slower the more frequent or polysemous the modifier noun is, or the less the range of contexts it appears in is constrained. Basically, it seems, where the modifier can take a variety of different interpretations, or can occur within a wide variety of contexts, it takes longer to reject the *combination* as plausible.

The work of Gagne and Shoben (1997) also indicated the importance of the modifier in affecting interpretation speed for noun-noun combinations: if the relationship type required to interpret the combination was implausible (i.e. infrequent) for the modifying noun, this slowed RT significantly. In other words, when the modifier appears in an unusual context, interpretation of the combination is slower. In our Experiment 2, we see that when the modifier can occur in a wide range of contexts, rejection of the com-

[10]POLY1 and POLY2 have opposite correlations with MEAN RT for SENSE items; thus MEANPOLY has a correlation of r=.0148, p=0.921

bination as nonsense is slower: presumably, there are a range of different relationship possibilities that have to be checked for.

The fact that POLY1 and MEANPOLY are both significant predictors for this portion of the data perhaps indicates that semantic access is more important here than it is for visual lexical decision, or for interpretation of SENSE combinations: the words are being reinterpreted in order to try and make sense of the combination. Although all the predictive measures are highly intercorrelated, the partial correlation patterns suggest that the POLY variables are accounting for a significant component of RT variability, independently of FREQ1 or RE1. Nevertheless, it should be noted that although the correlation between MEANRT and FREQ1 falls below significance when the POLY variables are taken into account, it still tends towards significance.

6.6 Conclusions

Research Contribution

This chapter investigated uses of corpus-derived statistical measures. Two approaches using co-occurrence vectors were examined: the use of such vectors to define similarities between words, displayed in terms of hierarchical clustering; and the use of such vectors to produce a measure of the entropy of word distribution, which was found to be predictive of subjects' response time in certain psycholinguistic tasks.

Quantitative analysis of corpus material is complimentary to qualitative analysis: objective measurements of distribution allow for the structure of language to be characterised without recourse to intuitive notions. The corpus can be used to measure aspects of a word's distribution, taking into account all the different patterns in which it occurs, and all occurrences of the word: individual examples do not have to be analysed by hand.

The clustering approach produces some interesting groups of semantically related adjectives and nouns from simple statistical data. It is an interesting finding that such an approach can be used to produce groups of words that are related in an extremely precise way, such as clusters of colour adjectives. It appears that the meaning of a word constrains its patterns of co-occurrence very closely. However, the clustering method is not precise enough to conclude what, precisely, the relationships between or within the groups are: they simply indicate the words are similar. Nevertheless, the co-occurrence data can be used to produce measures that characterise a word's pattern of distribution in precise numerical terms: the experiments undertaken in this chapter showed that one such measure is predictive of processing speed in certain psycholinguistic tasks.

It is well established that frequency predicts recognition speed for individual words. We examined a novel corpus-derived statistical measure, relative entropy (RE), which accounts for a greater portion of the RT variance than frequency. The predictive value of RE was explained in terms of an interactive activation model of word recognition in which the threshold for recognition for words that occurred in a wide variety of contexts was set to be lower than for words that occurred in a narrow range of contexts. This would be a sensible strategy for constraining word recognition: well-established perceptual evidence should be required for the recognition of a word outwith its normal contexts of occurrence.

We also found that both frequency and RE measures predicted the speed with which noun-noun combinations were interpreted. For combinations that made sense, the predictive value of the measures could be due to their predictive value for word recognition. However, for nonsense pairs, it was found that measures of frequency, RE, and polysemy for the first word were all predictive: this suggested, in accordance with other experiments on the time course of complex concept interpretation, that where a combination cannot be easily interpreted, the modifier is reinterpreted in order to try and find a method of combining the two word's meanings.

Chapter 7

Final Conclusions

7.1 Research Contribution

The models of complex concepts presented in this thesis were developed on the basis of a data-intensive approach: examination of a large number of examples of combination for specific words was used to drive the construction of representational theories that can cope with the wide range of types of combination that are found in real world language.

The use of corpus data in itself is not novel; however, in its use of an extremely large corpus sample, the thesis goes beyond previous work, allowing for the combinations entered into by specific words and groups of words to be examined in close detail. While such an approach is bound to be somewhat "noisy", cutting across the different uses of words as it does, the specificity of it is its strength: the large sample size means that intuitively non-obvious uses of words are brought to light: types of combinatorial regularities that might otherwise be obscured become apparent. The thesis contains many specific models that are shaped by the actual patterns of use for adjectives and nouns.

Chapter 2 presented models for groups of modifiers that operate on particular slots. Specific patterns that were observed included the use of adjectives to indicate the shape of cross-sections of three dimensional objects, and subparts of objects; the regularity with which particular types of modifying noun indicate COLOUR properties; and the more complex types of analogies required to interpret modifying nouns indicating size. A model for SIZE adjectives, in which the modifier operated on the head noun to carry out systematic property alterations, was described. This model does not require the adjective to be defined in terms of its comparative form: because of this, it also does not suffer from problems intrinsic to other formal "statistical" approaches.

Chapter 3 extended Pustejovsky's model of adjectival polysemy, in which seemingly different uses of *fast* were explained in general terms, as the adjective being an event predicate, operating on the TELIC slot. Although Pustejovsky describes a mechanism of selective binding, he does not actually apply it to adjective uses (other than *good knife*): the corpus study showed that uses of *fast* in which it operated on AGENTIVE were also common: a mechanism which allowed for these particular slots alone to be operated on was given. A connection was made between the work of Pustejovsky and that of Siegel (1980): a reinterpretation of Siegel's analysis suggested that the "doublet" uses of adjectives she found arose because these adjectives may operate both as formal and event predicates. This explains many classic cases of ambiguity in complex concepts. Both formal and event readings were found for the adjectives *clever* and *competent*. In addition, Chapter 3 discussed another pattern of adjectival polysemy, arising from metonymic uses of particular adjectives. The uses of emotion adjectives were investigated: clear, systematic patterns of use were found, and a model of how these metonymic effects could be generated was given. This chapter demonstrates well that, by taking a step back from the combinatorial effects specific to particular cases, and looking at the broad picture of combinatorial patterns, models which account for the general patterns of modifier operation can be developed.

In Chapter 4 it was found that many of the adjectives involved in privative combinations also had uses in which they were non-privative. Models of particular adjectives were given: the operations carried out were specific types of property mapping on the AGENTIVE slot of the head noun; these could account for both privative and non-privative uses of the words, unlike models that take privation as a process involved in semantic composition (Franks (1995)). It was argued that the privative effect arises instead from post-combinatorial processes of deduction (such as extensional feedback); the attribution of privation to a combination depends on deciding where the boundary of a category lies, but this is not something that can always be decided objectively.

Chapter 5 investigated patterns of noun-noun combination. Some striking biases in the use of particular nouns were found, such as the very high frequency with which mass nouns are used as modifiers to specify composition. The large scale analysis of combinations that was carried out revealed that the strategy used for interpretation was very rarely property mapping: in almost all cases, a thematic relation links the head and modifier. Thematic relations were modelled in terms of the modifier specifying the type of an argument of the head noun: this allows for the precise nature of the relationship to be found in some cases (e.g. where the argument is found in TELIC or AGENTIVE, unlike systems in which there are only a small set of highly ambiguous relationship predicates. Certain types of words do frequently enter combinations for

which property mapping is the appropriate strategy, as was demonstrated in Chapter 2. However, it was suggested that, for combinations in which the head noun refers to animate objects, property mapping might be more appropriate as a strategy for naming (i.e. christening the species), rather than a method of interpretation: the mapping motivates the combination name, but the properties mapped cannot always be deduced (it is unclear how systematic such mapping patterns are).

