Making sense of adjective-noun combinations

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Making sense of adjective-noun combinations

een wetenschappelijke proeve
op het gebied van Letteren

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Nijmegen, maart 2003.

We were young; obviously we wanted meaning from life.
Douglas Coupland, Girlfriend in a Coma

Contents

General introduction

CHAPTER 1

Words are not just blown air, they have a meaning. *Zhūang Zǐ, In: Bach, 1989*

1.1 Combining concepts

It is fairly uncontroversial to say that the main function of language is to serve as a medium for communicating ideas. In verbal communication, the speaker uses word sequences (linguistic utterances) to convey meaning. The listener, on the other hand, is engaged in the task of 'decoding' linguistic utterances and 'recovering', preferably, the intended meaning. For an illustration of what constitutes the realm of meaning interpretation (or, semantic interpretation) let us take a look at a well known instance of the so-called *syntactic prose*[1], in the Example 1.1, below.

(1.1) *Colorless green ideas sleep furiously.* *(Chomsky, 1957)*

Although syntactically correct, the linguistic utterance in the example above does not qualify as a proper sentence because the meanings of separate words do not compose into a meaningful message; the output of semantic interpretation can be said to approximate zero. Understanding how the meanings of separate words contribute to the meanings of larger phrases is one of the central questions in psycholinguistic research. The studies reported in this thesis investigate different aspects of semantic interpretation of a specific kind of word combinations, namely adjective-noun combinations such as *yellow table*. These kinds of combinations involve a modifier - head relation between the constituents. Other instances of noun modifiers are prenominal nouns, postnominal phrases and relative clauses (see, e.g., Murphy, 1990)

It has often been emphasized that the importance of studying semantic interpretation of word combinations, such as noun-noun or adjective-noun combinations,

[1]Syntactically correct phrases in which individual words do not combine into meaningful messages.

lies in providing opportunities to test theories on the nature of concepts comprising meanings of single words (see, e.g., Wisniewski, 1996; Wisniewski & Love, 1998). In addition, in Wisniewski and Love (1998) it is argued that studying word combinations contributes to a better understanding of a variety of their functions in communicative contexts, such as creation of new categories (e.g., *ostrich ranch*), and efficient information transmission (e.g., the use of short and elliptical noun-noun combinations like *football parking* instead of much larger phrases like *an area for parking one's car while attending a football game*). Although new combinations are frequently produced and easily understood, the precise nature of representations and processes involved in production and comprehension of (novel) word combinations is not very well understood. Regarding adjective-noun combinations, several factors have been shown to play a role in their semantic interpretation. In general, two sets of factors can be distinguished. The first set of factors can be characterized as affecting the complexity of operations (number of computations) required to arrive at the meaning of the combination. The second set of factors can be said to affect the on-line availability or level of activation of information needed to arrive at a complex meaning of the combinations. Some of these factors which are relevant for the studies reported in the present thesis will be discussed below. The purpose of this introductory discussion of the relevant factors in semantic interpretation of adjective-noun combinations is to emphasize the complexity of this process.

One of the factors that has been shown to influence interpretability of adjective-noun combinations[2] is the degree in which lexical concepts underlying these constructions are compatible. What does it mean for lexical concepts to be compatible? The 'syntactic prose' noun phrase *colorless green ideas*, which consists of two adjectives and a noun appears nonsensical. How does one come to decide that this particular sequence of words is nonsense? The noun in the combination refers to a set of entities, namely a set of ideas. The two adjectives tell us something about the properties common to the entities in this particular set. The first adjective in the sequence qualifies these entities as colorless, while the second one tells us that their color is green. This is clearly an *incompatible* sequence. Furthermore, even if the two adjectives were compatible with each other, none of them can be meaningfully combined with the noun. The reason for this is that color adjectives, in their non-figurative usage, can only be combined with nouns referring to concrete objects (physical entities). This

[2]Interpretability is often investigated using different versions of a semantic classification task involving, for instance, meaningfulness judgement for different kinds of combinations.

example illustrates that we can not combine just any adjective with any noun (in any context). A similar compatibility issue can be illustrated by the combinations involving adjectives like *good*. This kind of adjective does not seem to be compatible with nouns referring to entities which lack a 'built-in' function or purpose such as the natural kind terms *rock*, *tree*, and the like (see, e.g., Pustejovsky, 1999; Vendler, 1968; Ziff, 1964). In Pustejovsky (1999), it is argued that combinations of *good* with such nouns are only accepted if used in contexts which introduce a function for the noun, like *This rock is good for climbing*. The rules determining whether an adjective and a noun are compatible are referred to as *selectional restrictions* (Katz & Fodor, 1963). Psycholinguistic models dealing with the semantic interpretation of adjective-noun combinations (discussed below) approach the problem of compatibility resolution in different ways. As will become clear below, the suggested solutions depend on the assumptions regarding the representational content and format of concepts comprising word meanings.

Another factor which affects semantic interpretation is the degree in which the adjectival meaning is dependent on the noun (and/or the remainder of the context). Typically, the semantic interpretation of an adjective varies across combinations. For instance, the interpretation of the adjective *interesting* varies across combinations with different nouns; compare *interesting book* with *interesting wish*, or *interesting volcano*. Similarly, depending on the context, the combination *interesting book* can be interpreted as *a book with an interesting content*, *a book with interesting illustrations*, *a book which is interesting because it is very old*, and so on. For these kinds of adjectives it has often been argued that they display a high level of semantic underspecification and are highly dependent on the noun and the rest of the context for the computation of their semantic value (Murphy, 1988; Pustejovsky, 1995; Ruhl, 1989; Sedivy, Tanenhaus, Chambers, & Carlson, 1999). In Sedivy et al. (1999) this factor has been referred to as the level of *adjectival head noun dependence*. Even the meanings of relatively unambiguous adjectives, such as color adjectives, have been shown to vary across contexts. Halff, Ortony, and Anderson (1976) suggested that the adjective *red*[3] involves different representations in combination with different nouns such as *red apple, red hair, red face, red knife blade, red wine, Red Army* (see, e.g., Gärdenfors, 1996, for a conceptual space model of color representations).

A different kind of context dependency has been observed with relative or dimensional adjectives like *big*, and *long* (see, e.g. Bierwisch, 1987; Kamp & Partee, 1995; Maloney & Gelman, 1987; Sedivy et al., 1999). In some of these studies (Kamp & Par-

[3]Apart from being used figuratively to signify, for instance, political 'color'.

tee, 1995; Sedivy et al., 1999), it has been argued that these adjectives represent the same property in different combinations. However, they seem to depend on the noun and the rest of the context for determination of the scale appropriate for the noun category (compare, e.g., *big mouse* vs. *big elephant*).

A third factor of interest has to do with the source and the extent of knowledge involved in interpreting adjective-noun combinations. One of the combinations used in the Halff et al. (1976) study was the relatively novel combination *red knife blade*, which may lead to the inference that the knife is *covered with blood*. The inferred property does not seem to belong to the constituents of the combination, but it is typical for the referent of the combination. These kinds of properties are often referred to as *emergent properties* (Hampton, 1997c; Springer & Murphy, 1992). In Hampton (1997d) the novel combination *beach bicycle* was shown to be assigned the property of having *particularly wide tires* (in order not to sink in the sand). Assuming that there is no information about wide tires in any of the constituent concepts, and that there is no knowledge of actual instances, Hampton (1997d) argues that the emergent property *wide tires* must be inferred from background knowledge (e.g., a naive theory of bicycle mechanics). Springer and Murphy (1992) have found that emergent properties (e.g., *white* for *peeled apples*) were verified as being true of the combination faster than properties verifiable on the basis of the noun alone (e.g., *round* for *peeled apples*). These findings have implications for the theories of conceptual combination. They will have to provide an account of how emergent properties are being computed given one of the basic assumptions in semantics, namely that the combinatorial process is compositional in nature. According to this principle, the meaning of the combination is a function of the meanings of its constituents. Emergent properties, however, seem to be at odds with this principle. In order to account for these findings, either the psychological relevance of the compositionality principle has to be reconsidered or the nature of the combinations used in these studies has to be studied more closely. In Chapter 6 of this thesis, these issues will be reconsidered in the light of the findings reported in Chapters 2-5. In general, the semantic interpretation of a large number of combinations seems to require compositional combinatorial interpretation as well as triggering inferences and activating more or less remotely (noun) related knowledge. For instance, the interpretation of the combination *easy jail* as *a jail which is easy to escape from* is a function of its constituents, while, at the same time, it requires an inference regarding the appropriate *jail* related event which will render it *easy*.

The factors discussed above can be said to affect the computational complexity of semantic interpretation. Different kinds of factors affect availability of adjective and noun meaning components in on-line semantic interpretation. Two of these factors that have been demonstrated to affect the ease and speed of semantic interpretation of adjective-noun combinations are salience and typicality of the meaning components of the noun. Regarding salience, intuitively the property *temperature* is more salient for the description of the noun *beer* than for the noun *garbage* (Murphy, 1990). Regarding typicality, in Smith, Osherson, Rips, and Keane (1988) it is stated that *red apple* is judged as a more typical instance of an apple than a *brown apple*. Hence, the adjective *brown* represents a less typical meaning component of the noun *apple* compared to the adjective *red*. The assumption is that both salience and typicality are positively correlated with on-line availability of the properties of the noun. In other words, less salient (and similarly, less typical) properties are assumed to take longer to retrieve than highly salient or highly typical ones. Below, in outlining the main models of adjective-noun combination, more attention will be paid to how exactly these factors are assumed to affect combinatorial semantic interpretation.

Although these are only some of the factors in the semantics of adjective-noun combination, they clearly show the complexity of this process. In the next section, the main representational and interpretational assumptions of the current models of adjective-noun combination will be outlined. It will be indicated to what extent they provide satisfactory accounts for the effects of these factors.

Models and empirical findings

Current models of combinatorial semantic interpretation dealing with adjective-noun and/or noun-noun combinations adopt the early Katz and Fodor (1963) assumption that word meanings or lexical concepts are a collection of discrete components, be it single features, slot - filler units, dimensions and the like. In other words, lexical concepts are assumed to be decomposable into smaller elements (for an alternative, atomistic theory of lexical concepts see, e.g., Fodor, 1990; Margolis, 1999). One piece of evidence that seems to be in favor of the decomposition assumption is the often repeated finding that participants are able to list words referring to different meaning components of other words (e.g., *bird*: flies, has feathers, nests, etc.), when asked to do so (see, e.g., Halff et al., 1976; Smith et al., 1988, etc.). In addition, participants are also able to assign salience and typicality ratings to these meaning components (see, e.g., Smith et al., 1988; Murphy, 1990). Although not necessarily supporting particular representational assumptions (feature lists, slot - filler or attribute - value pairs), these findings indicate that people are able to discriminate different meaning components, or pieces of information pertaining to word use.

Assumptions regarding the representational format and content of lexical concepts vary in complexity from simple, prototype denoting *feature lists* (see, e.g., Hampton, 1997d; Katz & Fodor, 1963) to complex (theory embedded) attribute-value schemata (see, e.g., Murphy & Medin, 1985; Murphy, 1988; Smith et al., 1988). However, it is the latter kinds of models, which adopt a version of schemata format (Rumelhart, 1980), that seem to prevail. Two of these models will be discussed here: the *Selective Modification Model* (see, e.g., Smith & Osherson, 1984; Smith et al., 1988) and the *Concept Specialization Model* (see, e.g., Murphy & Medin, 1985; Murphy, 1988; Murphy, 1990; Murphy & Medin, 1999). Considering that it is not the aim of this thesis to test any of the models of conceptual combination as a whole, the outlines of these models below will be brief. In addition, the review of the empirical evidence bearing on the architecture of these models will include only the most basic findings rather than being exhaustive.

The Selective Modification Model. One of the basic assumptions of the *Selective Modification Model* is that concepts represent experientially acquired characteristics of prototypical instances of categories by means of abstract descriptions.[4] In this model, concepts are conceived of as matrices of attribute - value pairs (e.g., for the noun *apple*, the suggested attribute-value pairs are 'COLOR - red', 'SHAPE - round', 'TEXTURE - smooth'). In general, attributes differ with respect to their *diagnostic value* or usefulness in discriminating instances of the concept from instances of contrasting concepts. For instance, the attribute SHAPE is highly diagnostic in discriminating amongst physical objects, such as chair and typewriter, while *color* is not, since both objects may have the same color. In addition, attribute values differ with respect to their salience (see Table 1.1, below). For example, in Table 1.1 below, the value *red* for the attribute COLOR has higher salience weight (25) than the value *brown* in the schema for the concept *apple*. In their account of semantic interpretation of adjective-noun combinations, Smith et al. (1988) assign asymmetric roles to the constituents, with adjectives being the 'operators' or the modifiers and the nouns being modified, rather than assuming that the features of the two concepts are intersected. This choice is motivated by the observed change in meaning when the order of constituents in

[4] In Smith et al. (1988, p. 486) it is argued that "[...] it seems reasonable to posit that experience, direct or indirect, with exemplars of a concept gives rise to a prototype for that concept, that the rated typicality of an instance is a good predictor of its similarity to its prototype, and that similarity to prototype plays some role in categorization, memory, and communication."

adjective-noun combinations is reversed, as in *red apple* vs. *apple red*. According to the authors, this kind of change is not to be expected if a simple feature intersection mechanism is at the basis of the combinatorial interpretation process.

The *feature weighting* processing component of this model uses the following sequence of operations: (1)The adjective selects the relevant attribute in the noun (e.g., COLOR), (2) shifts all votes on that attribute into the value named by the adjective (e.g., *red*), and (3) boosts the diagnosticity (see above) associated with the attribute (see, Smith et al., 1988, p. 492). This processing component accounts for the interpretation of adjective-noun combinations involving relatively simple adjectives such as RED or BROWN.

Smith et al. (1988) report a series of experiments in which central predictions of their model were tested. In study 1, they collected lists of properties for the various instances of the concepts *fruit* and *vegetable*. The aim of that study was to determine empirically, for the two categories and their instances, the attributes (e.g., COLOR), their values (*e.g., green*), 'votes' for each value (i.e., the frequency of occurrence of the values: attribute - COLOR, value - *green*, votes - 25), and the diagnosticities of attributes for the instances and for the categories (i.e., diagnosticity of the attribute COLOR for the instance *apple* and for the category *fruit*). The results obtained in their study 1 served as the basis for predicting typicality for each of the instances (e.g., *apple, carrot*) in the simple concepts *fruit* and *vegetable* and in the adjective-noun combinations (e.g., *red apple*). In part two of study 1, the participants rated the typicality of instances ("how good an example it is of the category"), for two simple concepts, namely *fruit*, and *vegetable*, and for the eight conjunctions formed by combining each of them with the adjectives *red, white, round*, and *long*. For each concept, the obtained and the predicted ratings were correlated showing a fairly high average relatedness ($r \approx .70$). With respect to the typicality of instances for the conjunctions (adjective-noun combinations), the following was found: for good members of conjunctions (those that had 5 or more votes on the adjectival value, e.g., cauliflower had 9 votes on the value *white* which makes it a good member of *white vegetable*), an instance is judged more typical of the conjunction than of the constituent (e.g., cauliflower is judged more typical of *white vegetable* than of *vegetable*). For poor members (zero votes on the relevant value) a reverse conjunction effect was found. That is, an instance is judged less typical of the conjunction than of the noun constituent (e.g., carrot is less typical of *white vegetables* than of *vegetables*). These ratings were consistent with the predicted ratings.

In study 2 (Smith et al., 1988), ratings were obtained for the typicality of instances in the two simple noun concepts, the eight conjunctions, as well as in the adjectives

Table 1.1: Illustration of the attribute-value representational format for a prototype (apple) and relevant instances (a red apple [I_1] and a brown apple [I_2]); beneath each instance representation is the computed similarity between the instance and a prototype. In: Smith et al., 1988, p. 490

	Apple(A)		I_1		I_2	
	1 *colour*	*red* 25	*colour*	*red* 30	*colour*	*red*
		green 5		*green*		*green*
		brown		*brown*		*brown* 30
		–		–		–
		–		–		–
	0.50 *shape*	*round* 15	*shape*	*round* 20	*shape*	*round* 20
		square		*square*		*square*
		cylindrical 5		*cylindrical*		*cylindrical*
		–		–		–
		–		–		–
	0.25 *texture*	*smooth* 25	*texture*	*smooth* 30	*texture*	*smooth* 30
		rough 5		*rough*		*rough*
		bumpy		*bumpy*		*bumpy*
		–		–		–
		–		–		–
			$Sim(A,I_1) = 1(25-5-5)$ $+.50(15-5-5)$ $+.25(25-5-5)$ $= 15+2.5+3.75$ ≈ 21		$Sim(A,I_2) = 1(0-30-30)$ $+.50(15-5-5)$ $+.25(25-5-5)$ $= -60+2.5+3.75$ ≈ -54	

[a] Note. According to Smith et al. (1988), to determine the similarity between the typical red apple ("I_1") and the prototype for *apple* ("A") on the color attribute, one notes that *apple* and the red apple share 25 red votes, that *apple* has 5 distinct green votes, that the red apple has 5 distinct red votes, and that each component of the contrast is multiplied by the diagnosticity of 1.0. The computations for other attributes are similar.

alone. Their study 3 differed from the study 2 only in that the set of *fruit* instances also included 8 vegetables and vice versa. In both study 2 and study 3, the correlations between the obtained and the predicted typicality ratings were mostly high. However, the authors report three concepts for which the model's predictions failed to correlate highly with the obtained ratings. The concepts are *long fruit*, *white fruit*, and *vegetable*. They argue that this is due to a lack of variability in length, whiteness, and 'vegetableness' among the instances paired with the relevant concepts (e.g., the instances paired with *long fruit* hardly varied in length). After excluding these combinations from the analyses (study 2), and increasing the variability of the items paired with *fruit* by adding a number of non-instances (study 3), the results showed higher correlations of predicted and obtained typicality scores. These findings are interpreted as providing evidence for many of the models' assumptions (see, Smith et al., 1988, for other findings bearing on typicality effects in concept conjunctions, and for findings bearing on adverbial modification).

In Smith et al. (1988) it is argued that the model has difficulties in accounting for the interpretation of combinations in which the adjective specifies an attribute which is unlikely to be represented by the noun (e.g., in the combination *upside-down fruit* the attribute *upside-down* is not part of the noun meaning). Smith et al. consider the possibility that such an attribute, together with its diagnosticity, value and the salience weight (votes) filled in, is temporarily added to the noun representation. For instance, in the combination *upside-down fruit* the attribute *spatial orientation* would have to be inferred and added to the noun schema. They note that inferring the appropriate attribute from the adjective is not always self-evident.

The applicability of the Selective Modification model is also questionable for a large class of adjective-noun combinations involving underspecified adjectives like *interesting, easy,* and *nice.* These adjectives do not seem to specify any particular attribute (attribute - value pair). Yet, they form meaningful combinations with nouns (e.g., *nice house, easy exam, interesting book*). Similar arguments hold for multi-dimensional adjectives, that is, adjectives that presumably represent more than one attribute (see Chapter 4, this thesis). In addition, a specifically problematic class of adjectives is formed by non-predicating adjectives like *corporate, musical,* and *lunar* (see, e.g., Murphy, 1988). Non-predicating adjectives can only be used attributively (i.e., prenominally). For instance, while *corporate lawyer* is perfectly grammatical *the lawyer is corporate* is not. As argued in Murphy (1988), these adjectives do not have a single attribute which is then reweighted in the noun concept. Rather, these adjectives are derived from nouns from which they seem to inherit complex conceptual structures (Murphy, 1988). Each usage of adjectives like *corporate* seems to involve a different relation between the constituents in the combination, hence also involving a different slot in the noun concept. For instance, *corporate lawyer* and *corporate car* possibly involve the relations *x works for y*, and *x used by the employees of y*, respectively.

The Concept Specialization Model. With regard to the assumptions about the representational format of lexical concepts, the concept specialization model is also a schema or frame-based model (see, e.g., Minsky, 1977; Murphy & Medin, 1985; Murphy, 1990; Murphy, 1991; Murphy & Andrew, 1993; Murphy & Medin, 1999; Rumelhart, 1980). With respect to the assumptions about the content of lexical concepts it is a theory-based model in which concepts are assumed to be embedded in larger knowledge structures, the so-called mental theories, or naive theories of the world (see, e.g., Murphy & Medin, 1985).

The model specifies two interpretational components (stages). In *the concept specialization stage*, correspondence is established between the attributes of the modifier and the head. For instance, in the noun-noun combination *apartment dog*, the concept *apartment*, belonging to the category HABITAT, replaces all other fillers in the HABITAT slot of the concept *dog* which becomes more 'specialized'. Hereby, world knowledge is used to select the appropriate slot (in the example above the slot HABITAT is chosen rather than slots LOOKS LIKE, or TYPICAL DIET). In *the concept elaboration stage* world knowledge is used to enhance the coherence of the combination through inferences (e.g., for the *apartment dog* it can be inferred that it is smaller, more quiet and more friendly than a *farm dog*). In these models, the represented properties of objects are not independent but are linked and organized by known relationships (e.g., part - whole relationships) and causal connections. The model posits two types of conceptual coherence:

1 *Concept-internal* coherence realized through two types of schemata, namely structure - function, and causal schemata.

2 *Concept-external* coherence, brought about by the interconnectedness of lexical concepts with relevant knowledge.

In Murphy (1990), it is argued that research on conceptual structures has shown that concepts are organized into larger knowledge structures (theories) that have effects on concept acquisition and use. Murphy and Wisniewski (1989) investigated whether, in concept formation and use, advantage is taken of the knowledge of clusters of correlated features found in the environment. For instance, animals that have wings also often fly, nest, and lay eggs. These features are correlated. An important question is how these correlations are represented. Murphy and Wisniewski (1989) suggested that the knowledge of conceptual domains (e.g., a naive theory of flying) provides links between features in a concept representation. Different types of knowledge include knowledge of causal connections between features, of processes that generate object attributes and of mutual involvement of features in various situations. (see, Murphy & Wisniewski, 1989, p. 25). In the studies reported in Murphy and Wisniewski (1989) no evidence was found for the use of feature correlations in acquiring new concepts. The authors suggest that people seem to learn concepts primarily by forming concept-feature links rather than feature-feature links. At the same time, individual features may be embedded into several causal theories. The findings reported in the Murphy and Wisniewski (1989) study also suggest that feature correlations in novel concepts are not learned easily, and that people seem to use their theories of the world to constrain the selection of features to be related to a particular lexical concept, such that any new feature is checked for consistency with others.

Regarding the role of world knowledge in conceptual combination, the findings from the Murphy (1988) study suggest that "adjective-noun concepts are constructed through some interactive process that involves knowledge of both concepts" (Murphy, 1988, p. 552). Knowledge-based inferences were shown to aid the understanding of the combinations such as *empty store* yielding emergent properties such as *a store that is losing money*. Murphy (1988), argues that the combinatorial process of *feature weighting*, proposed by the Concept Specialization model (Smith et al., 1988), cannot account for the observed knowledge-based concept elaborations. Furthermore, in Murphy (1990) evidence was found in favor of a general schema-based representation of the meaning components of lexical concepts together with some further evidence in favor of the Concept Specialization model and its emphasis on the role of knowledge in conceptual combination. In Experiment 1, Murphy (1990) compared semantic interpretation of adjective-noun combinations with that of noun-noun combinations. While adjectives were assumed to represent single attribute value pairs, such as 'COLOR - *brown*' pair for the adjective *brown*, nouns were taken to represent complex attribute-value schema's where no single salient attribute dominates others. Therefore, it was assumed that semantic interpretation of noun-noun combinations is computationally more complex and that this process is heavily knowledge-dependent. For instance, world knowledge was assumed to be involved in assigning the most plausible relation between the constituents in the combinations *an apple basket* (a basket *for* carrying apples), and *an apple pie* (a pie *made out of* apples). In a task involving meaningfulness judgements, Murphy (1990) compared reaction times as well as interpretability rating scores (on a 7-point scale) for the following three types of adjective-noun combinations: 1. the adjectives represent typical values for the noun (e.g., *edible paste*), 2. the adjectives represent atypical values for the noun (e.g., *inedible paste*), 3. interpretable but novel noun-noun combinations (e.g., *prostitute committee*). The stimuli were pre-tested for typicality, relatedness between the constituents, and interpretability. Furthermore, for the frequency of modifiers and familiarity of both the objects being described and the combinations was controlled for. The results confirmed the prediction of the concept specialization model that novel noun-noun phrases are more difficult to interpret than either typical or atypical adjective-noun combinations (see Murphy, 1990). This finding is explained as an effect of conceptually more complex semantic representations for nouns than for adjectives. In Hampton (1997d), it is argued that the concept specialization model offers an account for the appearance of emergent features in novel concept conjunctions (e.g., *beach bicycle*). Recall that emergent features are features that are true of the conjunction but not of its constituents. However, Hampton (1997a) argues that, at the same time, this also constitutes a problem for the concept specialization model: since the underlying naive theories largely determine how a combination is interpreted, the process is highly combination-specific.

In general, the findings reviewed above may suggest a larger applicability of the Concept Specialization Model (Murphy & Medin, 1985) compared to the Selective Modification Model (Smith et al., 1988). However, the difference between the models is small. As pointed out in Murphy (1990, p. 284): "There is nothing in the model of Smith et al. (1988) that prevents it from employing domain theories or knowledge ... It may be that such processing can be simply added on to their system." However, one problem with using a knowledge-based concept elaboration component in any model of conceptual combination is that it has yet to be developed. In other words, questions of what knowledge is being accessed in different stages of combinatorial semantic interpretation and how it affects the process are only beginning to be investigated (see, e.g., Murphy, 1988). Although there can be little doubt that world knowledge does play a role in semantic interpretation of conceptual combinations, much more research is needed before the knowledge-based component of the combinatorial interpretative process can be specified with any precision.

Empirical findings in research on conceptual combination suggest that factors such as salience (relevance) and typicality of the meaning components do affect their availability in combinatorial semantic interpretation. However, these findings are compatible with both variants of the schema-model outlined above. Rather than testing any of the models as a whole, the present thesis will investigate the role of several factors (some being derived from the models described above) for which it can be expected that they affect the interpretability of adjective-noun combinations. One strategy in research on conceptual combination is to leave the models for what they are, and, for the time being, focus on clarifying a number of issues related to the above-mentioned and other factors that seem to affect the interpretability of the combinations. This strategy has been adopted in the studies reported in the present thesis. In this, it is important to take into account that single as well as combined lexical concepts have several functions, and that their representation and use are constrained by these functions and possible interactions among them (see, e.g., Margolis, 1999; Solomon, Medine, & Lynch, 1999).

The following section contains a brief introduction to specific problems addressed in the studies reported in chapters 2, 3, 4, and 5. This thesis contains four more or less independent chapters reporting studies on different aspects of semantic interpretation of adjective-noun combinations, rather than investigating one problem in depth.

1.2 An introduction to the problems studied in the present thesis

One feature common to the models discussed above is that they focus on combinatorial processes which make use of pre-stored meaning components (slot - filler, attribute - value). Briefly, these models assume that, in order for the meaning of the combination to emerge, the attributes in the representation of the adjective and the noun have to be put in some kind of correspondence, in that an adjectival attribute has to be found in the noun. Furthermore, semantic interpretation is assumed to involve a change in diagnosticity of the attributes and in salience of a particular attribute value. In this view, the factors that are modulating the interpretation process are those that influence the availability of pre-stored information such as salience. For example, since flowers come in various colors, which presumably serves the purpose of attracting insects, the attribute COLOR is more relevant for the concept *flower* than for the concept *soil*. Another factor affecting availability is typicality of the adjectival and noun semantic values (see, e.g., Murphy, 1990). For example, the adjective *edible* represents a more typical value of the attribute EDIBILITY for the noun *food* than the adjective *inedible* or, in other words, *edible food* is a more typical instance of food than *inedible food*. However, both models have problems with adjective-noun combinations in which the adjective does not seem to represent a clear property, the so-called adjectives with underspecified meanings (see above) which seem to be dependent on the noun for their semantic interpretation.

The problems addressed in this thesis have to do with a number of less thoroughly investigated aspects of semantic interpretation of adjective-noun combinations. They are briefly introduced below, while more elaborate introductions can be found in Chapters 2-5 of this thesis in which the studies examining these problems are reported.

1. Adjectival polysemy. At the beginning of the previous section the role of the factor adjectival noun dependence in semantic interpretation of adjective-noun combinations has been discussed. For an illustration consider the adjective-noun combinations in the Example 1.2, below.

(1.2) *good wine*
good lawyer
good idea

If we try to paraphrase the combinations we might arrive at something like *a wine that tastes good, a lawyer that wins cases,* and *an idea that seems good in a given situation,* respectively. Apparently, the meaning of the adjective *good* in each of the three combinations is not the same. Although the reader may not agree completely with the interpretations offered, coming up with three entirely different paraphrases instead, the chances are small that one and the same interpretation of the adjective would be involved in all three paraphrases (e.g., *a wine that tastes good, a lawyer that tastes good,* and *an idea that tastes good,* respectively). Does this imply that the adjective *good* has several meaning representations listed in its lexical entry? The hypothesis that words which apparently have multiple and related meanings, and which are commonly referred to as *polysemous,* have all these meanings listed in the mental lexicon is referred to as *the sense enumeration* hypothesis (Pustejovsky, 1995). This hypothesis is held improbable by many researchers studying ambiguity of word meaning (see, e.g., Caramazza & Grober, 1976; Frazier & Rayner, 1990; Gerrig, 1986; Murphy & Andrew, 1993; Pustejovsky, 1995; Ruhl, 1989). The main argument against it is that the sets of enumerated meanings are bound to be incomplete due to the observed changes in meaning with almost every new combination. An alternative hypothesis holds that polysemous words are semantically underspecified (see, e.g., Frazier & Rayner, 1990; Pickering & Frisson, 2001; Pustejovsky, 1995), and that their meaning variants are fully computed in context. Various kinds of mechanisms have been proposed for context-dependent meaning computation (see, e.g., Caramazza & Grober, 1976; Frazier & Rayner, 1990; Ruhl, 1989; Pustejovsky, 1995). The importance of studying mechanisms involved in semantic interpretation of polysemous adjectives lies in the fact that a large number of adjectives, perhaps most of them, are polysemous to some degree (Panman, 1982). The aim of the study reported in Chapter 2 of this thesis was to test the meaning computation hypothesis for polysemous adjectives.

2. *Adjectival polysemy and noun concreteness.* Irrespective of whether it is assumed that the meanings of polysemous adjectives are listed or computed, it is necessary to explain why and how these meanings vary across adjective-noun combinations. If it is assumed that the meanings are listed, we have to explain the noun-dependent retrieval and disambiguation of the contextually appropriate meaning. If, on the other hand, we assume that polysemous adjectives are semantically underspecified, and that their meanings are computed in context, we have to explain how this is accomplished and how the nouns contribute the relevant information to the semantic interpretation of the combinations. In the paraphrases of the combinations in Example 1.2 above, the verbs *to taste* and *to win* are related to the noun rather than to the adjective. These concepts can be inferred on the basis of our general knowledge about wine, and lawyers. This suggests that noun characteristics are an important source of constraints on models of semantic interpretation of adjective-noun combinations. In Chapter 3 of this thesis, the focus is on investigating the role of the factor *noun concreteness*, which is assumed to affect the amount of noun-related information that is retrieved during the combinatorial interpretation. For an illustration of how noun concreteness might affect the interpretability of the combination, compare the combinations *good wine* (concrete noun), and *good idea* (abstract noun). Even if presented without any further context, properties of wine that render it good easily come to mind. This, however, does not seem to be the case with the combination *good idea*; without additional context there are no constraints on the set of possible properties which render an idea a good one. Quite different semantic interpretations will be assigned to the combination *good idea* in the context of discussing alternatives for going out for an evening than in the context of discussing theoretical alternatives in quantum physics. Hence, selecting a particular interpretation before sufficient clues are provided by the context could easily lead to a misinterpretation of the noun. Findings from a number of studies (see, e.g., Kounios & Holcomb, 1994; Martin, Ungerleider, & Haxby, 2000; Paivio, 1986) suggest that the variation in noun concreteness may have implications for the level of *processing commitment* (Frazier & Rayner, 1990), or, in other words, for the extent of the process of selecting particular noun properties in semantic interpretation. The study reported in Chapter 3 of this thesis investigates this issue.

3. Adjectival complexity and salience of the noun related properties. At the beginning of this chapter the concept of *selectional restrictions* was introduced. It was argued that the fact that the combinations like *green idea* are judged as meaningless, as opposed to combinations like *green dress*, is due to the adjective *green* selecting nouns which refer to *concrete objects*. Put in this way, the mechanism used in resolving compatibility between adjectives and nouns seems quite straightforward; it involves checking if the noun is of the required type. But, consider once again the adjective *good*. It is very difficult to come up with a noun which is incompatible with this adjective (see, e.g., Pustejovsky, 1999; Vendler, 1968, for analyses of the adjective *good*). The adjective *good* is seemingly without any selectional restrictions. However, the adjective *skilful*, which, in some contexts, may act as a close synonym of the adjective *good*, seems to be more restrictive. According to some analyses (see, e.g., Kamp & Partee, 1995; Pustejovsky, 1995), it combines well with nouns referring to various professions (e.g., a surgeon) and pertains to the noun-related information about the events in which a particular professional takes part (e.g., surgery). These restrictions rule out many other classes of nouns (e.g., the noun *rock* which has no built-in function). It can be argued that the more restrictive adjectives require elaborate noun dependent combinatorial interpretation. Nouns, on the other hand, provide the required properties which may differ in their salience (see, e.g., Murphy, 1990). One of the reasons why some combinations are difficult to interpret (e.g., *skilful mouse*) may lie in the fact that the required semantic properties of the nouns (e.g., *laboratory mouse*) are not salient for the noun in question and have to be inferred from our knowledge of the world. Chapter 4 reports a study in which the role of the complexity of adjectival selectional restrictions and the salience of the noun properties in semantic interpretation of adjective-noun combinations has been investigated.

4. Adjectival logical type and complexity of semantic interpretation. The research issues presented so far concern primarily a view of word meanings as mental entities having the capacity to combine into larger structures. At the same time, their capacity to refer to the entities in the world (discussed in, e.g., Bach, 1989; Dowty, 1979; Margolis, 1999) is seldom being taken into account. In Laurence and Margolis (1999) it is argued that concepts fulfill several roles (functions) such as the role of reference determining structures, and the role of structures involved in categorization, inference, and conceptual combination (see also, Solomon et al., 1999). It can be argued that all these roles represent sources of constraints on representational format and content of word meanings thus jointly affecting semantic interpretation process. Adjectival logical type seems to be one of the factors which by determining the way adjectives refer to entities in the world also affects the combinatorial interpretation of adjective-noun combinations (see, e.g., Kamp & Partee, 1995; Sedivy et al., 1999).

The purpose of this section was to introduce the issues studied in this thesis. The remainder of this chapter contains a brief outline of the thesis. The main thread linking the studies presented here is an emphasis on the factors affecting computational complexity in combinatorial interpretation. As argued above, current models have difficulties accounting for the interpretation of adjective-noun combinations in which adjectival meaning is not clearly specified and has to be computed from the noun-related knowledge.

1.3 Outline of the thesis

In Chapter 2, the hypothesis is tested that *sense enumeration* applies to the highly unrelated meanings of homonymous adjectives but not to the apparently related meanings of polysemous adjectives. The main distinction within the class of semantically ambiguous words is made on the basis of relatedness of their different meanings. If the different meanings are unrelated, like the meanings of the noun *bank* (financial institution, river bank) or of the adjective *light* (bright, not heavy), the word is regarded as homonymous. If, on the other hand, the different meanings are related, like those of the adjectives *nice* (interpreted as pleasant, kind, etc.), and FINE (interpreted as fine grained, subtle, etc) the word is considered polysemous (Cruse, 1986b; Panman, 1982). Separate lexical entries seem to be needed only in cases of syntactic ambiguity (consider *light* as an adjective, a noun, and a verb). However, while it seems uncontroversial to assume that the different meanings of the noun *bank* or the adjective *light* need to have separate meaning representations, a similar assumption about the adjectives like *nice* and *fine* seems less plausible (see e.g., Frazier & Rayner, 1990; Pustejovsky, 1995; Ruhl, 1989). In the study reported in Chapter 2, the hypothesis is tested that only homonyms have separate representations for their highly distinct meanings (e.g., the adjective *light*) while polysemous adjectives (e.g, the adjective *nice*) acquire their different senses in combination with nouns.

Chapter 3 reports a study on the processing strategies that influence the level of 'semantic processing commitment' in the interpretation of combinations involving polysemous adjectives. Hypotheses tested in this study are based on the *minimal processing commitment* hypothesis (Frazier & Rayner, 1990), adapted to adjective-noun combinations. It is assumed that the level of contextual dependence of nouns, which varies with their concreteness, determines the extent in which noun properties will be included in combinatorial adjective-noun interpretation. The main hypothesis is that the similarity of computed meanings is higher in pairs of adjective-noun combinations that are congruent in processing strategy (i.e., if two combinations both involve either high or low processing commitment), when compared to incongruent combinations.

Chapter 4 investigates the role of adjectival complexity, manipulated by varying the degree of complexity of selectional restrictions, in semantic interpretation of adjective-noun combinations. The focus is on differences in semantic interpretation of adjective-noun combinations constructed with relatively simple versus relatively complex adjectives. The former kind of adjective imposes a single, highly abstract selectional restriction on the semantic type of the noun. For example, Dutch adjective *nat* (wet) requires the noun to be a concrete object. Relatively complex adjectives, carrying additional, more specific restrictions, like the Dutch adjective *drassig* (soggy), require the noun to include reference to *soil* (e.g., meadow, garden). Both types of adjectives will be combined with nouns varying in salience of the properties which satisfy adjectival constraints. The main hypothesis concerns the interaction of the two factors. The complexity of adjectives will have a stronger effect on the interpretability of the combinations for low salience than for high salience nouns. In other words, if the noun properties which satisfy adjectival constraints are highly salient, the complexity of these constraints will have a smaller effect on interpretability than if the noun properties are low in salience.

Chapter 5 explores the possibility that the factor adjectival logical (formal) type affects the complexity of adjective-noun combinatorial interpretation. Furthermore, the compatibility of concepts being combined is assumed to affect the complexity of the interpretation process as well. In the first experiment reported in Chapter 5, the hypotheses are tested that (1) the subsective mode of combination is computationally more complex than the intersective one, and that (2) the interpretation of subsective incompatible combinations requires additional processing in the form of semantic type coercion which further enlarges the computational load. These hypotheses are tested by comparing speed and accuracy of semantic classifications for the following three types of combinations: intersective (e.g., *wooden ship*), subsective compatible (e.g., *safe ship*), and subsective incompatible (e.g., *slow ship*). In the second experiment, an off-line paraphrase task is used to collect data bearing on the content of semantic interpretations assigned to adjective-noun combinations. The main hypothesis in this experiment is that the three types of combinations differ reliably with respect to the kinds of concepts comprising the interpretations assigned to the combinations.

