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Wearing frog hats and attempting walls: The processing of conceptual combination and coercion

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Declaration

This thesis has been composed by myself, and the research presented herein is my own. No portion of the work has been submitted for any other degree or professional qualification.

Claudine Nina Raffray Edinburgh, January 17th, 2007

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Abstract

This thesis is concerned with the mental representation and online processing of conceptual structure. In particular, it investigates two issues: First, it explores some of the processing mechanisms underlying the comprehension of conceptual combinations. Second, it explores some of the processing mechanisms underlying the production of coerced expressions. These two issues are investigated experimentally using a priming paradigm.

Noun-noun combinations like *dog scarf* are common in everyday discourse but often have more than one interpretation. How do language users arrive at an interpretation of the relationship between the two nouns? The first half of the thesis reports four expression-picture matching experiments that used priming to investigate the influence of modifier and head constituents on the comprehension of novel ambiguous noun-noun combinations. Experiment 1 examined the effects of lexical repetition and semantic relation. Results showed reliable relation priming, regardless of whether the modifier or head was repeated between prime and target: Participants tended to choose target pictures involving the same relation as a preceding prime picture. Experiment 2 demonstrated significant relation priming when neither constituent was repeated. Experiment 3 showed significant relation priming when each picture contained both possible semantic relations, arguing against a possible visual-priming account of the effect. Experiment 4 showed that relation priming did not have an effect on the time taken to comprehend a combination. The findings are interpreted in light of competing models of conceptual combination.

The second half of the thesis reports four experiments designed to investigate the effects of priming on the production of complement coercions like *The author began the book*. Recent work in lexical semantics has demonstrated that verbs such as *begin* and *enjoy* semantically select for event complements. Where such verbs occur with entity-denoting nouns (e.g., *begin the book*, *enjoy the wine*), the NP complement undergoes semantic type coercion, inducing a reference shift to the event associated with that NP. Using a combined picture-description/sentence completion task, participants were presented with pictures followed by sentence fragments which they were instructed to complete. Experiment 5 showed a reliable effect of Prime: Participants tended to produce a target description involving the same level of semantic specification as the preceding prime.

Experiment 6 did not show fully significant priming in the absence of (coercing) verb overlap between prime and target. Experiment 7 revealed evidence of semantic and syntactic components to the priming effect. Experiment 8 showed no evidence for differing global and local contextual influences on priming. Taken together, the results of Experiments 5–8 are interpreted in terms of a model of language production based on Levelt, Roelofs, and Meyer (1999). Overall, this study offers insight into the representation and processing of conceptual structure in comprehension and production from a psycholinguistic perspective.

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Chapter 1

Introduction

1.1 Overview

This thesis adopts an experimental approach to a number of issues concerning the mental representation and online processing of abstract conceptual structure. Under this umbrella theme, the research questions addressed across the eight experiments reported here are in respect of two disparate linguistic phenomena, studied from opposite language processing perspectives. The first series of experiments investigates conceptual combination, explored in the context of comprehension. The second series of experiments investigates the mapping mechanisms underlying semantic type coercion, examined in the context of production. Both sets of experiments use procedures centred around priming, the phenomenon long exploited in psycholinguistic research whereby prior exposure to a stimulus with a particular characteristic affects processing of a subsequent stimulus with the same (or a related) characteristic (e.g., Meyer & Schvaneveldt, 1971).

It is well documented that language use is highly creative, and that interpreting relations between constituent parts is a core element of language comprehension. Conceptual combination provides rich evidence for both of these claims. As speakers, we are continually combining individual concepts to create new referring expressions in the form of conceptual combinations such as *castle tourist*; similarly, as listeners we routinely interpret combinations we have never before encountered. Some combinations make their way into everyday language (e.g., *computer chip*, *bird flu*), while others remain relatively temporary, only surviving for the purposes of the current discourse. (Imagine an Edinburgh resident commenting on the city's increasing numbers of *castle tourists*.) As listeners we are able to interpret such novel noun-noun combinations with ease, yet the individual concepts can, of course, be related in myriad ways. Because there is no signal to meaning in the way of overt syntactic relations between the two nouns (cf. *castle tourists* vs. *angry tourists*, an adjective-noun phrase), the meanings of combinations are potentially highly flexible. So how do we combine concepts and understand novel combinations such as *castle tourist*? What determines the relation that links the two noun concepts? More specifically, does the linking relation depend on one or other of the individual concepts (*castle* and *tourist*) or on neither? The focus of the first half of the empirical work of this thesis is the way in which prior experiences may influence how people interpret such novel ambiguous noun-noun combinations.

A second topic investigated in this thesis concerns aspects of the workings of the meaning-to-form mapping process in production. Turning thoughts into language requires converting communicative intentions into semantically, syntactically, and phonologically well-formed utterances. There is a large body of work on the comprehension of coerced expressions such as *began the book* but researchers have paid much less attention to the workings of semantic type coercion in production. Extensive evidence suggests that interpreting such expressions requires the generation of abstract event structure to recover the predicate *reading* (or *writing* or *editing*, etc.) that is missing between *began* and *the book*. Consistent with linguistic accounts of semantic type coercion (Pustejovsky, 1991, 1995; Jackendoff, 1997), these findings are couched in terms of processing costs caused by the type-mismatch between event-taking verbs (e.g., *began*) and entity-denoting nouns (e.g., *book*). But do the same abstract representations operate in language production? More specifically, how do speakers encode the missing event structure associated with complement coercions? The second series of experiments reported here addresses these questions.

Overall, this thesis has two main goals. First, it aims to establish what the evidence of relation priming offers the debate between proponents of competing theoretical models of conceptual combination. Second, it aims to explore the conceptual representations and meaning-to-form mapping procedures underlying the production of coerced expressions by looking for evidence of the priming of abstract event structure.

1.2 Organization of the thesis

The thesis is organised into five parts. Chapter 2 provides an introduction to the background theoretical and empirical literature. This begins with overviews of the two general processing perspectives of comprehension and production. I outline the standard theoretical and methodological approaches, focusing on aspects concerning the levels of representation and processing relevant to the current studies. The second half of the chapter concerns the fields of conceptual combination and semantic type coercion. For each, I outline the dominant theoretical accounts as well as some of the empirical evidence that supports the respective approaches.

Chapter 3 reports three experiments designed to investigate the influence of modifier and head constituents on the comprehension of novel ambiguous noun-noun combinations. This set of experiments used relation priming to evaluate the proposals put forward by recent theoretical accounts of conceptual combination, which make different predictions with respect to the influences of lexical repetition and semantic relation. Chapter 4 presents the results of a follow-up experiment, designed to examine the time course of relation priming using the same experimental procedure as that used in the first three experiments.

Chapters 5 and 6 turn to the topic of semantic type coercion, investigated in the context of production. Chapter 5 reports three experiments designed to investigate whether speakers employ mechanisms of enriched semantic composition in producing complement coercions such as *The author began the book*. Prime manipulations explore the effect of lexical repetition, as well as tease apart syntactic and semantic components to priming. Chapter 6 reports a follow-up experiment designed to explore the effects of contextual influences on priming of complement coercion in production.

Chapter 7 summarizes the main findings of the thesis, and discusses possible directions for future research in the respective areas explored here. First, the findings of relation priming are summarized and their implications for theoretical accounts of

conceptual combination discussed. Second, I recap the evidence of priming of event structure and consider questions for future experiments. Each of the two research areas offers clear avenues for follow-up studies. On the one hand, the field of conceptual combination is riddled with unresolved research questions and characterized by lively ongoing debate in the literature. On the other, coercion in production is largely understudied; as with anything new, there is uncharted territory to explore.

Chapter 2

Literature Review

2.1 Overview

This chapter presents a synthesis of the background theoretical and empirical literature relevant to the experiments reported in the thesis. I outline the psycholinguistic research domains of language comprehension and production, and review important work in two disparate areas involving semantic and conceptual processing: conceptual combination and semantic type coercion. The linguistic phenomena associated with conceptual combination and coercion are relatively well described; however, the perspectives on these problems originate from diverse fields, spanning formal linguistics, psycholinguistics and computer science. The principal aim in this review, then, will be to distil the key theories and supporting evidence from a heterogeneous body of relevant published work, thereby contextualising the experimental hypotheses underlying the current research.

The chapter is organized into four parts. In Section 2.2, I introduce the framework of language comprehension and provide some background to established assumptions concerning levels of processing, classic and newer methodologies used, and some key findings concerning semantic processing. Section 2.3 covers language production. Again, I present a bird's eye view of the field, including a sketch of the

architecture of the production system and a brief account of ongoing debates, with particular reference to conceptual influences on formulation processes. The next two sections relate to the topics of investigation of the thesis. Section 2.4 introduces the literature regarding conceptual combination. I outline two influential theoretical approaches to the phenomenon, and discuss the important empirical findings related to each. Finally, Section 2.5 is concerned with semantic type coercion. I review theoretical proposals from the field of linguistics, followed by behavioural findings from recent psycholinguistic studies.

2.2 Psycholinguistic approaches to language comprehension

Understanding a sentence entails several different processes. Guided by knowledge of the grammar of the language, a listener or reader needs to first identify the individual words, then determine how they are connected in larger units or phrases, in order to arrive at an interpretation of these phrases and their relations. Comprehension, then, is a staged process that relies on the fact that language is *compositional*; the meaning of a sentence is essentially a function of the meaning of its constituent parts (Frege, 1985). In technical terms, generation of abstract word representations are projected into phrasal representations to derive sentence meaning, which is in turn mapped onto situation models at the level of text or discourse. The latter stage forms the highest level of processing, involving pragmatic interpretation via mechanisms of reasoning and inference. Comprehension has been extensively studied over the past three decades, with research traditionally focusing on one of the three recognised processing domains: word recognition, sentence understanding, and discourse interpretation.

One well documented property of language has formed an integral part of psycholinguists' attempts to account for the rapid and effortless nature of language comprehension: Natural language is highly ambiguous, with instances of ambiguity at all levels occurring almost unremittingly in everyday discourse. In spoken language comprehension, for example, lexical ambiguity arises from a range of sources. Lexical items with different meanings may have identical phonological codes (e.g., *flour-flower*) or the same lexical item may have different senses (e.g., *straw*) or even related senses, as in the case of *newspaper*, which can refer to a publication or an organization. Ambiguity operates just as frequently at sentence level, resulting in more than one possible parse structure. A common example of this is prepositional phrase attachment ambiguity,

which has been exploited in a number of comprehension studies (e.g., Altmann & Steedman, 1988; Boland & Bohem-Jernigan, 1998; Branigan, Pickering, & McLean, 2005; Spivey-Knowlton & Sedivy, 1995) that seek to highlight listeners' strategies when faced with a choice of possible analyses. The challenge for a psycholinguistic model of comprehension is to explain how ambiguity is handled so efficiently by the processor.

A wide range of experimental techniques has been used to study comprehension (see Rayner & Clifton, 2002 for a comprehensive review). Most of these have typically focused on difficulties in processing, such as those associated with the two phenomena mentioned above. Reaction time (RT), i.e., the time between the presentation of a stimulus and the onset of a participant's response, has been an extremely common means of tapping into the time-course of a process and measuring difficulty. Straightforward RT experiments are often used when the stimulus is a single word. For larger chunks of language, methodologies such as self-paced reading and eye-tracking have been used. In self-paced reading experiments, the size of each piece of text presented to the participant (e.g., word or group of words) is most commonly controlled by a metaphorical moving window: The participant presses a button, causing each new segment to appear. Arguably allowing for a more naturalistic task, eye-tracking involves recording the patterns of participants' eye movements as they read (at their normal reading rate). Variables typically of interest in this paradigm are fixation time on a word, the distance between different fixation points, and the frequency of regressions to re-read text. This gives eye-tracking the advantage of being more sensitive than self-paced reading, since the experimenter is able to identify activities of reanalysis. Rayner and Sereno (1994) review a range of methodological issues associated with eye-tracking, noting its limitations with respect to elucidating the cognitive processes underlying comprehension and the consequent need to garner converging evidence from a range of sources and experimental procedures.

Recent years have seen the emergence of new techniques that connect psychological and neurobiological approaches to the study of language comprehension. Event-related potentials (ERPs) have been able to provide considerable detail about types of processing difficulties (Kutas & van Petten, 1994), as well as the time-course of activities. This methodology involves recording the brain's electrical activity through electrodes on the scalp. Distinct waveform deflections have been observed following different kinds of linguistic stimuli; e.g., a negative potential occurs approximately 400 ms after the presentation of a semantic anomaly. Similarly, a positive potential 500–800 ms after the onset of a stimulus correlates with syntactic anomaly. Positron emission

tomography (PET) and functional magnetic resonance imaging (fMRI) scans are two further physiological measures (see Rayner & Clifton, 2002 for a brief overview). These offer poor temporal granularity, but have the benefit of insight about the location of specific processing activities in the brain.

2.2.1 Levels of processing

Most psycholinguistic theories of language comprehension converge on a distinction between lexical, syntactic, and semantic processing, while differing on the degree to which such processes are independent and modular (e.g., Fodor, 1983; Frazier & Rayner, 1982; Frazier, 1987; Ferreira & Clifton, 1986) or interactive (e.g., Marslen-Wilson & Tyler, 1987; MacDonald, Pearlmutter, & Seidenberg, 1994; Tanenhaus & Trueswell, 1995). The first stage in comprehension is at the level of the individual word, with lexical processing. This involves encoding a mental representation of an individual word in the input, and looking up its meaning in the mental lexicon. The next stage, sentence-level processing, centres on syntactic parsing. It is at this level that the modularity-interactivity debate surfaces, with contrasting accounts of the lexical and semantic influences on parsing decisions (see Pickering, 1999 for a survey of these arguments). Another important issue debated in the literature has been whether processing occurs serially or in parallel. *Garden-path* accounts of sentence processing (e.g., Frazier, 1979; Ferreira & Clifton, 1986) are compatible with the former view, while *constraint satisfaction* models (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Kello, 1993; Trueswell, Tanenhaus, & Garnsey, 1994) support the latter. But despite differences on *how* processing takes place, there is broad agreement that the output of sentence-level processing is a hierarchically structured syntactic plan. Semantic processing determines the propositional content of the sentence, by establishing the conceptual and thematic relations connecting words and phrases within the sentence. This leads to discourse-level processing, which links the sentence with the extended linguistic context via a range of pragmatic inferencing mechanisms, including conversational implicatures and speech acts, and speaker-meaning (Grice, 1957, 1968; Clark & Gerrig, 1983; Clark, 1979).

2.2.2 The mental lexicon and lexical processing

It has traditionally been assumed that the meanings of words are represented in a person's lexicon, or mental dictionary, and that all lexically specific information is captured in each lexical item's stored entry (but see Elman, 2004 for a very different,

dynamic view of lexical representation). What precisely constitutes lexically specific information has been a matter of some debate (e.g., Jackendoff, 2002). It is typically understood to include the word's phonological features, orthographic representation, and morphological structure, along with grammatical and combinatory information (i.e., information about how that word combines with other words in phrases and sentences). Apart from the word's meaning(s), its syntactic category, number, gender, and argument structure are encoded. For example, the information captured for the word *give* would include the fact that it is a verb, which projects three arguments, which are in turn filled by the thematic roles of AGENT, PATIENT, and GOAL (though the terminology varies somewhat across the literature).

Diverse strands of research on natural language have come to focus on the importance of the lexicon in the generation of linguistic structures. The last two decades have seen a converging emphasis on lexical representations – from theoretical linguistics (e.g., Chomsky, 1995; Grimshaw, 1990; Jackendoff, 1997; Pollard & Sag, 1994), computational linguistics (e.g., Anick & Pustejovsky, 1990; Briscoe, Copestake, & Boguraev, 1990; Jurafsky, 1996), and psycholinguistics (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Tanenhaus & Trueswell, 1995; Trueswell, 1996; Trueswell & Tanenhaus, 1994). Within psycholinguistics, increasingly, lexical information has played an important role in accounts of the workings of the comprehension system (MacDonald et al., 1994). Lexical processing research is broadly divided into three areas of interest: word recognition, lexical access, and (contextually influenced) lexical interpretation. Word recognition refers to the process of identification of a word from the speech signal in the case of listening, or the visual input in the case of reading. Lexical access refers to retrieval of the semantic information associated with a word. Finally, lexical interpretation concerns contextual aspects of meaning, which are made available through reference relations such as anaphora.

Just as different kinds of linguistic information are captured in lexical representations, so different kinds of linguistic information are associated with lexical processing. Importantly, however, it is the *semantics* of lexical representation and processing that are most relevant for the purposes of this thesis. Much of the psycholinguistic research on lexical semantic processing has centred on the identification of isolated individual words, devoid of the linguistic context in which they would ordinarily appear to the listener or speaker. But a proper account of lexical semantic access during speech and reading must accommodate the fact that words are seldom

encountered as individual units. The contextual influences of the larger discourse or text will necessarily play an important role in lexical processing, most notably in lexical interpretation. To this end, a key testing ground for theoretical issues such as modularity versus interactivity has been in the area of lexical ambiguity resolution.

Extensive research has been carried out on contextual influences on lexical ambiguity resolution (see Simpson, 1994 for a thorough review). Historically, there has been a concentration of priming studies; in this paradigm, participants hear (or read) a sentence containing an ambiguous word and then perform a lexical decision task on presentation of a target word. The target is typically related to one of the ambiguous word's meanings (which could be one of two balanced meanings, or one of a pair of dominant and subdominant meanings respectively), or is unrelated to the ambiguous word's meaning. Response times reflect degrees of activation of the respective meanings. In arguably the most influential of this type of study, Swinney (1979) investigated the effects of sentential context on the interpretation of ambiguous words like *bug*. In a cross-modal paradigm, participants listened to sentences containing an ambiguous word (e.g., *For several weeks after the exterminator's visit they did not find a single bug in the apartment*) and simultaneously performed a lexical decision task. Target words were related to the contextually biased meaning of the ambiguous word (e.g., *insect*), related to another possible meaning of the word (e.g., *spy*), or unrelated to the critical word (e.g., *sew*). When participants saw the target word immediately after hearing the ambiguous word, response times were faster for both related targets (i.e., *insect* and *spy*) than for unrelated targets (*sew*). But when presentation of the target occurred four syllables after the critical word, response times for *insect* were faster than for both *spy* and *sew*. On the basis of these findings, Swinney argued for a *multiple access* model that supports modularity in processing: Alternative meanings of an ambiguous word are accessed in the first instance during processing, i.e., in parallel. Only after the initial stage of processing does contextual information come into play, at which point the appropriate meaning is selected and the alternatives inhibited.