Chapter 6 presented quantitative analyses of corpus material, which provided an alternative way of investigating constraints on word combination. Clustering studies on adjectives and nouns revealed that small scale patterns of semantically related words within the word classes could easily be found: co-occurrence data in some sense measures the meaning of words. A statistical measure, relative entropy, calculated using co-occurrence data, was found to be predictive for response time in a word recognition task, as well as in a task of complex concept interpretation.

7.2 Further Research

The use of corpus data allows examples of any combination involving particular words, either as modifier or head, to be studied in close detail. Naturally, the lower the frequency of the modifier, the larger the sample will have to be in order to find a variety of examples for low frequency words (or uncommon uses of words).

There is thus a vast amount of material that could be used as the basis for further research in this field. Besides close analysis of specific adjectives similar in type to those discussed in the thesis, there are classes of adjectives which this thesis does not analyse at all. For example: there are non-predicating adjectives such as *sheer, utter, total* which seem to suggest degree of category membership (i.e. whether the referent is a good or bad example of the head noun category); there are a range of denominal adjectives (studied by Levi (1978) and Warren (1978)) which seem to act like nouns, specifying argument types for the head noun; there are various classes of deverbal adjectives (e.g. *burnt, burning*) which were not considered in close detail. In addition, there is great scope for looking at the types of combination entered into by specific types of nouns: teleological, event, informational, animate, bodypart, mass, and other types of nouns.

Corpus data could also be used to investigate the semantic operation of adjectives in positions other than that of attributive modifier. Adjectives are frequently found in postmodifying positions (see Bolinger (1967)) and predicate position (see Levi (1978)); it seems that occurrence of an adjective after the head noun limits the number of readings possible for the adjective, but also allows for further arguments to be added

(qualifying the circumstances in which the quality is applicable). Adjectives also occur postnominally after various copulae (e.g. *seem, become, was*). All these will have to be modelled in any comprehensive theory of the semantics of noun modification. In addition, modifiers can occur in strings: adjectives may be affected by the role of other modifiers (e.g. a *tall Brobdingnagian man* might be a tall man who happens to be Brobdingnagian, if the two modifiers operate independently on the head noun; however, the phrase could also indicate someone tall "for a Brobdingnagian man", such men being much larger than the norm for men; see Beesley (1982)). Nouns also can occur in such strings; parts of the modifying string may themselves first need to be interpreted as complex concepts. Thus, methods are needed to parse such strings of modifiers.

Finally, the application of corpus-derived statistical measurement as predictors of psycholinguistic performance is a broad field which is practically unexplored, the exception being the validity of word frequency as a predictor in word processing tasks. As very large corpora of real-world language material and powerful computing resources become more widely available, a natural avenue for investigation is how the global structure of language affects its processing on a local (i.e. case specific) basis. Rather than relying on measures generated from subjects' introspective descriptions of word meaning or assessments of word association strengths, the ability to use mathematical techniques allows for standardised, replicable objective measurements of language characteristics.

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Appendix A

Word Lists for Clustering

Adjectives

The set of 172 adjectives used in the clustering studies (Section 6.2) was: *able, actual, afraid, alright, american, appropriate, available, aware, awful, back, bad, basic, beautiful, best, better, big, bigger, black, bloody, blue, bottom, brilliant, british, busy, careful, central, certain, cheap, clear, close, cold, common, concerned, correct, current, dead, dear, different, difficult, double, early, easier, easy, economic, english, european, excellent, existing, expensive, extra, fair, final, financial, fine, free, french, front, fucking, full, funny, further, future, general, glad, good, great, greater, green, happy, hard, heavy, high, higher, honest, horrible, hot, human, important, individual, interested, interesting, involved, labour, large, late, left, level, light, like, likely, little, local, long, lovely, low, lucky, main, major, married, middle, modern, national, necessary, new, nice, normal, odd, okay, old, older, only, open, ordinary, other, particular, past, personal, pleased, political, poor, positive, possible, present, previous, private, proper, public, quick, quiet, ready, real, reasonable, red, regional, right, round, serious, short, sick, silly, similar, simple, single, small, social, sorry, special, specific, strong, stupid, supposed, sure, terrible, top, total, true, used, useful, various, warm, wee, well, white, whole, wide, wonderful, working, worried, worse, wrong, yellow, young*

Nouns

The set of 555 nouns used in the clustering studies (Section 6.2) was: *access, account, act, action, advice, afternoon, age, air, amendment, america, amount, ann, answer, application, approach, area, areas, argument, attention, authorities, authority, b, baby, back, bag, ball, bank, bar, basis, bath, bed, bedroom, beginning, benefit, benefits, bill, birthday, bit, bits, bloke, blood, board, boat, body, book, books, bottle, bottom, box, boy, boys, bread, brian, britain, brother, budget, building, bus, business, c, cake, call, car, card, cards, care, cars, case, cases, cat, centre, chair, chairman, chance, change, changes, chap, charge, child, children, choice, chris, christ, christmas, church, circumstances, city, class, client, clothes, club, coal, coat, coffee, colleagues, college, colour, comment, comments, committee, community, companies, company, computer, conditions, conference, congress, contract, control, conversation, copy, corner, cost, costs, council, councillor, countries, country, county, couple, course, court, cup, dad, daddy, darling, data, date, daughter, dave, david, day, days, deal, death, debate, decision, department, development, difference, dinner, discussion, district, division, doctor, dog, door, drink, e, earth, east, education, effect, employment, end, england, environment, europe, evening, evidence, example, experience, extent, eye, eyes, face, fact, family, father, feeling, feet, field, figure, figures, film,*

fire, fish, flats, floor, food, foot, football, form, fox, friday, friend, friends, front, function, fund, future, game, garden, gas, george, girl, girls, go, god, government, greater, greenbelt, ground, group, groups, guy, hair, half, hall, hand, hands, head, health, heart, hell, help, hill, history, holiday, home, homes, horse, horses, hospital, hour, hours, house, houses, housing, husband, idea, ideas, income, increase, industry, information, insurance, interest, investment, issue, issues, item, james, jane, jean, jesus, jim, job, jobs, john, june, kids, kind, kitchen, labour, lady, land, lane, language, law, leg, legs, letter, letters, level, life, light, lights, line, lines, list, load, loads, london, look, lord, lot, love, lunch, machine, majority, man, management, manager, mark, market, marks, martin, mary, mate, matter, matters, may, means, meeting, meetings, member, members, men, michael, middle, miles, milk, mind, minister, minute, minutes, miss, moment, monday, money, month, months, morning, mother, motion, mr, mrs, mum, mummy, music, name, names, nature, need, needs, news, night, north, note, nottingham, number, numbers, office, officer, officers, operation, opportunity, order, others, oxford, p, page, pair, paper, papers, paragraph, pardon, parents, park, part, parts, party, past, paul, pay, pence, pension, people, per cent, percent, period, person, peter, phone, picture, piece, pieces, place, places, plan, planning, plans, play, point, points, police, policies, policy, position, post, pound, pounds, power, practice, president, press, pressure, price, prices, problem, problems, process, product, production, programme, project, provision, quality, quarter, question, questions, quid, radio, range, rate, rates, reason, reasons, record, region, relationship, report, reports, research, resources, responsibility, rest, result, richard, right, ring, road, role, room, rubbish, s, safety, sales, saturday, saying, scale, scheme, school, schools, second, secretary, section, sector, security, sense, service, services, set, settlement, sex, sheet, shit, shoes, shop, shops, show, side, sir, sister, site, sites, situation, size, society, son, sort, sorts, south, space, staff, stage, start, state, statement, states, station, steve, story, street, structure, stuff, subject, summer, sun, sunday, support, system, table, talk, tape, tax, tea, teacher, teachers, team, telephone, television, term, terms, test, thanks, thing, things, thursday, time, times, tony, top, town, trade, traffic, train, training, transport, tree, trouble, truth, tuesday, turn, type, union, unit, united, university, use, value, video, view, village, voice, wall, war, water, way, ways, weather, wednesday, week, weekend, weeks, weight, west, while, whole, wife, window, windows, woman, women, wood, word, words, work, workers, world, year, years, york, yorkshire