Finally, Chapter 6 contains a summary of the thesis and conclusions that can be drawn from the findings obtained in the reported experimental studies. In addition, possible directions for future research regarding the issues raised in this thesis are suggested.

Adjectival polysemy: enumeration or computation

CHAPTER 2

2.1 Introduction

In Chapter 1, it was argued that adjectives may differ in the level of their noun dependence (Pustejovsky, 1995; Sedivy et al., 1999), and that this factor may affect the interpretability of adjective-noun combinations. High noun dependence introduces ambiguity in semantic interpretation of adjectives; we do not know how the adjective has to be interpreted until the noun is being processed. For example, the meaning of the adjective *nice* is slightly different in the combinations *nice weather*, *nice person*, and *nice meal*. It can be expressed by the synonyms *pleasant*, *kind*, and *tasty*, respectively. One characteristic of adjectives like *nice* is that, although their different meanings can often be expressed by different synonyms, intuitively, these meanings are highly similar or related. Alongside with nouns and verbs with multiple and related meanings, adjectives of this kind are referred to as *polysemous*.

There are two alternative views on the representation and consequently on the interpretation of ambiguous words. In one view, for all ambiguous words it is assumed that their meanings are listed in the lexicon regardless of the degree of relatedness of the different meanings (see, e.g., Durkin & Manning, 1989; Hino & Lupker, 1996; Williams, 1992). This is the so-called *sense enumeration* view. Alongside, the *computational* view has been proposed which suggests that sense enumeration is necessary only for those ambiguous words that have highly distinct, unrelated meanings, the so-called homonyms, such as the noun *bank* (e.g., Caramazza & Grober, 1976; Frazier & Rayner, 1990; Murphy & Andrew, 1993; Pickering & Frisson, 2001; Pustejovsky, 1995; Ruhl, 1989). For homonyms, one meaning (e.g., financial institution) cannot be computed from the other (e.g., river bank); both have to be represented. For polysemous words, on the other hand, it is proposed that a highly abstract meaning representation may be sufficient, while the various meaning variants can easily be computed in context (Ruhl, 1989). This view on polysemy is also referred to as the *maximized monosemy* view (Ruhl, 1989). For polysemous nouns and verbs there is some evidence that their meanings are computed in context (see, Frazier & Rayner, 1990; Pickering & Frisson, 2001, for polysemous nouns and verbs, respectively). The question is whether this is also the case with polysemous adjectives.

Sense enumeration hypothesis suggests that polysemous adjectives depend on the noun for the *selection* of the appropriate meaning. In this view, different meanings of the polysemous adjective *nice* (pleasant, kind, tasty) are listed in the adjectival lexical entry. In the computational view, on the other hand, the noun does not aid the selection rather, it supplies information how to interpret a polysemous adjective. In this view (see, e.g., Caramazza & Grober, 1976; Pickering & Frisson, 2001; Pustejovsky, 1995; Ruhl, 1989), adjectival meaning is conceived of as being highly underspecified or highly abstract. Specific interpretations, such as *pleasant, kind* and *tasty* for the adjective *nice*, are derived from the noun. The main argument against sense enumeration for polysemous words is that, considering that each new usage of a polysemous word introduces new meaning aspects, fixed meaning lists are bound to be incomplete (see, e.g., Jackendoff, 1997; Murphy & Andrew, 1993).

So far, empirical evidence in support of the computational view on polysemy is restricted to polysemous nouns and verbs (see, e.g., Frazier & Rayner, 1990; Pickering & Frisson, 2001) while adjectives have received much less attention (see, e.g., Murphy & Andrew, 1993). In Pickering and Frisson (2001), processing of verbs with multiple meanings or homonyms (e.g., *to rule a country, to rule a line*) was compared with processing of polysemous verbs (e.g., *to launch a satellite* vs. *to launch goods on the market*). They obtained evidence that, rather than accessing multiple senses, processing of polysemous verbs involves activation of one underspecified meaning while context is used to settle on one of the many possible senses. In Frazier and Rayner (1990), similar findings were obtained for nouns with multiple senses such as the noun *newspaper* which may refer to a corporation as well as a physical object (see Chapter 3 for a more elaborate discussion of this study).

In the present study, the differences between homonymous and polysemous adjectives outlined above will be exploited in order to investigate the nature of semantic representations for polysemous adjectives. Both the sense enumeration and the computation theories assume that homonyms require all their meanings to be represented due to their high unrelatedness. In combinations with nouns, they are disambiguated by selecting one of the meanings (see Frazier & Rayner, 1990; Pickering & Frisson, 2001, for homonymous nouns and verbs, respectively). According to the computational view on polysemy outlined above, polysemous adjectives can be assumed to be semantically underspecified (see, e.g., Caramazza & Grober, 1976; Frazier & Rayner, 1990; Pickering & Frisson, 2001; Pustejovsky, 1995; Ruhl, 1989). This implies that their distinct meanings are not listed and will have to be computed or derived from the noun-related information rather than to be retrieved. Taking into consideration that computing of the appropriate noun-related information may not always be straightforward, this kind of semantic interpretation can be expected to be computationally more complex compared to the retrieval-based interpretation of homonymous adjectives. For instance, for the polysemous adjective *nice*, the abstract adjectival meaning can be further specified as concerning different meaning components of the noun. In the combination *nice person*, it can be interpreted relatively easily as concerning personality. The interpretation of the combination *nice evening* seems to be more complex. It may include noun-related concepts such as the evening sky, or different events that may take place in the evening.

Informal observation suggests that, in addition to being unrelated, the meanings of homonymous adjectives could be much less abstract or 'underspecified' than the meanings of polysemous adjectives. For example, in Dutch, the homonymous adjective *krom* (bent) is either synonymous with *gebogen* (curved) or with *inconsistent* (inconsistent). The two meanings are clearly distinct and highly specified with *gebogen* (curved) applying to concrete nouns and *inconsistent* (inconsistent) applying to abstract nouns. In other words, homonymous adjectives display a relatively low level of underspecification of listed meanings. This implies that, in combinatorial interpretation, their dependence on the head noun will be relatively low. In the example of the adjective *krom* (bent) the selection of the appropriate meaning will depend on the noun being either concrete or abstract. It needs to be said, however, that it is possible that for each of the highly distinct meanings of homonyms there may be contexts in which their meanings are modulated to accommodate for specific usage. For instance, each of the variants of the Dutch adjective *krom* (bent), may undergo slight changes, depending on the shape of the object the noun refers to, such as in *kromme draad* (bent wire) vs. *kromme weg* (bent street). These kinds of noun-related meaning extensions, however, do not seem to be different from the extensions of non-ambiguous, non-underspecified adjectives such as *white* (non-figurative usage) in *white car* vs. *white clouds*. Here, the concrete objects to which the combinations refer will determine the exact shade of white. As argued above, changes in meanings of polysemous adjectives are of a different kind.

If polysemous adjectives are indeed highly underspecified, they can be expected to be processed differently from homonyms. In other words, the level of adjectival meaning specification can be expected to affect the way in which they are combined with nouns. The hypothesis tested in the present study is that, similar to polysemous nouns and verbs (Frazier & Rayner, 1990; Pickering & Frisson, 2001) semantic interpretation of polysemous adjectives involves noun-dependent meaning computation (see, e.g., Pustejovsky, 1995; Ruhl, 1989).

In order to test this hypothesis, processing assumptions will be made based on the mechanism of spreading of activation. Due to this mechanism, activation can be expected to spread from concepts comprising highly specified meanings, (in our experiment these are the meanings of homonymous adjectives) to related concepts, like near-synonyms (see, e.g., Murphy & Andrew, 1993). According to both, the computation and the sense enumeration hypotheses, processing of homonymous adjectives, either in isolated presentation or in adjective-noun combinations, can be expected to facilitate subsequent processing of their near-synonyms (e.g., in isolated presentation *bent* is a prime and either *curved* or *inconsistent* are targets; in adjective-noun combinations: *bent wire* is a prime and either *curved* or *inconsistent* are targets). For polysemous adjectives, the computation hypothesis would not predict the same facilitation effects as for the homonyms. According to the computation hypothesis, the meanings of polysemous words are constructed (specified) in context. Hence, in isolated presentation there will be no pre-activation of related concepts. For an illustration, unlike the homonymous *bent* in the example above, processing of the polysemous adjective *nice* in isolation can hardly be expected to facilitate processing of near-synonyms of its contextualized meanings such as *warm* and *sunny*. It is only after the specific meanings have been computed in context (e.g., in the combination *nice weather*) that the activation can spread to related concepts. However, if according to the sense enumeration view, both homonymous and polysemous adjectives have their meanings listed, equal facilitation effects should be obtained for the near-synonyms of both kinds of ambiguous adjectives in isolated presentation and in adjective-noun combinations.

2.2 Experiment 1a and 1b: Adjectives in isolation

In Experiment 1, the computation hypothesis for the polysemous adjectives is tested under the condition of isolated presentation (no context). To that aim a priming paradigm was used with both homonymous and polysemous adjectives serving as primes and near-synonyms of their meanings as targets. A lexical decision task (word/-non-word decision) was used. The two types of adjectives were presented in two conditions (see Table 2.1). In the related condition, primes were either homonymous or polysemous adjectives and targets were their near-synonyms. In the Unrelated condition, targets were the same while primes were semantically unrelated adjectives.

Both hypotheses (sense enumeration, computation) predict that the retrieval of the meanings of homonyms will facilitate the processing of their near-synonyms. For these kinds of adjectives, significant difference can be expected between the related and the unrelated condition with reaction times in the related condition being significantly faster. For the polysemous adjectives, the computation hypothesis would predict that in isolated presentation no activation of concepts comprising the contextualized meanings occurs (e.g., the concepts *warm* and *sunny* are activated only upon encountering the combination *nice weather*, and are not activated upon encountering the adjective *nice* in isolation). Hence, the processing of the near-synonyms of polysemous meanings (e.g., *warm, sunny* for *nice*) will not be facilitated. The sense enumeration hypothesis, on the other hand, specifies that not only the meanings of the homonyms but also the meanings of polysemous adjectives are represented in the lexicon. Hence, according to this hypothesis both kinds of adjectives should prime their near-synonyms thus producing facilitation effects in the related condition.

In order to capture possible differences in temporal aspects in semantic interpretation for the two types of adjectives, two SOAs (160 and 350 ms) were used. The length of the SOAs is based on the measures of duration of an average fixation time (200-250 ms), which reflects the average word processing time in normal reading. In a number of studies, estimations of the duration of lexical access range from 50 to 150 ms (see, e.g., Rayner & Pollatsek, 1987, for a discussion on this issue). It seems plausible to assume that semantic representations will be retrieved and available for combinatorial processes at 160 ms SOA. This interval is shorter than the commonly reported 300 ms interval at which the effects of meaning activation are found for both dominant and subordinate meanings in neutral context (e.g., Simpson, 1981; Simpson & Krueger, 1991; Tabossi & Zardon, 1993). However, dominant (more frequent) meanings of ambiguous words have been reported to produce very early effects in neutral context (no bias) (see e.g., Simpson & Krueger, 1991). Taking these characteristics of the stimuli into consideration, a relatively early effect of meaning activation was expected (i.e., at 160 ms SOA). In Experiment 1b, a 350 ms SOA was chosen, which exceeds the 300 ms SOAs at which either meaning activation effects are commonly found for both dominant and subordinate meanings in neutral context (see above), or selective activation effects are found for the dominant meanings of unbalanced ambiguous words (Simpson & Burgess, 1985).

Table 2.1: EXAMPLE STIMULI IN EXPERIMENT 1

TYPE OF RELATED PRIME-ADJECTIVE	P/T	PRIME-TARGET RELATEDNESS: *Related*	*Unrelated*
Homonymous	P_1	krom (bent)	zeker (safe)
	T_1	BOCHTIG (CURVED)	BOCHTIG (CURVED)
	P_2	krom (bent)	zeker (safe)
	T_2	ONLOGISCH (INCONSISTENT)	ONLOGISCH (INCONSISTENT)
Polysemous	P_1	lekker (nice)	somber (gloomy)
	T_1	SMAKELIJK (TASTY)	SMAKELIJK (TASTY)
	P_2	lekker (nice)	somber (gloomy)
	T_2	PRETTIG (PLEASANT)	PRETTIG (PLEASANT)

Note. P/T = PRIME/TARGET

EXPERIMENT 1A

Method

Participants. Participants were 44 native speakers of Dutch. They were all students at Nijmegen University and were paid for their participation.

Materials and design. The preliminary materials consisted of 84 homonymous and polysemous adjectives. The procedure of selection and classification of adjectives in the two groups involved using dictionary information (van Dale, 1984) as a preliminary indication of relatedness of adjectival 'meanings'. Adjectives were pre-classified as homonymous if the listed meanings could be divided in two unrelated sets, and as polysemous if there was no such clustering. The number of meaning entries in the dictionary was comparable for both kinds of adjectives (means for the final set of 36 selected adjectives are M=7.0 for the homonyms, and M=6.7 for the polysemous adjectives). Per adjective, two meanings were selected. On the basis of descriptions in the Groot Woordenboek van Synoniemen (van Dale, 1991), and Groot Woordenboek der Nederlandse Taal (van Dale, 1984), one near-synonym was chosen for each meaning (e.g., the adjective *nice*, near-synonyms: *pleasant* and *attractive*). Additionally, data on meaning relatedness were obtained which were used to classify adjectives as either homonymous or polysemous. The selection of the stimuli for the on-line experiments involved three rating studies that are described below. The purpose of these studies was to select and match stimuli on a number of relevant variables. The first rating study served the purpose of selecting homonymous and polysemous adjectives. The second one was designed to select congruent and incongruent synonyms for adjectival meanings disambiguated in prime combinations. The third rating study set out to match the combinations for familiarity. The rating studies are briefly reported below. Full description these studies is reported in Appendix A. Table 1 and Table 2 in the Appendix A summarize means for the selection and matching variables for the stimuli in different conditions in Experiment 1 and 2. On the basis of these rating studies, 36 out of 84 adjectives were selected.

The rating studies. The purpose of the first rating study, involving 30 participants, was to collect the rating scores indicating the degree of similarity of adjectival meanings in combinations with different nouns (e.g., *zware studie - zware jas*) On the basis of this study, adjectives were classified as either homonymous or polysemous. The respective mean scores for the two groups in the final set of 36 stimuli were 1.9 and 2.9. The difference between the two means was significant [$F(1,34) = 40.89, MSe = .21, p < .001$].

The goal of the second rating study, involving 60 participants, was to test the selected near-synonyms for their similarity in meaning with corresponding adjectival meanings as disambiguated in adjective-noun combinations (i.e., to test the degree of their 'synonymity'). One near-synonym was congruent with one of the contextualized adjectival meanings (congruent condition) while the other was incongruent with the same meaning but congruent with an alternative meaning (incongruent condition). The analysis for the set of 36 selected adjectives showed significant differences between homonymous and polysemous adjectives $[(M_h = 3.5, M_p = 3.8), F(1,34) = 4.97, MSe = .43, p < .05]$, and between congruent and incongruent condition $[(M_c = 5.4, M_i = 1.9), F(1,34) = 1921.85, MSe = .11, p < .001]$. The interaction was not significant $[F(1,34) = 1.10, MSe = .11, p > .30]$. The second measure in this study, the difference score, was used as a criterion for the selection of homonymous and polysemous adjectives with comparably distinct disambiguated meanings. Irrespective of the possible differences in underlying representations, this kind of matching insures that the selected combinations for both kinds of adjectives do not disambiguate one and the same adjectival meaning (e.g., *long walk, long journey*), either by selection or by computation. The critical difference score for the inclusion of adjectives in the experimental set was 2.5 scale points. An ANOVA for the final set of adjectives showed no effect of adjective type $[F < 1]$, no effect of combination $[F(1,68) = 2.52, MSe = .81, p = .12]$, and no interaction $[F < 1]$.

In the third rating study, familiarity ratings for adjective-noun combinations were collected. For the set of 36 selected adjectives, there were no differences between the homonymous and the polysemous adjectives on familiarity ratings (reliability: Guttman Split-half = .95) Mean familiarity scores were 2.9 and 3.1 respectively $[F < 1]$. The main effect of Combination was not significant $[F(1,68) = 1.98 MSe = .62, p = .16]$. The means are 2.6 and 3.2 , for the combinations with homonymous adjectives, and 3.1 and 3.1 for the polysemous adjectives. The interaction effect was not significant $[F(1,68) = 3.01, MSe = .62, p = .09]$.

Lexical decision experiment. Half of the adjectives were homonymous and half were polysemous. In this and all further experiments in this chapter these adjectives served as primes, either in isolation or in adjective-noun combinations. Near-synonyms of the two distinct meanings per adjective served as targets (e.g., the adjective *hard*: near-synonym (1) - *firm* as in *hard mattress*, and near-synonym (2) - *severe* as in *hard punishment*). Another 36 adjectives, unrelated to the near-synonyms, were used as primes in the control condition. Thus, near-synonyms of homonymous and polysemous adjectives were presented in two conditions (related and unrelated). A 2x2 design was used, with prime-target relatedness and adjective type as factors (see Table 2.1). Materials used in experiments reported in this Chapter are listed in Appendix C.

Stimulus materials were divided into four lists. Each list contained 9 items in each of the four conditions. The four sets of 9 adjectives were matched for the length and log-transformed frequency of related and unrelated primes, length and log-transformed frequency of targets, synonymy score, difference score, homonymy/polysemy score, and familiarity score (all $p's > .05$). Eleven participants were randomly assigned to each list. Per list, the 36 experimental prime-target combinations formed one fourth of the presented items. In addition, 36 noun/noun prime-target pairs were constructed that served as 'word'-fillers (eliciting YES-responses); half of these items were related and half were unrelated (e.g., related: *doctor* - NURSE, unrelated: apple - ZOMBIE). For the purpose of the lexical decision task 72 word/non-word prime-target pairs were constructed; half of them had an adjective in prime position and the other half had a noun in prime position (e.g., *zalig* - *tuip*, *ivoor* - *lesend*). Thus, each participant was presented with 144 prime-target pairs. Filler items were the same for all four lists. There was no item repetition either in prime or in target position on any of the four lists.

Procedure. Participants were tested individually or in groups of two in individual noise-attenuating booths. Stimuli were presented on a CRT connected to an Olivetti M-24 computer which controlled the presentation of the stimuli and the registration of responses. Stimuli were presented at the center of the computer screen. Each trial started with the presentation of a fixation mark (*) for 800 ms. After a blank screen for 150 ms, the prime, printed in lower-case letters, was presented for 140 ms. After a 20 ms blank screen, the target, printed in upper-case letters, was displayed for 750 ms or until a response was obtained. Time-out was set to 1250 ms after target-offset. The inter-trial interval was 1000 ms.

Participants were instructed to read primes and targets carefully, and to decide as quickly and as accurately as possible whether a presented target was a Dutch word or not. They were to push the yes-button if the target stimulus was a Dutch word; otherwise they had to push the no-button. Both right- and left-handed participants gave yes-responses using their dominant hand. When an error was made on a trial immediately preceding a test item, a dummy item was inserted in between the two in order to attenuate the effects of erroneous responding on the subsequent processing of a test item. A set of 32 practice items was presented prior to the experimental session, four of which were buffer items at the beginning of the experimental series. The set of practice items had similar characteristics as the experimental set. The experimental session lasted about 25 minutes.

Results and Discussion

Reaction times for erroneous responses (4.7%) and reaction times above or below 2.5 standard deviations of the subject and item mean (0%)[1], were considered as missing values. A 2x2 analysis of variance (ANOVA) included the between-item factor type of the related prime adjective, and the within-item factor prime - target relatedness. Mean participant latencies and error percentages are presented in Table 2.2.

Table 2.2: MEAN LATENCIES (ms) AND ERROR PERCENTAGES IN EXPERIMENT 1A.

	PRIME - TARGET RELATEDNESS				
RELATED ADJECTIVE TYPE	*Related*		*Unrelated*		FE
Homonymous	562	2.4%	588	4.3%	26
Polysemous	587	4.6%	599	7.1%	12
M	575	3.7%	594	5.7%	19

Note. FE= facilitation effect in milliseconds

The main effect of prime - target relatedness was significant [$F_1(1,43) = 10.61, MSe = 1528.58,\ p < .005; F_2(1,34) = 7.75, MSe = 947.65, p < .05$]. The main effect of the (related) adjective type was significant in analysis by participants only, with mean latencies of 575 and 593 ms for the homonymous and polysemous adjectives respectively [$F_1(1,43) = 6.23, MSe = 2360.82, p < .05; F_2(1,34) = 2.12, MSe = 4507.48, p = .16$]. The interaction did not approach significance [$F_1\ (1,43) = 1.00, MSe = 2335.22, p = .323; F_2(1,34) = 1.29, MSe = 947.65, p = .265$].

The analysis of the error percentages yielded a significant main effect of prime target relatedness [$F_1(1,43) = 4.42, MSe = 47.68, p < .05; F_2(1,34) = 4.26, MSe = 17.25, p < .05$]. The main effect of the (related) adjective type was significant in the analysis by participants only (3.4 vs. 5.8) [$F_1(1,43) = 4.21, MSe = 63.77, p = .05; F_2(1,34) = 2.68, MSe = 42.77, p = .11$]. The relatedness by adjective type interaction was not significant [both $F's \leq 1$].

[1]The cut-off points are based on the combination of variables list, condition, item, and list, condition, subject

Contrary to our expectation, the interaction effect in the analysis of latencies was not significant. Additional tests showed that a relatedness effect was significant for of homonyms for which mean latencies in the related and the unrelated condition were significantly different [$F_1(1,43) = 11.72, MSe = 1316.50, p < .005; F_2(1,17) = 8.06, MSe = 902.16, p < .05$]. For the polysemous adjectives, the difference between the means in the related and the unrelated condition was not significant [$F_1(1,43) = 1.23, MSe = 2547.29, p = .274, F_2(1,17) = 1.30, MSe = 993.14, p = .270$]. However, in the absence of a significant interaction effect, this finding does not represent clear support for the computation hypothesis. Obtaining equal relatedness effects for both kinds of adjectives would support the sense enumeration hypothesis. The fact that polysemous adjectives showed a clear absence of facilitation, implies that there is no unequivocal support for this hypothesis either.

For the homonymous adjectives we assumed that their isolated interpretation involves activation of the enumerated (listed) meanings. In Experiment 1a we have studied meaning activation for adjectives in isolated presentation. In the introductory section it was argued that only in context (e.g., in adjective-noun combinations), the meaning representations can be expected to be active until the disambiguation by noun is completed, whereupon alternative meanings can be dropped. In isolated presentation, however, there is no real need to retain a high activation level for a long time. Therefore, it can be expected that the facilitation effect for the homonyms will disappear at a longer SOA.

Polysemous adjectives did not show a facilitation effect in Experiment 1a. Assuming that these adjectives have highly abstract meaning representations, a change in SOA should not make any difference. However, according to the sense enumeration hypothesis, also the meanings of polysemous adjectives are represented. Taking into consideration a large number of different meanings for this class of adjectives, enumeration of all these meanings could be expected to result in much more complex semantic representations than for the homonyms. Hence, the expectations concerning the time-course of the possible priming effects for their near-synonyms may not be the same as for the homonyms. It is possible that the priming effects for polysemous adjectives occur a later point in time compared to the early priming effects obtained with homonyms. In this view, polysemous adjectives can be expected to show facilitation effects at a longer SOA than the homonyms. Thus, the computation hypotheses would not predict any SOA effects for the polysemous adjectives at a longer SOA, while larger facilitation effects at a longer SOA for these adjectives would be consistent with the sense enumeration hypothesis.

EXPERIMENT 1B

Method

Participants. Sixty participants, native speakers of Dutch, participated in this experiment. They were all students at Nijmegen University, and were paid for their participation.

Materials and Design, and **Procedure.** Materials, design and procedure were the same as in Experiment 1a except for the SOA, which was 350 ms (330 ms presentation time and 20 ms blank screen).

Results and Discussion

Reaction times for erroneous responses (5.1%) were considered as missing values[2]. The ANOVA included adjective type as a between item factor, and prime - target relatedness as a within-item factor. Mean participant reaction times and error percentages are presented in Table 2.3.

Table 2.3: MEAN LATENCIES (ms) AND ERROR PERCENTAGES IN EXPERIMENT 1B.

	PRIME - TARGET RELATEDNESS				
RELATED ADJECTIVE TYPE	*Related*		*Unrelated*		FE
Homonymous	581	2.6%	589	4.1%	8
Polysemous	586	5.9%	589	7.8%	3
M	584	4.3%	589	5.9%	6

Note. FE = facilitation effect in milliseconds

The main effect of prime-target relatedness was not significant [$F_1(1,59) = 1.07$, $MSe = 1725.30$, $p > .30$; $F_2(1,34) = 1.23$, $MSe = 797.81$, $p > .25$]. This finding implies that,

[2]The cut-off point of 2.5 standard deviations of the participant and the item mean yielded 0 outliers

in isolated presentation, the activation level of adjectival meanings dissipates rapidly. In addition, the main effect of (related) adjective type and the interaction were not significant either [all $F's < 1$].

The analysis of the error percentages showed that the main effect of prime-target relatedness was not significant [$F_1(1,59) = 3.18$, $MSe = 49.86$, $p = .08$; $F_2(1,34) = 2.66$, $MSe = 18.77$, $p = .11$]. The main effect of adjective type was significant in participant analysis only (homonymous: $M = 3.3\%$, polysemous: $M = 6.8\%$) [$F_1(1,59) = 17.10, MSe = 44.02, p < .001$, $F_2(1,34) = 2.97, MSe = 75.13, p = .09$]. The interaction did not approach significance [both $Fs < 1$]

In order to test the predictions concerning the SOA factor, an ANOVA was conducted involving data from both experiments with SOA as a between-participants factor. The analysis showed no effect of SOA [both $F's < 1$]. The interaction of prime - target relatedness with SOA per adjective type was only marginally significant in participants analysis for the homonyms [$F_1(1,102) = 2.65, MSe = 1615.97, p = .106; F_2(1,17) = 2.12, MSe = 720.25, p = .163$]. For the polysemous adjectives the interaction was not significant [both $Fs < 1$].

At a longer SOA used in Experiment 1b, there was no effect of prime - target relatedness, indicating a relatively early deactivation of the adjectival meanings in the isolated presentation condition. Due to the absence of the interaction effect in Experiment 1, these findings are not strongly supportive of any of the two hypotheses. If anything, they may suggest that both kinds of adjectives are processed the same way. In some studies on the course of meaning activation for the ambiguous words (e.g., Simpson, 1981; Simpson & Burgess, 1985; Tabossi & Zardon, 1993, etc.) large facilitation effects have been reported at an SOA of approximately 300 ms. In these studies, either the critical ambiguous words were presented in context, or the primes were so-called unbalanced homographs with one dominant (more frequent) and one subordinate (less frequent) meaning, or a different experimental paradigm was used.[3] These conditions are, in fact, not completely comparable with those used in the present study which involved isolated visual presentation. Therefore, it can be argued that the results obtained in our experiment are not necessarily contradictory to those obtained in similar studies (see above). Compared to studies involving presentation of ambiguous words in context, our results indicate that meaning deactivation was obtained at an earlier point in time. It can be argued that the presence of context, even when con-

[3]In Simpson (1981), the task involved responding to both ambiguous *primes* and to 'targets'; in Simpson and Burgess (1985) unbalanced homographs were used; in Tabossi and Zardon (1993) a cross-modal priming paradigm was used.

text does not disambiguate meanings (as in the 'ambiguous sentence' condition in Simpson & Krueger, 1991), may induce prolonged meaning activation. The prolonged higher meaning activation level would allow for the integration of the meanings of single words into the meaning of the sentence. This, of course, is not necessary in isolated presentation.

2.3 Experiment 2a and 2b: Adjective-noun combinations

The results obtained in Experiment 1 do not clearly support any of the hypotheses (sense enumeration, meaning computation). However, in Experiments 1a and 1b processing of the two types of adjectives in isolation was studied; a condition where only the predictions about the effects of meaning activation can be tested. In Experiment 2, mechanisms involved in semantic interpretation of the two types of adjectives were studied in their 'natural environment', that is, in adjective-noun combinations. This kind of post-ambiguity context is referred to as right-disambiguating or late-disambiguating context, that is, the disambiguating context that *follows* rather than *preceeds* an ambiguous word (see, e.g., Frazier & Rayner, 1990; Hagoort & Brown, 1994). It seems plausible to assume that this kind of context will elicit whatever process may be involved in semantic interpretation of the two types of adjectives. In other words, context allows for both noun-related meaning selection processes, as well as noun-related meaning computation processes to take place.

For the homonymous adjectives, both hypotheses (sense enumeration and meaning computation) would suggest that in adjective-noun combinations their interpretation involves the following general mechanisms: (1) activation and retrieval of distinct adjectival meanings (e.g., *bright* and *not heavy* for the adjective *light*), (2) selection of the contextually appropriate meaning (e.g., *bright* in the combination *light room*, and *not heavy* in the combination *light luggage*), and (3) de-activation of contextually inappropriate meaning(s). For the polysemous adjectives, only the meaning computation hypothesis suggests that their interpretation involves (1) retrieval of their abstract meaning (e.g., something like *a positive characteristic of the noun* for the adjective *nice*), (2) computation of a specific meaning by determination of an appropriate noun property (e.g., *looks* or *personality* in the combination *nice boy*, *design* in the combination *nice shoes*, etc), resulting in interpretations such as *nice-looking boy*. Sense enumeration hypothesis treats polysemous adjectives the same way as the homonyms.

In Experiments 2a and 2b, a priming paradigm in a lexical decision task (LDT) was used. However, adjective-noun combinations rather than adjectives alone served as primes, and near-synonyms of distinct adjectival meanings served as targets. For each adjective type, near-synonyms (targets) were kept constant, while different conditions were created by varying the priming adjective-noun combinations. The conditions were as follows. In the congruent condition the near-synonym expresses the same meaning as the prime combination. In the incongruent condition the near-synonym expresses an alternative adjectival meaning, and in the control condition the near-synonym is unrelated to the adjective in the prime combination (see Table 2.4).

Table 2.4: EXAMPLE STIMULUS SET FOR EXPERIMENT 2(A,B)

		PRIME-TARGET RELATION TYPE		
CONGR/INCONGR. PRIME ADJECTIVE	P/T	*Congruent*	*Incongruent*	*Control*
Homonym.	P_1	krom verhaal (bent story)	kromme straat (bent street)	echte diamant (real diamond)
	T_1	ONLOGISCH (INCONSISTENT)	ONLOGISCH (INCONSISTENT)	ONLOGISCH (INCONSISTENT)
	P_2	kromme straat (bent street)	krom verhaal (bent story)	echte diamant (real diamond)
	T_2	BOCHTIG (CURVED)	BOCHTIG (CURVED)	BOCHTIG (CURVED)
Polysem.	P_1	lekkere pannenkoek (nice pancake)	lekkere wandeling (nice stroll)	saaie docent (boring teacher)
	T_1	SMAKELIJK (TASTY)	SMAKELIJK (TASTY)	SMAKELIJK (TASTY)
	P_2	lekkere wandeling (nice stroll)	lekkere pannenkoek (nice pancake)	saaie docent (boring teacher)
	T_2	PRETTIG (PLEASANT)	PRETTIG (PLEASANT)	PRETTIG (PLEASANT)

Note. P/T = prime/target.
Prime combinations are translated literally

Experiments 2a and 2b differed only in the length of the SOA. In Experiment 2a the

SOA was 350 ms, and in Experiment 2b 800ms. In addition to the effects of meaning activation obtained in different reaction time studies and reported above (Simpson, 1981; Simpson & Krueger, 1991; Tabossi & Zardon, 1993), the choice of the SOA duration was informed by results from a neurocognitive study on the processing of ambiguous words in a similar right-disambiguating context (Hagoort & Brown, 1994). The Hagoort and Brown (1994) study used the ERP-registration technique and it used unbalanced ambiguous words (one meaning was clearly dominant). The authors found an N400 effect, that is, a difference in N400 amplitude between ambiguous and unambiguous words, in a 'neutral context' condition, which does not favor any of the alternative meanings. The onset of the N400 effect was at approximately 300 ms after the stimulus onset, peaking at 400 ms. This finding of greater processing difficulties associated with ambiguous words compared to unambiguous words was interpreted as an effect of accessing multiple meanings for the former kind of words. What can be inferred from this finding is that, in a right-disambiguating context, the meaning(s) of ambiguous words are retrieved and available for the ongoing combinatorial processes in the range from 300 to 400 ms after the word onset. These findings suggest that different meanings of the fully specified adjectives, that is, homonyms, can be expected to be active at 350 ms SOA. In addition, effects of deactivation of the contextually *inappropriate* meaning can be expected as well.

According to the computation hypothesis, in Experiment 2 it was expected that, unlike in Experiment 1(a,b), the meanings of polysemous adjectives will be computed, and will produce facilitation for the synonyms in the congruent condition. In the incongruent condition, this hypothesis predicts no facilitation effects. Since, according to this hypothesis, for adjective-noun combination involving polysemous adjectives, only the contextually appropriate meanings are computed, it is to be expected that only the processing of the near-synonyms congruent with the computed meaning can be facilitated. Processing differences between the homonymous and the polysemous adjectives were expected to become evident in the incongruent condition. The enumerated distinct meanings of homonymous adjectives can be expected to be retrieved at the time of the target presentation (at 350 ms SOA). At this point in time the selection of the contextually appropriate meaning, and the de-activation of the inappropriate one, may not be fully accomplished yet (see above). Thus, both meanings may still be active and the processing of congruent as well as incongruent near-synonyms can be expected to be facilitated.

The sense enumeration hypothesis predicts no differences between the homonymous and polysemous adjectives in either the congruent or the incongruent condition. It would predict facilitation effects in the congruent condition for both types of adjectives. It would also predict the incongruence effect for both types of adjectives.

EXPERIMENT 2A

Method

Participants. Sixty participants, native speakers of Dutch, were involved in this experiment. They were all students at Nijmegen University and were paid for their participation.

Materials and design. On the basis of the results of the three rating studies, 36 adjective-noun combinations were selected. Half of the combinations were constructed with homonymous and half with polysemous adjectives. Per adjective two combinations were constructed expressing alternative adjectival meanings. In this experiment, the constructed adjective-noun combinations served as primes, while near-synonyms of the disambiguated adjectival meanings served as targets (e.g., 1. *hard mattress* - *firm*, and 2. *hard punishment* - *severe*). In addition, 36 adjective-noun combinations unrelated to the targets were selected as primes for the control condition. Each target was presented in the following three priming conditions: (1) *congruent* (2) *incongruent*, and (3) *control* (see Table 2.4). Stimulus materials were divided into six lists. Each list contained six items in each of the six conditions. The six sets of adjectives were matched for the length and log frequency of related and unrelated primes and targets, difference score, homonymy/polysemy score, and familiarity score. Ten participants were randomly assigned to each list. Per list, the 36 experimental prime-target combinations formed one fourth of the stimulus set. In addition, 36 combination/noun prime-target pairs were constructed that served as word fillers. Half of these items were related and half were unrelated. For the purpose of the lexical decision task 72 combination/non - word prime - target pairs were constructed and added to each list.

Thus, each participant was presented with 144 prime-target pairs. Half of the targets were words and half were pseudo-words. Primes were always adjective-noun combinations while half of word targets were adjectives and half were nouns. Of the 72 (prime - target) combination-word pairs half were related and half were unrelated. Filler items were the same for all six lists. There was no item repetition either in prime or in target position on any of the six lists.

Procedure. Participants were tested individually or in pairs. Stimuli were presented on a CRT connected to an Olivetti M-24 computer which controlled the presentation of the stimuli and the registration of responses. Each trial started with the presentation of a fixation mark (*) for 800 ms at the center of the screen. After a blank screen for 150 ms, the prime adjective-noun combination, printed in lower-case letters was presented for 300 ms. After a blank page for 50 ms, the target, printed in upper-case letters, was presented for 750 ms or until the response was given. The SOA was 350 ms. The 'time-out' was set to 2000 ms after target onset. The inter-trial interval was 1000 ms. Stimuli were presented at the center of the computer screen.

Participants were instructed to read primes and targets carefully, and to decide as quickly and as accurately as possible whether the targets were Dutch words. They were to press the yes-button (using their dominant hand) if the target was a Dutch word, otherwise they had to press the no-button (using their non-dominant hand) on the button-box in front of them. When an error was made on a trial that immediately preceded a test item, a dummy item was inserted. A set of 32 practice items was presented prior to the experimental session, four of which were buffer items at the beginning of the experimental series. One sixth of the trials was followed by a verification task concerning the prime combination. On these randomly appearing trials, participants were asked if a particular word (either an adjective or a noun) occurred in the prime combination. Feedback about the correctness of the response was provided immediately. This was to insure that participants read carefully not only the targets (to which they were to respond) but also the prime stimuli. The set of practice items had similar characteristics as the experimental set. The experimental session lasted about 25 minutes.

Results and Discussion

Reaction times (RTs) for the erroneous responses (3.8%) on the lexical decision task, RTs for the erroneous responses on the verification task (1.0%), and RTs above or below 2.5 standard deviations of the participant or item mean (3.8%), were considered as missing values (8.4% in total; 0.2% of overlap between errors on the Lexical Decision and the Verification task). The ANOVA was performed with the factors adjective type (between-items) and prime - target relation type (within-items). Mean participant RTs and error rates are presented in Table 2.5.

The ANOVA on latencies showed that the overall effect of prime - target relation type was significant in both analysis by participants and by items [$F_1(2,118) = 11.87, MSe = 2972.15, p < .001$; $F_2(2,68) = 11.15, MSe = 1228.14, p < .001$]. Differences between the congruent and the incongruent condition were significant for both homonymous and

Table 2.5: MEAN LATENCIES (ms) AND ERROR PERCENTAGES IN EXPERIMENT 2A.