Onifer and Swinney (1981) replicated the results of Swinney (1979) for biased ambiguities (e.g., *pool*, with the dominant meaning associated with *water*, and subdominant meaning associated with *billiards*), but other studies have suggested that only balanced ambiguities facilitate multiple access (Tabossi, 1988; Tabossi, Colombo, & Job, 1987). For example, Tabossi (1988) tested biased ambiguities using a cross-modal procedure in Italian. Participants performed a lexical decision task on presentation of a biased

ambiguous word (e.g., *port* in *The violent hurricane did not damage the ships which were in the port, one of the best equipped along the coast*). Targets were either dominant and contextually congruent (e.g., *sea*), subordinate and contextually incongruent (e.g., *liqueur*), or unrelated controls (e.g., *hand*). Results showed faster response times for *sea* than for both *liqueur* and *hand*, which did not differ from each other. Thus, a biasing context had an immediate effect on ambiguity resolution.

The *ordered access* model (Hogaboam & Perfetti, 1975) is similar to the multiple access model, in that it too is context-independent. However, on this account, meanings are accessed according to their relative frequencies, with the most common meaning of an ambiguous word accessed first, regardless of the context. Finally, a set of studies carried out by Rayner and colleagues using eye-tracking lead to the proposal of the *reordered access* model (Dopkins, Morris, & Rayner, 1992; Duffy, Morris, & Rayner, 1988; Pacht & Rayner, 1993; Rayner, Pacht, & Duffy, 1994). Measuring processing difficulty by gaze duration on the ambiguous word, Duffy et al. (1988) showed evidence that a disambiguating context following a balanced ambiguous word (e.g., *pitcher*) causes more difficulty than following both unbalanced ambiguous words (e.g. *port*) and following unambiguous controls (e.g., *whiskey*). In other words, unbalanced ambiguous words function like unambiguous words in sentences where the disambiguating context follows the ambiguity (e.g., *Last night the port was a great success when she finally served it to her guests*). But a *preceding* disambiguating context yielded the opposite pattern of results. In this case, given a subordinate-biasing context, fixation times were longer on the unbalanced ambiguous words (*port*) than on the balanced ambiguous words (*pitcher*). Rayner and colleagues presented this as evidence for the reordered access model (Pacht & Rayner, 1993; Rayner et al. 1994). Taken together, the above group of studies shows that the interpretation of ambiguous words involves a complex interplay between the relative meaning frequencies of the critical words and the surrounding sentential context.

Thus far we have used the term 'lexical ambiguity' to refer to meaning resolution, but of course words can also be ambiguous in as far as they have multiple *senses*. Recall the example of *newspaper* above, which can refer to the institution or the physical publication. In contrast with the extensive literature on meaning ambiguities, there has been much less work on the interpretation of words with more than one sense. Some studies have considered the processing of sense ambiguities in isolation (Klein & Murphy, 2001, 2002; Rodd, Gaskell, & Marslen-Wilson, 2002), while others have embedded the ambiguous words in a sentential context (Frazier & Rayner, 1990; Frisson

& Pickering, 1999). Frazier and Rayner (1990) used eye-tracking to investigate contextual influences on the processing of sense versus meaning ambiguities. They found that people processed words with more than one sense (e.g., *novel*) in the same way that they processed unambiguous words (e.g., *door*), compared to words with more than one meaning (e.g., *ball*). Finally, Frisson and Pickering (1999) considered sense ambiguity from the point of view of metonymy and found that people experienced no difficulty comprehending common place-for-event metonymies such as *Vietnam*, compared with interpreting the literal readings of the expressions. I shall return to the topic of lexical semantics and the flexibility of word meaning in the section on semantic type coercion.

In this section I have presented a general overview of the field of language comprehension, including linguistic phenomena typically addressed in the literature, key theoretical assumptions about the system architecture, and common methodologies used in experimental research. I mentioned influential models proposed for each of the processing domains, before focusing more closely on issues and theories relating to lexical representation and access. In the following section I turn to the flip side of language processing research, language production. Again, the aim is to give a broad outline, in order to set the scene for the topics of investigation covered in this thesis.

2.3 Psycholinguistic theories of language production

As discussed in the previous section, listeners and readers must first match linguistic input with individual word entries in the mental lexicon, from which point they generate various levels of abstract representation to determine meaning. In language production, these steps occur in reverse; speakers map from meaning to form. The starting point for the speaker is a nonverbal communicative intention, or message, and the end point is articulation of an utterance. The processes in between involve encoding the propositional content of the message by selecting the building blocks, namely the words, and combining them in a structure that accurately conveys the speaker-intended meaning (cf. *John despises Mary* versus *Mary despises John*). This process is informed by word order constraints as well as requirements of thematic structure. Once the message has been encoded into a syntactic structure, with full inflectional information (case, number/gender agreement, etc.), it undergoes phonological encoding. Finally, the speaker triggers the appropriate motor movements to produce the spoken utterance.

Bock and Huitema (1999, p. 365) summarize the domain of enquiry of language production as follows:

> The chief issues in language production centre on information processing, and include how and when the processing system retrieves different kinds of linguistic knowledge, how the system uses the knowledge once it has been retrieved, how the system interrelates linguistic and non-linguistic knowledge, and how the system is organized within and constrained by human cognitive capacities.

Within this framework, the major focus has been the formulation stage that intervenes between the message and the utterance, with empirical investigations addressing lexical selection, phrasal construction, and phonological encoding. Much of this research has used failures or difficulties in production as a point of departure. For example, speech errors (e.g., Fromkin, 1973) have proved invaluable data and evidence of different processing stages (e.g., Garrett, 1975, 1980), and have lead to the proposal of several models of production (e.g., Bock & Levelt, 1994; Dell, 1986; Garrett, 1980, 1988; Levelt, 1989).

This thesis is most concerned with *semantic* aspects of the thought-to-language mapping process, and the mechanisms underlying a speaker's choice of semantic structure. In particular, it is concerned with the implications that these factors have for the representation of semantic information. The next section introduces recent influential models of language production, describing the general architecture of the production system and focusing on the details relevant to the mapping of semantics onto syntax which have particular importance for the thesis. I shall begin by giving a very brief overview of the production system as a whole, before focusing on the parts of the system which are concerned with semantic processing.

2.3.1 The standard model of language production

Notwithstanding ongoing debate over the finer details of the processes underlying the path from message to utterance (e.g., Levelt, Roelofs, & Meyer, 1999; Dell, 1986), there is broad consensus among psycholinguists on the basic architecture of the language production system. The dominant models, based on proposals by Garrett (1980, 1982, 1988) and developed by others (e.g., Levelt, 1989; Bock & Levelt, 1994; Bock, 1995; Dell, 1986), all distinguish three processing components, reflecting the successive stages involved in planning and producing an utterance. Levelt (1989) presents an extensive

review of the literature on the components of this framework, depicted schematically in Figure 2-1 (reproduced from Bock & Levelt, 1994).

Figure 2-1: The organization of language production processing (from Bock & Levelt, 1994)

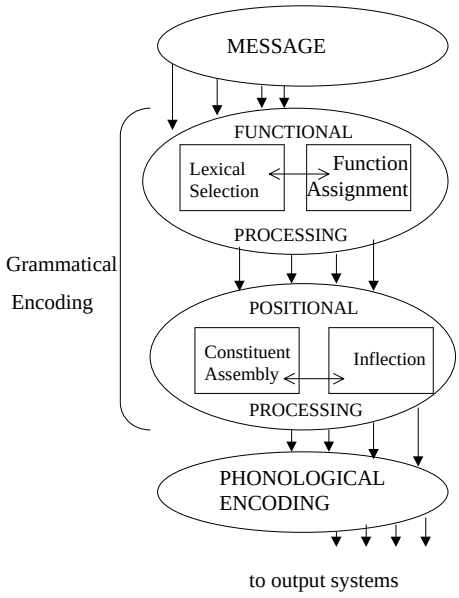


Figure 2-1 shows three distinct processing components: the message component, the grammatical component, and the phonological component, each one connected by vertical lines representing the flow of information through the system. The message component is responsible for conceptualization. At this stage a preverbal message is generated, representing the content of the speaker's intended communication. This message is fed to the grammatical component, which is responsible for building a surface structure. The grammatical component is standardly divided into functional processing and positional processing (Bock & Levelt, 1994; Garrett, 1980, 1988; Kempen & Hoenkamp, 1987; Levelt, 1989). Functional processing involves the access and selection of appropriate lexical entries from the mental lexicon to encode the pre-verbal message. Referred to as *lemmas* in the production literature (a term first used by Kempen & Huijbers, 1983), these are analogous to syntactically specified dictionary entries that list available words and capture their abstract grammatical properties (e.g., class and gender). The next step involves the assignment of grammatical functions. Message elements are assigned syntactic roles, e.g., subject, direct object, indirect object, and so on, and their grammatical features are checked against these roles, e.g., the lemma assigned as the head

of a subject phrase must be a noun. The output of this stage is a functional representation of the speaker's message, which is fed forward for positional processing.

Positional processing also consists of both lexical and structural mechanisms. Lexical retrieval involves activating the lexical and grammatical morphemes associated with the selected lemmas. These phonologically specified word forms are referred to in the production literature as *word forms* (Levelt et al., 1999). The structural element of positional processing involves assembling a hierarchically ordered syntactic structure from these word and morpheme representations, in a manner consistent with the word order constraints of the language. The output, then, is a syntactic plan specifying the final linear order of phrasal constituents and inflectional morphemes. Finally, the phonological component is responsible for generating a phonological representation of the utterance, including spelling out the individual sound forms, as well as capturing information about the prosodic features of the utterance, e.g., features relating to word length, rhythm, and intonation. The resulting fully specified linguistic representation is taken up by the output systems for articulation.

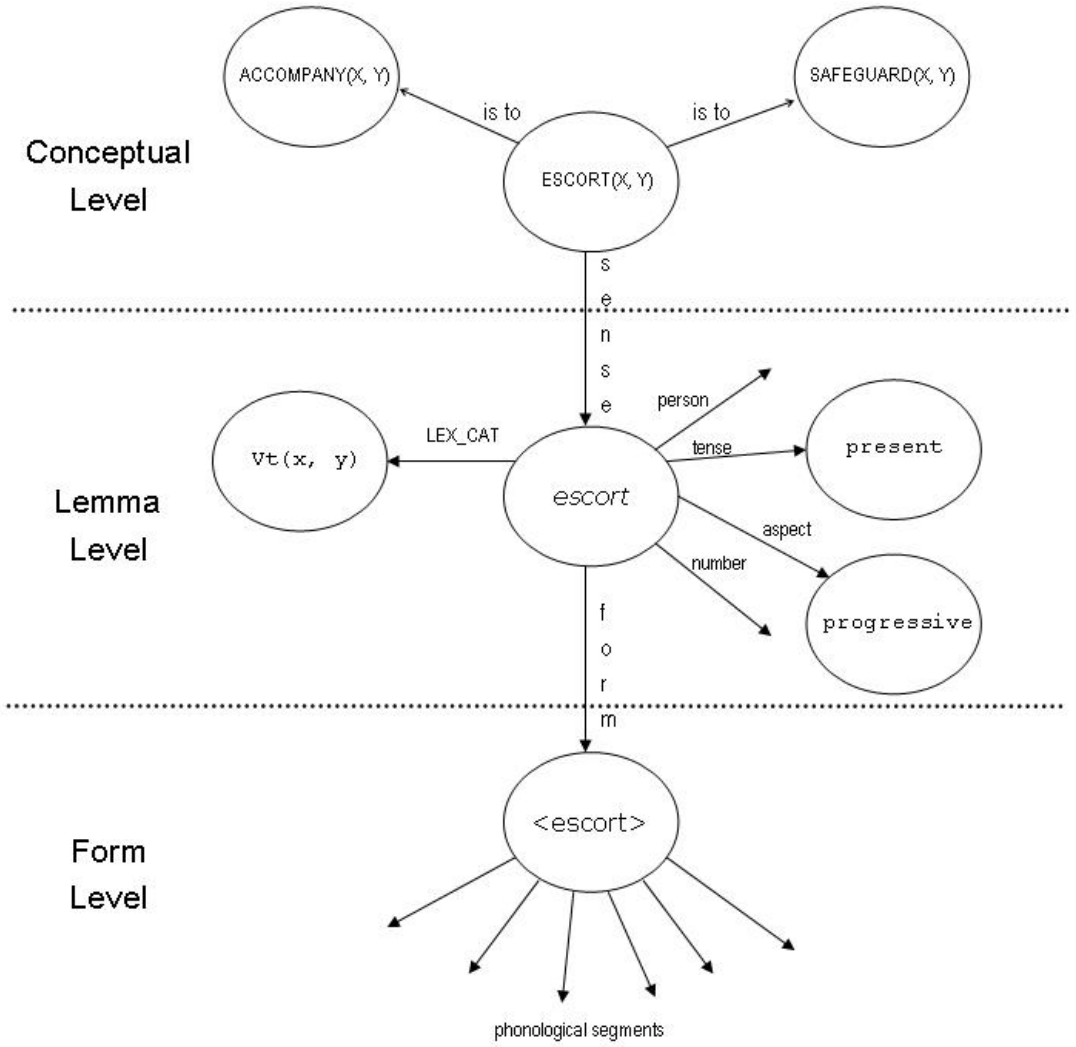
The processes underlying formulation are lexically driven in the sense that lexical entries mediate between the processes of grammatical and phonological encoding, after their activation has been triggered by concepts in the preverbal message (Levelt, 1989). The central role of the mental lexicon in language production is captured in the network model of lexical access (also known as the lemma model) as developed by Roelofs (1992, 1993; Bock & Levelt, 1994; Levelt et al., 1999). The next section describes this model. I first describe the structure of lexical entries and the relations between them, before moving on to how processing proceeds under this account.

The network model of lexical access

Figure 2-2 schematically depicts the lexical network, as conceived by Bock and Levelt (1994; Levelt et al., 1999). The model is made up of three levels of representation, reflecting the types of information that are stored as part of lexical knowledge. The levels of representation (conceptual, lemma, and form) contain nodes that capture information about a word, e.g., *escort*, as shown in the figure. The conceptual level contains nodes that capture information about the meaning of *escort*. Thus the lexical concept node ESCORT(X, Y) is linked to the conceptual nodes for semantically related lexical items, in this case, ACCOMPANY(X, Y) and SAFEGUARD(X, Y). Importantly, these conceptual nodes are not specified for grammatical or word-form information. The nodes are linked

by connectors representing the nature of relationships. (Note that arrows represent the type of relationship, rather than the flow of activation.) The fact that *accompany* and *safeguard* are synonyms of *escort* is captured by the is to connectors. Thus, the meaning of a word is captured in a network of relations, with lexical concepts represented within this network by discrete nodes.

Figure 2-2: Simplified representation of the lexical network (from Levelt et al., 1999)



The second level of representation is the lemma level; this corresponds to the process of grammatical encoding in the standard model of production described above (see Figure 2-1). Lemmas are abstract grammatical representations that encode properties such as word class, gender, number, tense, and aspect, as well as combinatorial

information. For example, the lemma *escort* in the figure has a category link to a transitive verb node (Vt), and takes two arguments, x and y. Importantly, lemma nodes are not specified for word-form properties. Furthermore, in the version proposed by Levelt et al., lemmas are not specified for semantic properties, but others have argued for their organization into semantic fields (Zorzi & Vigliocco, 1999). The third level of representation is the form level, where word-form nodes (also referred to as lexemes) encode information about a word's phonological and morphological properties. This information is retrieved during phonological encoding.

According to Levelt and colleagues (Bock & Levelt, 1994; Levelt et al., 1999), lexical selection proceeds by activation passing from the conceptual level via the lemma level to the word-form level as follows: A concept is activated at the message level, and activation spreads to semantically related concepts. Thus, activation of the lexical concept ESCORT(X, Y) leads to (some) activation of ACCOMPANY(X, Y) and SAFEGUARD(X, Y). In addition, activation spreads from the concept ESCORT(X, Y) to the associated lemma *escort*, where lexical selection takes place. Because the associated concepts ACCOMPANY(X, Y) and SAFEGUARD(X, Y) also receive some degree of activation, this will in turn cause some degree of activation of their associated lemmas (although the lemmas associated with these concepts are not shown in the figure). Since ESCORT(X, Y) is the concept with the highest activation relative to the total activation of all the lemmas in the set (Roelofs, 1992), the lemma *escort* should be selected, with its associated syntactic properties (e.g., lexical category, person, number, tense, and aspect) becoming available for function assignment.

Pickering and Branigan (1998) developed the model further by incorporating *combinatorial* information into the lemma-level representations. On their account, information about how lexical items combine with other lexical items to form phrasal structures is encoded in combinatorial nodes. For example, the lemma node for a verb such as *punch* is connected to nodes that capture the fact that it can occur in active and passive structures respectively. Each structural configuration is represented by a distinct combinatorial node linked to the verb, and each combinatorial node is linked to every verb that can project that structure. When *punch* is used in the passive (e.g., *The referee was punched*) the lemma *punch* and the passive node are activated, and their coactivation leads to a strengthening of the connection between them. This pattern of activation is the source of syntactic priming effects in production (Bock, 1986): Since activation does not decay immediately, the speaker will be more likely to reuse the same passive structure

than the alternative active structure. Cleland and Pickering (2003) applied the same model to nouns.

2.3.2 Discrete-stage versus interactive models

There is some variation in the way in which different production models view the implementation of the processes operating in the above framework, particularly those connecting phonological encoding with the higher level processes of lexical selection and retrieval. An important issue under debate is the nature of information flow, captured in the contrasting views of production as a modular, feedforward process (Levelt, 1989; Levelt et al., 1999) versus one which entails some degree of accessibility and interactivity between levels of representation (Dell, 1986).

Levelt's discrete-stage model is strictly modular (in the sense of Fodor, 1983), with each component informationally encapsulated such that the information undergoing processing within an individual component cannot be affected by information outside that component. This implies that each step in processing is completed before information passes to the next, and that there is no feedback between levels, e.g., from the form level to the lemma level. Information flows in one direction only, from the message component through grammatical and phonological encoding to articulation. Furthermore, mapping from a message takes place in two non-overlapping stages: The first involves retrieving the lemma, the second retrieving the associated word-form; operations which take place within the grammatical and phonological components respectively.

In contrast, Dell's (1986) interactive account argues that information from lower levels can affect higher levels of processing, thereby influencing the top-down flow. Under this view, lexical access is still fundamentally a two-step process, involving lemmas and word-forms, but the two are not discrete semantic and phonological stages. Rather, the lemma level has access to lower-level phonological information via feedback, and the word-form level has access to higher-level semantic information via cascading activation. This implies that in the case of the lexical access of *escort*, the phonological features of semantically related lexical items (e.g., *accompany*) will also be activated. Similarly, activation from the word-form <escort> can be fed back up to affect the lemma *escape*, with which it shares phonological features.