2000 Frequent Words

The set of 2000 frequent words[1] used in the clustering studies (Section 6.2) was: *'d, 'em, 'll, 'm, 're, 's, 've, a, a bit, a few, a little, a little bit, a lot, ability, able, about, above, absolute, absolutely, accept, accepted, access, accident, according to, account, accounts, achieve, acid, across, act, action, activity, actual, actually, add, additional, address, admit, advance, advantage, advertising, advice, affect, afford, afraid, after, afternoon, afterwards, again, against, age, agenda, ages, ago, agree, agreed, agreement, agricultural, ah, aha, ahead, ai, aid, air, alan, all, all right, allow, allowed, almost, alone, along, already, alright, also, alternative, although, altogether, always, am, amendment, america, american, amount, an, and, and so on, andrew, andy, animals, ann, annual, another, answer, answers, any, anybody, anyone, anything, anyway, anywhere, apart from, apparently, appear, application, apply, appointment, approach, appropriate, april, are, area, areas, argument, arm, army, around, art, as, as far as, as if, as it were, as long as, as soon as, as though, as to, as well, as well as, ask, asked, asking, association, assume, at, at all, at least, attack, attention, attitude, authorities, authority, available, average, aware, away, away from, awful, aye, b, baby, back, background, bad, bag, bags,*

[1]Note that certain of these items are not "words" as such: this is simply due to the encoding used in the original corpus.

balance, ball, bank, bar, base, based, basic, basically, basis, bath, bathroom, be, bear, bearing, beat, beautiful, became, because, because of, become, becomes, bed, bedroom, been, before, begin, beginning, behaviour, behind, being, believe, below, ben, benefit, benefits, best, bet, better, between, beyond, bid, big, bigger, biggest, bike, bill, birmingham, birthday, bit, bits, black, blind, bloke, blood, bloody, blow, blue, board, boat, bob, body, book, books, boring, born, borrow, both, bother, bothered, bottle, bottom, bought, box, boxes, boy, boys, branch, bread, break, breakfast, brian, bridge, brilliant, bring, bringing, britain, british, broke, broken, brother, brought, brown, budget, build, building, built, bus, business, busy, but, button, buy, buying, by, bye, c, ca, cake, call, called, calling, calls, came, campaign, can, capital, car, card, cards, care, careful, carefully, carpet, carried, carry, carrying, cars, case, cases, cash, cat, catch, caught, cause, central, centre, century, certain, certainly, chair, chairman, chance, change, changed, changes, changing, chap, character, charge, charlotte, cheap, cheaper, check, cheese, cheque, chicken, chief, child, children, chips, chocolate, choice, choose, chris, christ, christmas, christopher, church, circumstances, city, claim, class, clean, clear, clearly, clever, client, close, closed, clothes, club, coal, coat, coffee, cold, colin, colleagues, collect, college, colour, colours, come, comes, coming, comment, comments, commission, committed, committee, common, community, companies, company, compared, competition, complete, completely, computer, concern, concerned, conditions, conference, congress, conservative, consider, consideration, considered, consultation, contact, context, continue, contract, control, conversation, cook, cope, copy, cor, corner, correct, cos, cost, costs, could, council, councillor, councils, count, countries, country, countryside, county, couple, course, courses, court, cover, covered, crap, cream, create, credit, crime, criteria, cross, cup, cupboard, current, cut, cutting, d, d', da, dad, daddy, damage, damn, dangerous, dark, darling, data, date, daughter, dave, david, day, days, dead, deal, dealing, dear, death, debate, december, decide, decided, decision, decisions, dee, deep, defence, definitely, degree, degrees, demand, department, depends, design, detail, details, develop, developed, development, did, die, died, difference, different, difficult, difficulty, dinner, direct, direction, director, dirty, discuss, discussion, distance, district, division, do, doctor, doctors, document, does, dog, dogs, doing, done, doo, door, doors, double, doubt, down, downstairs, draw, drawing, dress, drink, drive, driver, driving, drop, dropped, dry, du, due, during, duty, e, each, each other, earlier, early, earth, easier, easily, east, easy, eat, eating, economic, economy, edge, education, ee, effect, effective, effectively, effects, effort, egg, eggs, eh, eight, eighteen, eighty, either, election, electricity, element, eleven, else, emma, employment, empty, end, energy, engine, england, english, enjoy, enjoyed, enormous, enough, ensure, entirely, environment, environmental, equal, equals, equipment, er, erm, especially, estate, etcetera, europe, european, even, even if, even though, evening, eventually, ever, ever so, every, everybody, everyone, everything, everywhere, evidence, exactly, exam, example, excellent, except, excuse, executive, exercise, existing, expect, expected, expensive, experience, explain, extent, extra, extremely, eye, eyes, f, face, facilities, fact, factors, factory, fair, fairly, faith, fall, families, family, fancy, far, farm, fast, fat, father, fault, favour, february, feed, feel, feeling, feet, fell, felt, few, field, fifteen, fifth, fifty, fight, figure, figures, file, fill, film, final, finally, financial, find, finding, fine, fingers, finish, finished, fire, firm, first, fish, fit, five, fixed, flat, flats, floor, flowers, follow, following, food, foot, football, for, for example, for instance, force, forget, forgot, forgotten, form, forms, fortnight, forty, forward, found, four, fourteen, fourth, fox, france, free, french, freud, friday, friend, friends, from, front, fruit, fuck, fucking, full, fully, fun, function, fund, funding, funny, furniture, further, future, g, game, games, garage, garden, gary, gas, gave, general, generally, gentleman, geoff, george, german, germany, get, gets, getting, girl, girls, give, given, gives, giving, glad, glass, glasses, go, goal, god, goes, going, gold, gon, gone, good, goodness, goods, got, government, grand, grant, grass, great, greater, green, greenbelt, ground, group, groups, grow, growing, growth, guess, guy, h, ha, had, hair, half, hall, hand, handle, hands, hang, happen, happened, happening, happens, happy, hard, hardly, harlow, harrogate, has, hat, hate, have, having, he, head, health, hear,