	PRIME-TARGET RELATION TYPE					
CONGR./INCONGR. PRIME ADJECTIVE TYPE	*Congruent*		*Incongruent*		*Control*	
Homonymous	610	0.8%	629	5.0%	651	2.8%
Polysemous	613	1.9%	635	6.1%	640	5.8%
M	612	1.4%	632	5.6%	646	4.3%

polysemous adjectives (homonyms - [$F_1(1,59) = 4.80, MSe = 2263.52, p < .05; F_2(1,35) = 4.15, MSe = 1974.32, p = .05$], polysemous adj. - [$F_1(1,59) = 7.69, MSe = 1964.43, p < .05; F_2(1,35) = 4.10, MSe = 1848.06, p < .05$]). For the homonyms, the difference between the incongruent and the control condition was significant in the analysis by participants [$F_1(1,59) = 5.84, MSe = 2464.29, p < .05; F_2(1,35) = 3.77, MSe = 2290.04$, $p = .06$]. For the polysemous adjectives, the difference between the incongruent and the control condition was not significant (both $F's < 1$). The main effect of the factor adjective type was not significant and the interaction between the prime-target relation type and adjective type was not significant [all $F's \leq 1$].

The analysis of error percentages showed that the main effect of prime-target relatedness was significant in both participants and items analysis. Mean error percentages in the congruent, incongruent and control condition were 1.4%, 5.6% and 4.3% ms respectively [$F_1(2,118) = 13.94, MSe = 39.35, p < .001; F_2(2,68) = 6.59, MSe = 24.97, p < .005$]. The main effect of the adjective type was significant in the participants analysis only [$F_1(1,59) = 4.86, MSe = 57.27, p < .05; F_2 \leq 1$]. The interaction was not significant [both $F's < 1$].

In order to exclude the possibility that the difference in RTs (analysis by participants) between the incongruent and control condition for the homonyms was due to a speed-accuracy trade-off, the correlation between the latencies and the error percentages in the unrelated condition for the homonyms was computed. Negative correlation would indicate speed-accuracy trade-off. The correlation [$r = .22$, $p > .05$] showed no indication of speed-accuracy trade-off. Furthermore, the inspection of error percentages per item revealed that significant differences in error percentages between the incongruent and the control condition (homonyms) were due to the items 5 (*enge film - griezelig/krap*) and 25 (*vette pan - smerig/veel*), which had extremely high mean error percentages in both Experiments (2a and 2b). The removal of these two items from the analysis of error percentages resulted in approximately equal differences between the incongruent and the control condition for both homonymous and polysemous adjectives [homonymous - $F_1(1,59) = 4.21, MSe = 35.15, p = .05; F_2(1,17) = 4.86, MSe = 9.15, p < .05$; polysemous - $F_1(1,59) = 4.64, MSe = 53.95, p < .05; F_2(1,15) = 3.46, MSe = 18.28, p = .08$]. At the same time, the removal of these items from the analysis of RTs did not alter the outcomes of the specific comparisons.

For the polysemous adjectives, in isolated presentation in Experiments 1a and 1b, no facilitation effects in the related condition were obtained. In Experiment 2a, facilitation effects were obtained in the congruent condition. Together, these findings can be accounted for if it is assumed that the alternative meanings of polysemous adjectives are not represented but computed in interaction with nouns. According to the computation hypothesis, processing of the near-synonyms of polysemous adjectives can be facilitated only after the specific meanings have been computed. The sense enumeration view does not provide an account of these findings.

Homonymous adjectives primed both their related targets in Experiment 1a and their congruent targets in Experiment 2a. The finding that, for the homonymous adjectives, a facilitation effect in the incongruent condition was obtained only in the analysis by participants is a fairly weak indicator of alternative meaning activation. A possible explanation of such a weak facilitation effect in the incongruent condition could be that, at the time the target was presented, the disambiguation by noun was already completed, paralleled by an early deactivation of context-inappropriate meanings. This would produce weak priming effects for the close synonyms of the alternative meanings. Alternatively, the meanings of the homonymous adjectives used in the present study could have been less clearly specified than expected. This would make their interpretation more similar to that of the polysemous adjectives.

In order to test the predictions of the two hypotheses concerning the time-course of meaning activation/computation for the two types of adjectives, in Experiment 2b, the length of the SOA was 800 ms. The sense enumeration hypothesis predicts an interaction effect between the prime-target relation type and SOA for both types of adjectives.

Possible activation of the incongruent meanings can be expected to dissipate by the time the target is presented thus producing significantly smaller facilitation effects in the incongruent condition compared to Experiment 1.

The meaning computation hypothesis predicts the same interaction effect only for the homonyms and not for the for the polysemous adjectives. The incongruent meanings of polysemous adjectives were not expected to be computed at any point in the interpretation process, so the lengthening of the SOA should not make a difference. At the same time, the activation of the incongruent homonymous meanings was expected to dissipate.

EXPERIMENT 2B

Method

Participants. Sixty participants, native speakers of Dutch, were involved in this experiment. They were all students at Nijmegen University and were paid for their participation.

Materials and design were the same as in Experiment 2a.

Procedure. The procedure was the same as in Experiment 2a, except for the SOA duration. In Experiment 2a, the SOA was set to 350 ms, in Experiment 2b, the SOA was 800 ms. The prime was presented on the screen for 750 ms. After a blank screen for 50 ms, the target synonym was presented for 750 ms or until a response was given. The time-out was set to 2000 ms after target-onset. The inter-trial interval was 1000 ms.

Results and Discussion

Reaction times (RTs) for the erroneous responses (3.4%) on the LDT, RTs for the erroneous responses on the verification task (1.0%), and RTs above or below 2.5 standard deviations of the participant or item mean (4.6%) were considered as missing values (8.9% in total; there was 0.3% overlap between the LDT errors and verification task errors). The ANOVA was carried out with factors adjective type (between-items) and prime-target relation type (within-items). Mean participants RTs, and error percentages are presented in Table 2.6.

In the analysis of RTs, the overall effect of prime-target relation type was significant in both participants and items analysis [$F_1(2,118) = 8.33, MSe = 2601.41, p < .001; F_2(2,68) = 6.61, MSe = 1520.09, p < .05$]. Significant differences were found only between the congruent and the control condition for homonymous (participants analysis only), and polysemous adjectives [$F_1(1,59) = 9.41, MSe = 2507.93, p < .005; F_2(1,35) =$

Table 2.6: MEAN LATENCIES (ms) AND ERROR PERCENTAGES, IN EXPERIMENT 2B.

CONGR./INCONGR. PRIME ADJECTIVE TYPE	PRIME-TARGET RELATION TYPE					
	Congruent		*Incongruent*		*Control*	
Homonymous	652	0.8%	663	2.2%	680	3.9%
Polysemous	650	3.1%	667	4.2%	676	6.1%
M	651	2.0%	665	3.2%	678	5.0%

$2.23, MSe = 6904.18, p > .10]$, $[F_1(1,59) = 9.01$, $MSe = 2190.06$, $p < .005, F_2(1,35) = 7.95$, $MSe = 2173.64, p < .05]$. The main effect of the adjective type and the interaction between the two factors were not significant [all $F's < 1$].

Analysis of the error rates with the factors adjective type and prime-target relation type showed the main effect of relation type to be significant in both participants and items analysis $[F_1(2,118) = 5.32, MSe = 53.27, p < .05; F_2(2,68) = 3.62, MSe = 23.47, p < .05]$. The main effect of adjective type was significant in the participants analysis only $[F_1(1,59) = 8.10, MSe = 50.36, p < .05; F_2(1,34) = 1.93, MSe = 63.30, p = .17]$. The interaction was not significant [both $F's < 1$].

The ANOVA of the RTs for the Experiments 2a and 2b together involving the between-participants factor SOA showed a significant main effect of SOA $[F_1(1,118) = 4.55, MSe = 49108.51, p < .05; F_2(1,32) = 68.79, MSe = 791.03, p < .001]$, with slower reaction times at longer SOA (630 ms vs. 665 ms). None of the two-way or three-way interaction effects involving the SOA factor was significant [all F's ≤ 1].

In sum, homonymous adjectives showed facilitative priming effects in the congruent condition in Experiments 2a and 2b, and in the incongruent condition in Experiment 2a. This is compatible with the sense enumeration hypothesis for this kind of adjective. Polysemous adjectives facilitated processing of their near-synonyms only in the congruent condition in both Experiment 2a and 2b. In the light of the findings obtained in Experiments 1a and 1b, where polysemous adjectives in isolation did not facilitate processing of their near-synonyms, this suggests that their meanings could be computed in context, rather than being pre-stored. This interpretation has to be taken cautiously, however, because none of the expected interaction effects were significant. One way to account for the absence of the interaction effect is to assume that a factor other than polysemy determines the level of underspecification and, ultimately, the level of noun dependent meaning computation in combinatorial interpretation. This possibility will be discussed in greater detail in the General discussion section below.

2.4 General Discussion

The questions addressed in the present study concerns the nature of the interpretive mechanism at the basis of semantic interpretation of polysemous adjectives. A number of theoretical and empirical studies on the polysemy of nouns and verbs (Frazier & Rayner, 1990; Pickering & Frisson, 2001; Pustejovsky, 1995; Ruhl, 1989) suggest that polysemy results from semantic underspecification, which is responsible for a high level of context dependence in semantic interpretation. In other words, in different contexts, different, though highly related meaning variants are computed rather than enumerated (e.g., the adjective *nice* in the combinations *nice day, nice blanket, nice boy*). A different kind of ambiguous words, often referred to as homonyms, require full semantic specification. Consider, for instance, the different meaning variants of the noun *bank*. Since there is no semantic similarity between the interpretations *financial institution* and *river bank*, the one cannot be computed from the other or from a common or core property. Both meanings have to be listed. In addition to nouns and verbs, adjectives can also be homonymous (e.g., Dutch adjective *apart* means *separate* in combinations like *aparte kamers* - separate rooms - but, it means *strange* in combinations like *aparte jurk* - strange dress). Similar to homonymous nouns and verbs, homonymous adjectives must have all their meanings listed in the lexicon. The degree of similarity in the processing of homonymous and polysemous adjectives may provide an indication of the kind of semantic representations polysemous adjectives may have. A high similarity with the homonyms would indicate that the meanings of polysemous adjectives are simply listed in the lexicon. Otherwise, meaning computation is implied.

In the present study it was assumed that the mechanism involved in semantic interpretation of homonyms is the noun-dependent retrieval and selection of adjectival meanings, while for the polysemous adjectives it is the noun-dependent meaning computation. In order to test this hypothesis, spreading-of-activation-based effects of semantic interpretation for the two types of adjectives (in isolation, and in adjective-noun combinations) on the subsequent processing of their near-synonyms were investigated.

The results obtained in two experiments reported in the present study are fairly inconclusive. Polysemous adjectives showed no effects of meaning activation in Experiment 1, and they facilitated processing of the congruent near-synonyms in Experiments 2a and 2b. At the same time, homonyms showed meaning activation effects for the related targets in Experiment 1a together with facilitative priming effects for the congruent targets in Experiments 2a and 2b. The predicted interaction effects were not significant. It can be speculated that the results obtained with polysemous adjectives are incompatible with the assumption that all of their senses are enumerated. In isolated presentation, no effects of meaning activation (retrieval) were obtained at any SOA. This can be explained if it is assumed that, in the absence of context, specific meanings could not have been computed. Hence, the processing of near-synonyms was not facilitated. However, when polysemous adjectives were placed in adjective-noun combinations, evidence was obtained that their different meaning variants were computed. Upon the presentation of adjective-noun combinations, processing of the congruent near-synonyms was facilitated. This facilitation effect can be assumed to be caused by the activation of concepts common to both the prime combination and the target near-synonym (Murphy & Andrew, 1993). As the processing of the incongruent near-synonyms was not facilitated, although the alternative meanings of polysemous adjectives are usually taken to be highly related, it can be concluded that the widely acknowledged relatedness of the different senses of polysemous adjectives may concern their context-dependent interpretations rather than their listed meanings. This kind of interpretation of the findings obtained in the present study is congruent with the interpretation of the findings reported in the Frazier and Rayner (1990) study on polysemous *nouns*, and with the interpretation of the findings reported in the Pickering and Frisson (2001) study on polysemous verbs. However, the 'multiple sense' nouns used in the Frazier and Rayner (1990) study can be characterized as exhibiting primarily 'logical polysemy' (term from Pustejovsky, 1995; Ruhl, 1989), as is the case with the noun *newspaper* which refers to a physical object *newspaper*, as well as to an institution which produces it. This kind of ambiguity is typical for nouns but not for adjectives, and it is a different kind of ambiguity than the polysemy of adjectives used in the present study (see also Pickering & Frisson, 2001, for a similar treatment of polysemous verbs). It is important to acknowledge these variations in manifestations of polysemy across different syntactic classes of words in further explorations of the phenomenon.

One way to account for the absence of the predicted interaction effects is to assume that homonymy/polysemy and meaning specification are not highly correlated. In other words, although homonyms may have a tendency of being fully specified, in some cases, although still being highly unrelated, their meanings may at he same time also be underspecified. A closer inspection of the stimuli used in the present study showed that a number of adjectives may have been wrongly classified as homonymous or polysemous. [Recall that the classification was based on the relatedness score.] Adjectives *aardig, fijn, ijdel, woest* (nice, fine, vain, furious), which were classified as homonymous in our stimulus set, could easily be classified as 'polysemous'. At the same time, irrespective of the measured degree of relatedness of the meaning variants of the adjectives *bezopen, kort,* and *lang* (silly/sloshed, short, long), these meanings seem to be much more clear-cut or specified than that of the adjectives *nice* and *fine* (see also Chapter 5, this thesis). These observations suggest that in further experiments relatedness and underspecification of meanings for ambiguous words should be disentangled.

If we consider the results for the homonyms separately from the polysemous adjectives, the obtained effects of meaning activation are generally consistent with earlier findings in studies on ambiguous words. The finding of early activation of both meanings of balanced homonyms in isolated presentation (Experiment 1a) is compatible with the similar findings of Simpson (1981), Simpson and Krueger (1991), Tabossi and Zardon (1993). This effect was obtained with a 160 ms SOA which is comparable to the Simpson and Burgess (1985) finding of multiple meaning activation at an 100 ms SOA. However, in the present study, in Experiment 1b, a rather early effect of deactivation was found (350 ms). This finding may be typical for the no-context condition. It can be argued that, especially for adjectives, which, other than nouns or verbs, seldom occur in isolation, a prolonged meaning activation can only be sustained in context.

The finding of meaning activation for the homonyms in the right-disambiguation condition in Experiment 2 is congruent in timing with the results of the studies involving the ERP-registration technique (see e.g., Hagoort & Brown, 1994) and the right-disambiguation condition in which the N400 effect (difference in N400 between the ambiguous and the unambiguous word) is found for unbalanced ambiguous words in neutral sentence context starting at approximately 300 ms (peak at 400 ms), indicating processing costs of accessing multiple meanings. It is also congruent in timing with findings in the Coolen, van Jaarsveld, and Schreuder (1993) study on the semantic interpretation of novel nominal compounds.

The findings from the studies on polysemous nouns and verbs, alongside with some of the findings from the present study, seem to suggest that the various possible contextualized meanings of polysemous words do not get stored in the lexicon. For this kind of adjectives, enumeration strategy would not be very useful because meaning lists are bound to be incomplete due to a practically infinite number of possible contextualizations (see, e.g., Murphy & Andrew, 1993). At the same time, the computation of alternative meanings in context may be relatively easy. The results of the present study suggest that the homonymy - polysemy distinction may be less clear-cut for adjectives than for nouns and verbs. When it comes to the issue of mechanism involved in the computation of meanings of polysemous words, it can be argued that the assumption that these meanings are computed by applying some kind of production rules, as suggested by Caramazza and Grober (1976), would still leave us with the problem of unconstrained and possibly incomplete meaning lists. That, however, seems less plausible than to assume that polysemous adjectives simply have highly underspecified meaning representations (e.g., Frazier & Rayner, 1990; Murphy & Andrew, 1993; Pickering & Frisson, 2001; Ruhl, 1989) which are filled in depending on the noun. An alternative to the Caramazza and Grober (1976) notion of instruction rules is to treat (polysemous) adjectives and nouns as active 'partners' in the process of semantic interpretation (see, e.g., Pustejovsky, 1995). Polysemous adjectives can be treated as functions that map appropriate noun properties onto the properties of adjective-noun combinations (see, Kamp & Partee, 1995). For example, in the combination *nice food*, the adjective nice could select the property of food, that it *has taste*. Thus, in some contexts, *nice food* could be interpreted as *nice - tasting - food*. Another combination with the same adjective, e.g., *nice house* could be interpreted as a *nicely - designed - house*. An important notion here is that the relevant properties can be provided by nouns. Thus, senses like *tasteful*, or instruction rules that say something like *interpret 'nice' as 'nice design' when it comes to artifacts like houses*, do not have to be stored as (partial) adjectival meanings.

Adjectival polysemy and noun-dependent interpretation strategies

CHAPTER 3

3.1 Introduction

The results obtained in the previous study (Chapter 2) suggest that polysemous adjectives (such as *nice*) could be highly underspecified (Ruhl, 1989) and noun-dependent in combinatorial adjective-noun interpretation. To illustrate their noun-dependence we can compare the combination *nice boy*, which can be interpreted as *boy behaving nicely* or as *nice-looking boy*, with the combination *nice dress* which can be interpreted as *nice-looking dress* but not as *dress behaving nicely*. For polysemous adjectives like *nice* it can be argued that their multiple meanings are in fact different contextualizations that are computed primarily in combination with nouns rather than being listed. This is in accordance with the *maximized monosemy* hypothesis by Ruhl (1989).[1]

In most studies on ambiguity resolution, the influence of prior context on the processing of ambiguous words has been investigated. It is, however, important to note that in studies involving adjective-noun combinations in isolation (such as the present study), nouns act as a post-access disambiguating context for adjectives. In the Frazier and Rayner (1990) study, semantic processing of nouns with 'multiple meanings' (homonymous nouns) was compared with the processing of nouns with 'multiple senses' (polysemous nouns). The two types of ambiguous nouns were embedded in four different types of disambiguating (two-clause) sentences bringing about either prior or late disambiguation of either dominant or non-dominant meaning. In the

[1]According to Ruhl (1989) most words and expressions are monosemous and do not require separate lexical entries or separate meaning representations. He argues that the seemingly different meanings of a word can be computed in some way from a highly abstract meaning in combination with information from the semantic and pragmatic context.

prior disambiguation condition, the clause preceding the other clause with an ambiguous word contained disambiguating information[2] while in the late disambiguation condition it was the clause following the other clause with an ambiguous word.[3] The dependent variables in the Frazier and Rayner (1990) study were the first-pass reading time per character averaged over different target regions, namely the ambiguous or target word, the post-target region, the disambiguating region (either before or after the ambiguous word), as well as the entire sentence. In addition, they also analyzed the target word spillover effects (reading times for the word immediately following the ambiguous word), and average target and post target word reading time. One of the findings in this study was that the garden path effect (the initially selected meaning turns out to be incongruent with the context following the ambiguous word) occurred only for the nouns with multiple meanings like *date, match,* and *coach,* but not for the nouns with multiple senses like *newspaper, book,* and *letter.* Frazier and Rayner report longer sentence reading times (due to delayed disambiguation) for the sentences containing nouns with multiple meanings than for the sentences containing nouns with multiple senses. The same pattern was also obtained in the more localized analyses of the target word reading time, reading time for the post-target region, and for the disambiguating region. To explain the finding that the 'multiple senses' nouns showed no garden-path effect, which implies that their senses are not enumerated, Frazier and Rayner (1990) argue that after an initial (immediate) activation of those noun properties which are common to their various senses, further processing of the 'multiple senses' words involves additional specification of the context-favored sense. This is achieved by a shift in the selected subset of properties, favoring one of the alternative meaning aspects. This kind of 'disambiguation' costs much less processing time compared to the reanalysis after a 'garden-pathed' selection of context-inappropriate meaning of homonyms (multiple meanings). In the analysis involving the Target Word Spillover Effects, and the average target and post-target word reading times in the prior disambiguation condition, the effect of preference (dominance) of meanings was obtained for both nouns with multiple meanings and nouns with multiple senses. The 'unpreferred meaning' bias in the prior context caused larger spillover effects than the 'preferred meaning' bias. It is argued that this finding "...suggests that readers do commit themselves to a particular sense of a word when the intended sense

[2]In the prior disambiguation sentence *Throwing so many curve balls, the pitcher pleased Mary,* the ambiguous noun *pitcher* is of a 'multiple meaning' or homonymous type.

[3]In the late disambiguation sentence *Unfortunately the newspaper was destroyed, lying in the rain* the ambiguous noun NEWSPAPER is of a 'multiple sense' or polysemous type.

is implied by the content of prior context."(Frazier & Rayner, 1990, p. 191).

Compared to polysemous adjectives, nouns with multiple senses are somewhat different. In Pustejovsky (1995), the kinds of polysemous nouns used in the Frazier and Rayner (1990) study (e.g., *book*, and *newspaper*) are said to exhibit so-called logical polysemy. These nouns can refer to two aspects of the same referent, namely the physical object *book*, and the informational content of the book (a container/containee alternation). This is an instance of complementary polysemy in which different senses are systematically related. Nouns of this kind unify alternative meaning aspects such as the *physical object - information* aspects unified by the noun *book*. The different sets of properties constituting the two different meaning aspects *complement* each other, that is, together they comprise a full noun description. Adjectives in general are different in that they act as functions over (head) nouns (or functions from intensions to intensions Kamp & Partee, 1995). They can be said to map the properties of nouns onto the properties of adjective-noun combinations (see Kamp & Partee, 1995). Treating adjectives as functions poses a requirement that they specify the type(s) of noun properties they select for in adjective-noun combinations. For instance, adjectives like *nice* preferably select properties denoting form-related characteristics of a noun (a *nice dress* interpreted as a *nice-looking dress*), while adjectives like *fast* select noun-related events (*fast car* interpreted as a *fast-driving car*). In this view, polysemous adjectives constitute a class of adjectives with the characteristic of being able to select and map a great variety of noun properties. In Pustejovsky (1995), it is argued that these adjectives also exhibit complementary polysemy but, unlike the complementary polysemy of nouns (*newspaper, book, window*, see above), adjectival complementary polysemy does not involve sense alternation (container/containee, product/producer, figure/ground, etc.) but a *functional dependency* of adjectives on the noun being modified.

Frazier and Rayner (1990) obtained evidence for the use of the so-called *minimal commitment strategy* in semantic interpretation of polysemous nouns. According to their *immediate partial interpretation* hypothesis, when nouns with multiple senses (polysemous) are processed in a late (post-access) disambiguation condition, initially only the properties common to different senses are activated, while the disambiguation by late context involves additional specification of the appropriate sense. Taking into consideration adjectival characteristics as intensional functions (see above), it can be expected that, in adjective - noun combination, the minimal commitment strategy applied to adjectives will be realized as a minimal commitment to the selection of the noun properties. The extent of the process of selection of the noun properties, that is, the level of processing commitment, can be expected to depend on a number of noun-related factors. In the present study, the possibility will be explored that the level of noun concreteness is one factor that affects the level of processing commitment. Concrete nouns are often assumed to have richer and more diverse semantic representations than abstract nouns (see, e.g., Kounios & Holcomb, 1994; Paivio, 1986). For an illustration of differences in context-dependence between combinations with concrete and abstract nouns, compare the combination *goede stoel* (good chair), containing a polysemous adjective and a concrete noun with the combination *goed resultaat* (good result) containing the same adjective and an abstract noun. In the former combination, the referent of the noun is unequivocally a chair; the referent of the combination depends on the relatively straightforward selection of the context-appropriate noun property which will render it good (e.g., constructional characteristics of the chair). In the latter combination, on the other hand, it is not just the referent of the combination *good result* that is not known without additional information, but also the referent of the noun *result* varies with context. For instance, in the sentence *De experimentator vond het een goed resultaat* (The experimenter found it a good result) *a good result* may refer to an expected interaction effect in statistical analysis. However, in the sentence *De voetballer vond het een goed resultaat* (The soccer player found it a good result), a plausible interpretation of *a good result* would be 'a winning goal score'. From the above it follows that a high level of commitment to the selection of noun properties in the case of combinations with abstract nouns would pose a greater risk of selecting contextually inappropriate properties than in the case of combinations with concrete nouns. In other words, it can be expected that the access of concrete nouns will result in the activation of quantitatively more and perhaps also representationally more divers kinds of information than accessing abstract nouns. This higher processing commitment in interpreting concrete words implies a higher computational complexity.

It can, therefore, be argued that the main differences in semantic interpretation between adjective-noun combinations constructed with concrete nouns and those with abstract nouns are as follows. Taking into account lower informational content (higher context dependence) for abstract than for the concrete nouns, it can be expected that semantic interpretation of adjective-noun combinations with abstract nouns involves lower property selection commitment than the interpretation of combinations with concrete nouns. In isolated presentation, the successive processing of two adjective-noun combinations constructed with the same polysemous adjective and with the same type of noun (either concrete or abstract), will invoke the same kind of *process-*

ing strategy (high commitment for the concrete pairs and low commitment for the abstract pairs).

In Experiment 1, it was investigated whether this kind of congruence plays a role in on-line semantic interpretation of 'concrete' and 'abstract' adjective-noun combinations. This experiment employed a priming paradigm in which adjective-noun combinations served both as primes and as targets. Different prime-target pairs constituted the congruent, incongruent, and control condition. In the congruent condition, nouns in prime and target combinations were either both concrete or both abstract. In the incongruent condition, target combinations with concrete and abstract nouns were preceded by prime combinations involving nouns of a different type (abstract/concrete, concrete/abstract). In both the congruent and incongruent pairs, the same adjective was included in the prime and in the target combination. In the control condition, adjectives and nouns in the prime and target combinations were different altogether. Examples of the three types of prime-target combinations appear in Table 3.1 below.

In the two congruent conditions, combinations in the prime - target pairs were of the same type with either high commitment/concrete noun combinations or low commitment/abstract noun combinations. Our first prediction is that the congruent prime - target pairs of adjective-noun combinations will show larger facilitative priming effects than the incongruent pairs (which is henceforth called the congruence effect).[4] In the incongruent concrete condition, target combinations with concrete nouns were preceded by prime combinations with abstract nouns. In other words, low commitment combinations preceded high commitment combinations. In the incongruent abstract condition the situation is reversed: high commitment combinations were followed by the low commitment combinations. Moreover, due to a low informational content associated with abstract nouns, it was expected that concrete targets will be hurt by incongruence more than the abstract targets. The letter kind of target is preceded by the informationally rich concrete primes. Thus, larger facilitative priming effects were predicted in the incongruent abstract than in the incongruent concrete condition (henceforth called the incongruence asymmetry effect). A finding of equal priming effects for the congruent and incongruent condition would presumably be due to repeated access for the adjective in these conditions and would indicate that the extent of combinatorial semantic processing was low.

[4]Note that in the present study we are dealing with polysemous adjectives, for which different combinations with nouns are taken to express semantically similar meanings. Therefore, it can be expected that not only *congruent* but also *incongruent* pairs will be semantically similar to some degree. Compared to the control condition, however, incongruent pairs can be expected to show much less facilitation than the congruent pairs.

Experiment 2 investigated whether the obtained effects are due to semantic similarity between the prime and the target combinations.

3.2 Experiment 1

Method

Participants. In this experiment, 126 students at Nijmegen University took part. All participants were native speakers of Dutch and all were paid for their participation.

Materials and design. Stimulus materials consisted of adjective-noun combinations which were constructed using 78 polysemous adjectives and either concrete or abstract nouns (see Table 3.1). Stimuli were presented in a priming paradigm in which adjective-noun combinations served as primes and as targets. The task for the participants was double Lexical Decision for the target combinations. In this task, participants were to give a 'yes' response only if both words comprising the target were existing Dutch words. Otherwise, they were to give a no response. The results obtained in a similar study involving novel nominal compounds (Coolen et al., 1993) suggest that the task induces interpretive semantic processing. The selected adjectives had at least three different but related senses, as listed in Van Dale Groot Woordenboek der Nederlandse Taal (1984). The mean number of listed senses (main senses) for the 78 selected adjectives was 6.5 ($SD = 2.9$). All adjectives were morphologically simple words. No deverbalized or denominalized adjectives were included. The length of the adjectives ranged between 3 and 8 letters ($M = 6.5, SD = 1.6$).

Each polysemous adjective was combined with two concrete nouns and two abstract nouns. The degree of concreteness for the nouns was determined on the basis of available imageability norms (van Loon-Vervoorn, 1985). Mean imageability rating scores for the selected concrete and abstract nouns were $M = 5.9(SD = .68)$ and $M = 3.2(SD = .72)$, respectively. This difference was significant ($F(1,154) = 567.59, MSe = .48, p < .001$). For the congruent condition, the prime-target difference was not significant (for concrete nouns - $M_{prime} = 5.8, M_{target} = 5.9 \;\; [F < 1]$; abstract nouns $M_{prime} = 3.3, M_{target} 3.2 \;\; [F < 1]$), while in the incongruent condition the difference between primes and targets in mean imageability scores was significant (abstract - concrete $M_{prime} = 3.3, M_{target} = 5.9, \;\; [F(1,154) = 514.77, MSe = .53, p < .001]$; concrete - abstract $M_{prime} = 5.8, M_{target} = 3.2, [F(1,154) = 512.40, MSe = .51, p < .001]$).[5]

[5]The three-way interaction between the factors congruence, concreteness and prime/target was sig-

Care was taken to avoid associative relations between prime and target nouns. On the basis of existing Dutch association norms (amongst others, de Groot & de Bill, 1987), it was established that only in two cases (abstract pair *actie* - *ingreep*, and the concrete pair *reling* - *leuning* the prime and the target nouns were weakly associated (frequency ≤ 2)).

Finally, noun-related effects such as length, frequency, and semantic relatedness were controlled for by conducting a control experiment that is reported in Appendix B. In this experiment, prime - target pairs of nouns were presented in isolation. The results obtained in this experiment show that the nouns on their own in the congruent and incongruent condition do not differ in the amount of prime - target facilitation. This implies that any congruence effects that may be obtained in Experiment 1 can safely be attributed to the effects of combinatorial semantic interpretation rather than to the noun-related factors such as semantic similarity, prime-target integration, frequency or length effects.

Table 3.1: EXAMPLE STIMULUS SET IN EXPERIMENT 1

	CONGRUENCE		
TARGET CONCRETENESS	*Congruent*	*Incongruent*	*Control*
	droge borstel (*dry brush*)	*droge vracht* (*dry cargo*)	*gewone stoel* (*regular chair*)
concrete	*droge pannenkoek* (*dry pancake*)	*droge pannenkoek* (*dry pancake*)	*droge pannenkoek* (*dry pancake*)
	droge vracht (*dry cargo*)	*droge borstel* (*dry brush*)	*gewone stoel* (*regular chair*)
abstract	*droog product* (*dry product*)	*droog product* (*dry product*)	*droog product* (*dry product*)

The control prime combinations were the same for concrete and abstract target combinations. Of each two adjective-noun combinations constructed with concrete nouns, one combination was randomly assigned as prime combination and the other as target combination. The same held for the two combinations with abstract nouns.

nificant [$F(1,308) = 1044.39, MSe = .25, p < .001$]. As indicated in the text, for the congruent pairs the difference between the primes and targets on imageability scores for both concrete and abstract stimuli was not significant while for the incongruent pairs it was significant.

By combining concrete and abstract target combinations with each of the three prime combinations, six prime-target pairs resulted for each polysemous adjective. Two of these pairs were congruent, two pairs were incongruent and two were control pairs. Examples of the six pairs of prime-target combinations are presented in Table 3.1. In this design, comparisons between target combinations with concrete and abstract nouns involve different items. The three different priming conditions for a particular concrete or abstract target combination, however, constitute a within-item factor: target combinations were the same in all three conditions. Both Concreteness and Congruence are within-participants factors.

Stimulus materials were divided into six lists. Each list contained 13 items in each of the six conditions displayed in Table 3.1. Items in the six lists were matched for the length and *log* of the frequencies of adjectives and nouns and the imageability scores of nouns. Twenty-one participants were randomly assigned to each list. The materials used in experiments reported in this chapter are listed in Appendix D.

For the purpose of the lexical decision task, three types of filler target combinations were constructed: 1. a pseudo-word in adjective position in combination with a noun, 2. an adjective in combination with a pseudo-word in noun position, 3. two pseudo-words. There were 30 items for each filler type. Pseudo-words were derived from existing words by changing or transposing one or two letters and were orthographically legal Dutch words. All filler target combinations were preceded by adjective-noun combinations as primes. Filler combinations were the same for all six lists.

In total, each participant was presented with 168 prime-target pairs involving 78 experimental pairs and 90 filler pairs (30 per filler type). No adjective or noun was used more than once in the whole set of stimulus materials.

Procedure. Participants were tested individually or in pairs. Stimuli were presented on a CRT connected to an Olivetti M-24 computer which controlled the presentation of the stimuli and the registration of responses. Each trial started with the presentation of an asterisk (*) for 800 ms at the center of the screen. After a blank screen of 150 ms, the prime combination was presented for 1350 ms. The combination was positioned approximately in the middle of the screen. The position of the first letter of the adjective was fixed. After a 150 ms empty screen, the target combination appeared for 1350 ms or until the participants responded. Target combinations were projected on the screen in the same way as the prime combination. Time-out was set to 2350 ms after target onset (1000 ms after target offset). Inter-trial intervals were 1000 ms. Participants were requested to perform a double lexical decision task for the target combinations. They were to press a yes-button only when both target letter strings were words; otherwise they had to press the no-button. When an error was made to an item that immediately preceded a test item, a dummy item was inserted in between to attenuate the effects of an erroneous response. To ensure that the participants read the prime combinations attentively, questions about the prime were inserted at one-fifth of all trials. Questions were presented visually after the participants had responded to the target combination. Either an adjective or a noun was presented on the screen in a fixed question frame (*'Did x occur in the first pair of words?'*) to which the participants had to answer YES or NO. Feedback about the correctness of the response was given immediately after the response. On half of these verification trials, either an adjective or a noun from the prime combination was repeated, while on the other half the test word was orthographically similar to the prime word. A set of 18 practice items was presented prior to the experimental items, 4 of which were buffer items at the beginning of the experimental series. The set of practice items had similar characteristics to those of the experimental set. The experimental session lasted about 30 minutes.

Results and Discussion

Latencies for erroneous responses (2.8%), time-outs (0.2%) and verification task errors (1.1%) were excluded from the analysis of RTs. Outliers (1.4%) were determined on the basis of participants and items statistics (2SD) and were also excluded from the analysis of RTs. Mean participant latencies and error rates for all conditions are presented in Table 3.2.

Table 3.2: MEAN LATENCIES (ms), AND ERROR PERCENTAGES IN EXPERIMENT 1

	CONGRUENCE					
TARGET CONCRETENESS	*Congruent*		*Incongruent*		*Control*	
concrete	897	2.8%	908	3.5%	918	4.3%
abstract	886	1.7%	901	2.5%	915	2.2%
M	892	2.3%	905	3.0%	917	3.3%

In the analysis of RTs the main effect of congruence was highly significant [$F_1(2, 250)$

$= 9.60, MSe = 4246.89, p < .001; F_2(2,308) = 13.70, MSe = 2058.45, p < .001$]. The effect of concreteness was significant only in the analysis by participants [$F_1(1,125) = 4.54, MSe = 2173.70, p < .05, F_2 < 1$]. The interaction between congruence and concreteness did not approach significance (both $Fs < 1$). A comparison of the two control conditions showed no difference (both $Fs < 1$).

Overall, the congruent condition differed significantly from the control [$F_1(1,125) = 21.17$, $MSe = 3846.58, p < .001, F_2(1,154) = 26.77, MSe = 2090.85, p < .001$]. The difference between the incongruent and the control condition was marginally significant in the analysis by participants, and was significant in the analysis by items [$F_1(1,125) = 3.21, MSe = 5662.70, p = .08, F_2(1,154) = 4.80, MSe = 2084.63, p < .05$]. Congruent and incongruent condition differed significantly [$F_1(1,125) = 6.98, MSe = 3261.38, p < .05, F_2(1, 154) = 9.32, MSe = 1999.86, p < .005$].

The control condition differed from the other two conditions in both the lexical form of the combinations (different combinations in prime and target position in the control condition vs. adjective repetition in the other two conditions), and semantic relation between the combinations (unrelated combinations in the control condition vs. congruent/incongruent prime - target combinations in other two conditions). It could be argued that the congruence effect may also be due to adjective repetition in the congruent and the incongruent condition. However, recall that the congruent and the incongruent condition also differed significantly. This difference was not due to noun-related factors as indicated by the results of the Control experiment with nouns alone. It can be concluded that the congruence effect is of a semantic nature. In Experiment 2, we will test an explanation of this effect based on assumptions concerning semantic similarity.

The analysis of error percentages showed a main effect of congruence [$F_1(2,250) = 3.55, MSe = 21.58, p < .05, F_2(2,308) = 3.28, MSe = 13.76, p < .05$]. The effect of concreteness was significant in the analysis by participants with means of 3.5, and 2.1 for the concrete and abstract targets [$F_1(1,125) = 16.86, MSe = 21.80, p < .001, F_2(1,154) = 3.28, MSe = 76.54, p > .05$]. The interaction between congruence and concreteness was not significant [$F_1(1,125) = 1.68, MSe = 19.37, p > .15, F_2 < 1$].

In sum, the analysis of RTs showed that the main effect of congruence was significant, with both the concrete and the abstract congruent conditions being faster than their respective control conditions, and also faster than the incongruent conditions. The incongruence effect did not differ for the concrete and abstract targets. This implies that semantic similarity between the combinations involving the same type of noun is stronger than in the combinations involving different noun types. In addition, incongruence in processing strategy between the prime and the target combinations seems to be equally impairing for the processing of concrete as well as the abstract targets.

Experiment 2 reported below investigates the nature of the obtained congruence effect. The hypothesis was tested that the priming effects obtained in the congruent condition in Experiment 1 are due to semantic similarity between the computed meanings in prime and target combinations. In other words, similarity in processing strategy employed in interpreting adjective-noun combinations involving the same polysemous adjective is assumed to be paralleled by similarity in the content of their semantic interpretations.

3.3 Experiment 2

In Experiment 1, larger facilitation effects were obtained in the Congruent than in the Incongruent condition. This effect may be accounted for by assuming differences in semantic similarity between primes and targets in these conditions. The aim of the present study is to seek evidence for this account of the results. The *semantic similarity* hypothesis may provide an explanation for the effect of congruence obtained in Experiment 1. If nouns in the prime and target combination are of the same (either abstract or concrete) type, involving the same processing strategy, the similarity of semantic interpretations of the combinations can be expected to be relatively high. In the incongruent condition, the similarity can be expected to be much smaller. For example, similarity of the interpretation of the congruent combinations *nice house* and *nice chair* will both involve physical characteristics of the objects in question. At the same time, interpretations of the combinations *nice house* and *nice idea* do not seem to involve similar concepts. A number of findings suggest that concrete and abstract nouns may differ in the amount and type of information they represent. Findings obtained in Martin et al. (2000) PET study on functional neuroanatomy of object semantics show high dependency of nouns referring to concrete objects on sensory/motor knowledge. In contrast, semantic interpretation of abstract nouns seems to be primarily based on non-sensory/motor knowledge (see e.g., Katz, 1989; Kounios & Holcomb, 1994; Wisniewski, 1996).