In summary, Dell's (1986) interactive model of language production shares basic organizational assumptions with the model proposed by Levelt and colleagues, but

differs on issues of information flow. The interactive account allows cascading spreading activation, as well as feedback of activation from lower to higher levels of processing.

2.3.3 Empirical investigations

There are fundamental issues that connect and intersect research in production and comprehension; indeed, explaining the one depends to some degree on explaining the other since speakers are also listeners, and vice versa. However, empirical approaches to the two processing domains differ in considerable measure. In an in-depth review of methodological issues concerning research into language production, Bock's (1991) starting point is to identify the major problem distinguishing production from comprehension. The difference, she claims, is 'getting the form right' (p. 142). That is, speakers' main activity in producing utterances is building linguistic structures (whereas listeners need to generate interpretations). This difference in processing perspectives translates to important differences in approaches to empirical study. Research in production proceeds from the assumption that the speaker starts with a nonverbal message and then proceeds to build linguistic structures at a sequence of different levels. In understanding the representations and processes that drive 'getting the form right', a well-known empirical goal for researchers in production is to control the *content* of the message, and in this way systematically isolate developments in the evolving *form* of the message. This opens the way to illuminating details about the flow of information and the interfaces between different processing components.

Until recently, however, most research on production has centred on the analysis of speech errors and other production failures in spontaneous speech, with a paucity of experimental studies (compared to comprehension) as a result of the above-mentioned problem of controlling the message content. Data from imperfect speech, including that involving speech errors (Fromkin, 1973; Garrett, 1975); tip-of-the-tongue phenomena (e.g., Vigliocco, Antonini, & Garrett, 1997); hesitations, filled pauses, and other disfluencies (e.g., Butterworth, 1980; Garrett, 1982) and the language of brain-impaired speakers (e.g., Caramazza & Hillis, 1991; Kay & Ellis, 1987), have been used to identify failed production processes, and from there infer details about how these normally function. But it has been argued that experimental findings allow for a more unbiased and accurate understanding (Bock & Huitema, 1999). Laboratory methods offer several advantages over pure observation, most notably that they permit investigation of normal speech and (thanks to the development of innovative tasks and paradigms) allow for

manipulation of precise variables of interest. Bock (1996) presents a comprehensive review of observational and experimental techniques for eliciting production data, involving both normal and flawed speech. In the following section, I turn to a series of important empirical findings relating to the grammatical component in production. As 'the heart of language production' (Bock, 1995, p. 184), and the locus of the meaning-to-form mapping mechanisms, it is of particular relevance to the second series of experiments reported in this thesis.

Isolating the meaning-to-form mapping mechanisms

A large body of work has been dedicated to establishing what determines the surface forms of utterances. On the one hand, there is substantial evidence for the independence of syntactic structure-building, on the basis that speakers regularly repeat sentence structure (in everyday discourse), and, moreover, can be reliably primed to do so (in controlled experiments). On the other hand, the mapping from message to syntactic structure has been shown to be determined to some extent by lexical and conceptual factors, e.g., animacy and concreteness of nouns, or the argument structure of verbs. An early account of speakers' tendency to repeat structure was reported in Levelt and Kelter (1982) for natural speech. In two question-answer setups carried out in Dutch, one laboratory-based and the other over the telephone, participants responded to questions that had either a prepositional or non-prepositional form (e.g., the Dutch equivalent of *At what time does your shop close?* vs. *What time does your shop close?*). Speakers' responses were more likely to take the prepositional form (e.g., *At five o'clock*) following a question that took the prepositional form, compared with the alternative structure.

In a widely cited and seminal paper, Bock (1986) provided the first experimental evidence of syntactic priming. Under the guise of a memory test, participants were made to study sentences and pictures. Ostensibly in order to facilitate recall, they repeated the sentences and described the pictures. The sentences were primes, and took one of two alternating syntactic forms, active versus passive or prepositional dative versus double object dative. The dependent variable of interest was the syntactic structure of the picture descriptions produced. Bock found that participants' picture descriptions consistently took the same syntactic form as the prime sentence, rather than the alternative form. In other words, speakers were more likely to describe a picture using an active structure (e.g., *The alarm clock is waking the boy*) if they had just produced an active sentence (e.g., *The lightning struck the church*), than if they had just produced a passive sentence (e.g., *The church*

was struck by lightning). Similarly, speakers were more likely to describe a picture using a prepositional dative construction (e.g., *The man is reading a story to the boy*) if they had just produced a prepositional dative construction (e.g., *A rock star sold some cocaine to an undercover agent*), than if they had just produced a double object dative construction (e.g., *A rock star sold an undercover agent some cocaine*). On the grounds that the prime and target sentences were not semantically related, Bock argued that syntactic processes are separate from conceptual processes, and that syntactic persistence was due to the activation of particular procedures associated with building grammatical structures in sentence production. That is, prior production of a particular syntactic form led to increased activation of the procedure responsible for generating that form, relative to activation of the procedure responsible for an alternative form. Bock (1989) showed that production of prepositional dative constructions (e.g., *The girl is handing a paintbrush to the man*) were primed equally effectively by prepositional datives that included the same preposition (e.g., *The secretary is taking a cake to her boss*), compared with ones that used a different preposition (e.g., *The secretary is baking a cake for her boss*). That is, the repetition effect was not due to repetition of the preposition *to*.

Bock and Loebell (1990) examined whether the syntactic priming effect could be based on the repetition of particular event roles rather than syntactic structure. To investigate this, they used prime-target pairs (in a picture description task) that shared phrase structures and event structures, or only phrase structures. Experiment 1 contrasted prepositional dative primes with prepositional locative primes (e.g., *The wealthy widow gave an old Mercedes to the church* vs. *The wealthy widow drove an old Mercedes to the church*), and Experiment 2 contrasted passive primes and locative primes (e.g., *The construction worker was hit by the bulldozer* vs. *The construction worker was digging by the bulldozer*). Experiment 3 compared primes that shared the same prosodic structure but different phrase structure (e.g., *John brought a book to Stella* vs. *John brought a book to study*). Crucially, across all three experiments priming occurred only where prime and target shared the same phrase structure, and it did not matter if conceptual structure differed. Bock and Loebell argued that these findings support a form-mapping (over a meaning-mapping) view, according to which syntactic construction is independent from conceptual or prosodic factors.

Further experimental evidence of the independence of syntactic structure-building is provided by Bock, Loebell, and Morey (1992). Using the same 'memory test' priming task, they manipulated animacy and phrase structure in prime sentences, in order

to investigate the influence of conceptual information on the assignment of grammatical subjects in the production of picture descriptions. Prime contrasts comprised animate subjects (e.g., *five people*) versus inanimate subjects (e.g., *the boat*), and active syntactic frames (e.g., *Five people carried the boat*; *The boat carried five people*) versus passive syntactic frames (*Five people were carried by the boat*; *The boat was carried by five people*). The first of these factors was aimed at priming the process of function assignment, while the second was aimed at priming constituent assembly. Results showed that both factors were susceptible to priming: Apart from replicating the syntactic priming effect of previous studies, they also found a conceptual priming effect; participants were more likely to produce sentences with inanimate subjects when they had just produced a sentence with an inanimate subject. This implied that function assignment and constituent assembly are separate processes.

A range of studies has used priming to investigate the influence of conceptual factors on functional and positional processing in production (e.g., Bock & Warren, 1985; Kelly, Bock, & Keil, 1986; McDonald, Bock, & Kelly, 1993). Experimental evidence has demonstrated that inherently more accessible entities (e.g., ones that are concrete, animate, or prototypical) tend to be placed in more prominent syntactic positions. For example, Bock and Warren (1985) used a recall paradigm to investigate the effect of conceptual accessibility (defined in terms of 'imageability') on recalled surface sentence structure, specifically the order of the particular grammatical relations (e.g., subject, direct object, and indirect object). In recalling transitive structures (e.g., *The doctor administered the shock* vs. *The shock was administered by the doctor*) and dative sentences (e.g., *The old hermit left the property to the university* vs. *The old hermit left the university the property*), participants reliably shifted more accessible noun phrases to higher positions in the syntactic hierarchy. Thus, sentences like *The shock was administered by the doctor* were remembered as *The doctor administered the shock*. However, this raising effect was not observed for noun phrases in conjunctive constructions (e.g., *The lost hiker fought time and winter*). In short, conceptual accessibility affected hierarchical positioning of grammatical roles, rather than serial ordering.

In a related study in which conceptual accessibility was defined in terms of animacy, McDonald et al. (1993) varied the animacy and order of NPs in to-be-recalled full sentences and conjoined phrases. Active and passive transitive sentences contained either an animate agent and an inanimate patient (e.g., *A policeman guarded the crown around the clock* vs. *The crown was guarded around the clock by a policeman*) or an inanimate agent and

an animate patient (e.g., *The sound frightened the students* vs. *The students were frightened by the sound*). A second manipulation involved sentences containing conjoined NPs made up of an animate first noun and an inanimate second noun (e.g., *The crew and the camera suffered minor injuries*) or an inanimate first noun and an animate second noun (e.g., *The camera and the crew suffered minor injuries*). In recalling the sentences, participants tended to place animate nouns in subject position, but they did not reliably place them in first position in conjoined phrases. This is presented as further evidence that the animacy bias is connected to grammatical role assignment rather than word order placement.

Using a similar sentence recall paradigm, Griffin and Weinstein-Tull (2003) investigated the influence of verbal conceptual structure on surface syntactic structure. They compared prime sentences with the same syntactic structure but different event structures. Exploiting the fact that the complements of object-raising verbs (e.g., *believe*, *suspect*) can be paraphrased by infinitival ones (e.g., *We believed the exam to be difficult*), they tested whether participants could be primed to paraphrase finite complements as infinite ones. The variable of interest was the proportion of target sentences that were recalled in the infinitival rather than the finite form. Results showed that speakers were more likely to produce the finite complement form after they had just produced a finite complement form, than after they had produced an infinitival complement form. This lead Griffin and Weinstein-Tull to argue that conceptual structure modulates structural priming.

The above studies are complemented by evidence of lexical conceptual influences from outside the priming paradigm. Ferreira (1994) investigated the influence of thematic roles on the surface syntactic structure (active or passive) produced. Participants were instructed to form sentences from sets of three words, comprising a transitive verb and two nouns. The verbs were one of three semantic classes: theme-experiencer (e.g., *embarrassed*), agent-theme (e.g., *ignored*), or experiencer-theme (e.g., *detested*). Participants produced significantly more passive sentences with the theme-experiencer verbs than the other two semantic types, even when animacy was controlled for. Importantly, theme-experiencer verbs require the passive structure in order for the more prominent thematic role to occur in subject position. Ferreira argued that agents and experiencers are more thematically prominent than themes. The results demonstrated, then, that speakers have a tendency to place thematically prominent constituents in the subject position of sentences, and that this determines their choice of active or passive sentence frame. Thematic information is the domain of (lexical) semantics, hence Ferreira's findings constitute evidence of lexical influences on the mapping of syntactic structure in

production. Taken together, these studies suggest that at least some of the meaning-to-form mapping procedures are, or can be, affected by conceptual features of the underlying message.

This section has been concerned with giving a brief overview of recent research in language production. I have reviewed assumptions concerning the architecture of the language production system, focusing in considerable detail on the grammatical component as conceived in two dominant production models, and summarized important experimental evidence of the mapping mechanisms that operate within this component. Specifically, I have drawn attention to recent work examining the influences of conceptual and semantic factors on the surface form of utterances. In the following section, I review the literature relevant to one kind of conceptual or semantic processing, conceptual combination, which is the topic of enquiry of the first series of experiments reported in this thesis.

2.4 Conceptual combination

Historically, the body of work on the topic of conceptual combination has come under an umbrella research program on the psychology of concepts. Concepts (and the way we label and categorize them) are fundamental to all aspects of cognition, notably perception, attention, memory, and, of course, language processing. Our knowledge and experience of the world is structured around how we acquire and use concepts, hence their psychological representation has been of enduring interest to cognitive scientists (as well as philosophers, logicians, and semanticists). It follows that the literature on concepts is vast and varied (see Hampton, 1997; Medin & Smith, 1984; Murphy, 2002; Smith & Medin, 1981 for reviews); the proliferation of theoretical models reflects both the broad range of research traditions and the complexity and flexibility of our conceptual representations.

The earliest view of concepts, dating back to Aristotle, is the *classical* view (a term first used by Smith & Medin, 1981), which is based on logical rules of classification akin to definitions. This view centres around two basic claims. First, instances of a concept share common properties, and these common properties are necessary and sufficient to define the concept. Second, all instances of a concept have the same properties in common; this means that a lack of any one of these properties (by definition) signals non-membership of the concept category. However, empirical findings of *typicality* effects

(e.g., Barsalou, 1987; Hampton, 1979; Rosch, 1975) signalled the decline of the classical view: In the real world, myriad things do not fall cleanly in or out of a category. In contrast, the *prototype* view (Rosch & Mervis, 1975) holds that a concept is represented in the mind by a summary representation of all the instances of that category (Murphy, 2002), which is essentially a prototype instance of the class. For example, the concept *fruit* is represented by an average or ideal fruit. Category members (in this case, other fruits) vary in the extent to which they share the most common attributes of the prototype concept; similarity, therefore, plays a key role in deciding whether or not an instance is an example of a particular concept. A third influential view has been the *exemplar* view. This theory rejects the notions that concepts are represented by an explicit set of necessary features or a single summary instance, in favour of the idea of many individual examplar representations. Medin and Shoben (1988) provided experimental evidence to support the exemplar approach. They asked participants to judge the typicality of objects, e.g., for the classes *spoon* and *large spoon*. Participants rated metal spoons more typical of *spoon*, and rated wooden spoons more typical of *large spoon*. In other words, participants categorized the items on the basis of a particular remembered examplar.

Apart from categorization, another phenomenon associated with concepts is combination, that is, combining simple concepts into complex ones, such as when we combine the concepts of *tourist* and *castle* to form *tourist castle*. This brings us to one of the central issues to be explored in this thesis: How do people determine the meaning of complex expressions such as *tourist castle*? Even when the meaning of the individual words is not in question, their meanings may be combined in many different ways. Thus, *tourist castle* appears to mean a castle for tourists, but the apparently similar *mountain castle* appears to mean a castle located on a mountain. Still other combinations can mean more than one thing – is a *dog scarf* a scarf possessed by a dog or a scarf with images of dogs on it? Because noun-noun combinations like *dog scarf* do not overtly mark the relation between the two concepts, listeners need to work out how they are related. This process of *conceptual combination* is highly productive and serves many communicative functions (Downing, 1977). Some combinations (or *combined concepts*, *compounds*, or *complex concepts*) are well established (e.g., *computer chip*), but others are novel (e.g., *dog scarf*). The meaning of the product of this process is unconstrained in some ways (so that many different relationships between the individual concepts are possible) but constrained in others. In English, the second noun in the phrase is typically the head noun and denotes the category; the modifier precedes the head and serves to specify the way in which the noun

differs from other members of its category (Clark & Berman, 1987; Berman & Clark, 1989; Glucksberg & Estes, 2000).

Early accounts of conceptual combination were based on traditional linguistic *extensional* analyses involving the logical operation of conjunction (see Murphy, 2002, for a review). This approach took as its point of departure the assumption that the extension of a concept is the set of all instances of that concept. For example, the extension of *dog* is the set of all dogs, and the extension of *scarf* is the set of all scarves. Furthermore, when *dog* and *scarf* are combined, the resulting complex concept *dog scarf* is a function of their constituent extensions. But this class of formal treatment is at odds with people's intuitions about how concepts combine; *dog scarf* clearly does not refer to the set of dogs-and-scarves. Murphy (2002) notes the failure of this approach to live up to any psychological explanation: Assuming that such rules of logic are valid, i.e., that the truth value of a combination such as *dog scarf* is a function of the truth values of its constituent concepts, this still does not offer any insight as to how people combine concepts.

More recently, two competing theoretical approaches to conceptual combination propose very different accounts for how people combine information to produce appropriate interpretations of noun-noun combinations. One approach is relation-based, known as the Competition Among Relations In Nominals (CARIN) model (Gagné & Shoben, 1997). The second entails schema-based theories (e.g., Estes, 2003; Murphy, 1988, 1990; Smith, Osherson, Rips, & Keane, 1988; Wisniewski, 1996, 1997). I describe the representational and processing assumptions of these two approaches in turn, before turning to the experimental evidence on which they are based.

2.4.1 Competition Among Relations in Nominals (CARIN)

This theory makes three basic claims. First, possible interpretations must be consistent with one of a set of 15 thematic relations, derived from the linguistic typology of Levi (1978), that link the two concepts and specify the precise manner in which the head noun is modified. Thus, *tourist castle* is formed using the relation *head* FOR *modifier* (as it means a castle for tourists), *mountain castle* is formed using the relation *head* LOCATED AT *modifier* (as it means a castle located on a mountain), and *stone castle* is formed using the relation *head* MADE OF *modifier* (as it means a castle made of stone).

Second, the relation is a *bound representation* (Estes & Jones, 2006), with no independent existence: It is captured within the representation of the modifier, but not the representation of the head noun. For example, the FOR relation is associated with

tourist in *tourist castle*; the LOCATED AT relation is associated with *mountain* in *mountain castle*; and so on. Finally, several relations become activated and are considered one after the other during comprehension (Gagné & Shoben, 1997). The modifier is primarily responsible for interpretation since it determines the order in which the candidate relations are considered. Activation depends on frequency, with more frequent relations for a given modifier receiving higher activation than less frequent relations for that modifier. For example, the modifier *mountain* is more frequently associated with the LOCATED AT relation than the ABOUT relation. Hence, *castle* LOCATED AT *mountain* would be more highly activated than *castle* ABOUT *mountain*. In contrast, the head noun plays a secondary role; it is used to decide whether a particular relation is *plausible* (i.e., compatible with existing knowledge; Gagné, 2002), a constraint also proposed by Costello and Keane (2000). Gagné and Shoben proposed that knowledge of a concept includes information about the frequency of these relations, so that the conceptual representation of every noun indicates the relations that it prefers when it serves as a modifier, but not the relations that it prefers when it serves as a head.