heard, heart, heat, heavy, held, hell, hello, help, helped, helpful, helping, her, here, herself, hey, hi, high, higher, hill, him, himself, his, history, hit, hm, hmm, hold, holding, hole, holiday, holidays, home, homes, honest, honestly, honourable, hope, hopefully, hoping, horrible, horse, horses, hospital, hot, hotel, hour, hours, house, houses, housing, how, however, huge, human, hundred, hurt, husband, i, ian, idea, ideas, if, ill, imagine, immediately, impact, important, improve, in, in case,. in front of, in order, in particular, in terms of, include, including, income, increase, increased, increasing, indeed, independent, individual, individuals, industrial, industry, information, inside, instead of, insurance, int, interest, interested, interesting, international, interview, into, investment, involved, iron, is, issue, issues, it, item, items, its, itself, jack, james, jane, january, jean, jenny, jesus, jim, job, jobs, joe, john, join, joined, joint, jonathan, july, jump, june, just, k, keen, keep, keeping, keeps, ken, kept, key, kick, kids, kill, killed, kind, kind of, king, kitchen, knew, knock, knocked, know, knowing, knowledge, known, knows, l, la, labour, lad, ladies, lads, lady, land, lane, language, large, last, late, later, laugh, law, lay, lead, leader, league, learn, learning, leave, leaves, leaving, leeds, left, leg, legal, legislation, legs, length, less, let, let's, letter, letters, level, levels, library, life, lift, light, lights, like, liked, likely, likes, limited, line, lines, list, listen, listening, little, live, lived, liverpool, lives, living, load, loads, local, lock, london, long, longer, look, looked, looking, looks, lord, lose, loss, lost, lot, lots, love, lovely, low, lower, lucky, lunch, m, machine, mad, made, main, mainly, major, majority, make, makes, making, male, man, manage, managed, management, manager, many, march, margaret, mark, market, marks, married, martin, marvellous, mary, massive, match, mate, material, maths, matter, matters, may, maybe, mayor, me, meal, mean, means, meant, measure, meat, medical, meet, meeting, meetings, member, members, membership, memory, men, mention, mentioned, mess, message, met, metal, mhm, michael, middle, might, mike, mile, miles, milk, million, mind, mine, minimum, minister, minus, minute, minutes, miss, missed, mistake, mixed, mm, model, modern, moment, monday, money, month, months, more, more than, morning, mortgage, most, mother, motion, mouth, move, moved, movement, moving, mr, mrs, much, mum, mummy, music, must, my, myself, n, n't, na, name, names, national, natural, nature, near, nearly, necessarily, necessary, neck, need, needed, needs, negative, neil, never, new, news, next, next to, nice, nick, night, nil, nine, nineteen, ninety, no, no one, nobody, noise, none, normal, normally, north, northern, nose, not, note, notes, nothing, notice, noticed, nottingham, nought, november, now, now that, number, numbers, o, o'clock, obvious, obviously, october, odd, of, of course, off, offer, offered, office, officer, officers, often, oh, oil, okay, old, older, on, on to, on top of, once, one, ones, only, onto, ooh, open, opened, opening, operation, opinion, opportunity, opposite, option, or, orange, order, ordinary, organization, original, other, others, otherwise, ought, our, ours, ourselves, out, out of, outside, over, over here, over there, overall, own, oxford, p, pack, page, pages, paid, pain, paint, pair, panel, paper, papers, paragraph, pardon, parents, parish, park, parliament, part, particular, particularly, parties, parts, party, pass, passed, past, patients, pattern, paul, pay, paying, peasants, pen, pence, penny, pension, people, per, per cent, percent, perfectly, performance, perhaps, period, person, personal, personally, peter, petrol, phil, phone, phoned, pick, picked, picking, picture, pictures, piece, pieces, pink, place, places, plan, planning, plans, plant, play, played, playing, please, pleased, plenty, plus, pocket, point, points, police, policies, policy, political, poor, pop, population, position, positive, possibility, possible, possibly, post, potatoes, potential, pound, pounds, power, practice, prefer, prepared, present, president, press, pressure, presumably, pretty, previous, price, prices, primary, prime, principle, private, probably, problem, problems, procedure, procedures, process, produce, produced, product, production, products, professional, profit, programme, project, proper, properly, property, proposal, proposals, proposed, protection, provide, provided, providing, provision, pub, public, pull, pulled, purpose, push, put, puts, putting, q, quality, quarter, queen, question, questions, quick, quickly, quid, quiet, quite, quote, r, race, radio, railway, rain, raise, raised, ran, rang, range, rate, rates, rather, rather than, reach, read, reading, ready, real, realize, really,

reason, reasonable, reasons, receive, received, recent, recently, reckon, record, recording, red, reduced, reduction, refer, reference, referred, region, regional, regular, related, relationship, relevant, relief, remember, remind, rent, report, reports, required, research, resolution, resources, respect, response, responsibility, responsible, rest, result, results, return, review, rich, richard, rid, right, rights, ring, rise, risk, river, road, roads, robert, role, roll, roof, room, rough, round, route, row, royal, rubbish, rule, rules, run, running, runs, s, sad, safe, safety, said, sake, sale, sales, same, sarah, sat, saturday, save, saved, savings, saw, say, saying, says, scale, scheme, schemes, school, schools, science, score, scotland, sea, season, seat, second, secretary, section, sector, security, see, seeing, seem, seemed, seems, seen, self, sell, selling, send, sense, sent, sentence, separate, september, series, serious, seriously, service, services, set, setting, settlement, seven, seventeen, seventy, several, sex, shall, shame, share, she, sheep, sheet, shh, shift, shit, shoes, shop, shopping, shops, short, shot, should, show, showed, showing, shown, shows, shut, sick, side, sides, sign, significant, silly, similar, simon, simple, simply, since, sing, singing, single, sir, sister, sit, site, sites, sitting, situation, six, sixteen, sixth, sixty, size, skills, skin, sleep, slightly, slow, small, smaller, smell, smoke, so, so that, social, society, sold, some, somebody, somehow, someone, something, sometimes, somewhere, son, song, soon, sorry, sort, sort of, sorted, sorts, sound, sounds, south, space, spare, speak, speaker, speaking, special, specific, speech, speed, spell, spend, spending, spent, spirit, split, spoke, square, squared, staff, stage, stairs, stand, standard, standards, standing, start, started, starting, starts, state, statement, states, station, stay, stayed, staying, step, steve, stick, still, stock, stone, stood, stop, stopped, stories, story, straight, strange, strategic, strategy, street, strike, strong, structure, stuck, students, study, stuff, stupid, style, subject, success, successful, such, such as, suddenly, sue, sugar, suggest, suggested, suit, sum, summer, sun, sunday, supply, support, suppose, supposed, sure, surely, surprised, survey, sweet, swimming, switch, system, systems, t, ta, table, take, taken, takes, taking, talk, talked, talking, talks, tape, tapes, tax, tea, teacher, teachers, teaching, team, technical, technology, teeth, telephone, television, tell, telling, tells, telly, ten, tend, term, terms, terrible, terry, test, than, thank, thanks, that, the, theatre, their, them, themselves, then, theory, there, therefore, these, they, thick, thing, things, think, thinking, thinks, third, thirteen, thirty, this, those, though, thought, thousand, thousands, three, through, throughout, throw, thursday, tickets, tie, till, tim, time, times, tiny, tired, to, today, together, toilet, told, tom, tomorrow, tonight, tony, too, took, top, tory, total, totally, touch, towards, town, track, trade, traffic, train, training, transport, travel, treatment, tree, trees, tremendous, tried, trouble, trousers, true, trust, truth, try, trying, tt, tuesday, turn, turned, turning, twelve, twenty, twice, two, type, types, u, under, underneath, understand, understanding, unemployment, unfortunately, union, unions, unit, united, units, university, unless, until, up, up to, upon, upset, upstairs, urgh, us, use, used, useful, using, usually, v, value, van, various, very, video, view, views, village, visit, voice, voluntary, vote, w, wages, wait, waiting, wales, walk, walked, walking, wall, wan, want, wanted, wanting, wants, war, warm, was, wash, washing, waste, watch, watched, watching, water, way, ways, we, wear, wearing, weather, wedding, wednesday, wee, week, weekend, weeks, weight, welcome, well, went, were, west, wet, what, whatever, when, where, whereas, wherever, whether, which, while, whilst, white, who, whole, whose, why, wide, wife, will, win, wind, window, windows, wine, winter, wish, with, within, without, wo, woman, women, won, wonder, wondered, wonderful, wood, word, words, work, worked, workers, working, works, world, worried, worry, worse, worst, worth, would, write, writing, written, wrong, wrote, x, y, y'know, ya, yeah, year, years, yellow, yep, yes, yesterday, yet, york, yorkshire, you, young, younger, your, yours, yourself, zero