In order to find out whether the semantic similarity factor can explain the congruence effect obtained in Experiment 1, the same pairs of adjective-noun combinations were rated by participants for similarity of contextualized adjectival meanings in Experiment 2.

The *semantic similarity* hypothesis would predict overall higher semantic similarity rating scores in the congruent than in the incongruent condition.

Method

Participants. 120 participants were involved in the experiment. All participants were students at Nijmegen University.

Materials and design. Stimulus materials consisted of the same pairs of adjective-noun combinations that were used in Experiment 1, but without the control condition stimuli. Stimulus materials were divided into four lists. Combinations with a particular polysemous adjective were rotated across the four conditions according to a Latin Square design. Since there were 78 polysemous adjectives, the four lists contained an unequal number of stimuli per condition. On each list, two conditions were represented by 20 stimuli each, and the other two by 19 stimuli each. To each list, 12 pairs of adjective-noun combinations were added as control fillers. These pairs contained homonymous adjectives (e.g., 'light piano - light shade'), which had highly distinct meanings. 12 additional pairs of combinations were constructed to serve as practice stimuli. Each participant was presented with 102 pairs of adjective-noun combinations. Thirty participants were randomly assigned to each list.

Procedure. Participants were tested in groups. They were handed a booklet containing an instruction on the first page and a list of 102 pairs of adjective-noun combinations on the subsequent pages, of which 12 were practice items at the beginning of each list. Below each pair of combinations, a 7-point rating scale (1= low similarity; 7 = high similarity) was printed. Participants were instructed to rate the pairs of adjective-noun combinations for the similarity of contextualized adjective meanings. Each participant was presented the list of items in a different random order. Experimental sessions lasted about 15 minutes.

Results and discussion

Mean scores for the four experimental conditions are presented in Table 3.3. Mean scores for the combinations with polysemous and control homonymous adjectives were 3.8 and 2.8 respectively. The difference between the means was significant [$F_1(1, 148) = 83.80, MSe = .28, p < .001, F_2(1,88) = 26.69, MSe = .38, p < .001$].

The analysis (ANOVA) of the semantic similarity scores showed a significant effect of concreteness [$F_1(1,119) = 64.61 MSe = .14, p < .001, F_2(1,154) = 6.14, MSe = .91, p < .05$].

Table 3.3: MEAN SEMANTIC SIMILARITY SCORES IN EXPERIMENT 3.

	CONGRUENCE	
TARGET CONCRETENESS	*Congruent*	*Incongruent*
Concrete	4.7	3.1
Abstract	4.2	3.0
M	4.5	3.1

Mean scores for the concrete and abstract conditions were 3.9 and 3.6, respectively. The effect of congruence was significant as well [$F_1(1,119) = 496.66, MSe = .48, p < .001, F_2(1,154) = 196.68, MSe = .78, p < .001$]. Mean scores for the congruent and incongruent combinations were 4.5 and 3.1, respectively. Interaction between target concreteness and congruence was significant only in the analysis by participants [$F_1(1,119) = 15.37, MSe = .22, p < .001, F_2(1,154) = 2.94, MSe = .78, p = .09$]. These findings suggest that the differences between the congruent and the incongruent condition obtained in Experiment 1 are due to differences in semantic similarity between the computed meanings of the combinations in these conditions. In order to find out to what extent the effects obtained in Experiment 1 can be explained by the semantic similarity hypothesis, an analysis of covariance was performed with the amount of facilitation obtained in Experiment 1 as the dependent variable and similarity scores as the co-variate. Overall, the results showed a marginally significant regression effect [$F_2(1,153) = 3.18, MSe = 1971.94, p = .08$] together with an insignificant congruence effect [$F_2 < 1$]. These results suggest that the congruence effect in Experiment 1 is largely due to the assumed differences in semantic similarity between the stimuli in the congruent and the incongruent condition.

3.4 General Discussion

In the two experiments reported in this chapter, questions were addressed concerning the effect of noun concreteness in the semantic interpretation of adjective-noun combinations involving polysemous adjectives. It was argued that facilitative priming effects in pairs of adjective-noun combinations may depend on the degree of congruence in processing strategy (Frazier & Rayner, 1990) used in their semantic interpretation, which, in turn, may depend on the concreteness of the noun. Larger facilitation effects were expected for the pairs of combinations congruent in processing strategy than for the incongruent ones. In addition to the congruence effect, an incongruence asymmetry effect was expected. It was expected that the incongruence in prime - target pairs would have a much smaller negative effect for the targets containing an abstract noun and their primes a concrete noun than the other way around. This expectation is based on the findings suggesting that semantic representations of concrete nouns are informationally richer than for the abstract nouns (see, e.g., Kounios & Holcomb, 1994; Paivio, 1986).

The results largely confirmed the first prediction showing a significant congruence effect in the expected direction. The prediction of the incongruence asymmetry effect was not confirmed. This implies that the semantic similarity of meanings computed in both concrete and abstract incongruent prime-target pairs was equally low. Although it might be the case that the interpretation of the prime combinations with concrete nouns involves higher processing commitment (Frazier & Rayner, 1990) which leads to higher informational richness and diversity, the content of semantic interpretation of the prime - target pairs used in the incongruent condition seems to involve fairly unrelated concepts.

The absence of the effect of congruence in the Control experiment, in which the nouns were presented in isolation (see Appendix B), suggests that the congruence effect in Experiment 1 is due to combinatorial interpretive processing of adjective-noun combinations. In the Control experiment and, less reliably, also in Experiment 1[6], the concreteness effect was significant. Abstract targets (nouns and combinations) were responded to faster than concrete ones. This finding is compatible with the minimal commitment strategy for adjectives with multiple senses. In a number of studies on the processing of concrete and abstract words, an advantage for concrete words was found (see e.g., Nelson & Schreiber, 1992) on tasks such as paired associate learning,

[6]In Experiment 1, the concreteness effect, significant only in the analysis by participants, was in the same direction as in the pre-experiment.

recognition, free recall, comprehension, lexical decision, and pronunciation. However, Nelson and Schreiber (1992) refer to several studies showing reduction in concreteness effects when the materials are encoded in a prose context and when there is a meaningful relation for both concrete and abstract pairs on experimental lists (e.g., concrete: *gem* - *jewel* and abstract: *cause* - *reason*). In the present study, however, we have found a 'reverse concreteness' effect, that is, an advantage for the abstract targets. Concrete and abstract nouns were either embedded in prime - target pairs of adjective-noun combinations or they were presented as prime - target pairs in isolation. A possible explanation of the reverse concreteness effect for the nouns in isolation may involve the notion that abstract words activate less information than concrete ones (Kounios & Holcomb, 1994; Paivio, 1986). Informationally richer and computationally more complex concrete stimuli may require longer processing times. In adjective - noun combinations, abstract pairs may have been interpreted with lower processing commitment than the concrete ones. This is compatible with the minimal processing commitment strategy (Frazier & Rayner, 1990), indicating that it could be extended from the contextualized processing of nouns with multiple senses to the contextualized processing of adjectives with multiple senses.

The aim of Experiment 2 was to find out whether the congruence effect obtained in Experiment 1 can be accounted for by the semantic similarity hypothesis. Analysis of the semantic similarity rating scores showed the same congruence effect as in Experiment 1. Overall, adjectival meanings in pairs of combinations in the congruent condition were rated as semantically more similar than those in the incongruent condition, thus supporting the semantic similarity account. The effect of congruence suggests that for pairs of adjective - noun combinations involving different nouns (while the adjective is the same), semantic similarity of the content of their combinatorial interpretations is greater if nouns are of the same type with respect to concreteness.

The importance of these findings lies in suggesting that polysemous adjectives are highly dependent on the noun in their semantic interpretation. This is in line with the assignment of a more active role to nouns which is mainly advocated by the *meaning computation* theories of adjective-noun combinations (Pustejovsky, 1995; Ruhl, 1989; Wisniewski, 1996) discussed in Chapter 2. According to these theories, the contributions of both constituents to the meaning of the combination are comparable. In the more traditional and often implicitly adopted sense enumeration approach to adjectival polysemy (Durkin & Manning, 1989; Jorgenson, 1990; Williams, 1992), the role of nouns is reduced to aiding the selection of pre-stored adjectival meanings.

Effects of collocational restrictions in semantic interpretation

CHAPTER 4

4.1 Introduction

In the studies reported in Chapter 2 the role of adjective-related factors in semantic interpretation of adjective-noun combinations was investigated while in Chapter 3 the focus was on noun-related factors. In the present study, the interaction between the adjective-related factor complexity of selectional constraints and the noun-related factor salience of the noun properties will be investigated. In what follows in this section, theoretical considerations regarding the role of the two factors in combinatorial interpretation will be outlined.

Current models of semantic interpretation of adjective-noun combinations typically adopt representational assumptions based on the schema format proposed in Rumelhart (1980). In these models (see e.g. Murphy & Medin, 1985; Murphy, 1988; Murphy, 1990; Smith et al., 1988), semantic representations for adjectives and nouns consist of sets of slots and fillers (or attributes and values). For example, the semantic representation for the noun *house* may contain a SIZE slot (or attribute) for which *big* or *small* are potential fillers or values. One assumption common to these models is that the semantic interpretation process for adjective-noun combinations involves establishing some kind of correspondence or relation (see e.g., Murphy, 1990; Smith et al., 1988; Wisniewski, 1996) between the *slots* or *attributes* specified by the adjective and the noun (see Chapter 1). This interpretive process becomes more complex with increasing complexity in the adjective (Murphy, 1990). It has often been argued that because of the relatively simple semantic structure of adjectives, the interpretation of adjective-noun combinations must be relatively simple as well (see e.g., Murphy, 1990, Experiments 1 and 2). Compared to the process of interpreting complex slot-filler structures underlying noun-noun compounds, adjective-noun combinations seem to be easier to interpret (see, e.g., Murphy, 1990; Wisniewski, 1996). However, although adjectives are presumably always simpler than nouns, some differences in the complexity of semantic representation for adjectives can still be expected. One of the issues addressed in the present study concerns the dependence of the complexity of combinatorial adjective-noun interpretation on the complexity of adjectival selectional constraints.

The complexity of combinatorial interpretation also depends on the salience of the noun properties. Murphy (1990) investigated effects of 'relevant' (salient) and 'irrelevant' adjectival modifiers. Relevant modifiers were said to represent properties that are present in the concept schema of the noun (e.g., *temperature* for *beer*). Irrelevant modifiers were said to represent properties that are not present in the noun schema (e.g, *temperature* for the noun *garbage*). Murphy argues that the combinations with irrelevant modifiers may eventually be interpreted by including the irrelevant property in the schema of the noun. This process may involve drawing inferences based on the knowledge of the world. In those cases in which irrelevant modifiers cannot be incorporated into the noun representation, combinations can be regarded as nonsensical. The results of Murphy's Experiment 3 showed that combinations with irrelevant modifiers were more difficult to interpret than combinations with relevant modifiers. Apparently, the interpretation of the combination is relatively easy when the information relevant for the interpretation is already available in the semantic representation of the noun. It becomes more complex when this information has to be inferred. Murphy (1990) noted that differences in the availability of adjectival dimensions (e.g., *color* for the adjective *blue*) in the semantic representation of the noun may reflect differences in the accessibility as well as in the complexity of required inferences. In sum, it can be hypothesized that both the complexity of the adjective and the salience of the noun properties will affect the complexity of semantic interpretation of adjective-noun combinations.

In the present study, the complexity of adjectives was manipulated on the basis of the model of structure of semantic memory for adjectives put forward by Gross, Fischer, and Miller (1989). According to this model, lexical organization for adjectives is based on the semantic relations of antonymy and synonymy (see also Gross & Miller, 1990). Central to the organization are pairs of direct antonyms like *wet* - *dry* or *warm* - *cold* that express opposite values on some underlying dimension. Clustered around these direct antonyms are sets of near-synonyms. For example, for the central antonym pair *wet-dry*, the antonym *wet* has *damp, moist, soggy* as its near-synonyms (which are indirect antonyms to *dry*). The antonym *dry* has *baked, arid, parched, dehydrated* as near-synonyms (which are indirect antonyms to *wet*). Differences between central and peripheral adjectives in the complexity of their semantic representations are manifested in their distributional characteristics. Generally, central adjectives can be combined with more (types of) nouns than the near-synonyms, that is, they have much larger distributions than their associated near-synonyms. Accordingly, they are also more frequent. As Gross et al. (1989) note, near-synonyms or peripheral adjectives are usually restricted to more specialized usages. For example, the central adjective *large* can be used in a much wider range of nominal contexts than its near-synonyms *bulky* or *spacious*. According to the Collins English Dictionary (1998), *bulky* is used for very large, massive, (movable) objects, whereas *spacious* applies to large areas. Informal observation suggests that peripheral adjectives within a cluster are not freely interchangeable in different noun contexts. For example, for the peripheral adjectives *arid* and *parched* clustered around the central adjective *dry*, the combinations *arid climate* and *parched lips* are clearly preferred to *parched climate* and *arid lips*.

These distributional characteristics were not analyzed systematically by Gross et al., but it can be argued that they are amenable to the analysis of synonymous adjectives in terms of co-occurrence restrictions (Cruse, 1986a; Cruse, 1990).[1] According to the analysis of (partial) synonymy outlined in Cruse (1986a), two main types of co-occurrence restrictions can be distinguished. The first type covers the so-called *selectional restrictions*, which involve presupposed meaning aspects. For instance, the use of the verb *to die* requires subjects to belong to the category *animate*. The second type are *collocational restrictions* which impose more specific constraints on the collocates of lexical items (e.g., *to pass away*, a near-synonym of *die*, selects subjects that in addition to being *animate* also belong to the category *human*). The latter kind of restrictions appear to be arbitrary and have no consequences for truth conditions since *to die* and *to pass away* have basically the same propositional content.

Collocational restrictions differ in the degree to which the (arbitrary) semantic properties of their collocates can be specified. Cruse distinguishes three categories, namely systematic, semi-systematic and idiosyncratic collocational restrictions. For the systematic collocational restrictions, the constraints for the collocates can be stated quite clearly (as for *to kick the bucket*). For the idiosyncratic collocational restrictions, however, the collocates do not share some obvious semantic properties. Examples from Cruse are different adjective - noun combinations constructed with the adjective *im-*

[1] In this kind of relation, one element in a sequence, for instance - a noun, is unilaterally determined by another, for instance - an adjective (Pustejovsky, 2000).

maculate. He argues that *immaculate argument* and *immaculate order* are acceptable; *immaculate complexion* or *immaculate behavior* are unacceptable, whereas the acceptability of *immaculate record* or *immaculate taste* is doubtful. No clear pattern with respect to required semantic properties of nouns emerges from these and other acceptability judgements and therefore the collocational restrictions of *immaculate* can be said to be idiosyncratic. Lexical items with semi-systematic collocational restrictions occupy an intermediate position. Most of the collocates of such words have a particular semantic property, but there are also clear exceptions. For instance, *customer* requires something material in exchange for money, whereas *client* receives less tangible services.

Taking into account the distributional characteristics of central and peripheral adjectives outlined above, it seems plausible to assume that peripheral adjectives share selectional restrictions with central adjectives. This is suggested by the observation that central adjectives can always be substituted for their near synonyms (e.g., *wet towel* for *soggy towel*) although this substitution may not always be conversationally the most suitable or the most informative. However, the relation is not symmetrical. Substituting *soggy cup* for *wet cup* is clearly wrong. The reason for this is that peripheral adjectives, in addition to inheriting selectional restrictions from the central adjectives, impose additional restrictions on the noun, the so-called collocational restrictions. Their semantic representations are more complex than for the central adjectives. It can be expected that semantic interpretation of adjective-noun combinations involving peripheral adjectives, which carry multiple restrictions, will be more complex compared to the combinations with central antonyms. For instance, the adjective *wet* (which is in an antonym pair with *dry*) may have a selectional restriction requiring the noun to be a concrete entity. The near-synonym *swampy* introduces an additional restriction requiring the noun not only to denote a concrete entity but also to include properties like *soil* (e.g., the noun *acre*). Therefore, it cannot be combined with just any concrete noun. Compare *swampy acre* and *swampy trousers.* Although trousers are a concrete entity, they do not satisfy the collocational constraint of the near-synonym *swampy*, that is, trousers do not include reference to *soil.* Therefore the combination appears somewhat odd although not necessarily uninterpretable (see, Murphy, 1990).

As argued above, the semantic structure of nouns may also add to the complexity of semantic interpretation of adjective-noun combinations. In Murphy (1990, Experiment 3), the effects of salience of the adjectival dimension in the semantic representation of the noun was investigated. The results showed that the combinations in which an adjective specified an irrelevant dimension were more difficult to interpret (significantly longer latencies, and higher error percentages) than combinations with relevant adjectival dimensions[2]. In general, the salience of the adjectival dimensions in the representation of the noun will be reflected in the availability of these dimensions in combinatorial interpretation.

From the above, it can be expected that the combinations with central adjectives will generally be interpreted faster than the combinations with peripheral adjectives. Central adjectives are not only more frequent than peripheral adjectives (due to differences in distributional ranges), they also do not require a search for collocational dimensions in the representation of the noun which is necessary for the peripheral adjectives (compare *wet acre* vs. *swampy acre*). More importantly, adjectival complexity in combination with low salience of the noun properties predicts an interaction effect. Adjectival complexity can be expected to have a relatively small effect on the complexity of semantic interpretation as long as the collocational dimension of the peripheral adjective concerns a and highly available (salient) noun dimension. However, the difference between the combinations with central and peripheral adjectives in the complexity of semantic interpretation will become much greater if the collocational dimension of the peripheral adjective is of low salience for the noun.

The purpose of Experiment 1 is to extend the empirical basis for the assumptions about the role of the factors adjectival complexity and salience of the noun properties, by comparing different kinds of adjective-noun combinations rather than comparing adjective-noun with noun-noun combinations as in Murphy (1990). In order to test the predictions outlined above, both adjectival complexity and noun salience were manipulated. Adjectival complexity was manipulated by selecting central and peripheral adjectives (see above). To manipulate salience, nouns were selected for which the collocational dimension of the adjective was of either high or low salience.

4.2 Experiment 1

Method

Participants. Thirty-two participants, all native speakers of Dutch, took part in this experiment. They were all paid for their participation in this experiment.

[2]It will be noted that the salience of a particular modifier is gradual and may reflect either the relative accessibility of the relevant piece of information or the complexity of inferences in the interpretation process. Furthermore, a combination can be expected to be judged as nonsensical if the adjectival dimension is not found or cannot be inferred.

Materials and design. Experimental materials consisted of 48 quadruples of adjective-noun combinations. In each quadruple, a central adjective and one of its peripheral adjectives were combined with two different nouns. For one of these nouns, the property corresponding to the collocational dimension of the peripheral adjective was highly salient and for the other noun it was low salient. Examples of the four types of combinations are presented in Table 4.1, below. Materials used in the Experiments reported in this chapter are listed in Appendix E.

Table 4.1: EXAMPLE OF MATERIALS USED IN EXPERIMENT 1

	SALIENCE OF COLLOCATIONAL DIMENSIONS	
ADJECTIVAL COMPLEXITY	*high*	*low*
central adjectives	*natte handdoek* *wet towel*	*natte sofa* *wet sofa*
peripheral adjectives	*vochtige handdoek* *moist towel*	*vochtige sofa* *moist sofa*

In order to select adjectives and nouns with which these combinations were to be constructed, two rating studies were carried out. In the first rating study, salience differences for collocational dimensions were assessed for pairs of central and peripheral adjectives. In the second rating study, these differences were assessed with respect to different nouns.

A preliminary selection of pairs of central and peripheral adjectives was made on the basis of the CELEX database (Baayen, Piepenbrock, & van Rijn, 1993), and the Groot Synoniemen Woordenboek (van Dale, 1991). Central adjectives were mostly members of familiar antonym pairs such as *wet* in the pair *wet-dry* (de Groot & de Bill, 1987). Peripheral adjectives were less frequent near-synonyms of the central adjectives (e.g. *swampy*) but were still familiar Dutch words.

To ensure systematic collocational restrictions for the peripheral adjectives, only those near-synonyms were selected for which the Groot Synoniemen Woordenboek (van Dale, 1991) dictionary provided a label for the collocational dimension. For example, the dictionary specifies that Dutch *priegelig* (*fine, fiddly*) is a synonym of *klein* (*small*) when applied to *handschrift* (*handwriting*). In this example, *handschrift* expresses the collocational dimension of the peripheral adjective *fiddly*.

In the first rating study, a list of 136 word triplets was presented to 32 participants. Each triplet consisted of a central adjective, one of its peripheral adjectives, and a label for the collocational dimension of the peripheral adjective (e.g., the adjectives - *wet,* *swampy*, label - *ground*). For most of the selected peripheral adjectives, the dictionary specified only one label. The task for the participants was to mark the adjective which was more strongly related to the label. In the triplets presented to the participants, the label for the collocational dimension was always the first word of each triplet. Labels could be adjectives, nouns or verbs (e.g., label - 'burgerlijk' (bourgeois), adjectives - 'gezellig' (cosy), 'kneuterig' (snug); label 'grond' (soil), adjectives - 'weak' (mellow), 'drassig' (swampy)). The central and the peripheral adjectives were randomly assigned to the second or third position. Sixteen triplets were listed twice in order to determine intra-rater reliability. For 70 pairs of central and peripheral adjectives, binomial tests showed significantly stronger relatedness of labels to near-synonyms than to central adjectives (for all pairs $p < .05$). For the whole set, the inter-rater (Cronbach's alpha) and the intra-rater reliability score (split-half method applied for the repeated scores) were both 0.73.

The second rating study was designed to select nouns for which the collocational dimension of the peripheral adjective was either highly or low salient. For each of the 70 labels selected on the basis of the first rating study, minimally two nouns were included in the materials. For each of these nouns, minimally one high-salient and one low-salient label for the collocational dimension of peripheral adjectives was selected. In the rating study, 32 participants were presented with 245 word pairs that consisted of labels for the peripheral adjectives and nouns. They were instructed to judge the degree of semantic relatedness of the labels and the nouns on a 7-point scale (1 - low-similarity, 7 high similarity). In the final set, 48 pairs (96 nouns) of high (M = 5.3; SD = .65) and low similarity (M = 3.0; SD = .54) nouns were selected. The difference between the two sets was significant [$F_1(1,31) = 443.64, MSe = .18, p < .001, F_2(1,94) = 77.88, MSe = 1.55, p < .001$]. By combining these nouns with the corresponding adjectives, 48 quadruplets of adjective-noun combinations were formed (see Table 4.1). Due to a negative correlation between adjectival complexity and frequency it was not possible to match central and peripheral adjectives for frequency.

Four different stimulus lists were created that contained 12 items in each of the four conditions presented in Table 4.1. Eight participants were randomly assigned to each of the four lists. Forty-eight filler adjective-noun combinations were added to each list to allow for no-responses. In 24 of these combinations, a clear violation of a selectional restriction occurred (e.g., *sensitive hotel*). For the other 24 combinations, acceptability was doubtful (e.g.,*ridiculous forest*). These filler combinations were the same for all four lists.

Procedure. The presentation of the stimuli and the registration of latencies and responses were computer-controlled. Participants were seated in front of a video display unit, connected to an Olivetti M-24 computer. Each trial started with a display of an asterisk (*) in the middle of the screen for 500 ms. Subsequently, the adjective-noun combination was displayed for a maximum of 2000 ms or until the response is given, whichever was earlier. The inter-trial interval was 2000 ms. Participants were instructed to judge combinations for meaningfulness. They were to press the yes-button on a button-box in front of them if they found a combination meaningful; otherwise they were to press the no-button. Experimental items were preceded by a series of 32 practice items exhibiting similar characteristics. Experimental series started with 10 warm-up trials for which no latencies were recorded. Participants were tested individually. The experimental sessions lasted about 15 minutes.

Results and Discussion

Missing data due to time-out responses amounted to 0.7% of all data. Latencies that exceeded two standard deviations from the subject and item means (per condition, per list) were excluded from further analysis. On the basis of this criterion, 6.1% of valid data for this set were left out. The mean latencies for the meaningful responses and mean percentages of meaningless ('error') responses ($M = 23.7\%$) for the four types of adjective-noun combinations are displayed in Table 4.2.

Table 4.2: MEAN LATENCIES AND PERCENTAGES OF NO-RESPONSES IN EXPERIMENT 1

	SALIENCE OF COLLOCATIONAL DIMENSIONS			
ADJECTIVAL COMPLEXITY	*high*			*low*
central adjectives	952	17.5%	958	13.0%
peripheral adjectives	1027	20.3%	1054	41.2%
M	990	18.9%	1006	27.1%

The analysis of the mean latencies for the yes-responses showed a significant effect of the factor Complexity in the participants analysis [$F_1(1,31) = 33.86, MSe = 3401.03, p < .001, F_2(1,47) = 2.51, MSe = 33837.12, p < .10;$]. Combinations containing central adjectives were responded to faster (955 ms) than combinations containing complex adjectives (1041 ms). No significant effect of salience was obtained [$F_1(1,31) < 1; F2 = 1.4$].

The interaction between the complexity and salience was also not significant (both $F < 1$).

The analysis of the percentages of meaningless responses showed a significant effect of the factor Complexity [$F1(1,31) = 95.86, MSe = 109.30, p < .001, F2(1,47) = 31.51, MSe = 499.1, p < .01$]. Combinations with peripheral adjectives resulted in more no-responses (30.7%) than combinations with central adjectives (15.3%). The effect of salience was also significant [$F1_{(}1,31) = 23.27, MSe = 111.24p < .01, F_2(1,47) = 6.30, MSe = 614.92, p < .05$]. Combinations with low salience nouns were classified as meaningless more often (27.1%) than combinations with high salience nouns (18.9%). Most importantly, the interaction between the complexity and the salience was also significant [$F_1(1,31) = 29.51, MSe = 132.80, p < .001, F_2(1,47) = 20.30, MSe = 289.62, p < .001$].

In the analyses of reaction times no interaction effect was obtained, while the effect of complexity can be ascribed to the differences in frequency of central vs. peripheral adjectives. However, the predicted interaction between complexity and salience was obtained in the analysis of percentages of no-responses. Post-hoc comparisons showed that this effect was due to the combinations involving complex near-synonyms and low salience nouns. These combinations were particularly difficult to interpret, yielding significantly more no-responses than the other three conditions. A similar discrepancy between the findings in the analyses of latencies and in the analyses of percentages of no-responses regarding the expected interaction effect has been obtained more often in experimental studies of adjective-noun combinations (Gagné & Murphy, 1996; Wisniewski, 1998). In experiments in which participants respond under time-pressure they sometimes develop a deadline response strategy, that is, they determine a response execution deadline at which they terminate the interpretation process irrespective of whether it is completed or not. With such a strategy, meaningful but more difficult combinations have a greater chance of being erroneously classified. In the present experiment, it could be the case that the low-relevant noun dimensions corresponding to the collocational dimensions of peripheral adjectives may not have been retrieved or inferred within the pre-set response deadline leading to erroneous classifications. The significant interaction obtained with percentages of no-classifications indicates that participants tended to classify difficult combinations as meaningless which may have affected the response latencies. The finding that filler combinations, in which selectional restrictions were clearly violated, are (correctly) classified as meaningless faster (M = 1005ms) than the difficult high complexity - low salience combinations indicates that the meaningfulness decision is easier to make if the irrelevant dimension cannot be retrieved or inferred.

In order to test the hypothesis that the test combinations that yielded the most meaningless classifications were not uninterpretable for the same reason as the filler combinations which involved violation of selectional restriction, but were simply very difficult to interpret in a speeded classification task, an off-line experiment (reported below) was designed in which the combinations were placed in sentence context and judged for meaningfulness.

4.3 Experiment 2

In Experiment 1, the interaction of complexity and salience was attributed to the complexity of semantic interpretation for the combinations involving complex adjectives and low salience nouns. When the noun dimension corresponding to the adjectival collocational dimension is highly relevant, the complexity of the adjective does not play a role and vice versa. It is often assumed that the salience measure reflects the ease of retrieval or inference of the required noun dimension (Murphy, 1990). In this view, only those combinations in which there is a clear violation of selectional restrictions, that is, in which the adjective dimension cannot be meaningfully related to the noun (e.g., *yellow idea*), are considered meaningless. In order to exclude the possibility that the interaction effect obtained in Experiment 1 was due to the meaninglessness of a high proportion of the difficult high complexity - low salience combinations, we designed a second experiment in which participants judged the meaningfulness of these combinations embedded in sentence context.

In Murphy (1990), it is pointed out that, in addition to meaninglessness, there will often be a whole range of properties for conceptual combinations that may explain interpretability differences between them, such as their typicality and familiarity. Instead of trying to control for each of the possible confounding variables (which sometimes may not even be possible), Murphy (1990, Exp. 4) embedded different types of combinations in either neutral or helpful contexts. The neutral context did not contain information relevant for the interpretation of the combination, while the helpful context specified the dimension (property) of the modifier relevant for the interpretation of the combination. Materials consisted of adjective-noun and noun-noun combinations. In adjective-noun combinations, adjectives represented either a typical or an atypical noun property. Noun-noun combinations involved modification of an atypical head noun property. The results of the Murphy (1990) study showed a significant interaction between the combination type and context type, with noun-noun combinations being the most difficult (longest latencies) in the neutral (non-facilitating) context condition. This finding suggests that the context can be helpful in the interpretation of complex combinations such as novel and atypical noun-noun compounds. When general knowledge is called upon in order to interpret a combination, the context may be helpful in giving cues regarding a possible interpretation.

The aim of Experiment 2 was to find out whether our combinations of complex adjectives and low salience nouns are difficult to interpret without the context due to the combined effect of the two factors or simply because of being atypical, unfamiliar or uninterpretable. The experiment involved similar context manipulation as in Murphy (1990). The combinations that consisted of complex adjectives and low salience nouns were embedded in facilitating and neutral sentence contexts. The facilitating context was designed to provide cues for the activation of the collocational dimensions of the complex adjectives. The neutral context did not provide such information. Subjects were asked to rate the combinations (embedded in sentences) for meaningfulness on a 7-point scale. If the interaction effect obtained in Experiment 1 is due to the low availability of the low-relevant collocational dimensions in the noun representation, then higher rating scores can be predicted for these combinations in facilitating than in neutral context. If the interaction obtained in Experiment 1 is due to other factors than those manipulated here, then there is no reason to expect a context effect. It does not seem plausible to expect that a single event of embedding combinations in facilitating contexts will significantly alter their familiarity status. In Murphy (1990, Exp. 4) it is argued that variables like familiarity are not affected by context manipulations.

Method

Participants. Fifty participants, all native speakers of Dutch, took part in this experiment. All were paid for their participation.

Materials and design. Facilitating and neutral contexts were constructed for the 48 adjective-noun combinations that consisted of peripheral adjectives and 'low-salience' nouns. Facilitating sentences were constructed so as to 'prime' collocational dimensions of peripheral adjectives rather than naming these dimensions explicitly. Intuitions about the facilitating character of the sentences were tested in a rating study. For each adjective-noun combination, four sentences were constructed; two for each context type. The sentences were presented without the sentence-final adjective-noun combinations, but with labels for the collocational dimensions (the same labels as in Experiment 1) underneath. Beneath each sentence - label pair, a 7-point rating-scale was printed. Participants were instructed to read the sentences carefully and to rate the semantic relatedness between the sentence fragments and the labels. The 192 pairs of labels and sentence contexts were divided into four lists. Each list consisted of 48 pairs. Half of the sentences in each list represented facilitating contexts, while the other half were neutral. Each label occurred only once in each list. Eighty participants took part in this experiment. They were given a booklet that contained the instruction and 48 sentence-word pairs. From the set of four sentences for each label, the best examples of facilitating and neutral sentences were selected. Mean semantic relatedness scores for the selected facilitating and neutral contexts were 5.32 and 2.32, respectively ($t = 17.49, df = 94, p < .01$).

In the rating study for the meaningfulness of the adjective-noun combinations in context, each combination was presented in a facilitating and neutral sentence context (see Example 4.1 and Example 4.2, below).

(4.1) FACILITATING CONTEXT

Op het verjaardagsfeest van Jantje kreeg ieder kind een fleurig ballon.

At the birthday party of Jan got every child a colorful balloon.
(Every child got a colorful balloon at Jan's birthday party.)

(4.2) NEUTRAL CONTEXT

Tijdens de wandeling door de stad zagen ze een fleurig ballon.

During the stroll through the city saw they a colorful balloon.
(While taking a stroll through the city they saw a colorful balloon.)

In the rating study, the selected facilitating and neutral sentences were divided into two lists. The lists contained an equal number of each type of sentences. To ensure the spreading of judgments across the whole range of the scale, two types of filler combinations were used. One type consisted of meaningless combinations like *zoete mouw* (sweet sleeve); the other of highly familiar combinations like *gouden medaille* (gold medal). No context manipulation was applied for the filler combinations. Each list consisted of 96 sentences. Twenty-four of these sentences were facilitating and 24 were neutral. The 48 filler sentences were the same for the two lists and contained the meaningless and highly familiar combinations.

To check whether participants read the complete sentences when performing the rating task, a recall test was used. For each list, a test was constructed that contained five repeated test sentences and five slightly changed test sentences. Participants had to indicate whether the test sentences had been on the experimental list.

Procedure. Participants were tested in groups. They were handed a booklet containing an instruction and the set of 96 sentences. A 7-point rating scale was printed under each sentence. The participants were instructed to read the sentences carefully and to judge the meaningfulness of the sentence-final adjective-noun combinations by encircling one of the numbers 1-7 on the scale (1 - low meaningfulness , 7 - high meaningfulness). 12 practice sentences similar to the experimental ones preceded the experimental series.

After completing the rating task, the participants received the instruction for the recall test and a list of 10 sentences. Their task was to read the list of 10 sentences and to decide for each sentence whether it had been included in the experimental set by encircling YES or NO in front of the sentences. Half of the sentences were the same as in the rating study list, while in the other half the original sentences from the rating study were slightly or considerably changed. The purpose of this task, about which the participants were informed before they begun with the rating study, was to ensure that the participants would read the whole sentences in the rating study carefully, and not just the fragments of the sentences.

Results and Discussion

The analysis of the results of the recall test showed that the participants made on average 2.1 errors. This is primarily due to a difficulty of discriminating between the original and the slightly changed sentences. The average amount of errors can be said to reflect the difficulty of this task. No significant difference in the mean number of errors was observed between the two lists (2.2, 2.0) $[(t = .48, df = 41.72, p > .60)]$. Mean meaningfulness scores for the facilitating (4.6) and neutral sentences (4.1) were significantly different $[F_1(1,49) = 23.10, MSe = 0.27, p < .001, F_2(1,47) = 13.46, MSe = .45, p < .005]$. This finding indicates that the combinations were only difficult to interpret in isolation (Experiment 1), but that they were not uninterpretable (meaningless). Even in neutral context, they were rated relatively highly meaningful.

The purpose of Experiment 2 was to adduce further support for the interpretation of the interaction effect found in Experiment 1. The interaction obtained in Experiment 1 indicated that the combinations that consisted of peripheral adjectives and low salience nouns were particularly difficult to interpret. It was assumed that they should become easier to interpret when the availability of the collocational dimensions is increased, that is, if context facilitates their activation or inference. In the present study, the high complexity - low salience combinations received higher ratings for meaningfulness in the facilitating context compared to neutral context. This proves that their meaningfulness can be manipulated by context. Therefore, it is plausible to conclude that the results of Experiment 2 support our interpretation of the interaction obtained in Experiment 1 and that the interaction effect reflects differences in interpretability of the combinations.

4.4 General discussion

The present study addressed the question of the role of complexity of adjectival selectional constraints and the salience of the noun dimensions satisfying these constraints in semantic interpretation of adjective-noun combinations. It was predicted that the difference in ease of semantic interpretation between the combinations constructed with central adjectives (a single selectional constraint) and complex adjectives (multiple selectional constraints) will be larger for the combinations in which the noun dimension that corresponds to the collocational dimension of the peripheral adjective is low relevant than for the combinations in which it is highly relevant. This prediction was confirmed in the analysis of percentages of no-responses showing an interaction effect in the predicted direction. The absence of the interaction effect in the analysis of latencies is explained as a result of deadline processing strategy for the combinations with complex adjectives and low-salience nouns.

Adjectives may vary in the complexity of constraints they impose on the semantic properties of nouns with which they can be meaningfully combined. In the present study, the complexity of adjectival constraints was determined on the basis of an independently motivated model for the semantic memory of adjectives (Gross et al., 1989). It was argued that, in antonymy/synonymy - based clusters of central and peripheral adjectives, the peripheral ones are more complex. For the latter type, the finding of the relevant dimensions or properties in the adjective and the noun was assumed to be more difficult. In addition to the selectional restrictions concerning highly relevant noun properties, peripheral adjectives carry collocational restrictions on the noun properties. For example, in the combination *wet greenhouse*, the adjective *wet* restricts the set of acceptable nouns to those of the type *concrete object* to which the greenhouse (as well as many other nouns) clearly belongs; there are no further restrictions concerning, for instance, parts of the greenhouse that should be wet. On the other hand, in the combination *swampy greenhouse*, the adjective constrains the interpretation to *a greenhouse in which the soil is wet*. Here the focus is on one component of the noun, that is, the soil. This property can be related to different nouns in different ways and may vary in salience across different nouns (e.g., compare *acre*, *greenhouse*, *flower*). In Experiment 1, evidence is obtained that both adjectival complexity and noun salience influence meaningfulness judgments, presumably by lengthening the interpretation process beyond a pre-set response execution deadline, thus producing a larger number of meaningless-classifications.

Current schema-based models of adjective - noun combination assume that adjectives and nouns must have the same meaning components (dimensions, attributes, slots, properties) in order to be meaningfully related to each other (Murphy, 1990; Smith et al., 1988). However, as argued in Chapter 1 of this thesis, many adjectives do not represent a clear dimension. Yet, they form meaningful combinations with nouns (e.g., the polysemous adjective *nice*). Furthermore, in those cases in which the adjectives do represent clear properties, it does not seem plausible to expect that nouns would represent (or allow to be added) all these properties. Clearly, these models will need additional components in order to be able to account for the full range of adjective - noun characteristics.