Taxonomy of relations

CARIN proposes that conceptual combination involves identifying the relation between the modifier and the head, and selecting this relation from a small number of highly generalized types (see Estes, 2003; Maguire, Devereux, Costello, & Cater, in press, for discussions of the problems of their generality). This set of basic types was adopted (and extended slightly) from a linguistic typology carried out by Levi (1978) in the formal framework of generative semantics. Levi posited a series of generative rules that derive noun-noun pairs (in her terms, *complex nominals*)[1] from higher level clausal representations. This occurs through one of two syntactic processes, which are akin to Chomskyan transformations: predicate deletion and predicate nominalization. In the first case, the thematic relations associated with the underlying predicate and present at the level of the clause are deleted to yield the surface noun-noun phrase. The rules of predicate deletion yield nine Recoverably Deletable Predicates (CAUSE, HAVE, MAKE, USE, BE, IN, FOR, FROM, ABOUT). For example, the predicate CAUSE is recovered in the noun compound *tear gas*, where the modifier was the direct object of a relative clause (*gas that causes tears*). Predicate nominalization results in four possible relations,

[1] Levi (1978) includes certain adjective-noun pairs in her label *complex nominals*, specifically those containing non-predicating adjectives. For example, *electrical engineer* is considered a complex nominal, on the grounds that *electrical* may not occur in a simple copular construction; *That engineer is electrical* is ungrammatical.

expressed as ACT, PRODUCT, AGENT, and PATIENT. In this case, the head noun is derived from a verb and retains its argument structure. For example, *car thief* is an AGENT nominalization, *oil imports* is a PRODUCT nominalization. In short, according to Levi, all noun-noun combinations express one of 13 predicates.

Downing (1977) criticized Levi's approach on the grounds that her analysis rested on general and underspecified relations. For example, the combination *daisy chains* is purportedly recovered from the predicate MAKE, but this phrase could equally be related to the underlying predicate BE. Similarly, *dog collar* could be derived from FOR or HAVE. Moreover, Downing argued that Levi's transformational rules do not capture the non-linguistic knowledge that listeners bring to bear when interpreting noun-noun combinations. Downing had participants interpret phrases like *oil bowl* and found that the responses were far more detailed than the information captured in the recovered predicate. The combination *oil bowl* was interpreted as 'the bowl into which the oil in the engine is drained during an oil change'. Similarly, *frog slime* was interpreted as 'the slime that frogs exude to keep from dehydrating'. Importantly, there have been no further linguistic proposals concerning the meanings of noun-noun combinations, suggesting that the role of world knowledge can only be captured with more than a purely linguistic account of interpretation.

A modified version of Levi's taxonomy (derived from the nine Recoverably Deletable Predicates) appeared as a set of 14 separate relations in Shoben (1991). To that set, Gagné and Shoben (1997) added the relation *head* DURING *modifier* (e.g., *summer cloud*), resulting in a catalogue of 15 relations, which are shown in Table 2-1, and on which CARIN draws.

Table 2-1: Basic relations assumed by CARIN[2]

	RELATION	EXAMPLE
1	head CAUSES modifier	*flu virus*
2	modifier CAUSES head	*college headache*
3	head HAS modifier	*picture book*
4	modifier HAS head	*lemon peel*
5	head MAKES modifier	*milk cow*
6	head MADE OF modifier	*chocolate bird*
7	head FOR modifier	*cooking toy*
8	modifier IS head	*dessert food*
9	head USES modifier	*gas antiques*
10	head ABOUT modifier	*mountain magazine*
11	head LOCATED modifier	*mountain cloud*
12	head USED BY modifier	*servant language*
13	modifier LOCATED head	*murder town*
14	head DERIVED FROM modifier	*oil money*
15	head DURING modifier	*summer cloud*

Experimental evidence

Gagné and Shoben (1997) provided some support for the CARIN model. They first identified which relations were more or less likely to occur with particular modifiers and head nouns. They then had participants evaluate the sensicality of combinations instantiating relations of high (H) versus low (L) frequency for modifier and head noun respectively. For example, *chocolate utensils* is HH (i.e., high modifier, high head), because its interpretation is *utensils* FOR *chocolate*, and both *chocolate* as a modifier and *utensils* as a head noun frequently instantiate the FOR relation. In contrast, *chocolate rabbit* is HL, because its interpretation is *rabbit* MADE OF *chocolate*, and the MADE OF relation is frequent for the modifier *chocolate* but infrequent for the head *rabbit*. Finally, *chocolate plant* is LH, because its interpretation is *plant* MAKES *chocolate*, and the MAKES relation is infrequent for the modifier *chocolate* but frequent for the head *plant*. Gagné and Shoben found faster response latencies for HH and HL combinations than LH combinations, but no reliable difference between the HH and HL combinations. Thus the frequency of

[2] Gagné and Shoben (1997) use the terms *modifier* and *noun*. To be consistent with terminology used in the rest of the thesis, we substitute *head* for *noun* here.

the relation associated with the modifier affected ease of processing, but the frequency of the relation associated with the head noun did not.

On the basis of these results, Gagné and Shoben suggested that relations are associated with modifiers and not head nouns. The modifier is primarily responsible for interpretation since it determines the order in which the candidate relations are tested. In contrast, the head noun plays a secondary role; it is used to decide whether a particular relation is plausible (i.e., compatible with existing knowledge; Gagné, 2002). Gagné and Shoben proposed that knowledge of a concept includes information about the frequency of these relations, so that the conceptual representation of every noun indicates the relations that it prefers when it serves as a modifier, but not the relations that it prefers when it serves as a head. This is, in Gagné and Shoben's terms, a concept's *relational distribution*. Importantly, relations are represented as part of a modifier concept, but are not represented as part of a head concept.

2.4.2 Schema-based theories

CARIN contrasts with *schema* theories, including the *selective modification model* (Smith, Osherson, Rips, & Keane, 1988), the *concept specialization model* (Murphy, 1988, 1990), and *dual-process theory* (Estes, 2003; Wisniewski, 1996, 1997). In these accounts, a concept is seen as a structured set of dimensions (or slots) and values (or fillers) for those dimensions (Rumelhart, 1980). Dual-process theory further posits two distinct forms of processing, namely relation linking and property mapping. Property mapping pertains to relatively infrequent combinations such as *zebra clam* (meaning a striped clam), in which a property of the modifier is attributed to the head noun. Relation linking involves assigning different thematic roles to the modifier and head constituents in a combination: In *mountain castle*, *mountain* fulfils the role of location, while *castle* is the located object. It is this form of combination that we focus on in the experiments reported below (and therefore we do not consider property mapping in detail). Modification of a concept involves altering the schema by instantiating a new value for a given slot. In adjective-noun combinations such as *green apple*, the adjective *green* straightforwardly matches a slot (i.e., COLOUR) in the head noun's schema and instantiates the value for this slot. In contrast, relation-linking in noun-noun combinations is heavily dependent on general knowledge and local context, as is apparent when considering the possible interpretations of *pie apple* (Medin & Shoben, 1988; Murphy, 1988, 1990; Gerrig & Murphy, 1992; Gerrig & Bortfeld, 1999). Because nouns are conceptually richer than adjectives, they do not

have a single salient dimension to automatically match a slot of the head noun's schema. Listeners therefore need to integrate a nominal modifier with its head to arrive at the most plausible interpretation for a given combination.

According to Estes and Jones (2006), this slot-filling process involves activating a linking relation from a set of possible relations that form part of the semantic network. The important claim is that the relations are not bound to modifiers (or indeed to heads) but are *independent representations*. They constitute representational structures in their own right, which are applied to specific conceptual combinations as appropriate. Neither the modifier nor the head is privileged in the process of combining two concepts. This contrasts with CARIN, which proposes that relations are specifically bound to modifiers and have no independent existence.

2.4.3 Distinguishing accounts of conceptual combination using priming

Priming is a well-established and robust phenomenon in psycholinguistic research. For the purposes of research in comprehension, the priming paradigm involves the presentation of paired prime-target stimuli, with participants instructed to make a decision concerning the target segment. The dependent measure is typically RT, but can also be the participants' selection. Meyer and Schvaneveldt (1971) reported one of the first studies demonstrating priming in language processing. Using a lexical decision task, they showed priming between words that were semantically related. For example, participants were faster in deciding that doctor was a word following presentation of *nurse* (semantically related) than *north* (unrelated) or *nuber* (non-word), indicating that the relationship between prime and target words affects the time taken to process the target. Priming effects also show up in measures of accuracy. Priming effects are assumed to be automatic and to occur in the absence of any task-related motivation.

A number of studies have used priming to investigate conceptual combination, e.g., the interpretation of combinations with fixed interpretations (i.e., where only one interpretation is plausible), and the results have been mixed. On the one hand, Gagné (2001) had participants judge whether combinations made sense, and found that target combinations such as *murder film* were comprehended faster and more accurately following combinations that used the same modifier and the same relation (*murder investigation*), compared to the same modifier and a different relation (*murder attempt*) or a different relation *and* a different modifier (*vocal range*). This constitutes relation priming. There was also evidence of repetition priming: Responses to the target combination were

faster and more accurate when the prime contained the same modifier (*murder attempt*) than when the prime contained a different modifier (*vocal range*). Notice that the interpretations of all of these compounds are fixed (e.g., *murder film* can only plausibly mean *film* ABOUT *murder*). But a comparable experiment using head repetition revealed repetition priming though no relation priming. That is, the same relation (*poverty film*) and different relation (*foreign film*) conditions were faster (though not more accurate) than the neutral condition with different relation and different head (*vocal range*), but there was no significant difference between same relation and different relation conditions on either measure.

However, Gagné and Shoben (2002) had participants verify definitions of ambiguous combinations and found statistically equivalent facilitation for target combinations such as *adolescent doctor* (*doctor* FOR *adolescents*) when the head was repeated (*animal doctor*, meaning *doctor* FOR *animals*) as when the modifier was repeated (*adolescent magazine*, meaning *magazine* FOR *adolescents*), compared with head repeated, unrelated (*country doctor*) and modifier repeated, unrelated (*adolescent experience*) conditions. The influence of modifier repeated and head repeated primes on both response times and accuracy did not differ.

Other studies demonstrated priming in the absence of head or modifier repetition. First, Gagné (2002) found relational priming when prime and target used semantically related modifiers but not when they did not. Thus, comprehension of *student vote* was facilitated by *scholar accusation* (compared with *scholar car*, which involves a similar modifier but different relation); but comprehension of *oil treatment* was not facilitated by *surgery remedy* (compared with *disease remedy*, which involves a similar modifier but different relation). This is evidence that the relation is more closely bound to the modifier than to the head, but does suggest that priming does not require modifier repetition.

In narrative comprehension, Gerrig and Murphy (1992) showed that selection of a specific relation to interpret a combination primes the interpretation of a combination using the same relation but different heads and modifiers. A target phrase such as *trumpet olive* (meaning *olive* SHAPED LIKE *trumpet*) was comprehended with greater ease and accuracy when the narrative in which the combination was embedded included a novel combination instantiating the same conceptual relation (here, a *kitten apple*, meaning *apple* SHAPED LIKE *kitten*). Wisniewski and Love (1998) showed priming of property-mapping and relation-linking interpretations of the same combination using different heads and modifiers. Participants tended to interpret novel combinations (e.g., *spear chisel*)

relationally (meaning *chisel* that MAKES *spears*) following a relational prime (*clothing truck*) and in property-mapping terms (a long chisel) following a property-mapping prime (e.g., *bus truck*). There is some evidence of relation priming for isolated combinations in the absence of repeated heads or modifiers (Spellman, Holyoak, & Morrison, 2001; Estes, 2003), though the effects found by Spellman et al. were not reliable across different tasks. Estes found that combinations such as *pancake spatula* (meaning *spatula* FOR *pancake*) were interpreted more quickly following *bacon tongs* (meaning *tongs* FOR *bacon*) than following *city riots* (not meaning *riots* FOR *city*). This led him to suggest that relation priming only occurs when prime and target relations are sufficiently similar.

However, other studies have not supported these findings. First, Gagné (2000) failed to replicate Wisniewski and Love's (1998) priming effects using the same materials. Additionally, Gagné, Spalding, and Ji (2005) argued that Estes' (2003) results could be due to a design confound, namely that the semantic similarity between prime and target combinations was greater in the same relation condition than in the different relation condition (e.g., *pancake* and *bacon* are more similar than *pancake* and *city*; similarly, *spatula* and *tongs* are more similar than *spatula* and *riots*). They argued that the priming effect reported by Estes (2003) could therefore be better explained as semantic priming than relation priming. In keeping with this, Gagné et al. found that when the semantic similarity of the constituent words was controlled there was no priming in the absence of repeated constituents. This is consistent with the CARIN model's predictions that the modifier must be repeated for relation priming to occur. However, Estes and Jones (2006) demonstrated relation priming between semantically dissimilar phrases. Targets such as *copper monkey* were comprehended significantly faster following *wheat bread* than *wheat field*, even though *copper* is unrelated to *wheat* and *monkey* is unrelated to either *bread* or *field*. Moreover, they found that Gagné et al.'s same-relation conditions often used primes and targets whose relations differed considerably (e.g., *bear paw* served as a prime for *honey soup*), and argued that relation priming could not be explained as semantic priming.

In summary, there is contradictory evidence concerning the determinants of relation selection in concept combination and the associated representational asymmetry between the modifier and head noun. Some of the evidence suggests that conceptual combination involves selecting conceptual relations that are in some sense anchored to the modifier, and hence supports the CARIN model; other evidence suggests that it involves selecting conceptual relations that are independent of the modifier, and hence

supports schema-based accounts such as that as of Estes (2003; Estes & Jones, 2006). The first series of experiments reported in this thesis (see Chapters 3 and 4) are concerned with testing some of the predictions which the theoretical proposals outlined above make with respect to the processing of noun-noun combinations. Meanwhile, in the next section I turn to the topic of semantic type coercion.

2.5 Semantic type coercion

Semantic type coercion, like conceptual combination, has been associated with the systematic flexibility of meaning. Recent work in lexical semantics (e.g., Briscoe et al, 1990; Copestake, 2001; Copestake & Briscoe, 1995; Pustejovsky, 1991, 1995) has been concerned with accounting for contrasts such as the following: *John finished the cigarette* versus *John finished the beer*. Clearly, the verb *finish* refers to the act of smoking when the syntactic context is *finished the cigarette*, but drinking when it is *finished the beer*. This type of structure is termed *logical metonymy* in the literature; an extension of simple metonymy, this label refers to the fact that the verb's argument structure induces an interpretation in which a subsegment of the projected complement (*the beer*, *the cigarette*) stands for the whole complement (*drinking the beer*, *smoking the cigarette*) (Pustejovsky, 1995; Lascarides & Copestake, 1998). A coherent set of commonly occurring verbs, including *enjoy*, *begin*, and *try*, has been shown to exhibit this behaviour. Similar sense alternations have been observed for particular adjective-noun combinations. A *quick beer* is a beer that is drunk quickly, whereas a *quick reader* is someone who reads quickly. Likewise, a *good cook* is someone who cooks well, whereas a *good soup* is one that tastes good. As the examples above show, the interpretations that are built for structures like these are easily expressed with paraphrases that include the missing predicates.

A related phenomenon is the sense alternation reflected in the following contrast (Jackendoff, 1997, 2001; Pustejovsky, 1991, 1995; Piñango et al., 1999; Verkuhl, 1993): *The girl slept until dawn* versus *The girl jumped until dawn*. The proposition *until* imposes a temporal bound on a continuous activity. The first sentence refers to a continuous (unbounded) activity so the interpretation can be computed through standard composition. In contrast, the second sentence is interpreted as referring to an iterative event, that is, that the girl jumped repeatedly until dawn. This is because it contains a mismatch between the verb *jump* and the aspectual modifier *until dawn*. The verb *jump* is an activity that has clear start and end points; it is bounded in time, and it is this

boundedness that causes the clash with the temporal boundary expressed in *until dawn*. The interpretation of *jump* as a repeated activity results, then, from a type-shifting (from a telic sense to a repeated sense), in order to arrive at an interpretation. The sense alternations arise from the interactions of lexical semantic features of the verb and aspectual modifier.

Jackendoff (1997) further describes a parallel to aspectual coercion for noun phrases, involving mass-count alternations, e.g., *I drank three coffees*, meaning *I drank three portions of coffee*. The noun *coffee*, normally a mass noun, has been shifted to being a count noun. The sentence *We're having rabbit for dinner* also involves a similar type shift, though this time it is in the reverse direction. The noun *rabbit* is normally a count noun, but has been shifted here into a mass interpretation, analogous to *beef*. Jackendoff addresses a further related phenomenon, in which the broader context is an additional factor influencing the composition of meaning. The noun phrase *the ham sandwich* in *The ham sandwich over in the corner wants more coffee*, said by a waitress, undergoes a similar type shift, termed *reference transfer* by Nunberg (1979). The interpretation that is constructed in this case can be paraphrased as *The person over in the corner who ordered a ham sandwich wants more coffee*.

These instances of systematic polysemy pose interesting theoretical problems for theories of lexical knowledge representation and processing. The chief representational issue centres on whether each distinct sense of words like *finish*, *quick*, and *coffee* should be listed separately in the mental lexicon, and what principles govern the types of relationships that connect the different senses. Theorists agree that the mental lexicon could not possibly encode all possible senses for these words since this would result in infinitely many different readings; rather, in each of the above cases, the meaning is derived from a complex interaction of the lexical semantics of the verb and noun, adjective and noun, or verb and preposition respectively. Principles of *enriched composition* (as distinct from standard composition; Jackendoff, 1997) determine which aspects of a noun's meaning adjectives like *quick* modify. Similarly, enriched composition generates the additional semantic material needed to interpret expressions containing a semantic type-mismatch like *John finished the cigarette* (where an event-selecting verb is combined with an entity-denoting object). In such cases, one type is shifted or 'coerced' into another, in order to comply with the relevant well-formedness condition. From a processing point of view, we must account for the mapping mechanisms underlying the production and comprehension of such expressions.

2.5.1 The Generative Lexicon and qualia theory

Pustejovsky's (1991, 1995) theory of the Generative Lexicon is aimed at accounting for the kinds of semantic flexibility illustrated by the phenomena described above. A fundamental assumption underlying this theory is the idea that a large part of (semantically) creative language use can be accounted for by lexically specific information, and Pustejovsky therefore proposes a rich terminology for describing this information. Besides highly specified lexical organization, the theory posits a set of generative devices that govern the mapping of semantic types onto syntactic frames, with meaning emerging compositionally from these mappings. One such operation, of particular importance for this thesis, is type coercion, an operation which legitimizes surface semantic type-mismatches. First, however, I outline the components of the Generative Lexicon view of lexical semantic structure.