Appendix B

Experiment 1: Lists and Values

Words and Non-Words

Words for Visual Lexical Decision
about, accept, across, after, army, away, back, before, being, bill, black, blue, both, button, call, century, chance, chicken, clothes, coffee, collect, come, company, corner, days, death, door, down, effort, enough, ever, exactly, face, fault, first, floor, forty, four, from, full, garden, general, good, grand, green, hall, hand, have, head, heart, herself, hill, himself, hotel, into, iron, just, kind, large, lead, lift, like, look, lord, machine, main, memory, mind, moment, morning, mother, neck, need, neither, never, next, office, once, only, onto, ought, outside, over, paper, peace, penny, play, pocket, post, private, railway, rather, ready, refer, remind, right, roof, room, round, save, school, season, second, side, smell, some, sorry, stage, station, stone, street, such, summer, surely, tell, term, than, that, theatre, their, there, these, think, this, thought, three, through, time, towards, turn, twenty, under, until, when, where, whether, which, while, wife, will, willing, wind, winter, wire, with, woman, write, wrong, young, your, brush, comic, deserve, elbow, fumble, instead, lounge, merely, might, piano, rugby, scarf, shade, stroke, worthy
Non-Words for Visual Lexical Decision
prost, antent, accort, inder, alde, tran, visk, beften, brild, salm, flich, prum, nowl, colton, neel, dentirt, prange, crichet, crochen, cortem, corrent, mide, corpare, sarder, dess, leask, cear, lawp, leport, plouge, trem, erandly, hich, frime, flish, clore, fonge, falt, trid, flep, washen, glacral, gren, prent, griel, tark, hort, mide, dern, slarp, harsest, dorl, hamseer, fower, ilon, inem, jark, krit, nidge, purd, drit, rabe, woal, farp, macried, dard, pelony, mard, talert, mauting, motent, lerf, brem, blitter, tivet, puct, ofaque, alch, ouce, oron, orgal, oubline, opad, pason, teant, fincy, cham, porrot, wask, cricane, radicay, ratble, refle, gewel, ravins, piche, poal, meon, boald, jarn, schedem, wedpon, sermod, dilk, slemp, dape, mongy, scine, staggen, smang, spreng, pume, lumben, sinery, mern, nard, trep, brap, theaper, crear, thant, tharp, shalk, trid, thouble, treep, throfty, fabe, tornads, corg, twelde, ulger, urtan, shap, chade, whasker, whock, trisp, sike, woff, calting, sant, woaver, pame, dist, tolar, blime, trolk, yodem, bont, crunk, patic, dessere, elden, tabble, instact, poulce, muriny, minch, blant, ragio, clerf, snige, strenk, worble

Table B.1: Words and Nonwords used in Visual Lexical Decision

Values for Measures

Variable	Mean	Std. Dev	Minimum	Maximum
RE	.61	.41	.05	2.40
FREQ	3.32	.74	1.56	5.35
POLY	6.49	4.62	1.00	29.00

Table B.2: Descriptive Statistics for Experiment 1

Table B.3: Measures for Words Used in Experiment 1

Word	FREQ value	POLY value	RE value
about	4.55	7	0.27
accept	3.19	8	0.58
across	3.32	3	0.49
after	3.84	10	0.30
army	2.69	4	0.69
away	3.69	4	0.46
back	4.21	5	0.31
before	3.90	2	0.21
being	2.52	4	0.74
bill	3.16	5	0.38
black	3.24	14	0.99
blue	3.04	6	0.83
both	3.49	1	0.24
button	2.66	5	1.17
call	3.88	16	0.28
century	2.68	3	1.10
chance	3.13	7	0.52
chicken	2.73	4	0.70
clothes	2.77	2	0.76
coffee	2.98	3	1.20
collect	2.85	6	0.53
come	4.50	14	0.26
company	3.38	6	0.38
corner	2.98	10	0.66
death	2.82	6	0.75
door	3.49	2	0.81
down	4.23	14	0.38
effort	2.70	4	0.91
enough	3.58	3	0.42
ever	3.46	6	0.42
exactly	3.32	3	0.29
face	3.30	8	0.48
fault	2.67	7	0.60
first	4.00	5	0.25
floor	3.02	7	0.59

Table B.3: Measures for Words Used in Experiment 1

forty	3.61	4	1.48
four	4.09	7	1.16
from	4.35	11	0.20
full	3.34	12	0.47
garden	3.04	8	0.56
general	3.24	10	0.68
good	4.33	14	0.29
grand	2.56	8	0.77
green	3.11	10	0.87
hall	2.93	7	0.73
hand	3.55	16	0.45
have	5.25	14	0.08
head	3.38	23	0.43
heart	2.82	9	0.51
herself	2.59	2	0.58
hill	2.81	3	0.87
himself	2.95	3	0.40
hotel	2.67	2	0.60
into	4.04	4	0.33
iron	2.68	9	0.59
just	4.60	4	0.11
kind	3.50	4	0.47
large	3.20	4	0.86
lead	3.12	12	0.50
lift	2.77	14	0.71
like	4.59	3	0.13
look	4.36	12	0.18
lord	3.26	6	1.13
machine	3.09	4	0.39
main	3.17	2	0.70
memory	2.74	8	0.63
mind	3.66	8	0.30
moment	3.49	5	0.18
morning	3.69	4	0.64
mother	3.31	6	0.56
neck	2.55	8	0.93
need	4.07	3	0.21
neither	2.48	2	0.70
never	3.86	3	0.40
next	3.79	2	0.60
office	3.30	13	0.51
once	3.40	4	0.37
only	4.14	4	0.16
onto	2.99	1	0.58
ought	3.11	4	0.47
outside	3.24	8	0.40
over	4.01	12	0.27
paper	3.48	10	0.48
peace	2.50	4	0.98

Table B.3: Measures for Words Used in Experiment 1

penny	3.05	4	1.13
play	3.68	20	0.42
pocket	2.63	8	0.90
post	3.01	4	0.74
private	2.86	7	0.80
railway	2.66	4	0.79
rather	3.34	5	0.30
ready	3.14	9	0.51
refer	2.52	10	1.19
remind	2.78	2	0.59
right	4.54	8	0.15
roof	2.60	4	0.88
room	3.44	4	0.48
round	3.86	13	0.38
save	3.20	7	0.47
school	3.76	9	0.42
season	2.63	10	0.71
second	3.56	10	0.60
side	3.64	12	0.55
smell	2.80	9	0.76
some	4.31	5	0.17
sorry	3.65	4	0.32
stage	3.17	6	0.39
station	3.06	8	1.03
stone	2.78	8	0.84
street	3.22	2	0.74
such	3.36	5	0.37
summer	2.86	6	0.61
surely	2.81	3	0.35
tell	4.09	11	0.21
term	3.28	12	0.73
than	3.85	2	0.67
that	5.35	7	0.05
theatre	2.62	6	0.74
their	4.12	3	0.26
there	4.86	5	0.11
these	4.12	4	0.14
think	4.72	10	0.09
this	4.77	4	0.10
thought	2.84	8	0.49
three	4.25	5	0.93
through	3.90	5	0.28
time	4.35	19	0.17
towards	3.11	4	0.54
turn	3.63	29	0.46
twenty	3.99	4	1.30
under	3.45	8	0.34
until	3.35	1	0.45
when	4.46	3	0.16

Table B.3: Measures for Words Used in Experiment 1

where	4.20	4	0.17
whether	3.63	1	0.44
which	4.36	1	0.20
while	3.40	3	0.37
wife	3.08	3	0.46
will	4.96	6	0.06
willing	2.45	2	1.01
wind	2.85	6	0.63
winter	2.62	5	0.83
wire	2.50	3	0.96
with	4.66	14	0.17
woman	3.58	9	0.46
write	3.68	16	0.49
wrong	3.45	4	0.34
young	3.39	6	0.68
your	4.47	2	0.18
brush	2.44	4	0.84
comic	1.79	2	1.89
deserve	2.25	1	1.26
elbow	1.92	2	1.66
instead	2.41	2	0.67
lounge	2.21	2	1.24
merely	2.27	1	1.17
might	1.56	5	1.89
piano	2.21	1	1.05
rugby	2.31	1	1.42
scarf	1.76	1	2.40
shade	2.00	13	1.40
stroke	2.30	15	0.89
worthy	1.77	3	2.31