Regarding the salience construct, Murphy (1990) argues that it may reflect two things, namely availability and the need for inferences. In those adjective - noun combinations in which adjectives specify dimensions present in the noun representation (e.g., *soil* for the noun *acre*), salience reflects the accessibility of such concepts. For other combinations, the relation of the concept to a noun may have to be inferred on the basis of world knowledge (e.g., *soil* for the noun *flower*). Further research is needed in order to be able to discriminate between the two interpretations of salience.

The results of Experiment 2 showed higher meaningfulness ratings for combinations involving complex adjectives and low-salience nouns embedded in contexts that were semantically related to the properties that determine their compatibility. However, by itself, this finding is compatible with different accounts of the role of context in conceptual combination. On the one hand, effects can be interpreted as indirect, that is, context can be assumed to affect the interpretation process by making the relevant property more accessible (cf. Murphy, 1990). Alternatively, semantic information from the larger context could be used directly as an additional source of constraints on the interpretation of the combination. For instance, in Kamp and Partee (1995), an example is given of contextual influence on the interpretation of the adjective-noun combination *tall snowman* (in which the adjective *tall* is both vague and context-dependent), depending on whether the snowman was built either by a 2-year old child or by grown-ups. In this example the choice of the appropriate scale for the dimensional adjective TALL is dependent on the noun as well as on the context. Thus, the interpretation process can exploit information from three different sources: the modifier, the head, and the context. Exploiting all available sources would be a good strategy, because it would ensure that the interpretation assigned to the combination fits the larger context.

These considerations point to two different roles that the context might play. It may enhance the availability of the adjective or the noun properties or it may provide additional constraints on the combinatorial process. Further research is needed in order to investigate the role of context in conceptual combination more closely.

On the one hand, the results of the present study support the assumption that modifier complexity as well as the salience of noun properties affect semantic interpretation of adjective-noun combinations. On the other hand, it points to the necessity of a closer theoretical analysis of different kinds of modifiers in order to be able to determine specific sets of factors that influence the cognitive processing of different modifier-head constructions. Traditionally, models of conceptual combination (Hampton, 1997a; Murphy, 1988; Murphy, 1990; Smith et al., 1988) assign the same status to various kinds of knowledge associated with lexical items. The semantic type information is mixed together with other kinds of information in a 'flat' feature list or slot-filler format (e.g., CAT [*animate, quadruped, mammal, black, has eyes, ears, legs, tail* etc.]). However, the concept *animate* is common to a very large number of nouns and is actually a superordinate concept to these nouns rather than a part of their 'local' semantic description. It is questionable that these kinds of semantic properties of adjectives and nouns are modified in the narrow sense as outlined in Smith et al. (1988). Rather, these properties may serve the purpose of establishing adjective - noun compatibility by resolving different kinds of adjectival restrictions such as the selectional and collocational restrictions investigated in the present study.

Adjectival noun dependence and complexity of semantic interpretation

CHAPTER 5

5.1 Introduction

In Chapter 2 of this thesis, the hypothesis was tested that the meanings of polysemous adjectives are computed in context rather than listed in the lexicon. This hypothesis was based on the assumption of semantic underspecification for polysemous words (Frazier & Rayner, 1990; Pickering & Frisson, 2001; Pustejovsky, 1995; Ruhl, 1989). In the semantic interpretation of polysemous adjectives, underspecification was assumed to be reflected in high noun dependence as well as dependence on larger context. In this view, polysemous adjectives (e.g., *nice*) are assigned different meanings in different adjective-noun combinations and in different contexts. However, the studies presented in Chapter 2 of this thesis did not yield unequivocal support for the assumption of a relation between the degree of meaning relatedness for ambiguous adjectives (homonymy - polysemy) and the degree of meaning specification. One reason for this could be that homonymy - polysemy and the degree of meaning specification (hence also, noun dependence) are not highly correlated. If we look at the set of stimuli used in experiments described in Chapter 2, we can see that the polysemous set involved adjectives like *hard, kaal,* and *kort* (hard, bald, short). Intuitively, although having related meanings, these adjectives seem to be much less semantically underspecified than adjectives like *slecht* and *lekker* (bad, nice or tasty). Different contextualized meaning variants of *hard, bald* and *short* involve concrete as well as metaphorical or figurative meanings of which the former seem to be the default. For example, the adjective *hard,* in the first place, represents a clear-cut property of physical objects concerning their resistance to pressure. In the second place, this adjective also has figurative meaning extensions concerning properties of abstract entities such as *problems*. Some dictionaries also use this order in listing different meanings. For adjectives like *nice*, however, there does not seem to be any particular order of either the concrete or the abstract interpretation. This is what one would expect if there are differences within the set of polysemous adjectives in the level of semantic underspecification. Even though for all polysemous adjectives their meanings are related, some have clearly specified, though extensible, meanings, while others are simply underspecified. This suggests that it might not be polysemy, as argued in Chapter 2, that determines the level of underspecification and ultimately the level of adjectival noun dependence. Rather, other factors may heave a more clear-cut relationship with head noun dependence. In the present study it will be argued that it is important to investigate possible determinants of head noun dependence because this factor will largely determine the level of computational complexity of semantic interpretation.

The focus of the present study is on exploring the possibility that the adjectival logical or formal semantic type (as outlined in Kamp & Partee, 1995) determines the adjectival level of underspecification. In the theoretical framework proposed by Kamp and Partee (1995), it is suggested that adjectives in general can best be treated as *intensional functions*, that is, as functions mapping the properties (*intensions*) of nouns onto the properties (*intensions*) of the combinations (see below). Since the application of this function defines a SUBSET in the noun extension[1], adjectives in general can be considered subsective (also called reference- or property-modifying, Siegel, 1976). Formally, subsection is expressed as: $\|skillful\ N\| \subseteq \|N\|$ (Kamp & Partee, 1995). For an illustration of subsective interpretation, let us consider the combination *skillful surgeon*. The combination refers to that subset of surgeons which are skillful in performing a surgery, (rather than chopping wood skillfully). One consequence of this kind of highly noun-specific mode of adjectival interpretation is that combinations of the same adjective with different nouns, such as *skillful violinist*, will refer to a different set of entities, that is, to person(s) skillful in playing a violin. In the semantic interpretation of the combinations *skillful surgeon* and *skillful violinist*, different noun-related properties are used in determining the subset of the noun extension to which the combination refers. Both the intension (set of properties) and the extension (set of entities having those properties) of the adjective *skillful* will be different across different combinations. In other words, the logical type affects both the referential (extensional) and the combinatorial (intensional) part of semantic interpretation.

In addition to the subsective type, Kamp and Partee (1995) identify and describe a

[1]Set of entities in the world or model to which the noun refers and which bears the noun properties.

subclass of adjectives called *intersective*, which act quite differently. As suggested in Kamp and Partee (1995), these adjectives ignore everything about the intension of the noun except the extension it assigns in the given state of affairs. Adjective-noun combinations in which adjectives combine with nouns in an intersective fashion, are also called referent-modifying (Siegel, 1976). They refer to the entities in the intersection of the sets denoted by the adjective and the noun (e.g., the adjectives *carnivorous, yellow, long, etc.*). Formally, $||carnivorous\ N|| = ||carnivorous|| \cap ||N||$ (Kamp & Partee, 1995). One characteristic of intersective adjectives is that they combine in the same way with different nouns (Kamp & Partee, 1995; Sedivy et al., 1999). This characteristic of intersective adjectives can be illustrated by using the adjective *carnivorous*. Compare the meaning of this adjective in the combinations *carnivorous mammal*, and *carnivorous plant*. In both combinations, the meaning of the adjective remains the same (flesh-eating) and the adjective has the capacity to define a set of entities independently of the noun. Generally, to be in the extension of the combination involving an intersective adjective, an entity must fall into the extension of both the adjective AND the noun. In contrast, the meaning of the subsective adjective *skillful* is always determined relative to the noun.

The differences outlined above between subsective and the intersective adjectives imply that intersective adjectives are not underspecified, which renders them much less dependent on the head noun than subsective adjectives (see also, Sedivy et al., 1999; Pustejovsky, 1995). The first question addressed in the present study is whether we can expect that these differences will affect the process of semantic interpretation.

Sedivy et al. (1999) investigated the effect of differences in the level of adjectival head noun dependence on one property of semantic interpretation of adjective-noun combinations, namely on the level of 'incrementality' of this process. Semantic interpretation of adjective-noun combinations can be said to be incremental if it is initiated immediately upon encountering the adjective. Intersective adjectives seem to satisfy this constraint. Sedivy et al. (1999) tested the incrementality hypothesis for adjective-noun combinations by using the method of eye-movement registration. Participants received verbal instructions containing adjective-noun descriptions of the objects on a display in front of them (e.g., *Touch the blue pen.*). The displays contained sets of objects varying with respect to a number of properties (color, shape, size or material). The authors argue that, due to the contrastive role of adjectives in context, they act to narrow down the set of possible referents independently of the noun (e.g., *blue* $\Rightarrow$ set of *blue objects*) irrespective of their level of head noun dependence. They manipulated the level of adjectival head noun dependence by using two kinds of intersective adjectives, namely clear intersective adjectives like *blue* and *round*, which were assumed to have low head noun dependence, and scalar intersective adjectives like *long*, assumed to have high head noun dependence. Clear intersective adjectives like *blue* were thought to have relatively stable and largely noun-independent meaning, which allows for immediate contextual interpretation narrowing the set of possible referents down to those belonging to the set of entities they denote (e.g., *blue objects*). Scalar adjectives (e.g., *long, tall, heavy*), are often believed to involve setting a range or value on an underlying adjectival scale with respect to some comparison class. By default, this is the class of entities denoted by the head noun (see, Bierwisch, 1987; Kamp & Partee, 1995; Sedivy et al., 1999). The process of setting the scale value can be expected to cause delay of full semantic interpretation of adjectives until the head noun is encountered. However, Sedivy et al. (1999) argue that, although these two kinds of intersective adjectives can be said to vary in their degree of head noun dependence, for both of them incremental (rather than delayed) processing is to be expected. One reason for this is that, in addition to using the noun, the process of setting the scale value or range can also be carried out on the basis of a contextually determined comparison class (e.g., the range of variation in the length of different objects in a setting). It was hypothesized that this kind of context sensitivity allows for incremental semantic interpretation of scalar adjectives. The results obtained in Sedivy et al. (1999) confirm this hypothesis, showing no delay in semantic interpretation for the clear intersective adjectives and for the scalar intersective adjectives. Since both types of adjectives represent a clear property (despite the scalars being ambiguous with respect to the exact scale), both may attain their contrastive capacity in context and can be interpreted incrementally. In other words, similar to clear intersective adjectives, scalars act to narrow down the set of possible referents before the noun is known; hereby an (initial) comparison class can be derived from context.[2]

The contrastive capacity of intersective adjectives does not seem to extend to subsective adjectives. While intersective adjectives may serve the purpose of introducing contrast across different classes of objects (e.g., *blue* vs. *not blue objects*), subsective adjectives seem to contrast within one class, (e.g., *good* vs. *not good chairs*, and not, *good* vs. *not good objects*). Due to the fact that subsective adjectives seem to lack the capacity to contrast across object classes, they are seldom, if ever, used in sentences requiring referent identification. For an illustration, the sentence *Please hand me the*

[2]These findings point to non-trivial similarities between the clear intersective and the scalar adjectives. Following Kamp and Partee (1995), I will treat both classes as intersective.

simple interesting easy block sounds odd, to say the least. In this example, the adjectival contrastive capacity simply does not work without further specification of a property which enables considering a block as simple, interesting, or easy. In other words, some noun property which renders a subset in its extension as either simple, or interesting, or easy is needed in order to interpret the combination fully (i.e., to complete both combinatorial and referential processing). This kind of head noun dependence for subsective adjectives prevents them from being interpreted incrementally. The compensation of adjectival head noun dependence by context, which is observed with intersective adjectives, would be very difficult if not impossible for combinations with subsective adjectives [3].

In what way can we expect these differences between intersective and subsective adjectives to affect the course of combinatorial processing? The extent of the effect could be that subsective adjectives lack the referent assignment component in most situations (recall that subsective adjectives are called *reference-* or property-modifying rather than *referent*-modifying; see, Siegel, 1976). At the same time, the incremental character of their semantic interpretation (Sedivy et al., 1999) suggests that intersective adjectives may have a significantly less elaborate combinatorial component. This implies that the combinatorial component can be expected to be less complex for combinations with intersective adjectives than for combinations with subsective adjectives, because the latter but not the former will require elaborate activation and selection of the noun-related properties.

Furthermore, since the semantic interpretation of subsective combinations is assumed to require the activation and selection of the noun properties, one more factor can be expected to affect the complexity of this process, namely the factor complexity of adjective-noun compatibility resolution (see General Discussion section in Chapter 4). For combinations with intersective adjectives, compatibility resolution seems quite straightforward (e.g., *yellow* combines with nouns that denote concrete objects such as the noun *table* rather than abstract entities such as the noun *idea*). These are familiar instances of resolution of selectional restrictions (see Chapter 4). Combinations with subsective adjectives, however, appear to be more complex in this respect. More specifically, although a subsective combination may consist of adjective-noun

[3]Sedivy et al. (1999, p. 115) suggest that "Incremental processing for subsective adjectives would presumably depend largely on immediate accessibility of information pertaining to the head noun." However, this is possible only if the combination referent is already established in discourse (perhaps in sentences like 'The Rhinoceros is a great book'). Unlike for intersective adjectives, context cannot provide relevant information for subsective adjectives. Since the relevant properties come from nouns, adjectival interpretation has to be delayed until the noun is processed.

types that are not prohibited by selectional restrictions, the types may still be incompatible in the sense of belonging to different basic concept types (entity, event or quality, Pustejovsky, 1999). According to the Generative Lexicon theory, the resolution of this kind of incompatibility requires a more complex computational procedure than for compatible types.

For an illustration, although the adjectives *easy*, *fast*, *experienced* and *funny* are all subsective, the former two are considered event modifiers (having strong adverbial usage), unlike the latter two (see, Pustejovsky, 1999; Pustejovsky, 2000). Some nouns like *race* and *meeting* denote events. If an event-modifying adjective like *fast* is combined with an event-denoting noun like *race*, the resulting combination involves compatible types of concepts (event - event). One interpretation of this combination may be something like *a race in which agents are moving fast*. In this interpretation, the adjective modifies the motion of agents in the representation of the event *race*. In the combination *fast car*, on the other hand, the adjective is an event modifier, while the noun denotes an entity and, although we are not dealing with selectional restrictions here, the phrase as a whole involves incompatible types. Nevertheless, combinations like *fast car* are quite common. In Pustejovsky (1995), it is argued that the interpretation of this kind of combination, which consists of incompatible types, makes use of the operation of *type coercion*. Type coercion is "...a semantic operation that converts an expression, α, to the type expected by a governing function, β" (Pustejovsky, 1999). The combination *fast car* can be interpreted through a Telic event of *driving* specifying the built-in function for a car (e.g., *a fast-driving car*). This kind of interpretation is possible only in those cases in which the noun represents a concept of the required type; *natural* type concepts, such as *rock*, do not have a built-in function or purpose (Pustejovsky, 1999).

One consequence of type coercion in the interpretation of subsective incompatible combinations is that adjectival modification of the noun actually becomes adverbial modification of the noun-related event. Apparently, type coercion in adjective-noun combination changes one type of semantic structure into another. It seems plausible to expect that the kind of semantic 'restructuring' present in type coercion will increase the level of computational complexity in subsective interpretation. The findings in the Piñango, Zurif, and Jackendoff (1999) study suggest that these kinds of semantic operations are complex and time-consuming. Piñango et al. (1999) argued that in interpreting sentences like *The girl jumped until dawn*, additional information, termed "repetition function", is called for in order "... to achieve compatibility between the head of the verb phrase *jump* and its aspectual modifier, the prepositional phrase *until dawn*" (Piñango et al., 1999, p. 397). The authors suggest that in these kinds of sentences, the incompatibility of a point-action activity (i.e., an activity with an intrinsic beginning and an end such as 'jumped') with any kind of additional temporal boundary ('until dawn') is resolved by using aspectual coercion. This semantic operation is assumed to introduce a repetition function in order to achieve aspectual compatibility between the verbal head and its temporal modifier (see also McElree, Traxler, Pickering, Seely, & Jackendoff, 2001). Piñango et al. (1999) found that sentences requiring the application of *aspectual coercion* took significantly longer to process than non-coercion sentences.

To summarize, with respect to differences in the level of computational complexity of semantic interpretation, the following three types of adjective-noun combinations are distinguished: (1) low complex, intersective (e.g. *yellow car*), (2) intermediate, subsective compatible (e.g. *interesting car*), and (3) highly complex, subsective incompatible (e.g. *fast car*). The hypothesis tested in the present study is that, due to a low level of adjectival noun dependence, combinatorial semantic interpretation of intersective combinations will be the least computationally complex, as it requires only a relatively straightforward selectional restriction type of compatibility resolution, and no selection of the noun properties. Semantic interpretation of the two subsective types of combinations can be expected to be progressively more complex. Subsective compatible combinations require establishing of the function-argument dependency relation between the constituents (Kamp & Partee, 1995), compatibility resolution and selection of noun properties (e.g., the combination *nice boy* activates/selects boy-properties and becomes *nice-looking boy*). Subsective incompatible combinations require the same operations as the subsective compatible ones plus the operation of type coercion.

The more complex types of combinatorial interpretation are assumed to include the operations of the simpler ones and to involve one or more additional operations. Hence, the processing time prediction tested in Experiment 1 is that differences in computational complexity between the three types of adjective-noun combinations will produce reaction time differences on a task requiring semantic interpretation. Intersective combinations are expected to be the easiest, requiring the least time to interpret, followed by subsective compatible and subsective incompatible combinations. Furthermore, the assumed differences in computational complexity were expected to result in differences in error rates between the three types of combinations. Computational complexity was expected to be positively correlated with error rates.

The theoretical framework outlined above also predicts differences in content of semantic interpretation between the three types of adjective-noun combinations. This issue was addressed in Experiment 2.

The framework proposed here is different, though not necessarily incompatible with the models of adjective-noun combination outlined in Chapter 1 (The Concept Specialization Model, and The Selective Modification Model; see e.g. Murphy, 1990; Smith et al., 1988, respectively). Rather, these models focus on different aspects of the interpretation process involving a different set of factors. The main difference is that both the concept specialization model and the selective modification model do not deal with the outlined differences in adjectival noun dependence. Therefore, it is not clear what these models would predict. Possibly, these models would predict no differences in complexity of semantic interpretation for the three types of combinations distinguished in the present study, as long as the combinations are comparable in typicality, salience of the adjectival properties in the noun, and the like. Both models adopt a 'retrieval-of-information', rather than a meaning construction view of semantic interpretation. In a retrieval-based model of combinatorial semantic interpretation, all combinations are equally complex in terms of number of processing stages in their semantic interpretation. At the same time, their processing time is affected by factors such as salience and typicality of the adjective and noun features (Murphy, 1988; Murphy, 1990; Smith et al., 1988) which determine their on-line availability. In the view expressed here, the processing stage of activation of the specific noun properties is necessary only for subsective combinations because their interpretation involves the selection and mapping of these properties.

5.2 Experiment 1

In Experiment 1, the hypothesis is tested that the proposed differences between intersective, subsective compatible and subsective incompatible combinations in adjectival head noun dependence will be reflected in differences in computational complexity. The proposed differences in computational complexity were expected to result in processing time differences. In order to test this hypothesis, the Speeded Semantic Classification task (SSC) was used, which requires semantic processing of stimuli. In this task, adjective-noun combinations are briefly presented on the computer screen. The participants are instructed to read the combinations carefully , and to decide as quickly as possible if these are meaningful or meaningless. Dependent variables are reaction times (RTs) and percentages of no-responses (classifying combinations as meaningless). The main prediction is that the latencies for the yes-responses (combinations classified as *meaningful*), will differ significantly amongst the three types of combinations, reflecting the assumed differences in the complexity of cognitive processing involved in their semantic interpretations. Latencies for the intersective combinations are expected to be shorter than those for the two subsective types, and the incompatible combinations are expected to take longer to interpret than the compatible ones. At the same time the complexity of semantic interpretation could be expected to affect percentages of no responses with more complex combinations yielding higher percentages of 'meaningless' classifications.

Discriminating intersective and subsective adjectives is a non-trivial matter. In the present study, we have used the argument validity test (Kamp & Partee, 1995) in the selection of the stimuli. Kamp and Partee (1995) observe that subsective adjectives typically yield invalid conclusions in the arguments of the type presented in the Example 5.1, while this is generally not the case with intersective adjectives.

(5.1) Mary is a skillful surgeon.
Mary is a violinist.

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*Therefore, Mary is a skillful violinist. (Kamp & Partee, 1995)

From the example above it is clear that in different combinations, the subsective adjective *skillful* selects for different noun properties. In the combination *skillful surgeon* above, a subset of surgeons is defined with respect to the skill of performing a surgery while in the combination *skillful violinist* a subset of violinists is defined with respect to the skill of playing a violin. Substituting an intersective adjective for a subsective one in the same kind of argument yields a valid conclusion, as can be seen from the Example 5.2 below.

(5.2) Mary is a carnivorous surgeon.
Mary is a violinists.

Therefore, Mary is a carnivorous violinist.

Method

Participants. 45 students of the Nijmegen University participated in this experiment. They were all paid for their participation.

Materials and Design. The set of stimuli consisted of 45 adjective noun-combinations (see Appendix F). The combinations were formed by pairing 15 nouns with three adjectives each, thus representing the three experimental conditions as presented in Table 5.1 below.

Table 5.1: EXAMPLE STIMULI IN THREE EXPERIMENTAL CONDITIONS IN EXPERIMENT 1

COMPLEXITY		
low complex *intersective*	*intermediate* *subsective compatible*	*high complex* *subsective incompatible*
GELE AUTO (*yellow car*)	INTERESSANTE AUTO (*interesting car*)	SNELLE AUTO (*fast car*)

The stimuli in the three conditions were assumed to differ with respect to the level of computational complexity in their semantic interpretation. A within-items design was used. The noun was kept constant, while different conditions were formed by replacing adjectives (*yellow car, interesting car, fast car*). Conditions were matched for length and (written) word frequency of the adjectives. The mean lengths of the adjectives in the Intersective, Subsective Property and Subsective Event condition are 6.9, 7.4, and 7.5 letters respectively $[F < 1]$, and mean log-frequencies (based on the Celex corpus of 42 million tokens (Baayen et al., 1993)) are 3.4, 3.5, and 3.5 respectively $[F < 1]$. In addition, two rating studies were conducted in order to match the stimuli in the three conditions on the variables salience of the adjectival property in the semantic representation of the noun, and typicality of the combination referent for the category of entities denoted by the noun (e.g., typicality of *red apple* for the category *apple* is higher than the typicality of *brown apple*). This kind of matching is important because salience and typicality may produce effects in the same direction as the factors manipulated in our experiment (see e.g., Hampton, 1997a; Murphy, 1990).[4] Both rating studies (salience, typicality) were performed in the same way. The 45 combinations were divided into three lists containing 15 combinations each. On each list, each condition was represented by 5 combinations. In addition filler combinations of high and low salience/typicality (15 and 10, respectively) were added to the lists. Five practice items

[4]Although in Sedivy et al. (1999) no effects of typicality on semantic interpretation of adjective-noun combinations were obtained, in order to exclude the possibility of an alternative explanation of our results, the stimuli will be matched on both salience and typicality variables.

were added to each list. In the salience rating study, noun - dimension pairs (e.g., LEAF - green) were printed together with 7-point rating scales. In the typicality rating study, adjective-noun combinations (e.g., *brown earth*) were printed together with 7-point rating scales. Participants (typicality: N = 15, salience: N = 15) were instructed to rate the stimuli for their salience/typicality. In both rating studies the mean scores in the three experimental conditions did not differ significantly. Mean scores for salience (on a 7-point scale)[5] in the intersective, subsective compatible and subsective incompatible condition are 3.0, 2.9, 2.7 respectively (both $F < 1$). Mean scores for Typicality (on a 7-point scale)[6] in the same three conditions are 4.4, 4.3, 3.8 respectively (both $F < 1$). In addition to typicality and salience, familiarity with the combinations is a possible covariate. As an indirect measure of familiarity, the co-occurence frequency of the constituents of the combinations was used. To that aim we have used corpus data from a (written) corpus based on the Dutch daily newspaper *Trouw*, editions from 1993/1994; approximately 163000 tokens. Two out of 45 test combinations appeared in the corpus. The combination *dik boek* (thick book) appeared 6 times (of which 3 times in plural form, and 1 time as *dik boekwerk* where the noun *boekwerk* is a synonym of *thick book*). The combination *Nederlandse acteur* (Dutch actor) appeared once. This low co-occurence frequency implies low familiarity of all test combinations.

The argument validity test. In order to differentiate between the intersective and subsective types of combinations, the argument validity test for subsectivity was used (see Table 5.2). For all 45 adjective-noun combinations, arguments with two premises and a conclusion were formed. In this test, valid conclusions indicate that the combination in the first premise is intersective, while invalid conclusions indicate that the combination in the first premise is subsective. Although this test does not differentiate between the subsective compatible and subsective incompatible combinations, it is important to establish that both are indeed subsective. Adjectives in the subsective incompatible condition were selected from the Celex list of adjectives with adverbial usage (e.g., slow - slowly) which renders them event modifiers. The 45 items (arguments) containing our experimental combinations (see Table 5.2) were divided in three lists according to a Latin-square design.

Each list contained 20 items (arguments): 5 arguments formed with intersective combinations, 10 arguments with subsective combinations (5 compatible, and 5 in-

[5]The scale included the 0-point, because some adjectival properties can be assumed to be entirely irrelevant for the noun i.e., not represented by the noun (see Smith et al., 1988; Murphy, 1990).

[6]The scale did not include a 0-point because 0 marks neither typicality nor 'atypicality'. (See also Hampton, 1997b, p. 891; here the typicality scale ranged from 1 to 3).

Table 5.2: EXAMPLE SUBSECTIVITY TEST: ARGUMENTS FORMED WITH THREE TYPES OF ADJECTIVE-NOUN COMBINATIONS

TYPE OF COMBINATION		
Intersective	*Subsective Compatible*	*Subsective Incompatible*
Jan is een *bejaarde tandarts*	Jan is een *ervaren tandarts*	Jan is een *trage tandarts*
(Jan is an *elderly dentist*)	(Jan is an *skilled dentist*)	(Jan is a *slow dentist*)
Jan is een *zwemmer*	Jan is een *zwemmer*	Jan is een *zwemmer*
(Jan is a *swimmer*)	(Jan is a *swimmer*)	(Jan is a *swimmer*)
Jan is een *bejaarde zwemmer*	*Jan is een *ervaren zwemmer*	*Jan is een *trage zwemmer*
(Jan is an *elderly swimmer*)	(*Jan is an *skilled swimmer*)	(*Jan is a *slow swimmer*)

compatible), and 5 additional intersective combinations which were added to each list in order to balance the proportion of intersective and subsective combinations. Nine judges were presented booklets containing an instruction and a list of 20 arguments. They were naive with respect to the relation between the argument validity and adjectival type. Their task was to decide, for each argument, whether the conclusion was valid i.e., whether the conclusion followed *necessarily* from the premises. The judges fulfilled the task individually, at their own pace. A 'yes' response classifies the conclusions as valid, indicating that the combination in the first premise is intersective, whereas a 'no' response classifies the conclusion as 'invalid', indicating that the combination is subsective. The percentage of agreement amongst judges was calculated for each combination. Combinations with minimally 67% agreement were entered into the experimental stimulus set. The combinations with less than 67% agreement were replaced by new ones which were also subjected to the argument test and for which the criteria for inclusion in the experimental set were the same as for the initial set. In this way, 15 triplets of adjective-noun combinations were selected and were used in the two experiments reported below.

Semantic classification experiment. Fifteen participants were randomly assigned to each list. Each participant was presented with 50 adjective-noun combinations: 15 experimental combinations (5 in each condition), 5 intersective filler combinations, 5 specialized filler combinations (e.g., *gold medal,* expected to yield fast YES-responses because of high familiarity). Twenty-five meaningless filler combinations (e.g., *sensitive folder*) were added in order to yield no responses in the Semantic Classification task. There was no adjective or noun repetition on any of the three lists. The 3 sets of 5 adjective-noun combinations on each list were matched for length and log frequency of adjectives. There were no significant main effects of list or condition [length: all $F < 1$, frequency: all $F < 1$], and no interaction effect [length: $F < 1$, frequency: $F < 1$].

Procedure. Participants were tested individually, in noise-attenuating booths. Stimuli were presented on a CRT connected to an 80486DX2/66 personal computer which controlled the presentation of the stimuli and the registration of responses. Stimuli (adjective-noun combinations) were presented at the center of the computer screen. Each trial started with the presentation of the fixation mark (*) for 800 ms. After a blank screen for 150 ms, adjective-noun combinations, printed in lower-case letters, were presented for 650 ms. Time-out was set to 1750 ms after target-offset. Inter-trial interval was 1500 ms.

Participants were instructed to read carefully the adjective-noun combinations appearing on the screen, and to decide as quickly and as accurately as possible whether the combinations were meaningful or meaningless. They were instructed to push the yes-button if they found a combination meaningful; otherwise they had to push the no-button. Both right- and left-handed participants gave yes-responses using their dominant hand. When an error was made on a trial immediately preceding an experimental combination, a dummy item was inserted in between the two in order to attenuate the effects of erroneous responding on the subsequent processing of an experimental item. A set of 28 practice items was presented prior to the experimental session, 4 of which were buffer items at the beginning of the experimental series. The set of practice items had characteristics similar to the experimental set. The whole session lasted about 15 minutes.

Results and Discussion

Two items were excluded from the analyses of Reaction times (RTs) in all three conditions, because the results of Experiment 2 reported below clearly showed that one of the combinations, *vlotte pen* (*facile pen*), involved an idiomatic reading (*talented writer*); the other combination elicited more than 70% responses in a different category in two conditions. Latencies for the no-responses ($M = 18.8\%$; based on the remaining 13 items) were excluded from the analysis of reaction times (RTs). Outliers were determined on the basis of items (per list, condition) and participant (per list, condition) statistics (2SD). No outliers were found. Analyses of RTs were conducted with complexity as a within-participants and within-items factor. Overall, the effect of complexity was significant [$F_1(2,88) = 6.09, Mse = 8,534, p < .005, F_2(2,24) = 3.41, MSe = 6,501, p = .05$]. Planned comparisons confirmed our prediction regarding differences in latencies between the intersective and both subsective combinations (see Table 5.3). Latencies for the intersective combinations are significantly shorter than those for either the subsective compatible [$F_1(1,44) = 14.60, MSe = 5,016, p < .001, F_2(1,12) = 7.38, MSe = 2,374, p < .05$], or the subsective incompatible combinations [$F_1(1,44) = 6.67, MSe = 12,368, p < .05, F_2(1,12) = 5.02, MSe = 8,610, p = .05$]. However, latencies in the latter two conditions did not differ significantly [$F_1 < 1, F_2 < 1$]. The finding of significant differences between the intersective and both subsective conditions support the hypothesis of lower computational complexity for the former than for the latter two types of combinations. The hypothesis that subsective incompatible combinations are the most complex is not supported in the analysis of RTs. This finding will be discussed in the context of the analysis of percentages of no-responses below.

Table 5.3: MEAN LATENCIES (ms) AND PERCENTAGES OF NO-RESPONSES IN EXPERIMENT 1

COMPLEXITY OF THE COMBINATIONS		
low complex intersective	*medium complex subsective compatible*	*high complex subsective incompatible*
794 10%	851 16%	855 28%

The analysis of percentages of no-responses was conducted with all items (N=15)[7]. Mean percentages of no-responses per condition are presented in Table 5.3. The three conditions differed from each other only in the analysis by participants: intersective vs. subsective compatible - [$F_1(1,44) = 4.60, MSe = 189.29, p < .05, F_2 < 1$]; intersective vs. subsective incompatible - [$F_1(1,44) = 28.54, MSe = 262.02, p < .001, F_2(1,14) = 4.16, MSe = 598.31, p > .05$]; subsective compatible vs. subsective incompatible [$F_1(1,44) = 18.37, MSe = 176.36, p < .001, F_2(1,14) = 2.43, MSe = 445.08, p > .10$].

Although the differences in percentages of no-responses in the three experimental conditions are significant in the analysis by participants only[8], a high percentage of no-responses (28%) obtained in the subsective incompatible condition suggests that

[7]The removal of the same two items as in the analysis of RTs did not affect the outcomes of the analyses.

[8]Perhaps due to too few items.

these combinations were difficult to interpret (approximately 50% of items had 20% or more no-responses in this condition). Considering that the combinations in this condition can be easily interpreted [9], this is a somewhat unexpected finding. It can be argued that participants might have used deadline processing strategies for this category of combinations. Assuming that semantic interpretation of the subsective incompatible combinations is the most demanding in terms of the complexity of cognitive operations, and taking into consideration the relatively fast pace of the experiment, it is possible that the participants terminated the most lengthy interpretations, i.e., those using type coercion, at a pre-set deadline

In addition to the differences in processing time, the theoretical framework outlined in the introductory section of this chapter predicts differences in the nature (content) of semantic interpretation for the three types of adjective-noun combinations. This issue was addressed in Experiment 2.

5.3 Experiment 2

The aim of the experiment is to test the hypothesis that the differences in computational complexity between the three types of adjective-noun combinations used in Experiment 1 will also be expressed in differences in the kind of content of their semantic interpretation. Intersective combinations, not involving activation and selection of the noun properties, can be expected to yield plain paraphrases (e.g., *a yellow table* is *a table that is yellow*). The subsective compatible and the subsective incompatible combinations should contain a mapped noun property or event, respectively (e.g., the compatible combination *an interesting book* can be paraphrased as *a book with an interesting plot,* and the incompatible combination *a fast car* as *a fast-driving car*). Note that both mapped concepts (plot, driving) originate from the noun and not from the adjective. In order to score the participants' responses, the criteria for their classification were specified (see below). For each combination type, responses were to be classified in four categories: intersective, subsective property mapping, subsective event mapping, and idiosyncratic (other).

[9]This is confirmed by the results of the paraphrase task in Experiment 2, in which a low percentage of idiosyncratic responses ($M = 2.7\%$) was obtained in this condition. This is comparable to the other 2 conditions.

Criteria for the classification of the Paraphrase task responses

1. *Intersective.* Responses are simple paraphrases of the combinations. No additional noun-related concepts are present. Adjectives and nouns may be substituted by their synonyms. In Example 5.3 below, the response is a simple paraphrase wit no additional noun-related concepts inserted. In Example 5.4, there is a substitution such that the synonymous *more than 70 years old* is substituted for the adjective *elderly.*

(5.3) *groene gesp: Een gesp die groen is.*
green clasp: A clasp that green is.
green clasp: A clasp which is green.

(5.4) *bejaarde tandarts: Tandarts van meer dan 70 jaar oud.*
elderly dentist: Dentist of more than 70 years old.
elderly dentist: A dentist who is more than 70 years old.

2. *Subsective compatible.* Paraphrases contain one or more simple (non-event) noun properties which define a nominal subset. In Example 5.5 below, *strong poison* is interpreted as *very concentrated poison* . In Example 5.6, *interesting novel* is interpreted as *a novel with an interesting plot.* In both cases, the interpretations involve knowledge related to the nouns and not the adjectives, This is suggested by the fact that changing the noun (or at least the noun class) automatically results in a different insertion (e.g., *a strong horse* is not *a very concentrated horse,* and *an interesting car* is not *a car with an interesting plot*).

(5.5) *sterk gif: Gif. dat zeer geconcentreerd is.*
strong poison: Poison that very concentrated is.
strong poison: A very concentrated poison.

(5.6) *interessante roman: Een roman die een interessant verhaal heeft.*
interesting novel: A novel that an interesting plot has.
interesting novel: A novel with an interesting plot.

3. *Subsective incompatible (event mapping).* Paraphrases of the event-mapping combinations contain one or more noun-related events. In Example 5.7 below, *slow dentist* is interpreted as *a dentist which works slowly,* that is, the event *to work* associated with the noun *dentist* is modified. In Example 5.8, *urgent letter* is interpreted as *a letter which has to be delivered urgently.* In both cases, adjectival modification became adverbial modification (or manner PPs), modifying the events of *working* and of *delivering,* respectively.

(5.7)	*trage*	*tandarts:*	*Een*	*tandarts*	*die*	*langzaam*	*werkt.*		
	slow	dentist:	A	dentist	who	slowly	works.		
	slow dentist: A dentist who works slowly.								
(5.8)	*urgente*	*brief:*	*Een*	*brief.*	*die*	*met*	*spoed*	*moet*	*worden*	*bezorgd.*
	urgent	letter:	A	letter	that	with	urgency	must	be	delivered.
	urgent letter: A letter that must be delivered urgently.									

4. *Idiosyncratic.* Either it is not clear from the paraphrase what the meaning of the combination should be, or no agreement amongst the judges can be reached regarding the classification of a response (e.g., for the combination *versleten machine* (worn-out machine) the paraphrase classified as idiosyncratic was *a machine which should be replaced*). This is an inference rather than a representation of the content of the semantic interpretation of the combination.

Method

Participants. The same 45 participants as in the Experiment 1 took part in the present experiment. All were paid for their participation.

Materials and Design. In this experiment, the same materials were used as in the Experiment 1, with the exception of the 'meaningless' filler combinations used only in Experiment 1. Forty-five experimental combinations were divided in three lists, so that each list contained fifteen combinations, that is, 5 in each of the three conditions. In addition, each list was supplemented with 5 filler intersective combinations (in order to counterbalance the number of intersective and subsective combinations), and 5 practice combinations. For each list, three different randomizations were made.

Procedure. The participants were tested individually. They received a booklet containing an instruction to perform a paraphrase task, and a list of 25 combinations, 5 of which were practice combinations at the beginning of each list. They were instructed to write down paraphrases for the combinations, reflecting as precisely as possible how they interpreted them. They were told that the combinations could vary with respect to their ease of interpretation. After reading the instruction, they performed the task at their own pace. The whole session lasted approximately 10 minutes. Participants performed this task after taking part in Experiment 1. They had a short break between the two tasks. The versions of experimental lists that participants received in the two experiments were counterbalanced.

Results and Discussion

On the basis of the criteria outlined above, the responses were scored by two judges (experimenters), independently of each other, as indicating one of the three types of semantic interpretation, namely intersective, subsective compatible, or subsective incompatible (event mapping). The final scoring involved forced agreement amongst judges. Responses for which no agreement could be obtained were placed in the category idiosyncratic, together with the responses that were idiosyncratic by consensus. Analyses involved factor response type: In each condition responses were classified in four categories, namely intersective, subsective property mapping, subsective event mapping, and idiosyncratic. For each condition, one of the response types is congruent with the combination type while the others are incongruent. For instance, in the condition intersective, a response classified as indicating an intersective kind of interpretation is congruent.