Levels of lexical representation

The major import of Generative Lexicon theory is arguably its richly elaborated framework for lexical knowledge representation. Pustejovsky's lexicon is a weighty construct; each lexical item is encoded with four kinds of representation which are connected by a set of generative operations that guide the composition of sentence meaning in context. The four levels comprise lexical typing structure, argument structure, event structure, and qualia structure. The lexical typing structure encodes the word type, in relation to other types in the hierarchical system; it also specifies relevant inheritance relations between types and incorporates world knowledge. Argument structure encodes the syntactic mapping requirements, including the number and type of arguments projected by the word (Grimshaw, 1991). Event structure encodes semantic mapping information, which matches verbs with event types (states, processes, or transitions) and the constraints on their composition. The final level of representation is qualia structure. Specified at this level are conceptual features associated with the lexical item. Since Pustejovsky's account of logical metonymy rests on his notion of a rich lexical conceptual structure for nouns, the idea of qualia is particularly important and merits some consideration.

The qualia structure of a lexical item encodes its conceptual make-up in much the same way that argument structure does for verbs. It comprises an index of features that capture the object's essential nature, origin, and purpose, catalogued according to four aspects of meaning: constitutive role (the relation between the object and its parts),

formal role (what distinguishes it within a larger domain), telic role (its purpose), and agentive role (how it came into existence). This set of features reflects world knowledge about the object; indeed, Pustejovsky claims that qualia structures constitute an interface between linguistic and real-world knowledge. Thus the qualia structure of the noun *book* would capture the facts that it is a body of text printed on paper and bound in a cover with a spine, brought into being through a process of writing and for the purpose of being read.

Type coercion

Pustejovsky's (1991, 1995) type coercion operation is a generative device that has scope over the process of composition, with the aim of ensuring that the selectional requirements of a predicate are met by its arguments. Allowing lexical items to be coerced from one type to another eliminates the need to list all possible senses of a word. Pustejovsky defines coercion as 'a semantic operation that converts an argument to the type which is expected by a function, where it would otherwise result in a type error' (Pustejovsky, 1991, p. 425). I shall explain in detail the mechanisms underlying this operation for a typical logical metonymy, such as that contained in *The boy began the book*.

The verb *began* requires an event complement but here takes an entity, *the book*; a metonymic interpretation is induced by this type-mismatch, the result of a two-stage operation. The first step involves the application of a type-shifting rule, expressed by Jackendoff (1997, p. 61) as follows: 'Interpret NP as $[_{\text{Activity}}$ F (NP)]', where F is a function inserted between the verb and the noun phrase which extends the meaning of the noun phrase to include an unspecified activity involving that noun phrase. In this case, the rule extends the interpretation of *the book* to 'doing something with the book'. The second step involves recovering the content of the projected activity (the 'something') from the lexical semantic representation of the noun *book*, specifically its qualia structure. (Recall that the qualia structure specifies four roles, and that the telic and agentive roles are most relevant for logical metonymies.) Thus, the semantic type of the noun *book* is coerced into its telic role *read* or its agentive role *write*, depending on the broader sentence context, e.g., the subject. In the case of *The boy began the book*, in the absence of further contextual information, the likely event role recovered would be the telic role, *read*; in fact, Pustejovsky (1995) claims that the telic role is the default event recovered. In this way, then, as a result of the process of coercion, *The boy began the book* results in an interpretation equivalent to *The boy began reading the book*.

Pustejovsky's Generative Lexicon theory has been criticized by Fodor and Lepore (1998), specifically its notion of qualia structure. Fodor and Lepore argue that the theory does not make a clear and adequate distinction between linguistic and non-linguistic (world) knowledge. Furthermore, they suggest that the qualia structure of a given noun is seldom as clear-cut as in the case of Pustejovsky's examples. For example, it is not axiomatic that *begin X* means *begin to use X to perform its function*. In other words, a car is supposedly for the purpose of driving, yet the expression *begin a car* does not mean *begin driving a car*[3]. Moreover, some objects do not appear to have a clearly discernable use, e.g., *a wall*. Lapata and Lascarides (2003) argue that interpretation depends on the noun, e.g., *begin the tunnel* can only mean *begin building the tunnel* (agentive), not *begin going through the tunnel* (telic), while Godard and Jayez (1993) claim that interpretation is subject to conventional constraints. Fodor and Lepore propose an alternative *atomistic* view of lexical concepts, according to which they are devoid of internal structure and have purely denotional meaning. On their account, the meaning that a lexical item brings to the processes of composition is independent of the syntactic context.

2.5.2 Empirical findings

While there is an extensive body of theoretical work on semantic type coercion, entailing full descriptions of the relevant surface phenomena and proposing representational accounts, there have been relatively scant empirical treatments of the problem. A few studies have come out of natural language processing research (in the form of corpus analyses), with psycholinguistic work thus far limited to comprehension studies that investigate the psychological reality of type-shifting operations.

Corpus studies

Briscoe et al. (1990) undertook a corpus study of the Lancaster-Oslo/Bergen corpus (LOB, one million words). They manually extracted seven type-shifting verbs like *enjoy*, based on the criterion that they could take both NP and progressive or infinitive VP complements. For the verbs analyzed (*enjoy*, *prefer*, *finish*, *start*, *begin*, *miss*, and *regret*), they summed the number of times each occurred with the respective complement types (NP,

[3] Lapata and Lascarides (2003) comment on the relative productivity of pairing certain metonymic verbs with certain complements. Related to this, Scheepers, Keller, and Lapata (2003) found that different metonymic verb-complement combinations differed in their default interpretations, and that this depended on the choice of metonymic verb. They identified three patterns among such verbs: those with a telic default (e.g., *endure the speech*), those with an agentive default (e.g., *regret the speech*), and those with no default reading (e.g., *enjoy the speech*).

infinitive, or progressive), in order to arrive at an estimate of the occurrence of logical metonymies in natural text. Of the possible complement patterns, they found that logical metonymy was a frequently occurring alternation, e.g., 38.4% in the case of *enjoy*.

Corpus studies have provided more than mere frequency data for default speaker preferences regarding levels of semantic specification with metonymic verbs. Briscoe et al. (1990) further tested the hypothesis that full-VP complements would occur precisely when the understood predicate was less commonly associated with the noun complement (e.g., *cover a book*, rather than *read* or *write*). Examining the VP complements of *start*, they found that the occurrence of fully specified forms correlated with default predicates (80.9%). That is, *start* was more likely to be followed by a VP when the most plausible interpretation was *start covering the book* or *start translating the book*, rather than *start reading the book*. Verspoor (1997) carried out a similar study on the British National Corpus (BNC, 100 million words) for the verbs *begin* and *finish*, and found that 95.0% of the understood predicates for *begin* and 95.6% of the understood predicates for *finish* could be resolved on the basis of the qualia structure of the noun complement. More recent computational work has obviated the need for qualia structures in the recovery of coerced predicates (Lapata & Lascarides, 2003). Lapata and Lascarides developed a probabilistic model, which they tested against verb-noun pairs extracted from the BNC corpus. They found that the paraphrases extracted by the model correlated reliably with human judgements.

Experimental evidence

A host of recent on-line studies has supported aspects of the theoretical proposals concerning enriched composition and coercion, by providing evidence that readers experience greater difficulty processing coerced than processing non-coerced expressions (McElree, Traxler, Pickering, Seely, & Jackendoff, 2001; McElree, Frisson, & Pickering, 2006; McElree, Pylkkänen, Pickering, & Traxler, 2006; Pickering, McElree, & Traxler, 2005; Scheepers, Mohr, Keller, & Lapata, 2004; Traxler, Pickering, & McElree, 2002; Traxler, Pickering, & McElree, 2005). In the earliest of these studies, participants were presented with sentences containing complement coercions like *The author was starting the book in the house on the island* in a self-paced reading task (McElree et al., 2001). Recall that the metonymic verb *start* requires an event complement; here it is combined with an entity, *the book*. McElree and colleagues compared participants' reading times on such expressions with sentences that spelled out the understood predicate, in preferred and

dispreferred alternations (established in a pretest). Thus they compared *The author was starting the book in the house on the island* (coerced) versus *The author was writing the book in the house on the island* (preferred) and *The author was reading the book in the house on the island* (non-preferred). Results showed longer reading times at the word *book* for coerced and dispreferred conditions than for the preferred condition, suggestive of processing costs. Interestingly, the pattern of results changed on the following word *in*; here, there was a significant difference between coerced and the other two conditions, but no longer any difference between preferred and non-preferred conditions. The authors argued that the cost of combining a coercing verb with an entity noun phrase is greater than that involved in interpreting atypical thematic role relations. Traxler et al. (2002, Experiment 1) replicated McElree et al.'s design using eye-tracking and the same set of materials. They found no differences between the preferred and non-preferred conditions, while the coerced condition was significantly different (on the two words following the complement noun) from the other two conditions, confirming the difficulty involved in processing complement coercions. Converging results were offered by Scheepers et al. (2004) for German. They found longer reading times for the literal translations of *began the book* (compared to *read the book* and *wrote the book*).

In order to distinguish between processing difficulty induced by the metonymic verb per se and that arising from the metonymic verb-entity noun pairing, Traxler et al. (2002, Experiment 2) used eye-movements to compare expressions containing entity complements (e.g., *started the puzzle*) with event complement controls (e.g., *started the fight*). The experimenters manipulated two factors in the verb-complement combination, (i) whether the verb was metonymic or non-metonymic, and (ii) whether the complement was an entity or an event. They therefore compared readers' performance on *The boy started the fight* (metonymic verb, event complement), *The boy saw the fight* (non-metonymic verb, event complement), *The boy started the puzzle* (metonymic verb, entity complement), and *The boy saw the puzzle* (non-metonymic verb, entity complement). Coercion is purportedly triggered by a type mismatch resulting from the pairing of an event-taking verb with an entity noun, therefore it is only the coerced condition (metonymic verb, entity complement) that should require enriched composition. Consistent with this, results showed that there was no difference between *started the fight* as compared to *saw the fight*, but readers did have more difficulty with *started the puzzle* as compared to *saw the puzzle*. This suggests that the difficulty is caused by the process of combining *started* with an entity object, rather than merely the nature of metonymic verbs. In a replication of

this last study using self-paced reading (Traxler et al., 2002, Experiment 3), the authors reported convergent results; the same effect emerged immediately after the word *puzzle*.

However, de Almeida (2004) reported data from two self-paced reading experiments that were inconsistent with the above findings. Importantly, his first experiment, which used very similar materials to those employed by McElree et al. (2001) in an identical three-condition design (i.e., coerced, preferred, and non-preferred), showed no difference in reading times (at the noun) between the three conditions. Experiment 2 used the same sentences as the first experiment but included a two-sentence context preceding the critical sentences. Results of this experiment showed that coerced expressions incur similar costs to non-preferred interpretations, with both recording longer reading times than the preferred condition. On the basis of these findings, de Almeida argued against the cost of coercion and the attendant theory of enriched composition. Pickering et al. (2005) responded by undertaking an eye-tracking study using de Almeida's (2004) materials with an additional control condition that included both the metonymic verb and the underlying predicate (e.g., *The author began writing the book*...), and again found longer reading times for the coerced condition (compared with the preferred, non-preferred, and full-VP control conditions). Finally, using multi-response speed-accuracy tradeoff (SAT) measures, McElree et al. (2006b) found that interpretation of coerced expressions (e.g., *The carpenter began the table*) was slower and less accurate than that of controls (e.g., *The carpenter built the table*).

In an eye-tracking study, McElree et al. (2006a) compared the processing of expressions containing complement coercions (e.g., *The gentleman started Dickens while*...) with standard metonymic expressions (e.g., *The gentleman read Dickens while*...) and a neutral condition (e.g., *The gentleman spotted Dickens while*...). Results (measured in first-pass regressions and total times) showed that only complement coercion (or logical metonymy) incurred processing difficulty; this condition was more difficult than the neutral condition, but there was no difference between the standard metonymy condition and the neutral condition. The authors suggested that the difficulty is associated with building the missing event structure needed to resolve complement coercion, and that the reference transfer underlying the interpretation of standard metonymies is a less complex semantic operation.

There is some evidence to suggest that aspectual coercion incurs similar processing costs to those demonstrated for complement coercion. Piñango et al. (1999) compared participants' performances reading sentences like *The insect glided effortlessly*

until... and *The insect hopped effortlessly until*... in a cross modal lexical decision task. The critical manipulation was the combination of bounded versus unbounded events with aspectual modifiers like *until*. Since the preposition *until* is incompatible with a bounded event, it coerces the aspectual meaning of *hop* from a single point-action event to an iterative activity. Results showed longer latencies in the *hop* condition, indicating greater processing load due to additional operations underlying the construction of a more complex meaning. However, Pickering, McElree, Frisson, Chen, and Traxler (2006) found no evidence for processing difficulty associated with an aspectual clash in conventional reading tasks, arguing that the findings of Piñango et al. are better explained by the fact that participants in their experiment were engaged in two concurrent tasks.

Taken together, these findings provide a convincing body of diverse behavioural evidence for complement coercion. However, this evidence has the limitations of being in some sense one-dimensional; it only informs us about the difficulty of coercion. The increased processing costs associated with comprehending a coerced expression like *began the book*, which show up in longer reading times, more regressions, and longer fixations, reflect the additional operations induced in recovering a representation for the missing event sense. Traxler et al. (2005) proposed that this recovery takes place in four stages. Firstly, on accessing the lexical entry for *book*, the language processor attempts to integrate the various stored senses for the noun with the semantic representation of the sentence. Secondly, a mismatch between the argument requirements of the verb and the stored senses of the noun triggers the process of coercion. Thirdly, the processor draws on salient properties associated with the noun to infer an action that could plausibly be associated with that noun in complement position. Finally, the inferred action is incorporated into the processor's semantic interpretation of the VP by reconfiguring the semantic representation of the complement. Thus, the semantic structure [*began* [*the book*]] is converted into [*began* [*reading the book*]]. The coercion cost is associated with the operations in this last stage, specifically with the time needed to compute the event structure representation associated with the complement (McElree et al., 2001; Traxler et al., 2002).

Contextual influences

Several studies have investigated the influence of context on the interpretation of complement coercion. Confirming the evidence for the cost of coercion, Traxler et al. (2005) found that readers still experienced difficulty at the noun complement of the

coerced expression, even when the context explicitly provided the missing predicate (e.g., *The carpenter was building all morning. Before he began the table...*). In a study focusing on the *intra*-sentential context, Lapata et al. (2003) manipulated the sentential subject of sentences containing complement coercions. In a sentence completion task, they compared the influence of sentential subjects supporting a telic reading of the understood predicate (e.g., *critic* for *book*) versus those that favoured an agentive interpretation (e.g., *author* for *book*) on participants' interpretations (as evidenced in their completions). In addition, they included a neutral control condition, which was always a person's name (e.g., *Peter*). Results supported the authors' hypothesis that the sentential subject influences which qualia role (telic or agentive) is accessed in interpreting the surface form. Subjects in the telic condition lead to telic completions, while subjects in the agentive condition lead to agentive completions. The neutral condition showed a preference for telic completions, which supports Pustejovsky's (1995) claim that this is the default qualia recovered during complement coercion.

In a further investigation of contextual influences, Lascarides and Copestake (1998) offered a theoretical account of logical metonymy, which attempts to explain lexical interpretation in a discourse context. The authors proposed a typed feature structure formalism, Persistent Default Unification, which is designed to explain the interaction between lexical semantics and pragmatics in comprehension. The principles governing the interpretation of expressions that go against lexical generalizations (e.g., *The goat enjoyed the book*) are captured in two axioms. The first, `Defaults Survive`, enforces lexical generalizations at the discourse level. The second, `Discourse Wins`, holds that in exceptional cases discourse information overrides lexical generalizations and guides interpretation. In the case of *The goat enjoyed the book*, the relevant pragmatic information is that goats do not read, and it is this information that rules out the interpretation 'the goat enjoyed reading the book' in favour of 'the goat enjoyed eating the book'.

In summary, there is a large body of evidence concerning the processing costs associated with comprehending coerced expressions, but a palpable gap in research concerning how these mechanisms might work in processes of production. In the second series of experiments reported in this thesis, I aim to complement the existing empirical work on the interpretation of coerced expressions by exploring how it is processed in the mapping of semantics onto syntactic representations during language production.

2.6 Summary

The aim of this chapter has been to introduce the background literature relevant to the experiments reported in the chapters that follow. The starting point was an overview of language comprehension, covering basic assumptions about levels of processing as well as some influential models and methodologies. Next, I turned to language production and presented a similar discussion of theoretical and empirical work in the field, again with greater focus on semantic and conceptual influences on processing. The second half of the chapter was dedicated to reviewing the literature relevant to the two topics of investigation covered in this thesis. I outlined the two dominant theoretical approaches to conceptual combination, and the body of experimental findings that both support and refute these. Lastly, I reviewed the literature concerning semantic type coercion. I covered the theoretical framework and reviewed work from computational linguistics and psycholinguistic studies which provide evidence for the phenomena discussed.

In the following four chapters, I report eight experiments designed to test predictions arising from some of the theoretical proposals and previous empirical findings outlined above. Experiments 1–4, on conceptual combination, evaluate competing models of conceptual combination in the light of evidence of relation priming in comprehension. Experiments 5–8, on semantic type coercion, provide evidence for mechanisms of enriched semantic composition in the mapping of meaning to form in production.

Chapter 3

Priming the interpretation of noun-noun combinations

3.1 Overview

This chapter reports three experiments designed to investigate the influence of modifier and head constituents on the comprehension of novel ambiguous noun-noun combinations like *dog scarf*. Using an expression-picture matching (forced-choice) priming paradigm, participants were presented with depictions of ambiguous novel noun-noun compounds (e.g., *dog scarf*) involving interpretations that were restricted by the picture alternatives to either *modifier* POSSESSES *head* (a dog wearing a scarf) or *head* DESCRIBES *modifier* (a scarf with pictures of dogs on it). Experiment 1 examined the effects of lexical repetition and semantic relation. The results demonstrated reliable relation priming, regardless of whether the modifier or head was repeated between prime and target: Participants tended to choose target pictures involving the same relation as a preceding prime picture. Experiment 2 demonstrated significant relation priming when neither constituent was repeated. The results of this experiment, and a comparison between the two experiments, are interpreted in terms of the *lexical boost* effect.

Experiment 3 was designed to address a possible visual priming explanation for the pattern of effects in Experiments 1 and 2; this experiment showed significant relation priming when each picture contained both possible semantic relations. The findings are interpreted in the light of competing models of conceptual combination. Specifically, they are inconsistent with predictions made by the relation-based CARIN theory (Gagné & Shoben, 1997); rather, they support a schema-based account, in which relational representations are at least partially dependent on both head and modifier concepts. This is couched in terms of a model of the conceptual stratum (based on Levelt et al., 1999).