Appendix C

Experiment 2: Lists and Values

Variable	Mean	Std. Dev	Minimum	Maximum
RE1	.91	.32	.38	1.78
RE2	.90	.34	.42	1.71
MEANRE	.90	.20	.45	1.35
REDIFF	.02	.53	-1.25	1.12
FREQ1	6.15	.95	4.63473	8.54091
FREQ2	6.33	1.14	4.60517	9.03599
MEANFREQ	6.24	.72	4.95	8.52
FREQDIFF	-.18	1.52	-3.57	3.32
POLY1	4.86	3.56	1.00	18.00
POLY2	7.30	5.79	1.00	32.00
MEANPOLY	6.08	3.27	1.50	21.00
POLYDIFF	2.44	7.03	-15.00	30.00

Table C.1: Descriptive Statistics for Experiment 2

Word Pair	FREQ values	POLY values	RE values
bible study	5.31, 6.80	3, 10	1.30, 0.64
blood group	6.28, 8.16	7, 8	0.86, 0.56
bonus point	5.47, 9.04	2, 32	1.12, 0.62
bread knife	6.44, 5.49	3, 3	0.81, 0.99
chain store	5.72, 6.18	10, 5	0.92, 0.85
cloud cover	5.11, 7.56	7, 12	1.32, 0.48
court order	7.04, 7.53	6, 20	0.70, 0.54
crime scene	6.10, 5.57	4, 8	0.86, 1.01
dance music	6.44, 6.67	5, 5	0.59, 0.58
depot clerk	4.79, 5.44	3, 6	1.04, 1.40
diary entry	5.45, 5.29	2, 10	0.86, 1.20
drama class	4.71, 7.30	4, 8	1.41, 0.63
essay title	5.31, 5.49	2, 8	1.44, 0.90
field mouse	6.80, 5.35	14, 4	0.62, 1.00
flood water	5.21, 8.02	6, 10	1.10, 0.55
floor cloth	6.96, 5.06	7, 5	0.59, 1.26
fruit stall	5.91, 5.35	6, 7	0.88, 1.20
ghost story	4.63, 7.20	5, 6	1.78, 0.68
glass panel	6.76, 6.15	4, 5	0.61, 1.03
horse owner	7.04, 5.48	7, 2	0.41, 1.09
hotel lobby	6.16, 4.61	2, 4	0.60, 1.71
lunch break	6.61, 7.67	2, 29	0.69, 0.53
maths tutor	5.95, 5.11	1, 3	0.69, 1.50
metal fence	6.03, 5.60	5, 4	0.80, 0.96
motor trade	5.71, 7.41	4, 4	1.12, 1.51
night shift	8.54, 6.26	4, 7	0.60. 0.68
noise level	6.20, 7.81	4, 7	0.94, 0.66
paper money	8.00, 8.80	10, 4	0.48, 0.54
peace march	5.76, 6.36	4, 4	0.71, 1.66
phone cable	7.93, 4.61	1, 6	0.99, 1.35
photo album	5.29, 4.74	1, 2	0.98, 0.95
pilot error	4.73, 5.31	5, 4	1.32, 1.04
power input	7.37, 5.49	18, 5	0.62, 1.03
press agent	7.10, 5.91	15, 2	0.38, 0.73
price guide	7.59, 5.67	3, 10	0.65, 0.98
radio staff	6.73, 7.36	2, 3	0.73, 0.70
rugby match	5.33, 6.69	1, 4	1.42, 0.48
score sheet	6.52, 6.69	10, 6	0.74, 0.59
share index	7.18, 4.84	3, 9	0.79, 1.44
shelf space	5.24, 6.87	2, 7	1.19, 0.46
shirt front	5.68, 7.43	3, 14	1.14, 0.69
smoke alarm	6.71, 5.56	4, 3	0.50, 1.22
speed limit	6.39, 6.42	6, 4	0.80, 0.67
spray paint	4.93, 6.44	3, 2	1.33, 0.76
stair light	5.96, 7.67	3, 16	1.34, 0.51
steam train	5.11, 7.67	3, 7	1.12, 0.42
steel screw	5.42, 5.54	4, 14	1.33, 0.98
tower block	5.35, 6.40	2, 18	1.15, 0.63
voice coach	6.39, 5.49	6, 6	0.76, 0.87
watch strap	7.96, 4.74	5, 6	0.45, 1.37

Table C.2: Sense Combinations

Word Pair	FREQ values	POLY values	RE values
bible staff	5.31, 7.36	3, 3	1.30, 0.70
blood panel	6.28, 6.15	7, 5	0.86, 1.03
bonus store	5.47, 6.18	2, 5	1.12, 0.85
bread error	6.44, 5.31	3, 4	0.81, 1.04
chain tutor	5.72, 5.11	10, 1	0.92, 1.50
cloud guide	5.11, 5.67	7, 10	1.32, 0.98
court shift	7.04, 6.26	6, 7	0.70, 0.68
crime stall	6.10, 5.34	4, 6	0.86, 1.20
dance alarm	6.44, 5.56	5, 3	0.59, 1.22
depot cover	4.79, 7.56	3, 12	1.04, 0.48
diary train	5.45, 7.67	2, 7	0.86, 0.42
drama match	4.71, 6.69	4, 4	1.41, 0.48
essay cloth	5.31, 5.06	2, 7	1.44, 1.26
field paint	6.80, 6.45	14, 2	0.62, 0.76
flood music	5.21, 6.67	6, 5	1.10, 0.58
floor clerk	6.96, 5.44	7, 6	0.59, 1.40
fruit entry	5.91, 5.29	6, 10	0.88, 1.20
ghost limit	4.63, 6.42	5, 4	1.78, 0.67
glass album	6.76, 4.74	4, 2	0.61, 1.35
horse cable	7.04, 4.61	7, 6	0.41, 1.66
hotel index	6.16, 4.84	2, 9	0.60, 1.44
lunch block	6.61, 6.40	2, 18	0.69, 0.63
maths fence	5.95, 5.60	1, 4	0.69, 0.96
metal water	6.03, 8.02	5, 6	0.80, 0.55
motor knife	5.71, 5.49	4, 3	1.12, 0.99
night level	8.54, 7.81	4, 7	0.60, 0.66
noise trade	6.20, 7.42	4, 4	0.94, 1.51
paper point	8.00, 9.04	10, 32	0.48, 0.62
peace mouse	5.76, 5.35	4, 4	0.71, 1.00
phone title	7.93, 5.50	1, 8	0.99, 0.90
photo lobby	5.29, 4.62	1, 2	0.98, 1.71
pilot screw	4.73, 5.54	5, 14	1.32, 0.98
power front	7.37, 7.43	18, 3	0.62, 0.69
press break	7.10, 7.67	15, 14	0.38, 0.53
price owner	7.59, 5.48	3, 2	0.65, 1.09
radio march	6.73, 6.36	2, 4	0.73, 0.95
rugby sheet	5.33, 6.69	1, 6	1.42, 0.59
score scene	6.52, 5.57	10, 8	0.74, 1.01
share class	7.18, 7.30	3, 8	0.79, 0.63
shelf input	5.24, 5.49	2, 5	1.19, 1.03
shirt light	5.68, 7.67	3, 3	1.14, 0.51
smoke strap	6.71, 4.74	4, 6	0.50, 1.37
speed money	6.39, 8.80	6, 4	0.80, 0.54
spray coach	4.93, 5.49	3, 6	1.33, 0.87
stair agent	5.96, 5.91	3, 2	1.34, 0.73
steam group	5.11, 8.16	3, 8	1.12, 0.56
steel space	5.42, 6.87	4, 7	1.33, 0.46
tower order	5.35, 7.53	2, 20	1.15, 0.54
voice story	6.39, 7.20	6, 6	0.76, 0.68
watch study	7.96, 6.80	5, 10	0.45, 0.64