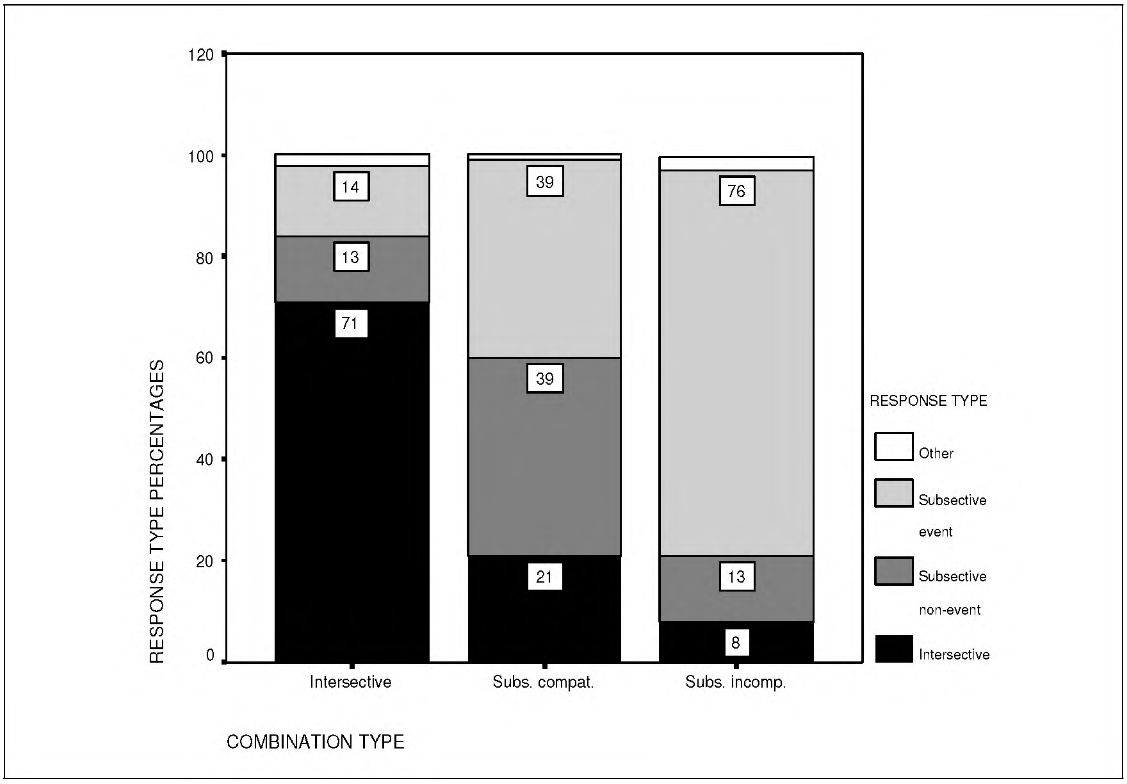
In general, the results are convergent with those obtained in Experiment 1 (see Figure 5.1 below). Overall, the percentage of idiosyncratic responses was very low (M = 2.1%) with 2.22% in the intersective condition, 1.33% in the subsective compatible condition, and 2.67% in the subsective incompatible condition. The difference between the three conditions in the percentage of idiosyncratic responses was not significant [$\chi^2 < 1, d.f. = 2, p = .92$][10].

The highest percentage of responses congruent with the combination type was obtained in the conditions intersective ($\chi^2 = 53.88, d.f. = 2, p < .001$) and subsective incompatible ($\chi^2 = 55.30, d.f. = 2, p < .001$) with means of 71%, and 76%, respectively. The lowest percentage of congruent responses was obtained in the subsective compatible condition (39%). However, in this condition, the effect of the response type was also significant ($\chi^2 = 11.54, d.f. = 2, p < .05$). This was due to a significantly lower percentage of intersective responses compared to both subsective types of responses; half (39%) of the subsective kind of responses in the subsective compatible condition involved event mappings, that is, alternative subsective interpretations. In addition, the three conditions differed significantly in percentages of each of the three response types (except the idiosyncratic). The differences were in the expected directions (intersective - $\chi^2 = 65.34, d.f. = 2, p < .001$; subsective property mapping - $\chi^2 = 32.08, d.f. = 2, p < .001$; and subsective event mapping - $\chi^2 = 63.33, d.f. = 2, p < .001$).

Our prediction that the responses on the paraphrase task would vary in complexity and in type of content across the three types of combinations has been confirmed

[10]The results were analyzed using the non-parametric Friedman test (Friedman ANOVA).

Figure 5.1: PERCENTAGES OF THE FOUR RESPONSE TYPES PER COMBINATION TYPE IN EXPERIMENT 2.



for the intersective and subsective incompatible combinations. A problematic finding is the relatively low percentage of subsective non-event responses in the subsective compatible condition (39%). An equal percentage of responses in this condition involved event mapping. This divergence from our expectation could be due to the fact that some adjectives in this condition, such as *interesting* and *nice*, appear to be less constrained with respect to the type of noun-related concept they select than expected. For instance, *interesting book* can be interpreted as a non-event (e.g., *having an interesting plot*), as well as event mapping (e.g., *interesting to read*). The reason why we included these combinations in the subsective property group is that in order to conclude that a book is *interesting to read* (see the example above), it has to be established that some property of its informational content is interesting, such as its plot or theme. In our view, some of the constitutive elements of a book concerning its informational content must be found interesting in order to qualify it as being interesting to read. Although the 'interesting-to-read' kinds of event-related interpretations can be arrived at in situations in which the processing time is not limited, property-related interpretations should logically occur prior to event-related interpretations in combinations with adjectives like *interesting*. However, the paraphrase task is not sensitive enough to trace eventual inferential processing in semantic interpretation of adjective-noun combinations.

5.4 General Discussion

The present study addressed the question whether, in adjective-noun combinations, the complexity of the combinatorial part of semantic interpretation is dependent on the level of adjectival noun dependence. Complexity is related to the amount of noun-related processing, that is, the activation and selection of the noun properties. The main assumption is that factors affecting adjectival head noun dependence will also affect the computational complexity of the combinatorial component of semantic interpretation. In Chapter 2 of this thesis, the degree of adjectival noun dependence was linked with the degree of relatedness of distinct meanings of ambiguous adjectives. There was, however, no strong support for the assumption that all polysemous adjectives (having highly related meanings) are highly underspecified and, hence, highly dependent on the head noun. In the introductory section of this chapter, it was argued that other factors may be responsible for generating differences in the degree of meaning specification, thus affecting the complexity of semantic interpretation.

The first factor considered in the present study was the adjectival logical type. Adjectives characterized as intersective were assumed to represent clear-cut properties (see Sedivy et al., 1999). This makes them less dependent on the noun than the underspecified subsective adjectives. The second factor which was assumed to affect the complexity of combinatorial semantic interpretation, was conceptual compatibility of the constituents in the combination (e.g., *fast car*). Incompatible types involving an event-selecting adjective and an entity-denoting noun were believed to make use of semantic operation of type coercion in combinatorial interpretation (Pustejovsky, 1995). The use of these kinds of semantic operations has been demonstrated to increase the computational complexity in semantic interpretation (McElree et al., 2001; Piñango et al., 1999).

Three types of adjective-noun combinations were distinguished: low-complex intersective combinations, medium-complex subsective compatible, and high-complex subsective incompatible combinations. In Experiment 1, the prediction was that the assumed differences in the level of computational complexity of combinatorial semantic interpretation will be reflected in the time required for their semantic interpretation. To test this prediction, the (speeded) semantic classification task was used. The latencies on the semantic classification task were significantly longer for the two subsective types of combinations than for the intersective one. This finding supports the hypothesis that the logical type differences are reflected in differences in the complexity of semantic interpretation. The predicted processing time differences between the compatible (property-mapping) and the incompatible (event-mapping) subsective combinations did not show in the analysis of latencies. However, the highest percentage of 'meaningless' classifications (28%) was obtained in the subsective incompatible condition. Nevertheless, the combinations in this condition were easily interpreted, and they consistently involved event mappings (see Experiment 2). Also, the percentage of idiosyncratic responses for these combinations was comparable to the other two conditions. Thus, the higher percentage of meaningless responses in Experiment 1 cannot be attributed to a possible low interpretability of these combinations. Our explanation is that participants may have used a strategy of terminating the interpretations that took too long (i.e., the event-mapping ones) at a pre-set deadline, and classifying these combinations as meaningless.

Involving the same principle of coercion as investigated in Piñango et al. (1999), our event-mapping combinations require a type mismatch resolution, whereby a noun of the type *entity* is coerced to the type *event* required by the adjective (Pustejovsky, 1995). For instance, in combinations like *fast poison*, the noun does not denote any kind of action by itself. Nevertheless, these kinds of combinations are fairly easily interpreted and, as the results of our Experiment 2 show, they consistently involve mapping of noun-related events (the event of *poisoning* in the example above). However, unlike Piñango et al. (1999), we have not find a processing time effect for the combinations involving coercion. What could be the reason for this discrepancy? In Experiment 2 of the present study, subsective compatible combinations showed larger variety in types of interpretation than expected. At the same time, interpretations of subsective incompatible combinations showed high consistency (a high percentage of event-related interpretations). This points to a higher level of underspecification for the adjectives in the subsective compatible combinations than for adjectives in subsective incompatible combinations. Adjectives of the latter type seem to be underspecified with respect to exactly which noun event should be selected although they clearly require an event and not some other type of noun property. This can be characterized as partial underspecification. The processing consequences of partial underspecification may be that, although the coercion operation for these combinations is computationally complex, processing time can be won by immediately narrowing down the set of possible types of noun properties to event representations. At the same time, in subsective compatible combinations, adjectives seem to be underspecified not only with respect to the exact property but also to the type of property they select. This can be characterized as full underspecification. For the compatible combinations, there is no narrowing down of the set of possible properties, which may make the selection process more difficult. In sum, it is possible that although the subsective compatible combinations do not involve coercion, they can not be interpreted faster than the incompatible ones due to a higher uncertainty with respect to the type of property that should be selected in their interpretation. It seems that the relation between semantic underspecification, noun dependence and computational complexity is not a completely straightforward one, because underspecification may concern different aspects or levels of meaning representation. Further experiments need to be conducted in order to gain more insight into processing consequences of adjective-noun type mismatches.

In Experiment 2, differences in the content of semantic interpretation of the three types of adjective-noun combinations were investigated. To that aim, the written paraphrases of the combinations were classified as indicating one of the following three types of semantic interpretation: intersective, subsective property mapping, subsective event mapping. The highest percentage of responses congruent with the combination type was obtained for the intersective and the subsective incompatible combinations (see Figure 5.1). In the subsective compatible condition, most of the responses indicated subsective interpretation. However, half of these responses were event mappings. In retrospect, this divergence from our classification is not so surprising, since a number of adjectives in this group (e.g., *interesting* and *nice*) are fairly unconstrained with respect to the kind of noun-related concepts they select. For instance, in Experiment 2, *interesting book* was interpreted as property-mapping in *having an interesting plot*, and as event mapping in *interesting to read*. However, the order of sub-events in the event of reading suggests that in order to conclude that a book is *interesting to read* it has to be established that some property of its informational content is interesting, for example, its plot or theme. The paraphrase task, however, is not suitable for tracking inferences in the process of arriving at semantic interpretation.

The view on conceptual combination outlined in the present study differs from the view of the standard models dealing with adjective-noun combinations like the Selective Modification model (see e.g., Smith et al., 1988) and the Concept Specialization model (see e.g., Murphy, 1990). These models suggest uniform semantic interpretation processes for all adjective-noun combinations. The complexity of interpretation and processing time differences are mainly predicted by factors influencing the availability of the information associated with lexical items, such as the salience of the 'adjectival dimension' in the noun representation, or typicality of the combination referent (see, e.g., the Discussion section in Murphy, 1990). In the present study, different factors were introduced, namely the factor logical type of the adjective and the factor adjective - noun compatibility. These factors are assumed to affect computational complexity by determining the number of semantic operations, rather than by affecting the availability of information required to compute the meaning. Since the stimuli in Experiment 1 (and Experiment 2) were matched on the variables salience of the noun properties and typicality of the combination referent, the above-mentioned models would not predict any processing time differences between the three types of combinations used in the present study. Clearly, the results obtained in our Experiment 1 can not yet be accounted for by these models.

One question here is whether the representational formats proposed by the standard models (prototype-denoting schemata, theory-embedded schemata) can accommodate the kind(s) of combinatorial interpretation proposed in the present study. A problem with the standard formats is that they do not incorporate structures representing information on the type of dependency relation between the adjective and the noun investigated in the present study, namely a predicate conjunction relation for the intersective combinations, and a function-argument relation for the subsective combinations (Kamp & Partee, 1995). The type of dependency relation may be very important for the configuration of combinatorial interpretative processes. One representational format that seems to allow for both types of combinatorial interpretation is the generative lexicon format (Pustejovsky, 1995). With its different levels of representation of linguistic information in the lexicon (argument structure, event structure, and qualia structure), the generative lexicon format seems to be well suited to accommodate logical type processing as well as fast and accurate compatibility resolution and property selection in conceptual combination.

In conclusion, the results obtained in the present study partly confirm the hypotheses derived from the framework introduced here. The main finding of this study is that the factor adjectival logical type, for which it has often been argued that it can be expected to affect only the referent resolution process, has been shown to affect the combinatorial component of semantic interpretation. The interpretation of intersective combinations is compatible with the findings obtained in the Sedivy et al. (1999) study. Their findings suggest that the reference resolution for the combinations with intersective adjectives can be supported by context, with largely mutually independent processing of adjectives and nouns. This mutual independence in referential interpretation seems to be extensible to combinatorial interpretation. Possibly, the two components of semantic interpretation are not independent (see, e.g., Barsalou, Yeh, Luka, Olseth, Mix, & Wu, 1993).

Summary and conclusions

CHAPTER 6

6.1 Summary

Chapter 1 introduced factors playing a role in semantic interpretation of adjective-noun combinations. The following factors were considered:

1. *Adjective-noun compatibility.* Adjectives typically vary in their level of compatibility with different nouns. This characteristic of adjectives is determined by so-called adjectival selectional restrictions. For example, the adjective *green* selects for (is compatible with) concrete nouns, such as *chair*. Compatibility of the constituents in adjective-noun combinations is positively correlated with their interpretability. In order to relate two low-compatible concepts (e.g., *green idea* interpreted as 'environmentally friendly idea'), elaborate knowledge of the domain of interpretation has to be used.

2. *Adjectival dependence on the noun.* This factor is a function of the level of adjectival underspecification. A comparison of the combinations constructed with underspecified adjectives like *interesting* (e.g., *interesting book, interesting car, interesting flower*) with those constructed with highly specified adjectives like *yellow* (e.g., *yellow book, yellow car, yellow flower*) suggests that the variation in meaning is much larger for adjectives like *interesting* than for adjectives like *yellow*. Different meanings of the former kinds of adjectives are often assumed to be computed on the basis of the noun properties rather than being pre-stored. Meaning of the adjective *yellow*, on the other hand, remains very much the same across different combinations (Kamp & Partee, 1995; Sedivy et al., 1999). In general, it seems to be so that highly specified adjectives, such as *yellow*, display much lower noun-dependence than highly underspecified adjectives like *interesting*.

3 *Knowledge and inferences.* In adjective-noun combinations in which the relation between the two constituents is not obvious (e.g., *swampy greenhouse, easy jail, beach bicycle*), it may be necessary to use elaborate world knowledge and/or to make inferences in order to arrive at a coherent interpretation (e.g., *greenhouse with swampy soil, a jail from which it is easy to escape, a bicycle with wide tires*). This assumption has been put forward by the Concept Specialization Model (Murphy & Medin, 1985; Murphy, 1990). Those combinations which require elaborate use of world knowledge have been shown to be more difficult to interpret.

4 *Salience and typicality.* Current models of conceptual combination adopt the assumption that word meanings consist of a number of components, and that these components vary in their salience (e.g., APPLE - instance of fruit; COLOR: red, green, red/green, brown, etc; SHAPE: roundish; TASTE: sweet, sour; CONTAINS: vitamins, sugar, etc.). If people are asked to list these properties, their responses differ in speed and frequency with which they are produced. These differences may reflect differences in their salience. Adjective-noun combinations which require the use of low-salient noun properties (e.g., *dry apple*) are more difficult to interpret than those requiring high-salient properties (*tasty apple*). Similarly, adjective-noun combinations in which adjectives refer to highly typical values of noun properties (e.g., value *red* for the property *color* in the combination *red apple*) are easier to interpret than those in which this is not the case (e.g., value *brown* for the property *color* in the combination *brown apple*).

In the introductory chapter it was stated that, in the present thesis, rather than adopting any of the representational formats proposed by the current models of conceptual combinations, the strategy was to focus on investigating the role of the above-mentioned factors in computing the meanings of adjective-noun combinations. It was argued that some of the assumptions of the current models may require reconsideration. The chapter ends with an outline of the thesis.

Chapter 2 addresses the question whether the sense enumeration hypothesis holds for both homonymous and polysemous adjectives. Homonymous adjectives often represent (minimally) two clear-cut and unrelated meanings (e.g., the adjective *heavy* refers to *weight* and *difficulty*). For homonyms, one meaning cannot be computed from the other; both have to be represented. The meanings of polysemous adjectives, on the other hand, seem to be highly related and, at the same time, also highly underspecified and dependent on the noun for their interpretation. Polysemous adjective *nice*, for instance, acquires slightly different but related meanings in different adjective-noun combinations (compare *nice meal, nice weather, nice tree, nice boy*). This implies that polysemous adjectives may not require enumeration of their different meanings. Rather, these meanings can be computed in context. In order to test this hypothesis about differences in meaning representation between homonymous and polysemous adjectives, two experiments were conducted. The experiments used a priming paradigm in which homonymous and polysemous adjectives, either in isolation or in adjective-noun combinations, were used as primes while their near-synonyms were used as targets. For example, the adjective *difficult* (which is a near-synonym of the homonymous adjective *heavy*) was presented as a target subsequent to the presentation of the prime adjective *heavy* (Experiment 1A and 1B) or subsequent to the presentation of the prime combination *heavy study* (Experiment 2A and 2B). In Experiment 1, the stimuli for both kinds of adjectives were presented in a related (heavy - difficult) and an unrelated condition (beautiful - difficult). In the related condition, a facilitative priming effect was expected for the homonymous adjectives but not for the polysemous adjectives. However, the interaction effect between relatedness and adjective type was not significant. There was only a weak trend in the expected direction in the analyses performed for each adjective type separately. In Experiment 2, both kinds of adjectives were presented in a congruent (heavy study - difficult), an incongruent (heavy jacket - difficult), and an unrelated condition (beautiful temple - difficult). It was predicted that the combinations with homonymous adjectives, due to their supposedly listed meanings, would prime not only the congruent near-synonyms, but also the incongruent near-synonyms. Assuming that the meanings of polysemous adjectives are not listed but computed in context, no priming in the incongruent condition was expected for this class of adjectives. The predicted interaction effect was once again not obtained. Again, there was only a weak trend towards such an effect in the separate analyses per adjective type. One way to account for these results is to assume that, for adjectives, meaning relatedness and noun dependence are not highly correlated. More specifically, although most homonyms have fully specified and unrelated meanings, requiring sense enumeration, some of them seem to have unrelated but low specified meanings requiring a certain extent of computation in context. For adjectives, there may be other factors which determine their level of underspecification and ultimately their level of noun dependence more clearly than meaning relatedness.

In Experiment 2 in Chapter 2, evidence was obtained that polysemous adjectives acquire noun-dependent interpretations in adjective-noun combinations. Chapter 3 focuses on the role of nouns in combinatorial interpretation. Assuming that the semantic interpretation of adjective-noun combinations constructed with polysemous adjectives involves a high level of activation and selection of noun properties, the question is which noun-related factors determine the extent of 'semantic processing commitment' (see, Frazier & Rayner, 1990). An answer to this question was sought by studying the effect of noun concreteness on the selection of noun properties. Several studies suggest that concrete and abstract nouns differ in the amount and type of information they represent (see, e.g., Kounios & Holcomb, 1994; Paivio, 1986). Compared to abstract nouns, concrete nouns seem to be less context dependent due to their high informational richness. This implies that in the semantic interpretation of combinations containing polysemous adjectives and concrete nouns, a higher level of noun-related processing will be achieved than in the combinations containing polysemous adjectives and abstract nouns. In Experiment 1, the hypothesis was tested that adjective-noun combinations congruent in processing strategy (both the prime and the target combination require high 'processing commitment', e.g., *real painter - real velvet*) will show larger facilitation effect than the incongruent pairs (e.g., prime combination requires low processing commitment and target combination requires high processing commitment, e.g., *real freedom - real velvet*). In addition, due to the above stated differences between concrete and abstract nouns, it was expected that the processing of concrete targets, preceded by abstract primes, would suffer more from 'incongruence' than the processing of abstract targets preceded by 'concrete' primes. The results showed a reliable congruence effect in the expected direction, while the incongruence asymmetry effect was not reliable. The absence of a congruence effect in the control experiment (Appendix B), in which nouns in isolation served as primes and as targets, suggests that the congruence effect obtained in Experiment 1 is due to the assumed differences in combinatorial interpretation and not to noun processing alone. Finally, in Experiment 2, the hypothesis is tested that the obtained congruence effect (Experiment 1) is due to a higher semantic similarity in the congruent than in the incongruent pairs of combinations. The analysis of the rating scores showed a significant effect of semantic similarity. The effect was in the same direction as the congruence effect obtained in Experiment 1. This suggests that the congruence effect obtained in Experiment 1 was due to a higher level of similarity of the computed meanings in the congruent than in the incongruent condition.

The results obtained in this study extend the applicability of the *minimal processing commitment* hypothesis van Frazier and Rayner (1990) from nouns with multiple senses to adjectives with multiple senses. In addition, these findings point to a high reliance of semantic interpretation of polysemous adjectives on the semantic characteristics of nouns. In this sense, they are compatible with the meaning computation hypothesis for polysemous adjectives.

The study reported in Chapter 4 investigated the combined effects of adjectival complexity and salience of noun properties on the complexity of the semantic interpretation of adjective-noun combinations. The main hypothesis is that the variation in the complexity of adjectival constraints will have less effect on the speed and accuracy of the semantic interpretation of combinations if the semantic properties of nouns which satisfy these constraints are highly salient. It was assumed that the two factors will interact so that the variation in complexity of adjectival restrictions will have a smaller effect on the speed and accuracy of the combinatorial semantic interpretation if the required noun properties are highly salient that if these properties are low salient.

The complexity of adjectives was manipulated by using central and peripheral adjectives (Gross et al., 1989). Central adjectives in antonym pairs such as *wet* - *dry* or *warm* - *cold* have a relatively simple conceptual structure (Gross et al., 1989). They impose fairly simple selectional restrictions on the nouns. These restrictions mainly concern the class of entities denoted by the noun, such as *concrete, human*, etc. (Cruse, 1986a; Cruse, 1990; Pustejovsky, 2000). For instance, the adjective *wet* restricts the set of nouns with which it combines to *concrete objects*. Peripheral adjectives, clustered around the poles of the central antonym-pairs, have a more complex semantic structure. In addition to the selectional restrictions inherited from their central adjectives, peripheral adjectives impose more specific collocational restrictions on the nouns. For instance, the adjective *swampy* is compatible with concrete nouns just as the adjective *wet* of which it is a near-synonym. However, *swampy* is compatible only with those concrete nouns which include reference to *soil*, like the noun *acre*. These differences in complexity of adjectival selectional restrictions were assumed to affect the complexity of semantic interpretation. As stated above, it was assumed that processing time differences between the combinations containing central adjectives and those containing peripheral ones would be smaller if the corresponding noun properties are highly salient than if they are low-salient. For example, in the combinations *wet acre* - *swampy acre* the noun properties *concrete object*, and *soil*, which satisfy the constraints of the central and the peripheral adjective respectively, are highly relevant, whereas in the combinations *wet greenhouse* - *soggy greenhouse* the property satisfying the central adjective wet (*concrete object*) is highly salient in both and the property of the peripheral adjective (*soil*) is low salient. It was predicted that the assumed differences in interpretability will affect the speed and accuracy of semantic interpretation. Differences in speed and accuracy on a semantic classification task for meaningfulness were expected to be smaller for the combinations involving high-salience nouns than for the combinations with low-salience nouns. This prediction was confirmed in the analysis of error percentages showing a reliable interaction effect. At the same time, no interaction effect was obtained in the analysis of latencies. In order to exclude the possibility that the combinations with complex peripheral adjectives and low-salience nouns acquired the highest percentage of 'meaningless' classifications due to their low co-occurrence frequency, low familiarity (pointed out as possible nuisance variables in Murphy, 1990), or simply uninterpretability, rather than to the interaction of the two factors, a second experiment was conducted. In this experiment, the combinations were embedded in neutral and facilitating sentence contexts. The main effect of context in the off-line meaningfulness judgments is predicted by the hypothesis explaining the findings of Experiment 1 on the basis of the manipulated factors complexity and salience. An alternative explanation of the results based on the above mentioned nuisance variables would predict no effect of context on the meaningfulness judgements. The results confirmed the former hypothesis. These findings support a general assumption, common to different models in the field, that the complexity of the modifier as well as the salience of the noun properties are of influence on the semantic interpretation of modifier-head constructions.

In the studies reported in Chapter 2, there was no strong support for the assumption that homonymy/polysemy and semantic (under)specification are highly correlated. In the study reported in Chapter 5, the possibility is explored that other factors determine adjectival (under)specification and its level of noun dependence more clearly. One of the investigated factors was adjectival logical type (Kamp & Partee, 1995). Adjectives of the intersective type are highly specified and are less dependent on the noun in combinatorial semantic interpretation (Kamp & Partee, 1995; Sedivy et al., 1999). Consequently, the meanings of intersective adjectives are fairly invariable across different adjective-noun combinations. For instance, in the intersective combinations *carnivorous mammal, carnivorous plant, carnivorous surgeon*, the adjectival contribution to the meaning of the combination can invariably be paraphrased as *flesh-eating*. Subsective adjectives, on the other hand, combine with nouns in such a way that the combinations refer to a subset of objects referred to by the noun. Prior to determining this subset, some noun property has to be selected as a criterion. Subsective adjectives select different noun properties in combination with different nouns. For example, in the subsective combinations *good wine, good lawyer, good book*, the adjective selects for the noun properties *taste, defense* and *plot*, respectively. This results in the interpretations *a wine that tastes good, a lawyer that defends her clients successfully*, and *a book with a good plot.* Higher noun-dependence of subsective adjectives renders their interpretation computationally more complex compared to intersective adjectives. It was predicted that this will be reflected in their processing time. Intersective combinations were expected to be interpreted faster than subsective ones. The hypothesis was tested using intersective and subsective types of combinations in a speeded semantic classification task for meaningfulness. The results confirmed the prediction by showing faster reaction times for the intersective than for the subsective combinations.

The second factor for which it was assumed that it affects (the complexity) of semantic interpretation for subsective adjectives is adjective-noun compatibility. Incompatible combinations involved adjectives which modify event-denoting nouns, such as the adjective *fast*, and nouns which denote entities, such as the noun *typist*. These combinations involve a more complex noun-dependent interpretation than compatible combinations (e.g., *fast race, nice typist*). Based on the Generative Lexicon theory (Pustejovsky, 1995), it is hypothesized that a computationally complex semantic operation of type coercion is needed in interpreting subsective incompatible combinations. Contrary to what was expected, the results obtained in Experiment 1 showed no significant differences between the compatible and the incompatible subsective combinations. Differences in percentages of 'meaningless' responses were reliable only in the analysis by participants. Further research is needed in order to investigate cognitive mechanisms underlying semantic interpretation of the two types of subsective combinations.

The results of Experiment 2, in which participants paraphrased the three types of adjective-noun combinations used in Experiment 1, confirmed the prediction that these combinations differ in the informational content of their computed meanings. The results showed that paraphrases of intersective combinations seldom involve specific noun properties, and that paraphrases of subsective incompatible combinations largely involve selection of noun-related events in their interpretation. Paraphrases of the subsective compatible combinations were somewhat problematic, showing an equal amount of event- and non-event-based interpretations. Apparently, given sufficient time to interpret the combinations, participants may arrive at event-based interpretations for the primarily non-event modifiers. For instance, the combination *interesting book* was frequently interpreted through the event of reading (*interesting to read*), although this is actually an inference from the qualification of the content of a book as interesting. This points to a higher level of underspecification for the adjectives in the subsective compatible condition than for the clear event modifying adjectives.

6.2 Conclusions

The studies reported in this thesis address a number of questions concerning semantic interpretation of adjective-noun combinations for which traditional models (Hampton, 1997a; Murphy, 1990; Smith et al., 1988) offer relatively weak accounts. In Chapter 1, it was argued that the sense enumeration hypothesis might be inadequate for a large class of adjectives which do not seem to represent a clear property (e.g., *interesting, nice, good*). For these kinds of adjectives the meaning computation hypothesis might be more plausible. This hypothesis was tested in the study reported in Chapter 2 by comparing the processing of homonymous and polysemous adjectives. In this study, only a weak support was found for the meaning computation hypothesis. It was concluded that the degree of meaning relatedness (homonymy/polysemy) may not be the sole determinant of the degree in which adjectival meanings are computed. The experiments reported in Chapter 3 showed that the noun-related factor concreteness plays an important role in semantic interpretation of combinations involving polysemous adjectives. In the experiments reported in Chapter 4, evidence was obtained that both the complexity of the adjective as well the salience of the noun properties affect the semantic interpretation of adjective-noun combinations. Finally, the findings reported in Chapter 5 suggest that adjectival formal type largely determines the level of adjectival noun-dependence in combinatorial semantic interpretation.

These findings seem to support the meaning computation hypothesis slightly more than the meaning (sense) enumeration hypothesis. It can be argued that, for adjectives, the extent to which their meanings are computed depends on the extent to which their meanings are specified. Distinction between high and low specified adjectives can be made on the basis of their formal type. Furthermore, there are indications that adjective-nouns compatibility plays an important role in combinatorial interpretation. Embedding the process of compatibility resolution in the interpretation process carries an implication that salience and typicality of the noun properties should be considered relative to the property type (e.g., formal, constitutive, telic, agentive). Possibly, these factors only play a role after an appropriate type of the noun property has been determined. Adjectives like *fast*, for instance, are compatible with nouns of the type 'event', such as *race*. The interpretation of incompatible combinations consisting of adjectives like *fast* and nouns like *car*, which do not refer to events, requires a search for noun-related events, such as *driving*. Obviously, *driving* is the most salient event related to the noun *car*. However, in some contexts, less salient events like *washing* or *repairing* might be involved in the interpretation. These differences in salience within a certain property type (e.g., 'event') might be much more relevant for the interpretation process than the differences in salience between properties belonging to different types. For example, although the event of 'driving' is perhaps more salient for cars than the property 'has seats', in the combination *comfortable car* these differences are not expected to play a role. Rather, differences in salience between the properties that make a car comfortable (e.g., seats, suspension) will be relevant. Further research in this area should investigate these issues more closely.

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Appendices

A Rating studies in Chapter 2

The rating studies. The purpose of the first rating study, involving 30 participants, was to collect the rating scores indicating the degree of similarity of adjectival meanings in combinations with different nouns (e.g., *zware studie - zware jas*). On the basis of this study, adjectives were classified as either homonymous or polysemous. For each adjective (N=84), participants rated the similarity of adjectival meanings in pairs of adjective-noun combinations on a 7-point scale (1 - low similarity, 7 - high similarity). Ten combinations, expressing highly similar disambiguated adjectival meanings, such as *zware jas - zwaar gordijn* (heavy jacket - heavy curtain), were added to the list as fillers, as well as 6 practice combinations varying in degree of relatedness. The mean score for the 84 pairs of combinations was 2.9, and the mean score for the final set of 36 items was 2.4 (reliability coefficient: Guttman Split-half = .94). All items below 2.4 were marked as homonymous, and all items above this point were marked as polysemous. The respective mean scores for the two groups in the final set of 36 stimuli were 1.9 and 2.9. The difference between the two means was significant $[F(1,34) = 40.89, MSe = .21, p < .001]$.

The goal of the second rating study, involving 60 participants, was to test the selected near-synonyms for their similarity in meaning with corresponding adjectival meanings as disambiguated in adjective-noun combinations (i.e., to test the degree of their 'synonymity'). Two adjective-noun combinations were constructed with each adjective (e.g., adjective *plat* (flat): 1. *platte schaal* (shallow plate), 2. *platte opmerking* (crude remark)). Each adjective-noun combination was presented in two conditions. In the congruent condition, combinations were paired with near-synonyms denoting the same meanings as the adjectives (e.g., combination: *platte schaal* (shallow plate) - synonym: *ondiep* (shallow), and *platte opmerking* (crude remark) - synonym: *ordinair* (crude)). In the incongruent condition, the same combinations were paired with near-synonyms denoting alternative adjectival meanings (e.g., combination: *platte schaal* (shallow plate) - synonym: *ordinair* (crude), and *platte opmerking* (crude remark) - synonym: *ondiep* (shallow)). The 84 adjectives were divided over four lists. Each list contained approximately an equal amount of combinations with homonymous and polysemous adjectives according to the pre-classification criteria (see above). Six practice items were added to each list (3 congruent and 3 incongruent). Two combinations were made for each adjective, followed by either a near-synonym of the same meaning or a near-synonym of an alternative adjectival meaning. Participants rated the similarity in meaning between the combinations and the near-synonyms on a 7-point scale where 1 indicated low similarity and 7 high similarity. For each adjectival meaning two scores were computed (see Table A.2): (1) the Synonymy score which indicates the degree of synonymity, and (2) the Difference score, that is, the difference between the mean synonymy scores in the Congruent and Incongruent condition [reliability coefficients Guttman Split-half per condition: Same 1 = .84, Same 2 = .83, Different 1 = .86, Different 2 = .90].

Table A 1: STATISTICAL CHARACTERISTICS OF THE STIMULI IN EXPERIMENT 1(A/B)

		PRIME - TARGET RELATEDNESS	
MATCHING VARIABLES	*H/P related prime*	*Related*	*Unrelated*
Length Prime	H	4.3	4.6
	P	4.7	5.1
log *Frequency Prime*	H	3.3	3.1
	P	3.4	3.2
Length Target 1	H	6.8	-
	P	7.4	-
log *Frequency Target 1*	H	2.6	-
	P	2.9	-
Length Target 2	H	7.7	-
	P	7.2	-
log *Frequency Target 2*	H	2.7	-
	P	2.6	-

Note. Means for the targets are the same in both conditions.
H/P = homonymy/polysemy van de gerelateerde prime adjectives.

The analysis for the selected set of 36 adjectives showed significant differences between homonymous and polysemous adjectives [$M_h = 3.5, M_p = 3.8, F(1,34) = 4.97, MSe = .43, p < .05$], and between congruent and incongruent condition [$M_c = 5.4, M_i = 1.9, F(1,34) = 1921.85$, $MSe = .11, p < .001$]. The interaction was not significant [$F(1,34) = 1.10, MSe = .11, p > .30$] (see

Table A 2: STATISTICAL CHARACTERISTICS OF THE STIMULI IN EXPERIMENT 2(A/B)

		PRIME-TARGET RELATION TYPE		
MATCHING VARIABLES	*H/P*	*Congruent*	*Incongruent*	*Control*
Length Prime (ANCs)	H	10.9	11.2	11.8
	P	12.2	11.4	11.7
log *Frequency Prime A.*	H	3.3	3.3	3.1
	P	3.4	3.4	3.2
log *Frequency Prime N.*	H	3.4	3.4	3.1
	P	3.2	3.1	3.3
Length Target 1	H	6.8	-	-
	P	7.4	-	-
log *Frequency Target 1*	H	2.6	-	-
	P	2.9	-	-
Length Target 2	H	7.7	-	-
	P	7.2	-	-
log *Frequency Target 2*	H	2.7	-	-
	P	2.6	-	-
RESULTS OF THE RATING STUDIES				
Synonymy Score	H	5.2	1.7	-
	P	5.5	2.1	-
Difference Score	H	3.5	-	-
(congr. - incongr.)	P	3.4	-	-
Relatedness Score	H	1.9	-	-
	P	2.9	-	-
Familiarity Score	H	2.9	-	-
	P	3.1	-	-

*Note.*Means for the targets are the same in all conditions
H/P = homonymy/polysemy of the prime adjectives in the Congruent
and the Incongruent condition; ANCs = adjective-noun combinations.

Table A.2). Homonymous and polysemous adjectives differed significantly in the incongruent condition only, with incongruent synonyms of the combinations with polysemous adjectives (e.g., *nice stroll* - *tasty*) being rated slightly less incongruent (or more similar to the adjectival meaning in the combination) than the incongruent synonyms of the homonymous adjectives $[F(1,48) = 6.78, MSe = 0.49, p < .05]$. The direction of this difference runs contrary to our predictions concerning the incongruence effect (see, Chapter 2, Experiment 2). The second measure in this study, that is, the difference score was used as a criterion for the selection of homonymous and polysemous adjectives with comparably distinct disambiguated meanings. Irrespective of the possible differences in underlying representations, this kind of matching insures that the selected combinations for both the homonymous and the polysemous adjectives do not disambiguate one and the same adjectival meaning, either by selection or by computation. The critical difference score for the inclusion of adjectives in the experimental set was 2.5 scale points. An ANOVA for the final set of adjectives showed no effect of Adjective Type [$F < 1$], no effect of Combination [$F(1,68) = 2.52, MSe = .81, p = .12$], and no interaction [$F < 1$].