3.2 Introduction

As discussed in Chapter 2, there has been increasing interest in cognitive psychology in the process of conceptual combination because of what this complex and flexible process can tell us about the nature of concepts. Several studies of conceptual combination have had important implications for theories of concepts (Hampton, 1988; Markman & Wisniewski, 1997; Medin & Shoben, 1988; Smith & Osherson, 1984). For example, Smith and Osherson (1984) demonstrated typicality effects for combinations like *pet fish*. In a discussion of the prototype view of concepts, they argued that a typical *pet fish* (e.g., a goldfish) is neither a typical *pet* nor a typical *fish*. Hampton (1988) provided similar evidence against definitional theories of concepts.

Simple concepts may be combined in myriad ways, and people standardly have little difficulty comprehending them. For example, (given the right context) a person would readily understand *dog T-shirt* to mean, on the one hand, a T-shirt worn by a dog, or, on the other, a T-shirt with a picture of a dog on it. Similar to analogy and metaphor, conceptual combination is a highly flexible and productive linguistic device that achieves diverse communicative ends, including extending the speaker's vocabulary (Downing, 1977; Gerrig & Murphy, 1992) and subcategorizing existing discourse referents (Markman & Wisniewski, 1997). Comprehending noun-noun combinations is not trivial for two reasons. First, the connection between the two concepts is not overtly marked, as it is in an adjective-noun phrase (e.g., *red apple*). Second, interpretation is highly knowledge-dependent (Gerrig & Murphy, 1992). This chapter is concerned with the way in which prior experiences may influence how people interpret such nominal (noun-

noun) combinations. Specifically, how do people combine information to produce appropriate interpretations?

Two theoretical models of conceptual combination dominate the recent relevant literature (see Section 2.4). Schema-based approaches (e.g. Murphy 1988, 1990; Smith et al., 1988, Wisniewski, 1996) hold that combined concepts are interpreted by modifying the dimensions or attributes in the representation of the head noun. On this account, conceptual combination involves selecting a dimension in the schema of the head, and changing its value to match the modifier. For example, the combination *apartment dog* is comprehended by adjusting the value of the HABITAT slot in the conceptual schema of *dog* (Murphy, 1988). Gagné and Shoben (1997; Gagné, 2001) propose an alternative relation-based model known as the competition-among-relations-in-nominals (CARIN) theory, according to which conceptual combination involves assigning a thematic relation between the head noun and its modifier; this relational information is stored with the modifier concept. These approaches make very different predictions concerning the roles of head noun and modifier in online processing of noun-noun combinations. According to Estes and Jones (2006), the slot-filling process underlying the schema model involves activating a linking relation from a set of possible relations that form part of the semantic network; relations are not bound to modifiers (or indeed to heads). In contrast, the CARIN model contends that the modifier alone is involved in the retrieval of semantic relations.

Chapter 2 reviewed the priming evidence in considerable detail. As discussed, the results are mixed. There is some evidence for differential priming of relations with repeated noun and modifier constituents (Gagné, 2001; Gagné & Shoben, 2002); however, using an identical task, Gagné and Shoben did not find differences between the modifier repeated and head repeated conditions (where the repeated constituents were not identical, but rather semantically similar). There is also evidence of relation priming without any repetition. Gerrig and Murphy (1992) showed that the selection of a specific relation to interpret a combined concept primes the interpretation of a subsequent combination using the same relation. Similarly, Wisniewski and Love (1998) demonstrated that property and relation interpretations of the same combination could be selectively primed. However, using the same materials, Gagné (2000) failed to replicate the priming results obtained by Wisniewski and Love (1998). Finally, Estes (2003) demonstrated reliable relation priming in the absence of lexical overlap between

prime and target, but Gagné, et al. (2005) attributed Estes' (2003) results to a confound involving similarity.

Because previous priming studies have produced conflicting results, the following set of experiments turns to expression-picture matching to help distinguish schema- and relation-based accounts of concept combination. Rather than consider the time-course of comprehension of (relatively) unambiguous expressions, I consider the process by which people select between interpretations for expressions that could instantiate different relations. Studies of syntactic comprehension (parsing) have shown that the interpretation of syntactically ambiguous sentences can be affected by prior comprehension of sentences with one or other syntactic structure (Carey, Mehler, & Bever, 1970). More recently, Branigan, Pickering, and McLean (2005) presented participants with an ambiguous prime expression, such as *The policeman prodding the doctor with the gun*, which is ambiguous between meaning that the policeman used the gun to prod the doctor (*verb-attachment analysis*) or the policeman prodded the doctor who had the gun (*noun-attachment analysis*). Participants then saw two pictures, one which matched one or other interpretation and one which matched neither interpretation, and selected the appropriate picture. They were then presented with a target expression, such as *The waitress prodding the clown with the umbrella*, which contains the same ambiguity as the prime. They then saw two pictures, but this time each picture corresponded to one interpretation of the target sentence. When prime and target shared the same verb, participants tended to choose the picture that matched the analysis (i.e., verb or noun attachment) assigned to the prime sentence. In contrast, when prime and target employed different verbs, participants did not (significantly) tend to choose the picture that matched the analysis assigned to the prime (and priming was significantly stronger when the verb was shared than when it was not).

The same method was applied in the current study to examine whether the process of conceptual combination could be primed. Participants were presented with a prime expression that was consistent with two interpretations involving different relations; they then saw two pictures, one which matched one or other interpretation and one which matched neither interpretation, and selected the appropriate picture. They were next presented with a target expression that was consistent with two interpretations involving different relations; after this they saw two pictures, one of which corresponded to one relation, while the other corresponded to the alternative interpretation. The stimuli were limited to combinations that clearly involved a relation between the two

nouns. There is ongoing debate as to whether property compounds (e.g., *zebra clam*) are interpreted using a different set of processes than relational compounds (Wisniewski, 1996, 1997; Estes, 2003) or whether both kinds of interpretations can be accounted for within a relation-based framework (Gagné, 2000). Hence, property compounds are not addressed in this study.

The current set of experiments focused on two of the 15 relations that are assumed by CARIN (numbers 3 and 4 in the table in Gagné and Shoben, 1997, p. 72), which are themselves derived from Levi's (1978) typology, namely *head* HAS *modifier* (e.g., *picture book*) and *modifier* HAS *head* (e.g., *lemon peel*). These relations were used to construct combinations that could plausibly instantiate both relations. For example, the combination *dog T-shirt* could be interpreted as meaning *dog* HAS *T-shirt*, analogous to *book* HAS *picture* in the example above, or as *T-shirt* HAS *dog*, analogous to *lemon* HAS *peel*. These two distinct interpretations of *dog T-shirt* could be depicted respectively as a dog wearing a T-shirt or as a T-shirt decorated with a picture of a dog (see Figure 3-1). In the former case, the modifier is in a possessor relation with the head noun; in the latter, the modifier acts as descriptor of the head noun.[4] Notice that these instantiations are subclasses of CARIN's more general *head* HAS *modifier* and *modifier* HAS *head* relations. I refer to them henceforth as POSSESSOR and DESCRIPTOR respectively.

One important reason for using two relations was that the form of the target could not be predicted from the form of the prime. When using 15 relations with half of the targets having the same relation as the prime, a target involves the same relation as the prime 50% of the time but any other specific relation only 3.6% (i.e., 50/14) of the time. But when using two relations with half of the targets having the same relation as the prime, a target involves the same relation as the prime 50% of the time and the alternative relation 50% of the time.

3.3 The picture description priming paradigm

The experiments reported in this chapter use an expression-picture matching task to test schema- and relation-based accounts of conceptual combination. On each trial, participants first read a noun-noun phrase (e.g., *rabbit scarf*), then saw two pictures and

[4] Although the English paraphrases for both relations rely on the verb *has*, this is an idiosyncrasy of the English language. The paraphrases do not make reference to a single HAS relation: In German, for example, the paraphrases are *Hund* HAT *T-shirt* AN (verb: *anhaben*) and *T-shirt* HAT *Hund* DRAUF (verb: *draufhaben*).

had to select which picture (left or right) matched the phrase. On prime trials, one picture depicted either the POSSESSOR or DESCRIPTOR interpretation, while the other picture depicted neither interpretation. The 'correct' picture on prime trials thus disambiguated the appropriate analysis of the prime phrase as *head* DESCRIBES *modifier* (a rabbit wearing a scarf) or as *head* POSSESSES *modifier* (a scarf decorated with rabbits). To select the appropriate picture, participants therefore had to resolve the prime phrase as involving the POSSESSOR interpretation (for POSSESSOR primes) or as involving the DESCRIPTOR interpretation (for DESCRIPTOR primes). Target trials did not disambiguate the associated phrase; both pictures depicted possible interpretations of the combination, with one corresponding to the POSSESSOR interpretation and the other to the DESCRIPTOR interpretation. The dependent measure was choice of target picture. Hence I examined whether participants interpreted the target phrase in the same way in which they had interpreted the prime phrase.

3.4 Experiment 1: Influence of head and modifier constituents on priming

Experiment 1 investigated whether relational priming occurred in the context of head repetition, modifier repetition, or both, and allowed direct comparison of the effects of head and modifier repetition.

3.4.1 Predictions for the current study

How might processing of a combination such as *dog scarf* be affected by prior processing in the models of conceptual combination outlined above? In CARIN, relations are exclusively linked to modifier concepts, so relational priming is predicted to occur when the modifier is repeated. Thus, people should be more likely to interpret *dog scarf* as a scarf decorated with a picture of a dog (i.e., *dog* DESCRIBES *scarf*) after interpreting *dog T-shirt* as a T-shirt decorated with a picture of a dog (i.e., *dog* DESCRIBES *T-shirt*) than after interpreting it as a T-shirt worn by a dog (i.e., *dog* POSSESSES *T-shirt*). In contrast, the CARIN model predicts no tendency to repeat relations when the head is repeated but not the modifier. Thus, people should not be more likely to interpret *dog scarf* as a scarf decorated with a picture of a dog (i.e., *dog* DESCRIBES *scarf*) after interpreting *rabbit scarf* as a scarf decorated with a picture of a rabbit (i.e., *rabbit* DESCRIBES *scarf*) than after interpreting it as a scarf worn by a rabbit (i.e., *rabbit* POSSESSES *scarf*). Similarly, there

should be no tendency to repeat relations when neither the head nor the modifier is repeated (e.g., *rabbit hat* should not relationally prime *dog scarf*).

In contrast, early schema models (e.g., Smith et al., 1988; Murphy, 1988, 1990; Wisniewski, 1996, 1997) do not make clear predictions about relation priming. However, Estes and Jones (2006) represent relations independently of concepts. Their model predicts that priming should occur whenever a relation is repeated, because prior activation of a relation should facilitate its subsequent selection. Hence, unlike CARIN, their model predicts that people should be more likely to interpret *dog scarf* as a scarf decorated with a picture of a dog (i.e., *dog* DESCRIBES *scarf*) after interpreting *rabbit scarf* as a scarf decorated with a picture of a rabbit (i.e., *rabbit* DESCRIBES *scarf*) than after interpreting it as a scarf worn by a rabbit (i.e., *rabbit* POSSESSES *scarf*). Furthermore, this tendency to repeat relations should occur when neither the head nor the modifier is repeated (e.g., *rabbit hat* should relationally prime *dog scarf*), and should be as strong when neither the head nor the modifier is repeated as when either the head or the modifier is repeated.

The current paradigm differs from previous priming studies on conceptual combination in that it primes the choice of interpretation of ambiguous expressions. That is, rather than facilitating the speed with which an expression is processed, priming in this paradigm facilitates a particular choice of interpretation. The stimulus set included clearly ambiguous target items whose interpretations were constrained by their associated pictures.

Although Branigan et al. (2005) did not find significant priming when prime and target used different verbs, studies in language production have shown syntactic priming in the absence of verb repetition (e.g., Bock, 1986). For example, participants tend to produce passives more often after passive primes than after denotationally equivalent active primes. Indeed, there is some evidence that abstract aspects of semantic structure can also be primed in production and comprehension with little or no lexical repetition (Bock, Loebell, & Morey, 1992; Garrod & Anderson, 1987; Watson, Pickering, & Branigan, 2004). Such data are compatible with the existence of independent syntactic and semantic representations, just like the independent relational representations postulated by Estes and Jones (2006). But although syntactic priming in production does not require lexical repetition, it is considerably enhanced by such repetition (Branigan, Pickering, & Cleland, 2000; Cleland & Pickering, 2003; Pickering & Branigan, 1998). This phenomenon is referred to as the *lexical boost*. One explanation for why there is clear

evidence of relational priming when the modifier is repeated, but less clear evidence of relational priming in the absence of repetition, is that relational priming occurs in both cases but repetition enhances priming, just as it appears to do in the syntactic domain.

To summarize, CARIN predicts that people's interpretation of relationally ambiguous compounds (e.g., *dog T-shirt*) should be affected by prior presentation of a relationally disambiguated prime if it involves the same modifier as the target (*dog scarf*), but not if it involves the same head but a different modifier (*rabbit T-shirt*) or a different head and a different modifier (*rabbit scarf*). Schema theories such as the independent representation account (Estes, 2003) predict comparable relational priming whether the prime and the target involve the same or different constituents. Finally, an account based on the analogy to syntactic priming predicts priming whether prime and target involve same or different constituents, but enhanced priming (i.e., a lexical boost) when one or other constituent is repeated.

3.4.2 Participants

Thirty-two undergraduate students from the University of Edinburgh community were paid to participate. They were all native English speakers and had no reading difficulties.

3.4.3 Materials and design

Thirty-two item sets were created. The full stimulus set is listed in Appendix A. Each critical item comprised a prime combination instantiating a POSSESSOR or DESCRIPTOR relation (such as *dog T-shirt*), a pair of prime pictures, a target combination (such as *dog scarf*), and a pair of target pictures. The first noun in the phrase was always animate; the second noun was always inanimate. Of the prime pictures, one matched either the POSSESSOR or the DESCRIPTOR interpretation of the relation between the two constituents, while the other matched neither interpretation. In addition, primes contained either the same modifier or the same head as the target expression. Thus primes were in four conditions, as shown in Figure 3-1. The target pictures corresponded to each interpretation of the expression; one was the POSSESSOR depiction, the other the DESCRIPTOR depiction.

In the PM (i.e., POSSESSOR, modifier repeated) condition, a prime expression such as *dog T-shirt* was displayed with the two pictures in the top-left quadrant of the primes in Figure 3-1. In the PH (POSSESSOR, head repeated) condition, a prime expression such as *rabbit scarf* was displayed with the pictures in the bottom-left quadrant of the primes in Figure 3-1. Pictures in the DM (DESCRIPTOR, modifier repeated) and

DH (DESCRIPTOR, head repeated) conditions are shown on the top-right and bottom-right quadrants respectively of the primes in Figure 3-1. In each quadrant, the match picture is shown on the left and the distracter picture is shown on the right (this was of course counterbalanced in the experiment). For both modifier repeated conditions the distracter pictures contained the same modifier as the correct prime picture but a different head (in this case *dog newspaper*). Similarly, distracters in the head repeated conditions contained the same head as the prime but a different modifier (in this case *duck scarf*). The target expression *dog scarf* was matched with the two pictures at the bottom of Figure 3-1, corresponding to the POSSESSOR and DESCRIPTOR interpretations of the phrase.

In addition to the 32 experimental item sets, there were 96 unambiguous filler expressions and pairs of pictures, one of which matched the expression presented. The set of fillers comprised 32 singular nouns such as *dancer*, *goat*, and *castle*, 32 plural nouns such as *lobsters*, *jesters*, and *staplers*, and 32 conjoined singular noun phrases such as *teapot and bucket*, *bird and boy*, and *mask and sharpener*. Distracter pictures were of the same type, also depicting singular, plural, or conjoined noun phrases. Half of the filler items were animate and the other half were inanimate. In addition, half of the filler words appeared in the experimental item set and the other half did not. Those that appeared in the experimental set were distracters (i.e. nonmatches) in the filler set. The fillers that did not appear in the experimental set appeared as matches half of the time and as distracters the other half of the time. Figure 3-2 shows exemplars of singular, plural, and conjoined filler expressions and pictures respectively (see Appendix A for the full set of filler items).

The experimental items were organized into four lists, each including eight items per condition, such that one version of each item appeared in each list. Each list of 160 noun phrases and pictures (32 primes, 32 targets, and 96 fillers) was individually randomized for each participant, with the constraints that each prime immediately preceded the associated target and that at least two filler trials intervened between experimental trials.