Table C.3: Nonsense Combinations

Appendix D

Relative Entropy: Context Words

The set of 2000 context words used in the production of the co-occurrence vector from which relative entropy values were calculated was: *get, go, say, know, well, think, just, like, right, come, see, two, mean, very, much, want, thing, look, time, people, good, take, some, make, put, three, really, use, down, work, back, year, give, other, way, only, five, something, actually, four, tell, need, day, hundred, quite, first, twenty, lot, pound, sort, six, talk, last, little, again, try, week, start, point, find, alright, still, before, ask, call, round, never, after, keep, big, pay, many, same, bit, number, leave, another, money, man, new, too, anything, ten, nice, old, eight, house, thank, always, next, long, probably, happen, more, end, half, nine, problem, seven, mr, also, home, thousand, feel, school, a bit, remember, of course, fifty, thirty, buy, change, sort of, fact, hear, today, anyway, different, area, sure, child, job, night, move, great, place, question, minute, council, morning, away, write, even, play, car, every, perhaps, mind, sorry, bring, let, part, word, side, sit, mum, run, help, turn, god, somebody, nothing, show, name, let's, forty, far, bad, seem, please, hour, live, road, woman, nineteen, stop, plan, enough, everything, late, month, service, second, ninety, hand, book, bloody, able, group, report, life, around, whole, read, local, idea, case, open, government, eighty, member, sixty, yet, set, cost, kind, walk, maybe, certainly, matter, door, obviously, moment, shop, love, water, stuff, believe, hope, paper, past, pick, suppose, high, speak, send, policy, important, twelve, a lot, at all, lose, watch, stand, ever, top, wrong, early, dad, most, county, phone, finish, small, already, everybody, wait, room, party, cut, eat, john, country, meet, ago, reason, person, course, girl, world, support, anybody, ring, sell, business, together, line, a few, understand, agree, once, hold, answer, dear, spend, level, boy, either, young, deal, stay, head, tomorrow, percent, couple, system, tape, lovely, company, wan, easy, carry, view, form, issue, hello, such, seventy, saw, listen, hard, become, family, forget, close, figure, particular, record, rather, full, interest, mark, friend, fifteen, committee, train, wonder, information, light, break, fucking, clear, difficult, fine, exactly, miss, mother, sometimes, situation, land, along, bed, christmas, build, police, price, letter, office, face, authority, stick, state, increase, o'clock, chairman, expect, happy, cover, meeting, term, absolutely, allow, sound, someone, war, drive, labour, order, drink, true, yesterday, tonight, mention, table, million, lord, age, tea, type, often, piece, union, somewhere, foot, town, page, fire, decide, present, general, box, outside, care, certain, public, national, black, dog, win, sense, officer, indeed, learn, straight, funny, programme, fall, forward, provide, front, near, street, suggest, trade, mummy, pass, market, add, thanks, wish, difference, city, kid, white, saturday, bottom, eleven, development, friday, amount, health, save, real, centre, afternoon, wear, particularly, short, power, game, during, draw, rest, sunday, staff, large, father, mrs, bye, hang, low, accept, comment, card, possible, trouble, list, offer, colour, plus, usually, red, nobody, main, cold, flat, check, window, control, die, class, sir, third, stage, district, interesting, pretty, charge, doctor, pull, position, notice, load, rate, british, fair, experience, benefit, behind, future, community,*

fund, follow, site, parent, bill, worth, holiday, quarter, test, produce, bag, picture, monday, teacher, decision, basically, park, north, ready, motion, major, chance, councillor, eighteen, result, body, tax, church, drop, budget, bother, supposed, story, worry, special, lead, effect, minus, note, nearly, share, middle, account, vote, green, cup, extra, south, pardon, building, chair, bus, period, grow, food, square, clean, free, sleep, consider, sign, eye, machine, quick, everyone, almost, shut, fit, anyone, size, press, team, board, wife, throw, hair, project, social, education, hospital, concerned, manage, enjoy, mile, hell, cheap, cause, bet, evening, traffic, news, fairly, act, join, law, sale, normally, baby, station, catch, actual, process, force, scheme, bank, computer, horse, club, court, continue, raise, explain, fill, tend, fourteen, penny, individual, date, department, poor, inside, clearly, sixteen, ball, daddy, wash, begin, section, settlement, double, garden, region, key, reckon, quality, blue, item, weekend, available, secretary, quid, opportunity, a little, english, management, hit, leg, brother, society, floor, push, example, wall, various, jesus, structure, receive, standard, dinner, post, develop, imagine, ground, copy, action, hot, wednesday, single, few, address, tree, simply, rule, lady, product, thirteen, knock, west, soon, involve, prepare, claim, client, total, cross, over there, strong, detail, basis, concern, teach, united, space, corner, kill, statement, likely, contract, choose, thursday, definitely, coffee, value, pension, industry, guy, sing, simple, realize, awful, subject, manager, air, discuss, film, bar, especially, approach, include, video, quickly, normal, language, possibly, apply, otherwise, bear, university, contact, laugh, husband, tuesday, field, application, equal, study, colleague, pressure, aware, propose, income, step, son, unit, terrible, glass, conference, president, stupid, lie, hate, involved, fight, evidence, wee, common, college, dead, east, condition, hall, proposal, reduce, bloke, radio, worker, dry, television, bedroom, left, football, affect, completely, birthday, smoke, based, choice, anywhere, complete, financial, conversation, afford, totally, kitchen, touch, sheet, debate, village, warm, sister, measure, match, fish, lad, discussion, correct, odd, boat, music, grant, count, lay, create, training, resource, relate, sector, waste, slightly, function, european, trust, appear, proper, bottle, wide, file, roll, degree, a little bit, improve, excuse, procedure, student, rid, role, responsibility, require, argument, properly, brilliant, lock, hey, cat, achieve, apparently, link, cook, minister, environment, document, seventeen, lunch, all right, shit, practice, per, weight, firm, travel, necessary, interested, political, none, central, guess, summer, history, depends, gas, design, pack, pair, beautiful, arm, similar, return, private, expensive, visit, american, shoe, fuck, per cent, exercise, collect, upstairs, range, wind, fast, beginning, current, switch, milk, jump, welcome, safety, cake, introduce, insurance, busy, transport, egg, telephone, blow, represent, wonderful, thought, animal, silly, heavy, election, dress, final, purpose, score, difficulty, tie, rain, christ, positive, seat, operation, research, hole, chap, appropriate, personal, wood, employment, careful, strike, describe, provision, advice, sick, serious, plant, activity, relationship, death, several, rise, nature, heart, amendment, direct, congress, paragraph, branch, above, goal, identify, hill, art, twice, feeling, hurt, conservative, average, property, fox, daughter, mate, french, surely, interview, finger, divide, beat, bath, ticket, organization, kick, capital, born, material, coal, june, paint, investment, review, peasant, supply, reach, necessarily, human, chip, honest, encourage, smell, plenty, bread, spell, quote, dance, coat, speaker, accident, weather, serve, recently, separate, scale, limit, generally, customer, balance, lane, treat, sport, mess, print, fee, factor, element, eventually, afraid, stone, specific, assume, darling, block, remind, fly, attack, meal, gentleman, burn, speed, useful, pop, patient, lucky, seek, profit, voice, int, clothes, dark, marry, director, model, extent, argue, lift, advance, reasonable, horrible, doubt, compare, skill, hopefully, quiet, march, earth, demand, shout, access, movement, rubbish, remain, sun, pub, option, pattern, male, division, excellent, admit, handle, race, character, direction, joke, requirement, unfortunately, song, aspect, yellow, nil, route, fourth, event, sweet, ordinary, economic, suffer, opposite, memory, cash, farm, chocolate, worried, previous, fancy, engine, production, appointment, driver, circumstance, operate, agreement, sex, release, safe, chicken, blood, toilet, basic, damage, self, leader, greenbelt, duty, chief, bird, attention, majority,