The third was a familiarity rating study which was conducted in order to avoid the confounding of familiarity (subjective frequency) with our Congruence factor in Experiment 2. Given our assumption that polysemous adjectives do not have multiple meaning representations, preference was given to the familiarity rating over other methods of assessing meaning frequency. A total of 168 combinations constructed with 84 adjectives were divided over two experimental lists. Six practice combinations, and 10 *specialized* (see Fleischeuers, 1997) filler combinations (e.g., *oud papier - waste paper*, i.e., highly familiar combinations that are not completely idiomatic) were added to each list. Forty participants rated the combinations on a 5-point scale where 1 indicated low familiarity and 5 high familiarity. For the selected set of 36 adjectives, there were no differences between the homonymous and the polysemous adjectives (experimental set) on familiarity ratings (reliability: Guttman Split-half = .95). Mean scores were 2.9 and 3.1 respectively [$F < 1$]. The main effect of Combination was not significant [$F(1,68) = 1.98 MSe = .62, p = .16$]. The means are 2.6 and 3.2 , for the combinations with homonymous adjectives, and 3.1 and 3.1 for the polysemous adjectives. The interaction effect was not significant [$F(1,68) = 3.01, MSe = .62, p = .09$]

B Control experiment in Chapter 3

Control experiment. In Experiment 1 (Chapter 3) the congruent and incongruent conditions, adjectives were the same in the prime and the target, while nouns differed. Rather than matching the nouns for length, frequency and semantic relatedness, we conducted an experiment in order to find out whether the nouns alone would produce effects in the same direction as the predicted congruence effect. In order to exclude the possibility of a noun-based explanation of the results obtained in Experiment 1, an experiment was conducted involving only the nouns in an otherwise identical priming paradigm. If no congruence effects are obtained with nouns alone, then it is plausible to interpret congruence effects obtained with the combinations as a product of combinatorial semantic interpretation.

Participants. Forty students at Nijmegen University participated in this experiment. All were paid for their participation.

Materials and Design. Materials consisted of prime - target noun pairs from the combinations constituting the stimulus set in Experiment 1. Stimulus materials were divided into two lists. A particular (concrete or abstract) target noun preceded by the same type of prime noun in one list was preceded by a different type of prime noun in the other list. As the nouns in the prime and the target position were different, both concrete and abstract target nouns preceded by either concrete or abstract prime nouns could appear on the same list. No noun was repeated within a list. Twenty participants were randomly assigned to each list. Each list contained 156 experimental noun-noun pairs, 39 in each condition. For the purpose of the lexical decision task, 180 word - non-word prime-target pairs were added to each list. These pairs were the same for both lists. In total, each participant was presented with 336 prime-target pairs (156 experimental, and 180 filler items).

Procedure. Stimuli were presented on the CRT connected to an Olivetti M-24 computer which controlled the presentation of the stimuli and the registration of the responses. All items were presented at the center of the computer screen. Each trial started with the presentation of a fixation mark (*) for 800 ms. After a blank screen for 150 ms, the prime noun, printed in lowercase letters was presented for 800 ms. After a 150 ms blank screen, the target noun, printed in upper case was displayed for 1000 ms or until a response was obtained. Time-out was set to 2000 ms after target-onset. The inter-trial interval was 1000 ms. Participants were instructed to read primes and targets carefully, and to decide as quickly and as accurately as possible whether a presented target was a Dutch word or not. They were to push the yes-button if a target stimulus was a Dutch word; otherwise they had to push the no-button. Participants gave yes-responses using their dominant hand. When an error was made on a trial immediately preceding a test item, a dummy item was inserted in between the two in order to attenuate the effects of erroneous responding on the subsequent processing of a test item. The experiment consisted of three equally long blocks with two short breaks between them. A set of 21 practice items was presented prior to the experimental series. Each experimental block started with five buffer items. The whole sessions lasted approximately 25 minutes.

Results. Latencies for the erroneous responses (3.9%) were excluded from the analysis of RTs. Together with the time-outs (0.1%) and outliers they were coded as missing data. Outliers (2.2%) were determined on the basis of participants and items statistics (2SD). Mean latencies and error rates for the experimental conditions are presented in Table B.1.

Table B 1: MEAN LATENCIES (ms) AND ERROR PERCENTAGES IN CONTROL EXPERIMENT

	CONGRUENCE	
TARGET CONCRETENESS	*Congruent*	*Incongruent*
concrete	589 (5.2%)	591 (5.0%)
abstract	564 (2.3%)	561 (2.6%)

Analysis (ANOVA) of RTs showed a significant main effect of concreteness [$F_1(1,39) = 111.05$, $MSe = 268.93, p < .001; F2(1, 154) = 13.75, MSe = 4754.21, p < .001$]. Mean latencies for the concrete and abstract targets were 590 and 563 ms, respectively. The effect of congruence was not significant [both $Fs < 1$]. Mean latencies for the congruent and incongruent priming conditions were 577 and 576 ms, respectively. The interaction between concreteness and congruence did not approach significance [both $Fs < 1$]. The analysis of the error percentages showed a significant main effect of concreteness (concrete: $M = 5.1\%$, abstract: $M = 2.5\%$) [$F_1(1,39) = 17.10, MSe = 16.55, p < .001; F_2(1,154) = 6.32, MSe = 87.41, p < .05$], no effect of congruence (both $Ms = 3.8\%$) [both $Fs < 1$], and no interaction between the two factors [both $Fs < 1$].

C Materials for experiments in Chapter 2

Table C 1: List of stimuli used in Experiment 1 and Experiment 2

Item	*Prime combinations*	*Congruent target*	*Incongruent target*	*Control primes*
HOMONYMOUS ADJECTIVES				
1	aardige groei	aanzienlijk	vriendelijk	waterig
2	aardige student	vriendelijk	aanzienlijk	somber voorstel
3	droge preek	vervelend	dor	donzig
4	droge vallei	dor	vervelend	gepast bedrag
5	enge film	griezelig	krap	gepast
6	enge opening	krap	griezelig	futloos haar
7	fijn feest	leuk	teer	ver
8	fijn weefsel	teer	leuk	felle reflector
9	flauwe reactie	kinderachtig	zouteloos	snel
10	flauwe saus	zouteloos	kinderachtig	snel verstand
11	gladde plank	effen	handig	bezig
12	gladde verkoper	handig	effen	oude baas
13	grof gedrag	onbeschaafd	ongepolijst	zwart
14	grof oppervlak	ongepolijst	onbeschaafd	langzaam gesprek
15	ijdele jongen	verwaand	vergeefs	groen
16	ijdele poging	vergeefs	verwaand	grijze kaft
17	krom verhaal	onlogisch	bochtig	zeker
18	kromme straat	bochtig	onlogisch	echte diamant
19	lage opmerking	gemeen	bas	sloom
20	lage stem	bas	gemeen	slome soldaat
21	platte uitspraak	ordinair	ondiep	roze
22	platte schaal	ondiep	ordinair	koude wind
23	vals document	namaak	gluiperig	gul
24	valse kat	gluiperig	namaak	scherpe schaar
25	vette pan	smerig	veel	blauw
26	vette winst	veel	smerig	boeiend boek
27	vitaal onderdeel	belangrijk	levendig	vaak
28	vitale oma	levendig	belangrijk	eetbare vrucht
29	vlakke muur	egaal	monotoon	bezig
30	vlakke uitleg	monotoon	egaal	glazen kas
31	vol gezicht	rond	afgeladen	loom
32	volle trein	afgeladen	rond	drassig weiland
33	woest gebied	onbewoond	woedend	paars
34	woeste agent	woedend	onbewoond	gezonde slaap
35	zware jas	dik	moeilijk	fraai
36	zware studie	moeilijk	dik	fraaie tempel
POLYSEMOUS ADJECTIVES				
1	bezopen gast	dronken	idioot	luchtig

Table C 1: List of stimuli used in Experiment 1 and Experiment 2

Item	*Prime combinations*	*Congruent target*	*Incongruent target*	*Control primes*
2	bezopen gedachte	idioot	dronken	luchtig kussen
3	fris idee	origineel	koel	enig
4	frisse ochtend	koel	origineel	juiste maat
5	harde matras	stijf	streng	schuin
6	harde straf	streng	stijf	schuine tafel
7	hete chips	pittig	gloeiend	jolig
8	hete oven	gloeiend	pittig	saaie wedstrijd
9	kaal tapijt	versleten	onbegroeid	dartel
10	kale heuvel	onbegroeid	versleten	brave leerling
11	knap gezicht	aantrekkelijk	slim	geel
12	knappe uitvinder	slim	aantrekkelijk	rijpe tomaat
13	korte afstand	dichtbij	eventjes	stom
14	korte vakantie	eventjes	dichtbij	stomme jongen
15	kwade invloed	ongunstig	boos	helder
16	kwade leraar	boos	ongunstig	heldere foto
17	lange gestalte	rijzig	tijdrovend	dapper
18	lange vergadering	tijdrovend	rijzig	bruine knoop
19	lekkere pannenkoek	smakelijk	prettig	somber
20	lekkere wandeling	prettig	smakelijk	machtige president
21	lelijk bankstel	onooglijk	gevaarlijk	rustig
22	lelijke bocht	gevaarlijk	onooglijk	breed aanbod
23	mager paard	benig	gering	puur
24	mager voordeel	gering	benig	pure alcohol
25	naakt lichaam	bloot	onverbloemd	grijs
26	naakte bekentenis	onverbloemd	bloot	groene oever
27	nauwe doorgang	smal	innig	bruin
28	nauwe relatie	innig	smal	dapper plan
29	open beraad	publiek	extravert	wijd
30	open karakter	extravert	publiek	wijde zee
31	ruwe schets	globaal	hobbelig	bang
32	ruwe steen	hobbelig	globaal	goedkope ring
33	stevige groei	behoorlijk	degelijk	vorig
34	stevige stoel	degelijk	behoorlijk	moderne kleur
35	vuile luier	vies	schunnig	nodig
36	vuile mop	schunnig	vies	beroemde atleet

note. in experiment 1, adjectives from prime combinations were presented in isolation. in the last column in the table above ('control primes') single words (e.g., *waterig*, in row 1) were used as control primes in experiment 1. adjective noun combinations printed beneath single word control primes were used as control primes in experiment 2 (e.g., *somber voorstel*, row 2).

FILLER STIMULI USED IN EXPERIMENT 1

Filler type 1: Semantically related prime-target pairs of nouns. 1. hoofd lichaam, 2. krans cirkel, 3. intellect theorie, 4. monnik klooster, 5. bakker slager, 6. kasteel baron, 7. oase nomade, 8 koets limousine, 9 klimaat regen, 10. insect kever, 11. tijger oerwoud, 12. minister document, 13 horloge minuut, 14. knie gewricht, 15. vezel textiel, 16. eiland oceaan, 17. aanrecht fornuis, 18. brief schrift.

filler type 2: semantically unrelated prime-target pairs of nouns. 1. galerij zwager, 2. lantaarn mummie, 3. manier naam, 4. bochel sauna, 5 kuiken vacature, 6. bandiet ledikant, 7. fluit scharnier, 8. boom artikel, 9. koning nummer, 10. soldaat bank, 11. salaris makreel, 12. boodschap structuur, 13. gist idylle, 14. zuster niveau, 15. wijn hond, 16. fanfare knobbel, 17. keuken zijde, 18. sleutel melk.

Filler type 3: Adjectives as primes and pseudoword as targets. 1. zalig tuip, 2. hoog firmaal, 3. juist hoolig, 4. dicht bornem, 5. licht amilair, 6. scherp pangrijk, 7. duizelig vorlaf, 8. zoet danotiek, 9. rijk polgerig, 10. fel rowaal, 11. stil waat, 12. vlot fuigzaam, 13. koud schombe, 14. arm zekker, 15. donker porend, 16. treurig inteblesse, 17. breed solwer, 18. nuchter dentig, 19. warm schup, 20. zacht morrect, 21. vrij woderig, 22. ruig manuscaal, 23. zuiver longsaam, 24. steil jeukdig, 25. ruim betruikt, 26. sterk panalijs, 27. duister bluikend, 28. rijp monossaal, 29. vast gonder, 30. mild enerp, 31. zwak schijdelijk, 32. scheef genuidig, 33. vreemd zerker, 34. blank ragode, 35. flink zodelijk, 36. kalm erwijl.

filler type 4: nouns as primes and pseudowords as targets. 1. verdriet gormule, 2. controle doogelig, 3. spons weldar, 4. kwal katerie, 5. trom solber, 6. braam bluik, 7. dreef beigord, 8. etter butloor, 9. truck particaal, 10. lont werduuld, 11. konijn dirensie, 12. ivoor lesend, 13. haver splonnen, 14. harem ocht, 15. souvenir kertap, 16. karnaval zwuurt, 17. krot wartel, 18. kandelaar echterlijt, 19. rits kypasch, 20. baard braai, 21. violet leiten, 22. zenuw weikelijk, 23. euvel woestel, 24. muil bruif, 25. cake molgooid, 26. harnas juchtig, 27. plaag felsteer, 28. veulen beleglijk, 29. engel klocht, 30. schaap kesser, 31. schilder treek, 32. vampier bliwaat, 33. buffel klern, 34. geul neeuw, 35. arbeid stooi, 36. smaak scheng

FILLER STIMULI USED IN EXPERIMENT 2

Filler type 1: Adjective-noun combinations (ANCs) as primes and nouns as semantically related targets. 1. rood hoofd schaamte, 2. mooie krans cirkel, 3. sterk intellect theorie, 4. listige monnik klooster, 5. dure bakker geld, 6. vervallen kasteel puin, 7. grote oase nomade, 8. zwarte koets limousine, 9. vochtig klimaat regen, 10. klein insect kever, 11. jonge tijger prooi, 12. gestolen horloge dief, 13. zere knie pijn, 14. lekke band fiets, 15. stalen aanrecht fornuis, 16. grappige brief schrift, 17. lamme spier paralyse, 18. manke been kruk.

Filler type 2: ANCs as primes and nouns as semantically unrelated targets. 1. failliete galerie zwager, 2. hoge lantaarn mummie, 3. ernstige ziekte sauna, 4. schattige kuiken vacature, 5. sluwe bandiet ledikant, 6. kapotte fluit scharnier, 7. ijzeren gordijn artikel, 8. mondaine koning nummer, 9. spontane lach bank, 10. laatste salaris makreel, 11. verloren tas structuur, 12. zachte gist idylle, 13. lieve zuster niveau, 14. zure wijn hond, 15. praktische keuken zijde, 16. roestige sleutel melk, 17. geestig programma postelein, 18. zieke koe antenne.

Filler type 3: ANC as primes and pseudowords as targets. 1. zalige martelaar tuip, 2. domme minister firmaal, 3. dichte mist bornem, 4. verlichte ruimte amilair, 5. grondig onderzoek pangrek, 6. droevige man vorlaf, 7. zoete aardappel danotiek, 8. rijke fantasie polgerig, 9. stille kracht waat, 10. vlotte kleding fuigzaam, 11. arm land zekker, 12. donkere trui porend, 13. treurig liedje inteblesse, 14. nuchtere schrijver dentig, 15. warme zomer schup, 16. vrije week woderig, 17. ruige berg manuscaal, 18. duidelijk motief longsaam, 19. steile wand jeukdig, 20. ruime kast betruikt, 21. duistere afkomst bluikend, 22. vaste blik gonder, 23. milde tabak enerp, 24. licht ontbijt schijdelijk, 25. zuivere bedoeling genuidig, 26. vreemd leger zerker, 27. scheef beeld ragode, 28. dunne panty zodelijk, 29. zwakke greep erwijl, 30. apart ontwerp gormule, 31. slechte tekening doogelig, 32. nieuwe kunst weldar, 33. dol avontuur katerie, 34. blanke huid solber, 35. flinke taart bluik, 36. kalm antwoord beigord, 37. blauwe haai butloor, 38. blij moment particaal, 39. giftige stof werduuld, 40. schitterend huis dirensie, 41. goed concert lesend, 42. geschikte kandidaat splonnen, 43. stabiele periode ocht, 44. nobele daad kertap, 45. koppige speler zwuurt, 46. jaloerse collega wartel, 47. keurige smaak echterlij, 48. dwaze ruzie kypasch, 49. bonte jurk braai, 50. komische situatie leiten, 51. massale opkomst weikelijk, 52. krachtige lens woestel, 53. lastig persoon bruif, 54. lenige zwemmer molgooid, 55. magische spiegel juchtig, 56. metalen buis preten, 57. militaire oefening beleglijk, 58. naar gevoel klocht, 59. negatief getal kesser, 60. formeel verzoek treek, 61. pijnlijk gewricht bliwaat, 62. redelijke prijs klern, 63. riante woning neeuw, 64. culturele beweging manding, 65. riskante onderneming trokade, 66. diverse winkels knidder, 67. knorrige arts spamerij, 68. speelse melodie krofijt, 69. stoute vraag duiges, 70. eervolle aftocht nochel, 71. gebakken groente zaper, 72. wankel bewind prekte,

D Materials for experiments in Chapter 3

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
1	1	aardig kostuum	aardige redder
1	2	aardige uitslag	aardige redder
1	3	oude lamp	aardige redder
1	4	aardige uitslag	aardige belofte
1	5	aardig kostuum	aardige belofte
1	6	oude lamp	aardige belofte
2	1	arme monnik	arme zanger
2	2	arm leven	arme zanger
2	3	sportieve vriend	arme zanger
2	4	arm leven	arm verleden
2	5	arme monnik	arm verleden
2	6	sportieve vriend	arm verleden
3	1	bewuste docent	bewuste partner
3	2	bewuste actie	bewuste partner
3	3	nat weiland	bewuste partner
3	4	bewuste actie	bewuste ingreep
3	5	bewuste docent	bewuste ingreep
3	6	nat weiland	bewuste ingreep
4	1	bitter fruit	bittere wortel
4	2	bittere hoop	bittere wortel
4	3	originele sonate	bittere wortel
4	4	bittere hoop	bitter gevolg
4	5	bitter fruit	bitter gevolg
4	6	originele sonate	bitter gevolg
5	1	brede krater	brede loge
5	2	brede inzet	brede loge
5	3	rode fles	brede loge
5	4	brede inzet	brede opdracht
5	5	brede krater	brede opdracht
5	6	rode fles	brede opdracht
6	1	dolle parade	dolle groep
6	2	dolle finale	dolle groep
6	3	slanke acteur	dolle groep
6	4	dolle finale	dolle gok
6	5	dolle parade	dolle gok
6	6	slanke acteur	dolle gok
7	1	domme passagier	domme chimpansee
7	2	domme poging	domme chimpansee
7	3	luie zoon	domme chimpansee

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
7	4	domme poging	dom betoog
7	5	domme passagier	dom betoog
7	6	luie zoon	dom betoog
8	1	donkere kantine	donkere mantel
8	2	donkere mystiek	donkere mantel
8	3	groen deksel	donkere mantel
8	4	donkere mystiek	donkere herinnering
8	5	donkere kantine	donkere herinnering
8	6	groen deksel	donkere herinnering
9	1	droog penseel	droog flensje
9	2	droge vracht	droog flensje
9	3	gewone stoel	droog flensje
9	4	droge vracht	droog product
9	5	droog penseel	droog product
9	6	gewone stoel	droog product
10	1	duistere zaal	duistere hut
10	2	duistere bedoeling	duistere hut
10	3	nodige moeite	duistere hut
10	4	duistere bedoeling	duistere invloed
10	5	duistere zaal	duistere invloed
10	6	nodige moeite	duistere invloed
11	1	dunne folder	dun kleed
11	2	dunne oplossing	dun kleed
11	3	blauwe vlinder	dun kleed
11	4	dunne oplossing	dunne spreiding
11	5	dunne folder	dunne spreiding
11	6	blauwe vlinder	dunne spreiding
12	1	echte schilder	echt satijn
12	2	echte vrijheid	echt satijn
12	3	duur horloge	echt satijn
12	4	echte vrijheid	echte twijfel
12	5	echte schilder	echte twijfel
12	6	duur horloge	echte twijfel
13	1	felle baas	felle leerling
13	2	fel conflict	felle leerling
13	3	doffe gloed	felle leerling
13	4	fel conflict	fel oproer
13	5	felle baas	fel oproer
13	6	doffe gloed	fel oproer
14	1	fijn strand	fijn kussen
14	2	fijn verzoek	fijn kussen
14	3	vroeg bericht	fijn kussen

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
14	4	fijn verzoek	fijne toekomst
14	5	fijn strand	fijne toekomst
14	6	vroeg bericht	fijne toekomst
15	1	flauwe melodie	flauwe likeur
15	2	flauw effect	flauwe likeur
15	3	bezige meester	flauwe likeur
15	4	flauw effect	flauwe reactie
15	5	flauwe melodie	flauwe reactie
15	6	bezige meester	flauwe reactie
16	1	flinke greep	flinke havik
16	2	flink gebrek	flinke havik
16	3	bange arts	flinke havik
16	4	flink gebrek	flink geheugen
16	5	flinke greep	flink geheugen
16	6	bange arts	flink geheugen
17	1	fris parfum	frisse meloen
17	2	frisse aanpak	frisse meloen
17	3	grijze ketel	frisse meloen
17	4	frisse aanpak	frisse geest
17	5	fris parfum	frisse geest
17	6	grijze ketel	frisse geest
18	1	gezonde tweeling	gezonde pret
18	2	gezonde aandacht	gezonde pret
18	3	moeilijke meting	gezonde pret
18	4	gezonde aandacht	gezonde durf
18	5	gezonde tweeling	gezonde durf
18	6	moeilijke meting	gezonde durf
19	1	glad terras	glad nylon
19	2	gladde tact	glad nylon
19	3	bekende foto	glad nylon
19	4	gladde tact	gladde opmerking
19	5	glad terras	gladde opmerking
19	6	bekende foto	gladde opmerking
20	1	harde vijl	harde liniaal
20	2	harde handel	harde liniaal
20	3	rustig paard	harde liniaal
20	4	harde handel	harde boycot
20	5	harde vijl	harde boycot
20	6	rustig paard	harde boycot
21	1	heerlijk spel	heerlijk najaar
21	2	heerlijke roem	heerlijk najaar
21	3	gelijke diepte	heerlijk najaar

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
21	4	heerlijke roem	heerlijke wending
21	5	heerlijk spel	heerlijke wending
21	6	gelijke diepte	heerlijke wending
22	1	hete planeet	hete fondue
22	2	hete bereiding	hete fondue
22	3	ernstig karakter	hete fondue
22	4	hete bereiding	hete prikkel
22	5	hete planeet	hete prikkel
22	6	ernstig karakter	hete prikkel
23	1	hoge antenne	hoge trapeze
23	2	hoge missie	hoge trapeze
23	3	totale kennis	hoge trapeze
23	4	hoge missie	hoge index
23	5	hoge antenne	hoge index
23	6	totale kennis	hoge index
24	1	jonge agent	jonge valk
24	2	jonge aanhang	jonge valk
24	3	enorme spin	jonge valk
24	4	jonge aanhang	jong uiterlijk
24	5	jonge agent	jong uiterlijk
24	6	enorme spin	jong uiterlijk
25	1	juist medicijn	juist publiek
25	2	juiste spanning	juist publiek
25	3	moderne tractor	juist publiek
25	4	juiste spanning	juiste handeling
25	5	juist medicijn	juiste handeling
25	6	moderne tractor	juiste handeling
26	1	kale tak	kale hyena
26	2	kaal oordeel	kale hyena
26	3	blije puber	kale hyena
26	4	kaal oordeel	kale indruk
26	5	kale tak	kale indruk
26	6	blije puber	kale indruk
27	1	kalme collega	kalme glimlach
27	2	kalme leiding	kalme glimlach
27	3	vorige cursus	kalme glimlach
27	4	kalme leiding	kalme situatie
27	5	kalme collega	kalme situatie
27	6	vorige cursus	kalme situatie
28	1	kleine viool	kleine trui
28	2	klein avontuur	kleine trui
28	3	zieke olifant	kleine trui

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
28	4	klein avontuur	klein verbond
28	5	kleine viool	klein verbond
28	6	zieke olifant	klein verbond
29	1	knappe minister	knappe familie
29	2	knappe analyse	knappe familie
29	3	gering verschil	knappe familie
29	4	knappe analyse	knappe list
29	5	knappe minister	knappe list
29	6	gering verschil	knappe list
30	1	koude studio	koude portiek
30	2	koude afgunst	koude portiek
30	3	praktisch bureau	koude portiek
30	4	koude afgunst	koude manier
30	5	koude studio	koude manier
30	6	praktisch bureau	koude manier
31	1	kwade gast	kwade beambte
31	2	kwade gedachte	kwade beambte
31	3	heldere ruit	kwade beambte
31	4	kwade gedachte	kwade stemming
31	5	kwade gast	kwade stemming
31	6	heldere ruit	kwade stemming
32	1	lage tunnel	laag podium
32	2	lage aanleg	laag podium
32	3	veilige doorgang	laag podium
32	4	lage aanleg	lage uitkomst
32	5	lage tunnel	lage uitkomst
32	6	veilige doorgang	lage uitkomst
33	1	lekkere kwark	lekkere wafel
33	2	lekkere triomf	lekkere wafel
33	3	smalle pantoffel	lekkere wafel
33	4	lekkere triomf	lekkere lust
33	5	lekkere kwark	lekkere lust
33	6	smalle pantoffel	lekkere lust
34	1	lelijke parkiet	lelijk overhemd
34	2	lelijk symbool	lelijk overhemd
34	3	vrolijke dolfijn	lelijk overhemd
34	4	lelijk symbool	lelijk bedrog
34	5	lelijke parkiet	lelijk bedrog
34	6	vrolijke dolfijn	lelijk bedrog
35	1	lief veulen	lieve prinses
35	2	lief voorstel	lieve prinses
35	3	schone lepel	lieve prinses

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
35	4	lief voorstel	lief verhaal
35	5	lief veulen	lief verhaal
35	6	schone lepel	lief verhaal
36	1	losse armband	losse ceintuur
36	2	los detail	losse ceintuur
36	3	actieve professor	losse ceintuur
36	4	los detail	los standpunt
36	5	losse armband	los standpunt
36	6	actieve professor	los standpunt
37	1	magere visser	magere slaaf
37	2	magere zege	magere slaaf
37	3	drukke markt	magere slaaf
37	4	magere zege	mager voordeel
37	5	magere visser	mager voordeel
37	6	drukke markt	mager voordeel
38	1	milde blos	milde dirigent
38	2	milde wellust	milde dirigent
38	3	gele rups	milde dirigent
38	4	milde wellust	milde ijver
38	5	milde blos	milde ijver
38	6	gele rups	milde ijver
39	1	mooie grafiek	mooie fjord
39	2	mooie afwerking	mooie fjord
39	3	blote schouder	mooie fjord
39	4	mooie afwerking	mooie vangst
39	5	mooie grafiek	mooie vangst
39	6	blote schouder	mooie vangst
40	1	naakte taille	naakte indiaan
40	2	naakte eenvoud	naakte indiaan
40	3	dubbele stapel	naakte indiaan
40	4	naakte eenvoud	naakte wanhoop
40	5	naakte taille	naakte wanhoop
40	6	dubbele stapel	naakte wanhoop
41	1	nauwe kajak	nauwe schacht
41	2	nauwe omvang	nauwe schacht
41	3	beperkte straf	nauwe schacht
41	4	nauwe omvang	nauwe voorsprong
41	5	nauwe kajak	nauwe voorsprong
41	6	beperkte straf	nauwe voorsprong
42	1	nieuwe trommel	nieuwe rechter
42	2	nieuwe grondslag	nieuwe rechter
42	3	gunstige stand	nieuwe rechter

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
42	4	nieuwe grondslag	nieuw voorschrift
42	5	nieuwe trommel	nieuw voorschrift
42	6	gunstige stand	nieuw voorschrift
43	1	nuchtere mentor	nuchtere gijzelaar
43	2	nuchter argument	nuchtere gijzelaar
43	3	koele steen	nuchtere gijzelaar
43	4	nuchter argument	nuchter beleid
43	5	nuchtere mentor	nuchter beleid
43	6	koele steen	nuchter beleid
44	1	open aula	open capsule
44	2	open bod	open capsule
44	3	boze portier	open capsule
44	4	open bod	open categorie
44	5	open aula	open categorie
44	6	boze portier	open categorie
45	1	pure inkt	pure honing
45	2	pure ironie	pure honing
45	3	trotse ridder	pure honing
45	4	pure ironie	pure tactiek
45	5	pure inkt	pure tactiek
45	6	trotse ridder	pure tactiek
46	1	rijke sultan	rijke toerist
46	2	rijke democratie	rijke toerist
46	3	hevige aanval	rijke toerist
46	4	rijke democratie	rijke inspiratie
46	5	rijke sultan	rijke inspiratie
46	6	hevige aanval	rijke inspiratie
47	1	rijpe framboos	rijpe vijg
47	2	rijpe vriendschap	rijpe vijg
47	3	gezette boerin	rijpe vijg
47	4	rijpe vriendschap	rijpe samenleving
47	5	rijpe framboos	rijpe samenleving
47	6	gezette boerin	rijpe samenleving
48	1	ronde gevel	ronde kachel
48	2	ronde waarde	ronde kachel
48	3	simpel examen	ronde kachel
48	4	ronde waarde	ronde score
48	5	ronde gevel	ronde score
48	6	simpel examen	ronde score
49	1	ruig concert	ruige dader
49	2	ruige ervaring	ruige dader
49	3	nuttige reis	ruige dader

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
49	4	ruige ervaring	ruige doorbraak
49	5	ruig concert	ruige doorbraak
49	6	nuttige reis	ruige doorbraak
50	1	ruime garage	ruime kajuit
50	2	ruime richtlijn	ruime kajuit
50	3	keurig rapport	ruime kajuit
50	4	ruime richtlijn	ruim uitstel
50	5	ruime garage	ruim uitstel
50	6	keurig rapport	ruim uitstel
51	1	ruwe plint	ruwe overval
51	2	ruw noodlot	ruwe overval
51	3	lastige klas	ruwe overval
51	4	ruw noodlot	ruwe misdaad
51	5	ruwe plint	ruwe misdaad
51	6	lastige klas	ruwe misdaad
52	1	scherp koraal	scherpe distel
52	2	scherpe indicatie	scherpe distel
52	3	roze sprei	scherpe distel
52	4	scherpe indicatie	scherpe indeling
52	5	scherp koraal	scherpe indeling
52	6	roze sprei	scherpe indeling
53	1	scheve reling	scheve leuning
53	2	scheve norm	scheve leuning
53	3	bleke piloot	scheve leuning
53	4	scheve norm	scheve matrix
53	5	scheve reling	scheve matrix
53	6	bleke piloot	scheve matrix
54	1	slappe cracker	slappe ballon
54	2	slap bewind	slappe ballon
54	3	raar portret	slappe ballon
54	4	slap bewind	slap antwoord
54	5	slappe cracker	slap antwoord
54	6	raar portret	slap antwoord
55	1	slechte mosterd	slechte geiser
55	2	slechte buffer	slechte geiser
55	3	beroemde danser	slechte geiser
55	4	slechte buffer	slechte zede
55	5	slechte mosterd	slechte zede
55	6	beroemde danser	slechte zede
56	1	snelle rover	snelle tandem
56	2	snelle ontdekking	snelle tandem
56	3	wijze redenatie	snelle tandem

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
56	4	snelle ontdekking	snelle ondergang
56	5	snelle rover	snelle ondergang
56	6	wijze redenatie	snelle ondergang
57	1	steile arena	steile berm
57	2	steile hiërarchie	steile berm
57	3	verse paprika	steile berm
57	4	steile hiërarchie	steile groei
57	5	steile arena	steile groei
57	6	verse paprika	steile groei
58	1	sterke doping	sterke ketting
58	2	sterk beheer	sterke ketting
58	3	blinde bedelaar	sterke ketting
58	4	sterk beheer	sterke stelling
58	5	sterke doping	sterke stelling
58	6	blinde bedelaar	sterke stelling
59	1	stevige tang	stevige kast
59	2	stevige rente	stevige kast
59	3	recente wet	stevige kast
59	4	stevige rente	stevige overlast
59	5	stevige tang	stevige overlast
59	6	recente wet	stevige overlast
60	1	stijve lippen	stijve kwast
60	2	stijve verklaring	stijve kwast
60	3	holle buis	stijve kwast
60	4	stijve verklaring	stijve strategie
60	5	stijve lippen	stijve strategie
60	6	holle buis	stijve strategie
61	1	stille wijk	stille pastoor
61	2	stille fantasie	stille pastoor
61	3	verrot hout	stille pastoor
61	4	stille fantasie	stille oppositie
61	5	stille wijk	stille oppositie
61	6	verrot hout	stille oppositie
62	1	stom toernooi	stomme rebus
62	2	stomme oorzaak	stomme rebus
62	3	intensief werk	stomme rebus
62	4	stomme oorzaak	stomme kwestie
62	5	stom toernooi	stomme kwestie
62	6	intensief werk	stomme kwestie
63	1	strakke baret	strakke jurk
63	2	strakke schatting	strakke jurk
63	3	unieke gitaar	strakke jurk

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
63	4	strakke schatting	strak advies
63	5	strakke baret	strak advies
63	6	unieke gitaar	strak advies
64	1	strenge oma	strenge lezer
64	2	strenge limiet	strenge lezer
64	3	slimme monteur	strenge lezer
64	4	strenge limiet	strenge instantie
64	5	strenge oma	strenge instantie
64	6	slimme monteur	strenge instantie
65	1	trage hommel	traag elftal
65	2	trage draai	traag elftal
65	3	bezorgde dochter	traag elftal
65	4	trage draai	trage metamorfose
65	5	trage hommel	trage metamorfose
65	6	bezorgde dochter	trage metamorfose
66	1	vet gezicht	vette toast
66	2	vette inhoud	vette toast
66	3	magische kamer	vette toast
66	4	vette inhoud	vette toename
66	5	vet gezicht	vette toename
66	6	magische kamer	vette toename
67	1	vlotte juffrouw	vlotte jongleur
67	2	vlotte houding	vlotte jongleur
67	3	zure aardbei	vlotte jongleur
67	4	vlotte houding	vlotte afloop
67	5	vlotte juffrouw	vlotte afloop
67	6	zure aardbei	vlotte afloop
68	1	volle kapstok	volle kliniek
68	2	volle seconde	volle kliniek
68	3	vurige wens	volle kliniek
68	4	volle seconde	volle betekenis
68	5	volle kapstok	volle betekenis
68	6	vurige wens	volle betekenis
69	1	vreemde denker	vreemde puzzel
69	2	vreemd onderzoek	vreemde puzzel
69	3	treurig masker	vreemde puzzel
69	4	vreemd onderzoek	vreemd aanbod
69	5	vreemde denker	vreemd aanbod
69	6	treurig masker	vreemd aanbod
70	1	vrije gorilla	vrije matroos
70	2	vrij protest	vrije matroos
70	3	soepele figuur	vrije matroos

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
70	4	vrij protest	vrij beraad
70	5	vrije gorilla	vrij beraad
70	6	soepele figuur	vrij beraad
71	1	vuile braadpan	vuil lint
71	2	vuile wraak	vuil lint
71	3	wrede dictator	vuil lint
71	4	vuile wraak	vuil excuus
71	5	vuile braadpan	vuil excuus
71	6	wrede dictator	vuil excuus
72	1	warme tomaat	warme zolder
72	2	warme omgang	warme zolder
72	3	gore steeg	warme zolder
72	4	warme omgang	warme respons
72	5	warme tomaat	warme respons
72	6	gore steeg	warme respons
73	1	wilde vakantie	wilde ruiter
73	2	wilde tempo	wilde ruiter
73	3	zonnige oever	wilde ruiter
73	4	wild tempo	wild verloop
73	5	wilde vakantie	wild verloop
73	6	zonnige oever	wild verloop
74	1	zachte rubber	zachte rollade
74	2	zacht signaal	zachte rollade
74	3	subtiele brief	zachte rollade
74	4	zacht signaal	zachte straling
74	5	zachte rubber	zachte straling
74	6	subtiele brief	zachte straling
75	1	zoete anijs	zoet cadeau
75	2	zoete scene	zoet cadeau
75	3	dappere generaal	zoet cadeau
75	4	zoete scene	zoete charme
75	5	zoete anijs	zoete charme
75	6	dappere generaal	zoete charme
76	1	zuivere poezie	zuivere magie
76	2	zuiver principe	zuivere magie
76	3	zielig kind	zuivere magie
76	4	zuiver principe	zuiver wonder
76	5	zuivere poezie	zuiver wonder
76	6	zielig kind	zuiver wonder
77	1	zwaar blok	zware schaal
77	2	zwaar ambt	zware schaal
77	3	saaie wedstrijd	zware schaal

Table D 1: List of stimuli used in Experiment 1

Item	*Condition*	*Prime combinations*	*Target combinations*
77	4	zwaar ambt	zwaar euvel
77	5	zwaar blok	zwaar euvel
77	6	saaie wedstrijd	zwaar euvel
78	1	zwak applaus	zwakke deining
78	2	zwak motief	zwakke deining
78	3	dwaze koning	zwakke deining
78	4	zwak motief	zwakke fusie
78	5	zwak applaus	zwakke fusie
78	6	dwaze koning	zwakke fusie

Legend: Conditions: 1. Concrete congruent, 2. Concrete incongruent, 3, Concrete unrelated, 4. Abstract congruent, 5. Abstract incongruent, 6. Abstract unrelated.

Note. In Control experiment, only the nouns from the combinations above were used in the stimulus set. In Experiment 2, the same combinations were used but without the stimuli from the Unrelated condition.

FILLER STIMULI USED IN EXPERIMENT 1

Filler type 1: Adjective-noun combinations (henceforth: ANCs) as primes and pseudo-adjective - noun combinations as targets. 1. centraal gebouw CENBRAAL ZICHT, 2. dikke atlas DIZZE MUUR, 3. dode walvis SODE LOEP, 4. vreemd krijt GREEMDE SOEP, 5. gezellige oppas GEVELLIGE BEUGEL, 6. ijzeren beeld AANDS TOUW, 7. angstige kraker ALGSTIGE LENING, 8. verkeerd loket VERKOORDE MOSSEL, 9. dwarse sprong DLARSE STICKER, 10. brutale tiran BRUKALE STUIVER, 11. befaamd theater BEDAAMDE MAGNEET, 12. ferme klap MERME GARNAAL, 13. grappig feest GROPPIGE HOEPEL, 14. idiote hoorn IDIOZE ROEST, 15. lichte reuma LOCHTE FORNUIS, 16. nederige woning NEVERIGE SNAAR, 17. paarse schmink PAAKSE STENCIL, 18. hartige sandwich PARTIGE ROMMEL, 19. pientere rivaal PIENDERE NATUUR, 20. speels meisje SFEELS LOKAAS, 21. aanwezige bandiet BUTTIGE ASTMA, 22. bewolkte hemel ONPIEPE BIJL, 23. bepaald atoom PRANDIOSE BARAK, 24. fier gemoed LEDEND BEZOEK, 25. fraaie gondel KEPPIGE BRUID, 26. geheim bordeel HETELSE CINEMA, 27. stoere directeur JAZIGE DREMPEL, 28. bijbels citaat KEUMIGE DATUM, 29. gierige eigenaar MENISCHE FAKKEL, 30. handige gieter POBLIEKE HALTE.