Figure 3-1: Experiment 1 sample experimental stimuli

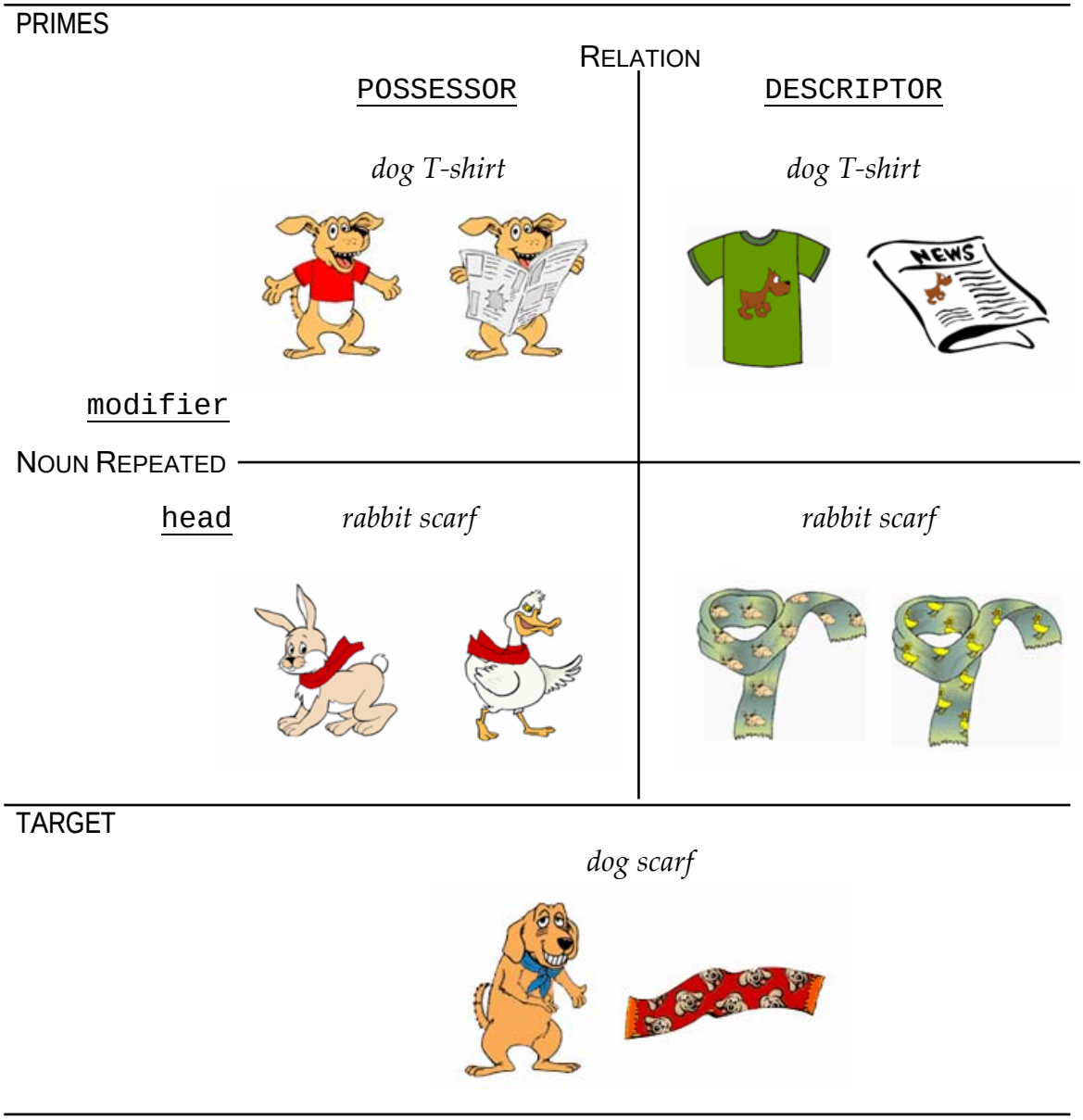


Figure 3-2: Experiment 1 sample fillers

	EXPRESSIONS	PICTURES
FILLERS		
Singular	*castle*	
Plural	*jesters*	
Conjoined	*bird and boy*	

3.4.4 Procedure

Participants viewed the materials on a computer screen, which was connected to a PsyScope button box. E-Prime software was used to present the experiment and record the data. There were seven practice trials before the beginning of the experiment, comprising two disambiguated (prime-type) POSSESSOR and DESCRIPTOR combinations and five filler-type phrases. A single trial (prime, target, or filler) comprised a fixation cross, a phrase displayed in the centre of the screen for 2000 ms, a blank screen for 500 ms, and then a pair of pictures. Participants were instructed to match each phrase with the corresponding correct picture. This involved deciding on the appropriate match and pressing the left and right keys on the button box, which signaled the end of that trial and the beginning of the next. Each phrase was viewed once, with the entire session lasting approximately 20 minutes (see Figures 3-3 and 3-4 for sample prime and target trials respectively). For each list, the matching picture for the phrase appeared on the left for half the trials and on the right for the other half. Similarly, the POSSESSOR picture for the target appeared on the left for half of the trials and on the right for the other half.

Figure 3-3: A sample prime trial in Experiment 1 (PM condition)

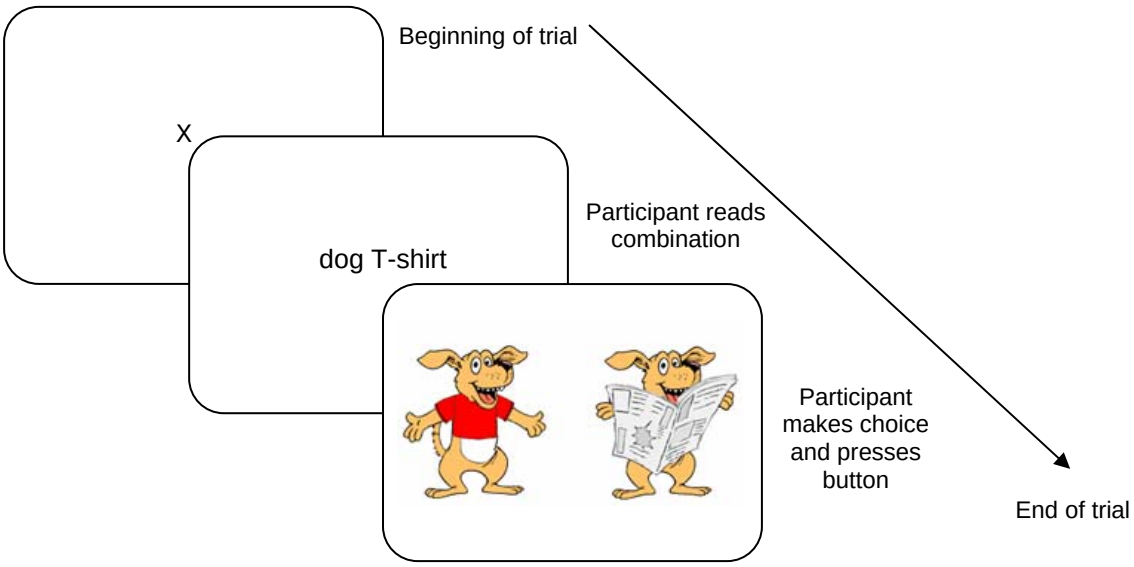
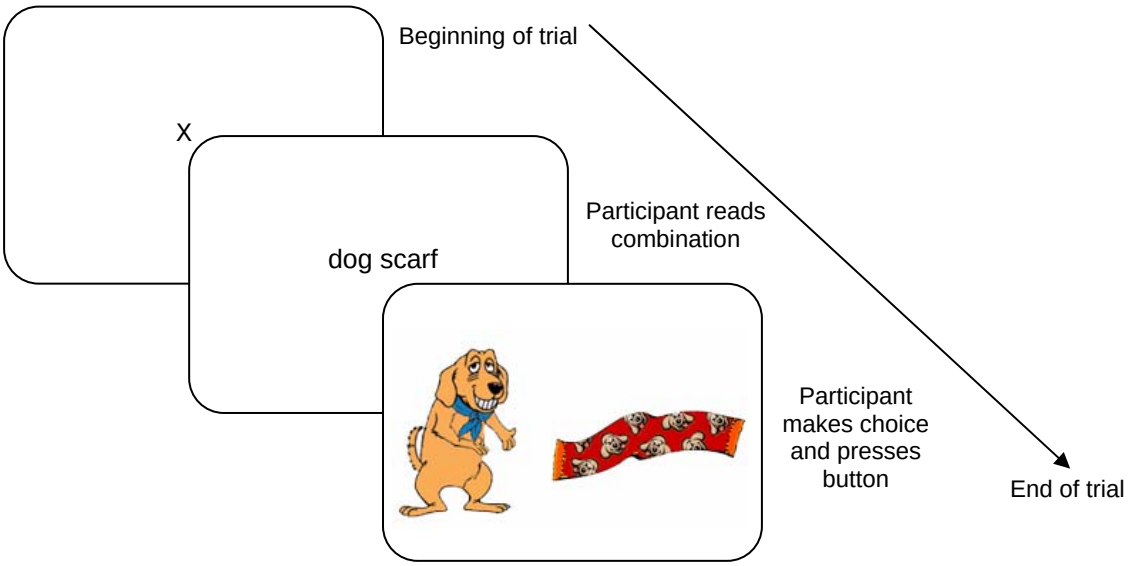


Figure 3-4: A sample target trial in Experiment 1



3.4.5 Coding and analysis

Each participant was presented with 32 targets, comprising eight in each of the four priming conditions (PM, PH, DM, DH). Each target expression and corresponding pair of pictures were presented to all 32 participants, such that eight participants saw any one version of an experimental item.

Any trial on which a participant selected the incorrect prime picture was eliminated from the analysis. The remaining responses were coded according to whether the corresponding target selected was a POSSESSOR picture or a DESCRIPTOR picture. Subsequent calculations were based on the probability of choosing a POSSESSOR target picture after choosing a POSSESSOR prime picture, and the probability of choosing a POSSESSOR target picture after choosing a DESCRIPTOR prime picture. (Note that the choice of POSSESSOR responses is arbitrary because the proportion of DESCRIPTOR responses is complementary: Participants always selected either a POSSESSOR or a DESCRIPTOR picture.) Hence the proportions of targets in both the participants and items analyses were calculated by dividing the number of POSSESSOR pictures selected following a POSSESSOR prime by the sum of POSSESSOR targets following POSSESSOR primes and POSSESSOR targets following DESCRIPTOR primes. This measure is analogous to that used by Branigan et al. (2005). This measure was used because it allowed for a comparison of priming between conditions in cases where the proportions of correctly selected prime pictures was not equivalent and obviated the need to compute separate analyses for the (non-independent)

POSSESSOR and DESCRIPTOR targets. ANOVAs were carried out on these data with Relation (POSSESSOR vs. DESCRIPTOR) and Noun (modifier- vs. head-repeated) as factors, and separate analyses treating participants (F_1) and items (F_2) as random effects. Both factors were treated as within participants and items.

3.4.6 Results

Correct prime pictures were selected on 982 trials (96%). Of these, 241 (25%) were PM trials, 254 (26%) were PH trials, 240 (24%) were DM trials and 247 (25%) were DH trials. In these 982 trials, participants chose 309 (31%) POSSESSOR and 673 (69%) DESCRIPTOR pictures respectively. Table 3-1 shows the number of POSSESSOR and DESCRIPTOR target responses in each of the four priming conditions.

Table 3-1: Raw figures for POSSESSOR and DESCRIPTOR target responses in the four priming conditions of Experiment 1

	TARGET RESPONSE	
PRIMING CONDITION	POSSESSOR	DESCRIPTOR
POSSESSOR, Modifier repeated	91	150
POSSESSOR, Head repeated	112	140
DESCRIPTOR, Modifier repeated	46	196
DESCRIPTOR, Head repeated	59	188

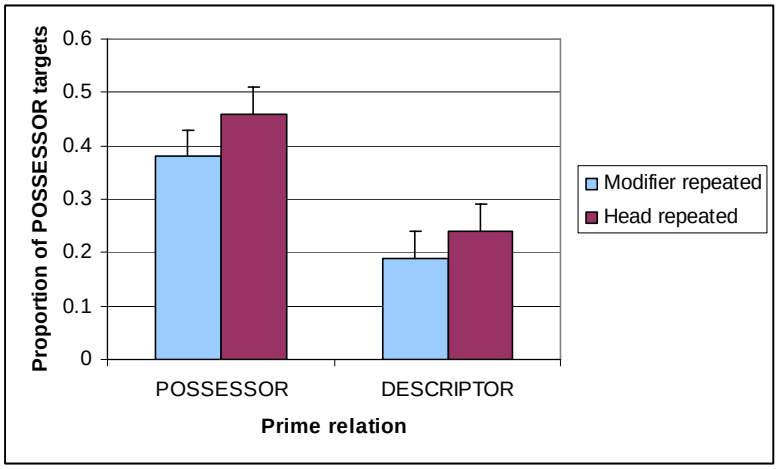
Table 3-2 shows the proportions of POSSESSOR target responses, represented graphically in Figure 3-5. (All graphs represent data from participant analyses, with error bars showing standard error by participants.) Two-way ANOVAs on these data revealed a main effect of Relation (F_1 (1, 31) = 24.018, $p < .001$; F_2 (1, 31) = 49.682, $p < .001$). There was a significant overall tendency to repeatedly interpret combinations in the same way, manifested as a relation priming effect of 21%; that is, participants made 21% more target responses that were of the same type (POSSESSOR or DESCRIPTOR) as the prime response than target responses that were of the alternative type to the prime response (0.42 vs. 0.21). In addition, there was a reliable effect of Noun (F_1 (1, 31) = 7.587, $p = .01$; F_2 (1, 31) = 6.535, $p < .05$); participants chose 7% more POSSESSOR interpretations when the second noun was repeated and this was significant (0.28 vs. 0.35). There was no interaction between Noun and Relation (both Fs < 1), indicating

that priming did not differ whether the modifier or the head noun was repeated. Planned comparisons showed that priming occurred both when the modifier was repeated (0.19; t_1 (31) = 4.178; $p < .001$; t_2 (31) = 3.942; $p < .001$) and when the head was repeated (0.22; t_1 (31) = 3.849; $p < .01$; t_2 (31) = 4.858; $p < .001$).

Table 3-2: Mean POSSESSOR target proportions for responses in each condition in Experiment 1 (based on participants analyses)

	RELATION	
NOUN REPETITION	POSSESSOR prime	DESCRIPTOR prime
Modifier repeated	.38	.19
Head repeated	.46	.24

Figure 3-5: Proportions of POSSESSOR target responses selected in the four experimental conditions of Experiment 1



It is conceivable that participants might have detected the relationship between matching prime-target pairs and hence begun to employ a strategy in choosing between the two pictures depicting the ambiguous target combinations. If they did so, we would predict that the tendency to repeatedly choose the same relation would increase through the experiment. To test this, the magnitude of priming in the two halves of the experiment was compared by introducing Half (first vs. second half) as a within-participants and -items factor. Half was defined as the first or last 16 prime-target trials seen by a participant. For each half, the proportion of targets that were interpreted in the

same way as the preceding prime was calculated by first excluding trials on which the prime picture was incorrectly selected, and then dividing all target responses that involved the same relation as the immediately preceding prime expression by the sum of all responses. In fact, the analysis revealed that the magnitude of priming was stable across the two halves of the experiment (both Fs < 1), with 59% of target responses involving the same relation as prime responses in the first half of the experiment, and 59% of target responses involving the same relation as prime responses in the second half of the experiment. Hence we can be confident that the pattern of effects does not reflect the development of a strategy for approaching the task over the course of the experimental session.

3.4.7 Discussion

In Experiment 1, participants were presented with novel ambiguous nominal combinations, disambiguated by pictures to involve either a *modifier* HAS *head* (POSSESSOR) or *head* HAS *modifier* (DESCRIPTOR) interpretation. When selecting between target pictures, participants chose DESCRIPTOR relations more frequently than POSSESSOR relations. More importantly, however, participants tended to interpret combinations in the same way as they had interpreted a preceding (disambiguated) prime. That is, they were more likely to select a POSSESSOR picture after seeing a POSSESSOR picture than after seeing a DESCRIPTOR picture. These results are consistent with previous findings of relation priming (e.g., Wisniewski & Love, 1998; Gerrig & Murphy, 1992; Estes, 2003; Estes & Jones, 2006) and extend demonstrations of relation priming to an expression-picture matching methodology.

Experiment 1 showed that relation priming occurred regardless of whether it was the head or the modifier that was repeated. Moreover, there was no indication that priming in the context of modifier repetition was any stronger than priming in the context of head repetition. These findings are incompatible with the predictions of CARIN, according to which relational information is associated with the modifier but not with the head. In contrast, they are compatible with schema-based models such as that of Estes and Jones (2006), in which relations are represented independently of the head and modifier concepts. There was also a reliable tendency to use more POSSESSOR descriptions when the head noun was repeated than when the modifier was repeated. Neither account specifically predicts this effect, but it is not inconsistent with them.

A further test of the two accounts would investigate priming in the absence of lexical repetition between prime and target. According to CARIN, priming should not occur under these circumstances because relation retrieval is dependent on modifier retrieval. According to Estes and Jones (2006), priming should occur because relation retrieval is independent of head or modifier retrieval. In Experiment 2, participants were therefore presented with primes that involved one of two semantic relations (POSSESSOR vs. DESCRIPTOR) followed by a choice of two target pictures, one of which corresponded to the same relation and the other of which corresponded to the alternative relation, but neither of which contained either of the two nouns that had appeared in the prime.

3.5 Experiment 2: Priming without repetition

Experiment 2 was designed to provide further evidence of relation priming in the comprehension of novel ambiguous noun-noun combinations, and specifically to investigate whether priming occurred in the absence of repeated constituents between prime and target. In other respects, it was identical to Experiment 1.

3.5.1 Predictions for the current study

According to CARIN, relation priming should only occur if the modifier concept is repeated between prime and target because relation retrieval is dependent on modifier retrieval. Therefore, CARIN predicts no relation priming in the absence of lexical repetition between prime and target. There should be no effect of prime Relation (POSSESSOR vs. DESCRITOR) on the interpretation of the ambiguous target. In contrast, according to Estes and Jones' (2006) independent model, relation priming *should* occur because relation retrieval is independent of head or modifier retrieval. Since under their account the representations of relations are distinct from the representations of the concepts they are linked to, the POSSESSOR and DESCRIPTOR relations should be activated by any combination that instantiates them. It follows, then, that *dog T-shirt* disambiguated with a POSSESSOR relation should prime participants to interpret *dinosaur flag* using the same POSSESSOR relation rather than the alternative DESCRIPTOR relation.

3.5.2 Participants

Thirty-two further participants from the University of Edinburgh student community were paid to take part. All were native speakers of English with no reading difficulties, and none had taken part in Experiment 1.

3.5.3 Materials and design

The pictures (including the fillers) for this experiment were identical to those in Experiment 1. However, the assignment of prime to target combinations was rotated, such that neither the head nor the modifier was repeated across prime and target (see Appendix A for a listing of prime-target pairs). Each item comprised a prime combination such as *dog T-shirt* together with a pair of pictures, one of which depicted either the POSSESSOR or DESCRIPTOR interpretation of the expression and one of which depicted neither interpretation of the expression; and a target combination such as *dinosaur flag*, together with pictures depicting each of the two interpretations of the phrase.

3.5.4 Procedure

This was the same as in Experiment 1 (see Section 3.4.4).

3.5.5 Coding and analysis

The dependent measure of interest was again whether participants selected a target picture depicting a POSSESSOR or a DESCRIPTOR relation. Coding of participant responses and calculations of POSSESSOR target ratios were therefore identical to those employed in Experiment 1.

3.5.6 Results and discussion

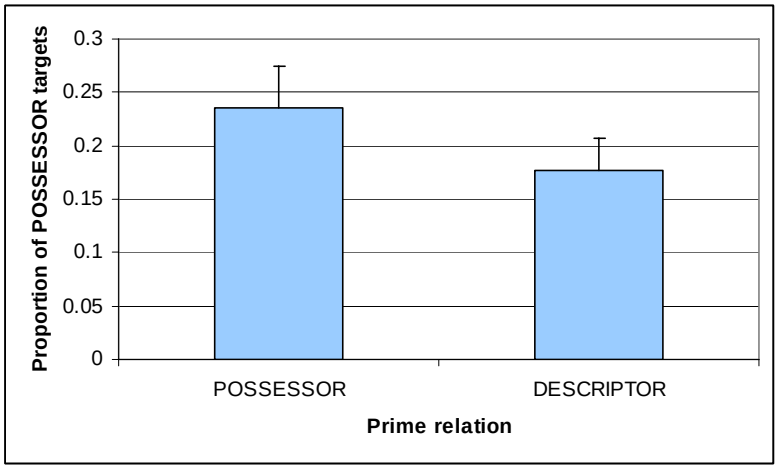
Correct prime pictures were selected on 982 trials (96%). Of these, 489 (50%) were POSSESSOR trials and 493 (50%) were DESCRIPTOR trials. On the corresponding target trials for these primes, participants chose 201 (20%) POSSESSOR and 781 (80%) DESCRIPTOR pictures respectively. Table 3-3 shows the number of POSSESSOR and DESCRIPTOR responses selected in each condition.