commission, attitude, mouth, exam, message, glad, data, base, slow, shift, occasion, dream, invite, yard, security, oil, objective, bid, regional, lesson, tory, sum, express, boot, response, spirit, truth, stock, modern, economy, borrow, suggestion, throughout, deep, suit, original, drug, association, employ, easily, due, cope, married, reference, flower, environmental, effort, criterion, biscuit, risk, population, presumably, sea, mistake, existing, rich, garage, finally, less, king, army, success, shoot, sentence, competition, arrive, mayor, favour, ahead, ship, opinion, noise, fun, recommendation, judge, estimate, earn, prefer, mix, lecture, enter, target, science, channel, campaign, spot, extremely, potato, fail, used, store, player, working, jack, iron, surprise, bite, star, estate, library, aid, hardly, century, principle, housing, factory, suddenly, pen, nurse, hotel, strange, nought, employer, afterwards, september, promise, panel, fault, energy, bridge, bike, respect, split, photograph, fix, organize, advantage, exist, deliver, cream, sue, responsible, plate, alone, shame, pain, huge, fat, brown, newspaper, april, ride, sixth, natural, immediately, wake, occur, button, successful, survey, river, railway, ensure, aim, german, commit, wages, wedding, regard, possibility, heat, recognize, obvious, telly, recommend, resolution, rent, empty, crime, consideration, vehicle, method, joint, attempt, prove, gun, carpet, thick, contribution, establish, distance, independent, honestly, freud, no one, ill, shape, influence, below, seriously, row, respond, protect, tired, reduction, orange, solicitor, negative, ladies, gate, agenda, mortgage, cheese, guarantee, parish, northern, everywhere, tip, season, professional, female, strategy, etcetera, meat, including, february, object, pocket, legal, intend, ken, commitment, wine, sugar, taste, length, style, january, alternative, additional, technology, background, track, tin, overall, ear, winter, nose, maintain, theatre, entirely, concentrate, retire, referred, neighbour, metal, van, over here, hat, challenge, fifth, fear, cry, theory, queen, farmer, edge, performance, fully, significant, blind, loss, impact, upset, blame, royal, indicate, inch, dirty, boundary, faith, appeal, ability, repeat, gain, wet, goods, attend, goodness, stress, session, mainly, international, transfer, roof, breakfast, beyond, agency, relief, parliament, july, equipment, tiny, industrial, badly, hi, battery, skin, priority, november, herself, arrangement, approve, stair, potential, clever, replace, maths, avoid, twelfth, root, cupboard, brief, reform, pink, facilities, spread, gold, duck, band, personally, medical, angle, acid, knowledge, cheque, presentation, define, context, spare, kind of, growth, belong, article, progress, october, league, recent, primary, keen, appreciate, living, feed, regular, magazine, enable, dig, sad, membership, arrange, zero, payment, extend, danger, bugger, trip, rush, ever so, agent, advertise, task, speech, settle, fruit, december, dangerous, credit, christian, mad, folk, executive, tremendous, defence, consultation, reserve, bind, bathroom, feature, effective, sheep, series, protection, master, representative, employee, arise, remove, flow, crap, grand, allowance, bowl, birmingham, net, grass, salary, damn, adult, wheel, reply, survive, pit, neck, location, gary, behaviour, unemployment, slip, effectively, voluntary, ice, hide, chat, rough, helpful, pleased, minimum, bomb, sake, packet, furniture, strategic, rock, perfectly, ignore, caravan, owe, countryside, swear, piss, bang, treatment, teeth, technical, relevant, official, clock, spring, forest, advise, suspect, surprised, stamp, select, massive, kiss, objection, honourable, complain, brain, temperature, struggle, premium, plastic, electricity, savings, prime, trousers, salt, partner, cell, refer, pot, boss, pie, marvellous, legislation, finance, shot, reaction, following, dare, camera, apple, sandwich, network, lorry, enormous, slide, conclusion, chapter, carefully, being, agricultural, mill, liberal, lack, somehow, reflect, package, desk, perfect, nasty, swim, source, solution, pool, petrol, fortnight, associate, annual, altogether, absolute, downstairs, communication, career, complaint, register, image, fresh, crack, tool, rail, plaintiff, licence, delegate, cow, screen, originally, assessment, peace, easter, delay, amongst, realise, multiply, engineer, dozen, contain, wire, snow, shoulder, nation, august, adopt, abuse, policeman, favourite, regulation, bright, tight, ridiculous, recall, expert, discover, pupil, pensioner, just about, impression, electric, tenant, st, publish, homework, version, request, repair, microphone, chain, boring, server, resident, bore, bell, motor, senior, poll, phrase, blah, wage, southern, shower, sample, pint, golf, confidence, virtually, shock, revolution, pipe, no longer, neither,

heaven, frank, ward, improvement, brick, bone, trial, tall, super, midland, mass, manufacture, summat, knee, satisfy, rural, elect, thin, sensible, landlord, gap, determine, variety, shirt, map, fridge, oppose, metre, expense, tank, no doubt, grey, gather, user, strength, pat, guide, granddad, essentially, disease, award, media, fellow, essential, dish, directly, code, soft, loud, grandma, curtain, amazing, plane, ideal, definition, fetch, allocation, unemployed, exception, sail, exchange, civil, boil, practical, holy, foreign, enquiry, confuse, confirm, popular, luck, instruction, guilty, graph, currently, cancel, willing, weird, relatively, inspector, youth, verse, prison, label, journey, alter, maximum, elderly, promote, highly, gift, formula, communist, blank, asleep, washing, chest, shopping, guidance, decent, bend, physical, conflict, assembly, fraction, complex, clue, brush, revenue, charity, briefly, update, secure, purchase, mostly, lordship, hurry, circle, camp, butter, sink, proportion, cycle, audience, refuse, plug, plain, junction, chop, prevent, jacket, fence, disappear, concept, chase, analysis, witness, urban, pudding, nevertheless, lump, among, western, tablet, accent, sky, roughly, pour, leaf, cigarette, tap, perform, description, wipe, volunteer, relative, patch, invest, exciting, content, alive, sin, sally, elsewhere, dictionary, capacity, secondly, scene, percentage, dot, annoy, advertising, reading, importance, commercial, bin, justice, alarm, moon, relation, pile, nowadays, comfortable, bracket, tidy, nursery, driving, carbon, mirror, minor, brochure, broad, beg, bastard, solve, reality, ps, prize, literally, implication, hire, famous, deputy, audit, violence, sight, screw, suitable, shed, initiative, daily, considerable, specifically, introduction, uncle, display, deny, reasonably, path, marriage, intention, active, stretch, professor, partly, nowhere, expenditure, joy, consequence, loose, entitle, leaflet, freeze, lend, title, sack, rob, recognise, pig, organisation, motorway, monitor, island, impossible, calm, sock, murder, hectare, religion, polish, knife, input, grateful, coach, aircraft, wow, topic, occasionally, citizen, terribly, tenth, owner, friendly, diet, awkward, toast, threaten, sufficient, inform, generation, disgusting, attach, muscle, migration, fashion, extension, cool, bearing, pump, organisations, gear, debt, crowd, bonus, rub, nail, draft, democracy, constant, acceptable, substantial, status, pleasure, incident, climb, assess, appoint, traditional, tear, persuade, mountain, belt, reject, instead, fuel, expand, discount, diary, delight, cough, consultant, volume, seventh, equally, representation, naughty, disaster, diagram, conscious, clerk, affair, statistic, highlight, coast, accommodation, technique, scottish, drawer, database, chinese, china, battle, wing, rose, pitch, grab, domestic, destroy