Filler type 2: ANCs as primes and adjective - pseudonoun combinations as targets. 1. bazige kok BAZIGE DENT, 2. edel beroep EDELE OPRIK, 3. complete bundel COMPLETE KROOG, 4. betere aankoop BETERE RINNING, 5. dichte afvoer DICHTE TAREN, 6. bonte badjas BONTE WORG, 7. bruine commode BRUINE DEMEN, 8. dierbaar boek DIERBAAR DUIL, 9. geestige opa GEESTIGE FLUIG, 10. spannend congres SPANNENDE GRUMEL, 11. schuldig gelach SCHULDIG KUPPER, 12. machtig gilde MACHTIGE KIPPEL, 13. kapotte ijskast KAPOTTE LANK, 14. normaal kader NORMALE MAALMIJD, 15. prettige massage PRETTIG MODDEN, 16. strikt motto STRIKT LAADS, 17. tuttige meid TUTTIGE MOOGD, 18. vochtig museum VOCHTIGE AGEN, 19. zoute oester ZOUTE PREKJE, 20. zuinige ouder ZUINIG PENTION, 21.

geldige betaling DANKBARE ZASTER, 22. geurige akker BLOEDIGE BRENST, 23. blonde student GELUKKIGE BEERT, 24. eeuwige armoede EFFEN BRECHE, 25. gehele ballast KRITIEKE BROND, 26. heftige beweging LUCHTIGE CAMAMEL, 27. oprechte aanslag SLOME DREUP, 28. reine lucht STOUT ENPEL, 29. jeugdige chirurg SCHUW EXNERT, 30. driftige broer AFWEZIG GEDAAT.

Filler type 3: ANCs as primes and pseudowords as targets. 1. gemengd bedrijf GELENGD CILLO, 2. kromme bloem DROMME CHOPS, 3. links doel LIRSE HAANT, 4. moedig geslacht MOODIG HAVING, 5. bejaarde graaf BETAARDE KATEEL, 6. fors bedrag FOTS JECHT, 7. haastige vlucht GAASTIGE JAFFER, 8. levende inktvis LAVEND KARET, 9. rechte ledemaat RACHTE KRIPTAL, 10. monter liedje MINTER WIPPEL, 11. stroeve deurmat SPROEFE WERVET, 12. schele heks SCHOLE VIJVED, 13. schaarse tabak SCHUURSE PRUID, 14. schuin rietje SCHAAN GACHT, 15. populair orkest POPELAIR KRENP, 16. oranje zegel OVANJE HUKSPOT, 17. trieste grijns GRIESTE BLAAI, 18. troebele benzine FROEBELE MIJFER, 19. rotte ananas RETTE KRONT, 20. hecht linoleum HOCHTE BUIST, 21. heuse diamant SPOTSE HONGEN, 22. kort gezang PREMPT HARTAS, 23. ijverige cadet ONKIJS KITLOF, 24. kattig gedoe LOTE PREGAT, 25. fleurig gordijn METAREN BLUIT, 26. kuis gebod GERE HOLFT, 27. langzame molen DEVE LEDERING, 28. muzikaal echtpaar WRANTE LEEMPIA, 29. nors mens ZEELIG NIEUTS, 30. schrale toendra VONNIG OLIJG.

E Materials for experiments in Chapter 4

Table E 1: List of stimuli used in Experiment 1: Quadruplets of adjective-noun combinations and, beneath each triplet, labels for the collocational restrictions of peripheral adjectives

Item	*central adj.* *high salient noun*	*periph. adj.* *high salient noun*	central adj. low salient noun	periph. adj. low salient noun
1	dikke alcoholist ongezond	pafferige alcoholist	dik schaap	pafferig schaap
2	dof lied stem	schor lied	doffe gans	schorre gans
3	goede knecht karakter	brave knecht	goede folder	brave folder
4	goede rasp gebruik	handige rasp	goede sjerp	handige sjerp
5	grappig veulen vertederend	koddig veulen	grappige agent	koddige agent
6	grappige zoon ondeugend	guitige zoon	grappige chef	guitige chef
7	grote poort verticaal	hoge poort	grote helm	hoge helm
8	grote smid kracht	potige smid	grote soldaat	potige soldaat
9	kleine paraaf handschrift	priegelige paraaf	klein opstel	priegelig opstel
10	kleine grot ruimte	nauwe grot	kleine auto	nauwe auto
11	leuk circus lachen	komisch circus	leuke theorie	komische theorie
12	magere mannequin welgevormd	slanke mannequin	magere kanarie	slanke kanarie
13	nieuwe sonate ideeën	originele sonate	nieuwe vloer	originele vloer
14	nieuwe hoop kwetsbaar	prille hoop	nieuwe school	prille school
15	trage dans prettig	lome dans	trage lezing	lome lezing
16	trage gevangene doen	luie gevangene	trage assistent	luie assistent
17	vage gloed glans	doffe gloed	vage vlek	doffe vlek
18	vrolijke ballon kleur	fleurige ballon	vrolijke krant	fleurige krant

Table E 1: List of stimuli used in Experiment 1: Quadruplets of adjective-noun combinations and, beneath each triplet, labels for the collocational restrictions of peripheral adjectives

Item	*central adj.* *high salient noun*	*periph. adj.* *high salient noun*	central adj. low salient noun	periph. adj. low salient noun
19	zachte dadel voedsel	smeuïge dadel	zachte nectar	smeuïge nectar
20	zachte spons vocht	weke spons	zacht karton	week karton
21	natte tuin grond	drassige tuin	natte stal	drassige stal
22	griezelig ravijn dood	macaber ravijn	griezelige reis	macabere reis
23	lange atleet gestalte	rijzige atleet	lange dochter	rijzige dochter
24	leeg etiket papier	blank etiket	leeg dossier	blank dossier
25	dunne muts kleding	luchtige muts	dunne luier	luchtige luier
26	deftige minister spreken	bekakte minister	deftige bakker	bekakte bakker
27	beleefde minnaar vrouwen	galante minnaar	beleefde dominee	galante dominee
28	duidelijk profiel lijnen	scherp profiel	duidelijke rimpel	scherpe rimpel
29	losse aarde grond	rulle aarde	los perk	rul perk
30	lichte pruik haar	blonde pruik	lichte stola	blonde stola
31	boze lerares ongeduldig	kribbige lerares	boze bruid	kribbige bruid
32	sterke professor oudere	kwieke professor	sterke eend	kwieke eend
33	mogelijk plan verwezenlijken	haalbaar plan	mogelijke rust	haalbare rust
34	gezond kruid genezing	heilzaam kruid	gezond weekend	heilzaam weekend
35	fors lijk botten	schonkig lijk	fors paard	schonkig paard
36	warme lente sensueel	zwoele lente	warme herfst	zwoele herfst
37	slimme spion geslepen	sluwe spion	slim cadeau	sluw cadeau
38	gladde vlecht	sluike vlecht	gladde penseel	sluike penseel

Table E 1: List of stimuli used in Experiment 1: Quadruplets of adjective-noun combinations and, beneath each triplet, labels for the collocational restrictions of peripheral adjectives

Item	*central adj.* *high salient noun*	*periph. adj.* *high salient noun*	central adj. low salient noun	periph. adj. low salient noun
	harig			
39	hevige drift	onstuimige drift	hevige klacht	onstuimige klacht
	onbeheerst			
40	gemene wraak	gluiperige wraak	gemene baas	gluiperige baas
	geniepig			
41	soepele acrobaat	lenige acrobaat	soepele sprong	lenige sprong
	lichaam			
42	zoute rijst	hartige rijst	zoute soja	hartige soja
	voedsel			
43	schone watten	steriele watten	schone douche	steriele douche
	ziekte			
44	formeel ritueel	plechtig ritueel	formele receptie	plechtige receptie
	ernst			
45	grootse polder	weidse polder	groots decor	weids decor
	landschap			
46	vreemde blunder	malle blunder	vreemde paraplu	malle paraplu
	uitingen			
47	moeilijk debat	beladen debat	moeilijke norm	beladen norm
	bespreken			
48	gezellige pantoffels	kneuterige pantoffels	gezellige galerie	kneuterige galerie
	burgerlijk			

Note. In Experiment 2, the test combinations were embedded in facilitating and neutral sentence-contexts.

FILLER STIMULI USED IN EXPERIMENT 1

Filler type 1: adjectival dimension is irrelevant for the noun but the combinations are interpretable. 1. pipse rug, 2. rank hek, 3. troebele fles, 4. capabele oma, 5. solide speld, 6. log gedicht, 7. malse salade, 8. romantisch archief, 9. bruusk gesprek, 10. zeldzame peper, 11. schril bevel, 12. serene hal, 13. ridicuul bos, 14. markant kapsel, 15. lijvige brief, 16. machtige tante, 17. ordelijk koor, 18. pittige film, 19. zwierige trui, 20. drammerige piloot, 21. ergerlijke zomer, 22. imposant viaduct, 23. kroezige hond, 24. klef koekje,

Filler type 2: meaningless combinations. 1. duizelige klok, 2. stille kam, 3. gevoelig hotel, 4. haveloos oog, 5. tochtig bier, 6. brutale steen 7. dreigende veter, 8. roerige bril, 9. zoete mouw, 10. pijnlijk parfum, 11. trouwe nacht, 12. daverende traan, 13. domme sneeuw, 14. spontaan gebit, 15. wrede deur, 16. matige darm, 17. serieuze schaar, 18. bloot hooi, 19. dwaze drop, 20. pezig riool, 21. fiere pap, 22. rauw hemd, 23. rijpe lepel, 24. gelaten gitaar.

F Materials for experiments in Chapter 5

Table F 1: LIST OF STIMULI USED IN EXPERIMENT 1 AND 2

	COMBINATION TYPE		
	low complex intersective	medium complex *subsective compatible*	*high complex subsective incompatible*
1.	bejaarde tandarts	ervaren tandarts	trage tandarts
2.	dodelijk gif	sterk gif	snel gif
3.	*kapotte pen	goede pen	vlotte pen
4.	versleten machine	domme machine	precieze machine
5 .	kleine brief	komische brief	urgente brief
6.	*moderne roman	interessante roman	korte roman
7.	groene gesp	bijzondere gesp	makkelijke gesp
8.	*nieuwe sonate	leuke sonate	lange sonate
9.	bolle lens	zwakke lens	moeilijke lens
10.	verloren opstel	simpel opstel	slordig opstel
11.	houten schip	veilig schip	langzaam schip
12.	dik boek	slecht boek	consequent boek
13.	rode trein	comfortabele trein	vroege trein
14.	verdwaalde kapitein	bekende kapitein	voorzichtige kapitein
15.	Nederlandse acteur	betrouwbare acteur	briljante acteur

Note. Combinations marked with an asterisk were excluded from the analysis of RTs in Experiment 1.

FILLER STIMULI USED IN EXPERIMENT 1

Filler type 1: Additional intersective combinations. 1. metalen lepel, 2. groot hotel, 3. gestolen jas, 4. rijpe appel, 5. hete soep.

Filler type 2: Highly familiar (specialized) combinations. 1. lekke band, 2. eerste hulp, 3. gouden medaille, 4. tamme kastanjes, 5. witte haai,

Filler type 3: Meaningless combinations. 1. wrede deur, 2. spontaan gebit, 3. tochtig bier, 4. machtige spons, 5. rijp vliegtuig, 6. dwaze drop, 7. pezig riool, 8. brave folder, 9. dreigende veter, 10. brutale steen, 11. roerige bril, 12. duizelige klok, 13. blauwe klacht, 14. stille kam, 15. sluw cadeau, 16. zoete mouw, 17. boze reis, 18. slanke storm, 19. lenige pap, 20. zwoele sprong, 21. lenige zon, 22. blonde receptie, 23. rauw hemd, 24. serieuze schaar, 25. luchtig stoplicht.

Samenvatting en conclusies

Samenvatting

In hoofdstuk 1 werden factoren geïntroduceerd die een belangrijke rol spelen in de semantische interpretatie van adjectief-nomen combinaties. De volgende factoren werden besproken:

1. *Adjectief-nomen compatibiliteit.* Typisch voor adjectieven is dat ze variëren in de mate waarin ze met verschillende zelfstandige naamwoorden samengaan (compatibel zijn). Deze eigenschap wordt bepaald door de zogenaamde selectierestricties van adjectieven. Het adjectief *groen* bijvoorbeeld selecteert (is compatibel met) voornamelijk concrete nomina zoals *stoel*. De mate waarin de constituenten in adjectief-nomen combinaties compatibel zijn beïnvloedt hun interpreteerbaarheid. Om twee laag compatibele concepten te kunnen interpreteren (b.v. *groen idee* geïnterpreteerd als *milieu-bewust*) is het nodig om extra kennis van het interpretatiedomein en/of van de context erbij te betrekken.

2 *Nomen-afhankelijkheid.* Adjectieven kunnen variëren in de mate waarin hun semantische interpretatie afhankelijk is van het nomen. Als we de combinaties met ondergespecificeerde adjectieven (zoals *interessant*: *interessant boek, interessante auto, interessante bloem*) vergelijken met combinaties met duidelijk gespecificeerde adjectieven (zoals *geel* - *geel boek, gele auto, gele bloem*) lijkt het dat de variatie in betekenis veel groter is voor adjectieven als *interessant* dan voor adjectieven als *geel.* Deze variatie lijkt tot stand te komen tot doordat de betekenis van het adjectief *interessant* telkens door verschillende nomeneigenschappen wordt ingevuld. De betekenis van het adjectief *geel* daarentegen blijft vrijwel hetzelfde in combinaties met verschillende nomina. In het algemeen lijkt het zo te zijn dat adjectieven die duidelijk gespecificeerd zijn, zoals

geel, weinig afhankelijk zijn van het nomen terwijl adjectieven die ondergespecificeerd zijn, zoals *interessant*, in grote mate afhankelijk zijn van het nomen.

3 *Kennis en inferenties.* In sommige adjectief-nomen combinaties is de relatie tussen de constituenten niet meteen duidelijk (bv. *drassige kas, makkelijke gevangenis*). Om tot een coherente interpretatie van deze combinaties te komen is het soms nodig om kennis van de wereld te gebruiken en inferenties te maken (bv. *kas met drassig grond, gevangenis waaruit je gemakkelijk kunt ontsnappen*). Deze veronderstelling werd naar voren gebracht door Murphy and Medin (1985) en Murphy (1990) in hun Concept Specialisatie Model. Er is evidentie dat de combinaties die veel kennis van de wereld vereisen om de constituenten aan elkaar te relateren moeilijker te interpreteren zijn dan de combinaties met een relatief duidelijke relatie tussen de constituenten (bv. *kleine kas, groot gevangenis*).

4 *Saillantie en typicaliteit.* Heersende modellen van conceptuele combinaties gaan uit van de assumptie dat woordbetekenissen uit verschillende componenten zijn opgebouwd. Deze componenten variëren in hun relevantie (saillantie) voor de beschrijving van het object waar het woord aan refereert. Voor het woord *appel* bijvoorbeeld zijn de verschillende componenten als volgt: APPEL - instantie van de categorie *fruit*; KLEUR - rood, groen, rood/groen, geel, bruin; VORM - rond; SMAAK - zoet, zuur; BEVAT - suiker, vitamines. Als mensen gevraagd wordt om dit soort lijstjes met objecteigenschappen te produceren, worden sommige eigenschappen sneller en/of vaker genoemd dan andere. Zulke verschillen in beschikbaarheid van verschillende eigenschappen kunnen veroorzaakt worden door de verschillen in relevantie (saillantie) van deze eigenschappen. Combinaties gemaakt met adjectieven die betrekking hebben op hoog relevante nomen-eigenschappen (bijvoorbeeld *smakelijke appel*) zijn makkelijker te interpreteren dan de combinaties met laag relevante eigenschappen (bijvoorbeeld *droge appel*). Een soortgelijk effect treedt op bij de typicaliteit van waarden voor de verschillende eigenschappen. Combinaties met adjectieven die een zeer typische waarde van een eigenschap van het nomen representeren (bijvoorbeeld de waarde *rood* voor de eigenschap KLEUR in de combinatie *rode appel*) zijn makkelijker te interpreteren dan de combinaties met adjectieven die een zeer atypisch waarde van een nomen-eigenschap representeren (bijvoorbeeld *bruine appel*).

In Hoofdstuk 1 werd gesteld dat in dit proefschrift geen van de bestaande modellen van conceptuele combinaties in zijn geheel geadopteerd en getoetst zou worden. De strategie was om de rol van de bovengenoemde vier factoren in de semantische interpretatie van adjectief-nomen combinaties te onderzoeken. Het hoofdstuk eindigt met een overzicht van het proefschrift.

Hoofdstuk 2 behandelt de vraag naar mogelijke verschillen in de representatie van de betekenis van homonyme en polyseme adjectieven. Homonyme adjectieven, zoals *zwaar* representeren twee duidelijk te onderscheiden ongerelateerde of laag gerelateerde betekenissen (bijvoorbeeld *hoog gewicht* en *moeilijkheid*). Het feit dat deze betekenissen zeer laag gerelateerd zijn en dat de ene betekenis niet op basis van de andere berekend kan worden, suggereert dat ze allebei gerepresenteerd moeten worden. Onderscheid tussen de verschillende representaties van de betekenissen van polyseme adjectieven is veel moeilijker te maken. Bij voorbeeld, in de combinaties *leuke maaltijd, leuk weer, leuke boom, leuke jongen*, is de variatie in de betekenis van het adjectief *leuk* in grote mate afhankelijk van het zelfstandig naamwoord. Dit impliceert dat de betekenissen van polyseme adjectieven waarschijnlijk niet zijn opgeslagen maar dat ze geconstrueerd worden op basis van het nomen. Met andere woorden, polyseme adjectieven lijken semantisch ondergespecificeerd te zijn. Om deze hypothese over de verschillen in opslag en interpretatie van homonieme vs. polyseme adjectieven te toetsen werden er twee experimenten uitgevoerd. In de experimenten werd gebruik gemaakt van een priming paradigma. De snelheid en de correctheid van de semantische verwerking van bijna-synoniemen werd onderzocht onder invloed van de aanbieding van de twee typen adjectieven, in isolatie of in een adjectief-nomen combinatie, als prime. Zo werd de verwerking van het adjectief *vriendelijk* (bijna-synoniem van het homoniem adjectief *aardig*) gemeten na aanbieding van het adjectief *aardig* (experiment 1A en 1B) of de adjectief-nomen combinatie *aardige student* (experiment 2A en 2B). In Experiment 1 werden de stimuli voor de beide typen adjectieven in een gerelateerde (*aardig - vriendelijk*) en in een ongerelateerde (*waterig - vriendelijk*) conditie aangeboden. Er werd een faciliterend effect van priming in de gerelateerde conditie verwacht voor homoniemen maar niet voor polyseme adjectieven. De resultaten lieten geen geen significant interactie-effect zien voor gerelateerdheid en type adjectief maar alleen een kleine trend in de voorspelde richting in de afzonderlijke analyses per type adjectief. In Experiment 2 werden de stimuli voor de beide typen adjectieven in een congruente (*aardige student - vriendelijk, aardig bedrag - aanzienlijk*), een incongruente (*aardig bedrag - vriendelijk, aardige student*

- *aanzienlijk*) aangeboden. Voorspeld werd dat de combinaties met homonieme adjectieven, dankzij hun opgeslagen betekenissen, priming effecten zouden produceren zowel in de conditie met congruente prime-target stimuli (prime en target hebben betrekking op dezelfde betekenis van het adjectief) als in de conditie met incongruente prime-target stimuli (prime en target hebben betrekking op verschillende betekenissen van het adjectief). Op basis van de assumptie dat de betekenissen van polyseme adjectieven niet opgeslagen zijn maar in context geconstrueerd worden, werden geen priming-effecten in de incongruente conditie voor dit type adjectieven verwacht. Het interactie-effect was wederom niet significant. Er was slechts een zwakke trend in de voorspelde richting in de afzonderlijke analyses per adjectief type. Een mogelijke verklaring voor deze resultaten is dat de mate van betekenisgerelateerdheid voor adjectieven niet volledig samenvalt met (onder)specificatie van betekenis en daaraan gerelateerde contextafhankelijkheid. De resultaten verkregen met polyseme adjectieven in Experiment 2A en 2B (in adjectief-nomen combinaties) laten wel de conclusie toe dat de betekenissen van dit type adjectieven in grote mate worden berekend.

Als wordt aangenomen dat de semantische interpretatie van polyseme adjectieven in adjectief-nomen combinaties in grote mate activatie en selectie van nomen-eigenschappen inhoudt, rijst de vraag welke nomen-gerelateerde factoren de omvang van deze activatie- en selectieprocessen bepalen (de zogenaamde 'semantic processing commitment' Frazier & Rayner, 1990). Op deze vraag is in Hoofdstuk 3 een antwoord gezocht door het effect van concreetheid van het nomen op de omvang van de activatie en de selectie van nomen eigenschappen te bestuderen. Voor concrete nomina kan verondersteld worden dat ze, dankzij hun informationele rijkdom en diversiteit, minder contextafhankelijk zullen zijn dan abstracte nomina (zie bijvoorbeeld Kounios & Holcomb, 1994; Paivio, 1986). Dit zou betekenen dat in de semantische interpretatie van combinaties van polyseme adjectieven en concrete nomina contextuele invulling van van betekenissen van adjectieven op basis van nomen-eigenschappen een grotere rol zal spelen dan in de interpretatie van combinaties met abstracte nomina. In het eerste experiment werd de hypothese getoetst dat de semantische gerelateerdheid van de berekende betekenissen groter zal zijn in paren van 'prime-target' adjectief-nomen combinaties die congruent zijn in verwerkingsstrategie (zowel prime als target vereisen hoge 'processing commitment', bijvoorbeeld *echte schilder - echt satijn*) dan in de incongruente paren (prime is van een lage 'processing commitment' type en target van het hoge 'processing' commitment type, bijvoorbeeld *echte vrijheid - echt satijn*). Daarnaast werd er een incongruentie-asymmetrie effect verwacht: concrete targets voorafgegaan door abstracte primes (bijvoorbeeld *echte vrijheid - echt satijn*) zullen kleinere facilitatie-effecten vertonen dan abstracte targets voorafgegaan door concrete primes (bijvoorbeeld *echt satijn - echte vrijheid*). In het experiment werd gebruikt gemaakt van een 'dubbele lexicale decisie' - taak. De resultaten van de reactietijdenanalyse vertoonden een significant effect van congruentie maar niet van congruentie-asymmetrie. Om uit te sluiten dat het gevonden congruentie-effect toegeschreven zou kunnen worden aan verschillen tussen de nomina zelf in plaats van aan de geïnduceerde combinatorische processen werd een controle-experiment uitgevoerd waarin alleen de zelfstandige naamwoorden uit de combinaties in prime-target paren werden aangeboden. De resultaten van het controle-experiment ondersteunden de interpretatie van het verkregen congruentie-effect op basis van factoren die een rol spelen in combinatorische interpretatie en niet als effect van nomina alleen.

In het tweede experiment in Hoofdstuk 3 werd onderzocht of de semantische gerelateerdheid inderdaad groter was in congruente dan in incongruente prime-target paren. De semantische gerelateerdheidscores lieten een significant effect van gerelateerdheid zien in dezelfde richting als het congruentie-effect in het eerste experiment. Dit effect suggereert dat het congruentie-effect in het eerste experiment gebaseerd is op de semantische gerelateerdheid van de combinaties.

De resultaten verkregen in dit onderzoek verruimen de toepasbaarheid van de *'minimal processing commitment'* hypothese van nomina met meerdere gerelateerde betekenissen naar adjectieven met meerdere gerelateerde betekenissen (Frazier & Rayner, 1990). Tevens impliceren deze bevindingen dat de interpretatie van polyseme adjectieven in grote mate afhankelijk is van de semantische eigenschappen van de nomina. Deze bevindingen zijn compatibel met de 'betekenisconstructie-hypothese' voor polyseme adjectieven die naar voren werd gebracht in Hoofdstuk 2.

In Hoofdstuk 4 werd de semantische interpretatie van adjectief-nomen combinaties onderzocht onder invloed van de complexiteit van adjectieven en de saillantie (relevatie) van nomen eigenschappen. De veronderstelling was dat de twee factoren zouden interacteren en dat de variatie in complexiteit van adjectivische restricties een kleiner effect zou hebben op de snelheid en de correctheid van de semantische interpretatie van combinaties als de restricties betrekking hebben op hoog saillante eigenschappen van de nomina dan wanneer ze betrekking hebben op laag saillante eigenschappen. De complexiteit van adjectieven werd gemanipuleerd middels het onderscheid tussen centrale en perifere adjectieven (Gross et al., 1989). Centrale adjectieven zoals die in de antoniem-paren *nat droog* of *warm - koud*, hebben een relatief simpele conceptuele structuur (Gross et al., 1989; Gross & Miller, 1990) en zijn verbonden met relatief simpele selectie-restricties. Deze restricties kunnen onder andere betrekking hebben op de categorie waartoe een nomen moet behoren om met het gegeven adjectief gecombineerd te kunnen worden (Cruse, 1986b; Cruse, 1990; Pustejovsky, 2000). Bijvoorbeeld, het adjectief *nat* beperkt de set van nomina waarmee het gecombineerd kan worden tot het type *concreet object*. Perifere adjectieven, daarentegen, die geclusterd zijn om centrale adjectieven (zoals *drassig* om *nat* en *dor* om *droog*) hebben een complexe semantische structuur. Deze adjectieven erven de selectierestricties van de corresponderende centrale adjectieven en voegen er meer specifieke collocationele restricties aan toe. Dit soort adjectieven wordt meer specialistisch gebruikt. Zo heeft het perifere adjectief *drassig* (een bijna-synonym van *nat*) weliswaar betrekking op concrete nomina maar beperkt het die set tot de nomina die aan grond refereren, zoals *akker*. Deze restrictie beperkt het gebruik van het adjectief *drassig* waardoor zijn frequentie lager is dan van het adjectief *nat*.

Daarnaast speelt de saillantie van de nomen-eigenschappen die met de adjectivische restricties corresponderen een belangrijke rol. De veronderstelling was dat het verschil in verwerkingstijd tussen combinaties met centrale adjectieven en combinaties met perifere adjectieven kleiner zal zijn als de corresponderende eigenschappen van het nomen hoog saillant zijn dan wanneer ze laag saillant zijn. Lage saillantie kan zowel lage beschikbaarheid van informatie reflecteren als ook de noodzaak om de informatie te infereren (Murphy, 1990). Ter illustratie, in de combinaties *natte akker - drassige akker* zijn de nomen eigenschappen *concreet object* en *grond*, die aan de restricties beantwoorden van respectievelijk het centrale en het perifere adjectief, hoog saillant. In de combinaties *natte kas - drassige kas* zijn de nomen-eigenschappen die aan de restricties van het centrale adjectief beantwoorden wel hoog saillant (*concreet object*), terwijl de eigenschappen die aan de restricties van het perifeer adjectief beantwoorden laag saillant zijn (*grond*). De voorspelling was dat deze combinatie van factoren de interpreteerbaarheid van de combinaties zal beïnvloeden en daardoor effect zal hebben op de snelheid en de correctheid van de proefpersonen in een semantische classificatie taak waarin de combinaties op zinvolheid beoordeeld moesten worden. Er werd een interactieeffect verwacht met kleinere verschillen tussen de combinaties met hoge saillantie nomina dan tussen de combinaties met lage saillantie nomina. Deze voorspelling werd bevestigd in de analyse van de foutenpercentages, maar de analyse van de reactietijden liet geen interactieeffect zien. Om de mogelijkheid uit te sluiten dat het interactieeffect in de analyse van de foutenpercentages te wijten was aan 'nuisance'-variabelen (Murphy, 1990) zoals een lage bekendheid van de combinaties met complexe adjectieven en laag saillantie nomina, werd een tweede experiment uitgevoerd. In dit experiment werden de combinaties ingebed in neutrale en faciliterende zinscontexten. De resultaten van het tweede experiment lieten zien dat het oordeel over de zinvolheid van de combinaties veranderde afhankelijk van de context. Deze bevinding ondersteunde de oorspronkelijke interpretatie van het interactieeffect verkregen in het eerste experiment en sloot de alternatieve verklaring uit dat de resultaten in het eerste experiment toe te schrijven zijn aan andere factoren.

De resultaten van de experimenten in Hoofdstuk 4 ondersteunen de algemene assumptie die ten grondslag ligt aan de verschillende modellen voor de interpretatie van conceptuele combinaties dat zowel de complexiteit van het adjectief als de saillantie van de nomen-eigenschappen effect hebben op cognitieve verwerking van adjectief-nomen combinaties.

In de studies in Hoofdstuk 2 werd geen sterke ondersteuning verkregen voor de assumptie dat homonymy/polysemie en semantische (onder)specificatie van adjectieven sterk gecorreleerd zijn. In Hoofdstuk 5 werd de mogelijkheid onderzocht dat er andere factoren zijn die een sterkere relatie vertonen met onderspecificatie en daaraan gerelateerde nomenafhankelijkheid van adjectieven. Een van de onderzochte factoren was het logische type van het adjectief. Er werd gebruik gemaakt van een typologie voor adjectieven voorgesteld door Kamp and Partee (1995) waarbij een hoofdtype (subsectief) en een subtype (intersectief) onderscheiden worden. De interpretatie van adjectief-nomen combinaties met intersectieve adjectieven (bijvoorbeeld *gele auto*) resulteert in een verwijzing naar de entiteiten in de intersectie van de sets aangeduid door het adjectief en het nomen. Bij dit soort interpretaties blijft de betekenis van het adjectief in grote mate invariabel in combinaties met verschillende nomina (Kamp & Partee, 1995; Sedivy et al., 1999). Bijvoorbeeld, voor de intersectieve combinaties *vleesetend zoogdier, vleesetend plant,* en *vleesetend chirurg* blijft de contributie van het adjectief aan de betekenis van de verschillende combinaties gelijk. Adjectief-nomen combinaties gemaakt met subsectieve adjectieven daarentegen zijn anders. Deze combinaties verwijzen aan de subsets van entiteiten aangeduid door de nomina. Om een subset te kunnen bepalen moeten een of meer nomeneigenschappen als criterium geselecteerd worden. In verschillende adjectief-nomen combinaties selecteert het adjectief verschillende nomen-eigenschappen. Bijvoorbeeld, in de subsectieve combinaties *goede wijn, goede advocaat, goed boek* kunnen de eigenschappen *smaak, verdediging,* en *plot* geselecteerd worden. Het respectievelijke eindresultaat van de semantische interpretatie van deze drie combinaties zou kunnen zijn *wijn die goed smaakt, advocaat die zijn klanten goed verdedigt* en *boek met een interessant plot.* De subsectieve adjectieven tonen een sterkere afhankelijkheid van het nomen in combinatorische semantische interpretatie dan de intersective adjectieven. Daardoor is hun interpretatie tevens computationeel meer complex dan van de intersectieve adjectieven.

Er werd voorspeld dat de verschillen in complexiteit uitgedrukt zouden worden in een snellere verwerking van intersectieve combinaties dan van subsectieve combinaties. Deze hypothese werd getoetst door gebruik te maken van combinaties met zowel intersective als subsectieve adjectieven in een semantische classificatie taak voor de zinvolheid van de combinaties. De resultaten bevestigden de hypothese: combinaties met intersectieve adjectieven werden sneller verwerkt dan de combinaties met subsectieve adjectieven.

Voor de combinaties met subsectieve adjectieven werd verondersteld dat de complexiteit van hun semantische interpretatie beïnvloed kan worden door adjectief-nomen compatibiliteit. Incompatibele combinaties bestonden uit adjectieven die betrekking hebben op (het verloop van) gebeurtenissen ('events'), zoals het adjectief *snel* en nomina die niet naar gebeurtenissen maar naar entiteiten verwijzen, zoals het nomen *typist.* Voor deze combinaties werd verondersteld dat ze een meer complexe nomen-afhankelijke interpretatie vereisen dan compatibele combinaties, *snelle race, aardige typist,* waarbij de nomina verwijzen naar gebeurtenissen. Gebaseerd op de assumpties van de Generatieve Lexicon theorie (Pustejovsky, 1995) werd verondersteld dat de interpretatie van incompatibele combinaties het gebruik van de semantische operatie van 'type coercion' vereist. Anders dan verwacht lieten de resultaten van het eerste experiment in Hoofdstuk 5 echter geen verschil zien in reactietijden tussen de compatibele en de incompatibele combinaties en verschillen in foutenpercentages waren alleen significant in de proefpersonenanalyse. Verder onderzoek is nodig om de cognitieve mechanismen te onderzoeken die ten grondslag liggen aan de interpretatie van de twee soorten subsectieve combinaties.

In het tweede experiment van Hoofdstuk 5 hadden de proefpersonen de taak om de adjectief-nomen combinaties uit het eerste experiment te parafraseren, zodat het duidelijk werd welke betekenis zij er aan toe kenden. De verwachting was dat, in tegenstelling tot de parafrases van de subsectieve combinaties, de parafrases van de relatief simpele intersectieve combinaties eenvoudiger zouden zijn en dat ze geen nomen-gerelateerde concepten zouden bevatten. Daarnaast werden verschillen verwacht tussen de compatibele en de incompatibele subsectieve combinaties met betrekking tot het type nomen-gerelateerde informatie. Deze verwachtingen werden deels bevestigd. De resultaten geven aan dat er bij de interpretatie van intersectieve combinaties weinig nomen-eigenschappen betrokken werden en dat er bij de interpretatie van incompatibele subsectieve combinaties grotendeels nomen-gerelateerde gebeurtenissen geselecteerd worden. De parafrases van de compatibele subsectieve combinaties waren enigszins problematisch. Deze combinaties ontlokten evenveel parafrases met als zonder 'gebeurtenissen'. Kennelijk is het zo dat wanneer proefpersonen in een off-line taak voldoende tijd hebben om over de combinaties na te denken zij ook minder waarschijnlijke interpretaties produceren. Deze bevinding wijst op een grotere mate van onderspecificatie voor compatibele dan voor de incompatibele subsectieve combinaties.

Conclusies

In dit proefschrift is getracht antwoorden te vinden op vragen die betrekking hebben op enkele minder goed belichte aspecten van de semantische interpretatie van adjectief-nomen combinaties. In Hoofdstuk 1 werd beargumenteerd dat de assumptie van de huidige modellen van conceptuele combinaties (Hampton, 1997c; Murphy, 1990; Smith et al., 1988) dat woordbetekenissen altijd opgeslagen zijn mogelijk inadequaat is voor adjectieven die geen duidelijke eigenschappen representeren. Dat zijn bijvoorbeeld polyseme adjectieven zoals *interessant, leuk*, en *goed*. Voor dit soort adjectieven lijkt het meer plausibel dat hun betekenissen in context berekend worden. In de experimenten in Hoofdstuk 2 werd echter alleen een zwakke indicatie gevonden voor deze hypothese. Er werd geconcludeerd dat semantische onderspecificatie van adjectieven en de daarmee samenhangende nomen-afhankelijkheid weinig samenhang vertonen met betekenisgerelateerdheid. De resultaten van experimenten in Hoofdstuk 3 lieten zien dat nomen-gerelateerde factoren zoals concreetheid een belangrijke rol spelen in de semantische interpretatie van combinaties met polyseme adjectieven. Dit suggereert dat de nomina een complexe rol zouden kunnen spelen in combinatorische interpretatie. In de experimenten in Hoofdstuk 4 werd evidentie verkregen voor de assumptie dat zowel de complexiteit van het adjectief als de saillantie van de nomen-eigenschappen effect hebben op de cognitieve verwerking van adjectief-nomen combinaties. De bevindingen gerapporteerd in Hoofdstuk 5 tenslotte suggereren dat het logische type van het adjectief een goed diagnostisch middel is voor het bepalen van semantische onderspecificatie en de daarmee samenhangende mate van nomen-afhankelijkheid.

Deze bevindingen lijken in grotere mate compatibel te zijn met de hypothese van 'context afhankelijke berekening van betekenis' dan met de 'betekenisopslag' hypothese voor adjectieven. De mate waarin de betekenissen van adjectieven in context worden berekend hangt af van de mate waarin ze semantisch gespecificeerd zijn. Het onderscheid tussen hoog- en laaggespecificeerde adjectieven kan gemaakt worden op basis van hun formele type. Tevens zijn er aanwijzingen dat de compatibiliteit tussen adjectieven en nomina een belangrijke rol speelt in de interpretatie van hun combinaties. Inbedding van het proces van compatibiliteitsresolutie in het interpretatieproces heeft de implicatie dat factoren als saillantie en typicaliteit van nomen-eigenschappen waarschijnlijk pas een rol spelen nadat het vereiste type nomen-eigenschap bepaald is. Sommige adjectieven, zoals *snel*, hebben betrekking op gebeurtenissen. In combinaties met nomina die niet aan een gebeurtenis refereren, zoals *auto*, moet er eerst in de representatie van het nomen gezocht worden naar een eigenschap van het type gebeurtenis zoals *rijden*. Pas nadat het juiste type van de eigenschap gevonden is, zal zijn saillantie en/of typicaliteit een rol gaan spelen. De meest saillante eigenschap van het type gebeurtenis voor auto's is ongetwijfeld *rijden*. In sommige contexten zullen echter minder saillante gebeurtenissen zoals *wassen* of *repareren* in de interpretatie betrokken worden hetgeen het interpretatieproces zal beïnvloeden. Verder onderzoek op dit gebied zou zich moeten richten op een verdere exploratie van de processen die betrokken zijn bij de betekenisconstructie in conceptuele combinaties. Aangezien adjectief-nomen combinaties een verwijzende functie hebben naar de entiteiten in de wereld (of in het model), is het belangrijk om de combinatorische interpretatie in samenhang met de verwijzende (referentiële) interpretatie te onderzoeken (see, e.g., Barsalou et al., 1993).

Curriculum Vitae

Irena Drašković werd geboren in Zadar (Kroatië) op 23 maart 1961. Ze behaalde in 1979 haar VWO-diploma aan het Gymnasium J. Baraković in Zadar. In 1987 studeerde zij af in de Psychology (BA) aan de Universiteit van Zagreb en in 1989 behaalde ze haar doctoraal Psychology aan de Universiteit van Nijmegen. Na twee jaar als AiO werkzaam te zijn geweest aan de Universiteit van Tilburg, startte ze in 1992 met het AiO project ”Semantic interpretation of adjective-noun combinations” gesteund door NWO en de Universiteit van Nijmegen. In die tijd was ze twee keer uitgenodigd door prof. dr. J. Pustejovsky als ’visiting researcher’ bij de Computer Science Department, Brandeis University, Boston. Van januari 2001 tot maart 2003 werkte ze als onderzoeker bij de afdeling Onderwijsontwikkeling en Onderzoek aan het UMC St. Radboud in Nijmegen.