Table 3-3: Raw figures for POSSESSOR and DESCRIPTOR target responses in the two priming conditions of Experiment 2

	TARGET RESPONSE	
PRIMING CONDITION	POSSESSOR	DESCRIPTOR
POSSESSOR	117	371
DESCRIPTOR	85	409

One-way ANOVAs on the proportions of POSSESSOR target responses revealed a main effect of prime Relation (F_1 (1, 31) = 4.707; $p < .05$; F_2 (1, 31) = 4.370; $p < .05$); participants selected a higher proportion of POSSESSOR target pictures following POSSESSOR prime pictures (0.24) than following DESCRIPTOR prime pictures (0.18). These proportions are presented graphically in Figure 3-6.

Figure 3-6: Proportions of POSSESSOR target responses selected in the two experimental conditions of Experiment 2



As in Experiment 1, participants chose DESCRIPTOR relations more frequently than POSSESSOR relations. More importantly, the findings constitute strong evidence for relational priming in the interpretation of nominal combinations: Participants tended to select the same interpretation for an ambiguous combination that they had just used on a preceding prime trial. However, Experiment 2 demonstrated that these effects occurred in the absence of any lexical repetition between prime and target. That is, interpretation was facilitated on the basis of repetition of the semantic relation alone,

when neither the modifier nor the head was repeated. This result is inconsistent with CARIN's assumption of modifier-dependent relational representation (Gagné & Shoben, 1997). Rather, it offers support for Estes and Jones' (2006) independent representations model.

3.6 Comparison of Experiments 1 and 2

Estes and Jones (2006) did not directly address the issue of the effects of lexical repetition (of the head or modifier) on relation priming, but their account provides no reason to assume a lexical boost. In contrast, if relation priming is similar to syntactic priming (e.g., Cleland & Pickering, 2003), lexical repetition should enhance relational priming. To contrast these accounts, a combined analysis of Experiments 1 and 2 was conducted, in order to determine whether relation priming was enhanced by lexical repetition. Given that modifier-repeated and head-repeated conditions in Experiment 1 showed nearly identical results and Experiment 2 contained no comparable distinction, these two conditions were collapsed for the purposes of the following analysis. Accordingly, Relation (POSSESSOR vs. DESCRIPTOR prime) x Experiment (repetition vs. no repetition) ANOVAs were carried out on the POSSESSOR target proportions. Relation was within participants and items; Experiment was between participants but within items. The analysis revealed a main effect of Relation (F_1 (1, 62) = 28.501; $p <$ .001; F_2 (1, 31) = 41.715; $p <$ .001): Across experiments there was a 12% greater tendency to select target responses that were of the same type (POSSESSOR or DESCRIPTOR) as the prime response than target responses that were of the alternative type to the target response. More importantly, there was an interaction between Relation and Experiment (F_1 (1, 62) = 8.045; $p <$ .01; F_2 (1, 31) = 9.665; $p <$ .01): The 21% priming effect in Experiment 1 (i.e., when head or modifier was repeated) was significantly larger than the 6% priming effect in Experiment 2 (i.e., when neither head nor modifier was repeated). In other words, lexical repetition enhanced priming.

This result is not predicted by Estes and Jones' (2006) independent representation model, according to which there should be no difference in priming effects in the presence of repetition compared with priming effects in the absence of repetition. Since conceptual relations are independently primed in this account, the level of activation that a given relation receives should be the same whether or not there is overlap of lexical items between prime and target. Hence, although the results of

Experiments 1 and 2 argue against CARIN, they also suggest that Estes and Jones' (2006) independent model does not fully account for processes of conceptual combination.

Experiments 1 and 2 demonstrated a reliable tendency for participants to choose a picture to match an ambiguous combination that involved the same relation as they had used to match a combination to a picture on a preceding trial. I have interpreted this finding in terms of a linguistic priming effect centered on repetition of a particular relation. However, in both experiments the different interpretations of the ambiguous target combination were associated with visually distinct pictures; one in which the modifier was the visually most salient (e.g., in most cases, the largest) element in the picture (the POSSESSOR interpretation), and one in which the head was the visually most salient element (the DESCRIPTOR interpretation). Depending on the prime condition, the match (i.e., 'correct') prime picture would similarly contain either a visually salient modifier (for POSSESSOR primes) or a visually salient head (for DESCRIPTOR primes). Recall that in all experimental materials the modifier was animate and the head was inanimate. Hence, the priming effect found in Experiments 1 and 2 could reflect facilitation of perceptual processing by prior processing of a visual stimulus with similar salient visual characteristics: Participants might have preferred to choose similar over dissimilar pictures, without accessing the conceptual relation instantiated by the combination and depicted in the associated picture. For example, they might have preferred to choose a picture with a salient animate entity (modifier) after choosing a picture with a salient animate entity than after choosing a picture with a salient inanimate entity (head), or vice versa. That is, they would show a greater preference for choosing a picture of a tortoise after choosing a picture of a dog than after choosing a picture of a hat. The goal of Experiment 3 was to eliminate a possible visual priming account of the findings of Experiments 1 and 2. The dependent measure was again the proportion of POSSESSOR targets selected on target trials, with Relation manipulated in the prime.

3.7 Experiment 3: Is the priming effect visual or linguistic?

Experiment 3 employed the same technique as that used in the previous two experiments, with a new set of prime pictures. In this experiment, prime pictures contained both POSSESSOR and DESCRIPTOR relations within the same picture.

3.7.1 Predictions for the current study

Experiments 1 and 2 have shown that interpreting a combination like *dog T-shirt* using a POSSESSOR relation primes interpreting *dog scarf* (and indeed *dinosaur flag*) using the same relation. If the priming obtained in Experiments 1 and 2 was due to an interference of perceptual processing with language comprehension, reflecting facilitation by visual features of the pictures used, then this effect was non-linguistic. In this case, any priming effect would have been associated with the interpretation of visual stimuli, with participants paying attention to salient features of the pictures presented. If a visual priming explanation is correct, then the effect is dependent upon the match prime picture depicting a single relation. Hence this explanation predicts that the priming effect should disappear if the match prime picture depicts both relations, such that both alternative target pictures share common visual elements with the match prime. If, however, the priming effect is a linguistic effect based upon retrieval of the activated linking relation, then exposure to pictures containing both (POSSESSOR and DESCRIPTOR) relations *within the same picture* should yield relation priming. Experiment 3 was designed to distinguish between these two accounts. We used the conditions in which neither head or modifier was repeated between prime and target, so that we could be more confident that relational priming in the absence of lexical repetition is robust.

3.7.2 Participants

Twenty-four volunteers from the University of Edinburgh student community were paid to take part. All were native speakers of English with no reading difficulties, and none had taken part in the previous two experiments

3.7.3 Materials and design

The experimental prime pictures used in Experiments 1 and 2 were modified using GIMP image manipulation software, such that each picture contained both POSSESSOR and DESCRIPTOR relations within the same picture. The full stimulus set is presented in Appendix A. As before, each critical item comprised a prime combination and corresponding pair of (matching and nonmatching) pictures, and a target combination and corresponding pair of pictures. Primes were in two conditions, as shown in Figure 3-7, with the prime contrast between combinations like *dog T-shirt* (POSSESSOR) and *rabbit T-shirt* (DESCRIPTOR). In each quadrant, the match picture is shown on the left and the distracter picture is shown on the right; as in Experiments 1 and 2; this was counterbalanced in the experiment.

Figure 3-7: Experiment 3 sample experimental stimuli

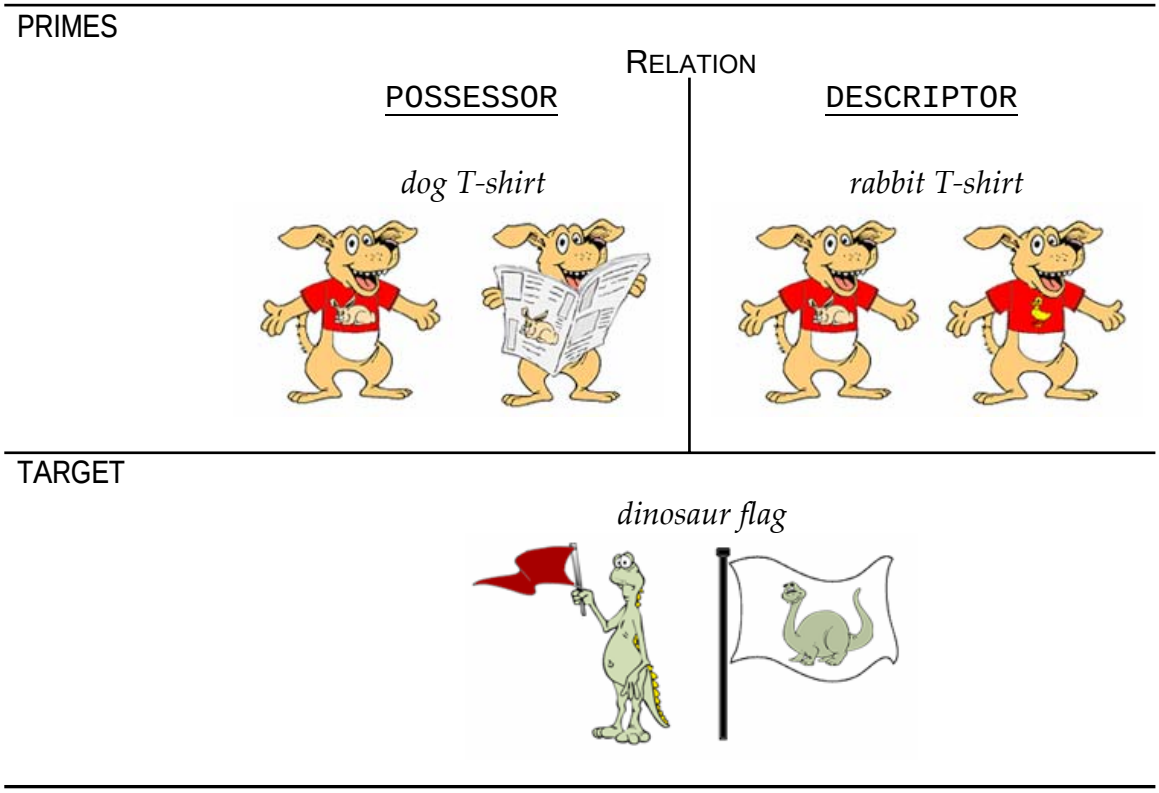


Figure 3-7 shows that the matching picture associated with the POSSESSOR interpretation of *dog T-shirt* depicted a dog wearing a T-shirt with a picture of a rabbit on it. In the DESCRIPTOR prime the identical picture appeared, this time matching the phrase *rabbit T-shirt*. In other words, a dog wearing a T-shirt with a picture of a rabbit on it depicted the phrase *dog T-shirt* and the phrase *rabbit T-shirt*, for POSSESSOR and DESCRIPTOR interpretations respectively. The alternative relation in each case was also included in the distracter picture. Prime combinations were the same as those used in Experiments 1 and 2, with the exception of 12 items. For these items, the combination that had appeared as the distracter in the first two experiments was used instead (e.g., *flamingo plate*, which had been a distracter in Experiments 1 and 2, replaced *flamingo ice-cream*), on the grounds that in these cases the distracter combinations allowed for easier depiction of the two relations within the same picture. Target combinations and picture pairs were the same as in Experiments 1 and 2. The example target *dinosaur flag* is shown at the bottom of Figure 3-7, with the corresponding pictures. As in Experiment 2, the item set was organized so that there was no lexical repetition between prime and target

phrases. The dependent measure of interest was again the proportion of POSSESSOR targets selected on target trials.

3.7.4 Procedure, coding, and analysis

These were the same as in Experiments 1 and 2 (see Section 3.4.4).

3.7.5 Results and discussion

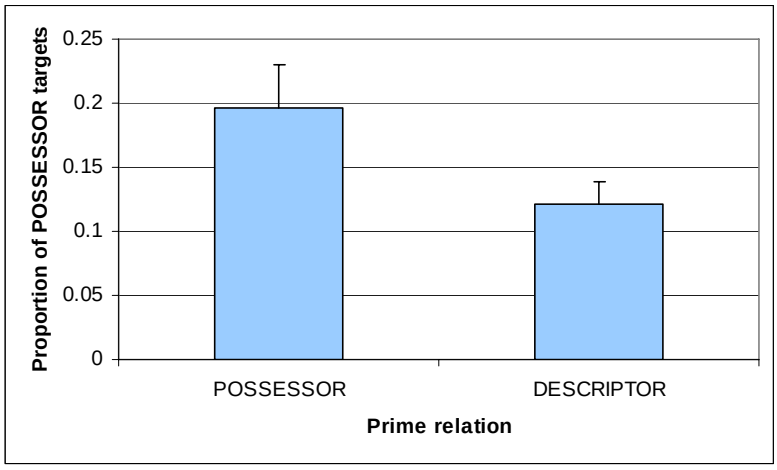
Correct prime pictures were selected on 737 trials (96%). Of these, 362 (49%) were POSSESSOR trials and 375 (51%) were DESCRIPTOR trials. In these 737 trials, participants chose 116 (16%) POSSESSOR and 621 (84%) DESCRIPTOR pictures respectively. Table 3-4 shows the number of POSSESSOR and DESCRIPTOR responses selected in each condition. As in Experiments 1 and 2, participants chose DESCRIPTOR relations more frequently than POSSESSOR relations.

Table 3-4: Raw figures for POSSESSOR and DESCRIPTOR target responses in the two priming conditions of Experiment 3

	TARGET RESPONSE	
PRIMING CONDITION	POSSESSOR	DESCRIPTOR
POSSESSOR	69	291
DESCRIPTOR	44	330

Figure 3-8 shows the proportions of POSSESSOR target responses in the two experimental conditions. One-way ANOVAs on the proportions of POSSESSOR targets in each condition revealed a reliable effect of Prime (F_1 (1, 23) = 5.939; $p < .05$; F_2 (1, 31) = 8.837; $p < .01$); participants produced reliably more POSSESSOR target interpretations following POSSESSOR primes (0.20) than following DESCRIPTOR primes (0.12). The magnitude of priming was 8%.

Figure 3-8: Proportions of POSSESSOR target responses selected in the two priming conditions of Experiment 3



In sum, there was significant relation priming when the prime picture contained both relations, arguing against a possible visual priming account. In selecting the correct prime picture to match the given phrase, participants were forced to assess both POSSESSOR and DESCRIPTOR relations; moreover, they could not choose a target picture based on visual similarity to the prime picture that they had previously chosen, because both alternative target pictures were visually similar (though in different ways) to the chosen prime picture. Hence these results suggest that the effect is linguistic in nature. Activation of the relevant relation, rather than visual properties of the pictures, led participants to reliably interpret the ambiguous target combination in the same way as they had interpreted the prime. It is worth noting, however, that the current design does not rule out another kind of visual strategy for interpretation, that is, one involving the discrimination of embedded objects: Participants might have preferred to choose a picture depicting the modifier noun as an embedded object (DESCRIPTOR) after choosing a picture depicting the modifier noun as an embedded object (DESCRIPTOR) than after choosing a picture depicting the modifier noun has a non-embedded object (POSSESSOR), or vice versa. That is, they would show a greater preference for choosing a picture of an embedded dinosaur after choosing a picture of an embedded rabbit than after choosing a picture of a non-embedded dog.

3.8 General discussion

Three forced-choice expression-picture matching experiments examined the interpretation of novel noun-noun combinations. They all showed reliable relation priming. Experiment 1 demonstrated that participants tended to interpret an ambiguous novel combination as involving the same relation as a disambiguated novel combination that they had just comprehended; this effect was stable over the course of the experiment. The priming effect was reliable and comparable in magnitude both when the head was repeated and when the modifier was repeated. Experiment 2 extended these findings by showing that priming occurred when both nouns in the prime differed from both nouns in the target. Experiment 3 demonstrated that priming without noun repetition did not depend upon visual similarities between the prime and target pictures.

Hence these results provide evidence of relation priming in the absence of lexical repetition. Previous empirical demonstrations of relation priming in the absence of lexical repetition have been open to alternative explanations. Gerrig and Murphy (1992) demonstrated relation priming between novel prime and target compound nouns embedded in the context of narratives. However, Gagné et al. (2005) suggested that participants' interpretations of the novel targets might not have depended on the prime, but rather on the content of the story. Thus their effects need not have been due to the repetition of a conceptual relation. Gagné et al. also argued that Estes' (2003) apparent relation priming of novel combinations could be due to a design confound, because prime and target modifiers and heads were not controlled for semantic similarity across experimental conditions. They therefore suggested that what was reported as relation priming could not be distinguished from semantic priming.

The design of the current set of experiments addressed these two points. The semantic relations expressed between modifier and head in the novel combinations were depicted in pictures. Hence the possible interpretations were clear and there was no possibility of discourse cues affecting comprehension. Furthermore, by constructing the materials set around ambiguous combinations, (word pairs that allow both the *head* POSSESSES *modifier* interpretation and the *head* DESCRIBES *modifier* interpretation, with the appropriate interpretation depending on the associated picture), identical phrases appeared across experimental conditions, ruling out the possibility of one condition being linguistically more similar to the target than the other. Hence we can be sure that the effects that we found reflect priming of relations and not of lexical representations.

The current findings also demonstrated relation priming both when the head and when the modifier was repeated, and suggested that priming was very similar in both cases. Although reliable differences in magnitude of priming occurred in the contrast between repetition and no repetition, they did not occur in the contrast between repeated modifier versus repeated head. This suggests that modifier concepts do not have a special role in the processing of combinations but rather play a comparable role to that of head concepts.

Importantly, Gagné and Shoben (2002) also demonstrated head repetition relation priming: They had participants verify definitions of ambiguous combinations and found that repeating the head and repeating the modifier facilitated response times and response accuracy to an equivalent extent. They pointed out that these data contrast with Gagné and Shoben's (1997) data on frequency effects and suggested that different mechanisms may underlie long-term versus short-term effects of head and modifier repetition in relation selection. They concluded that these data are not consistent with CARIN and that the theory needs modification to deal with short-term effects based on head repetition.

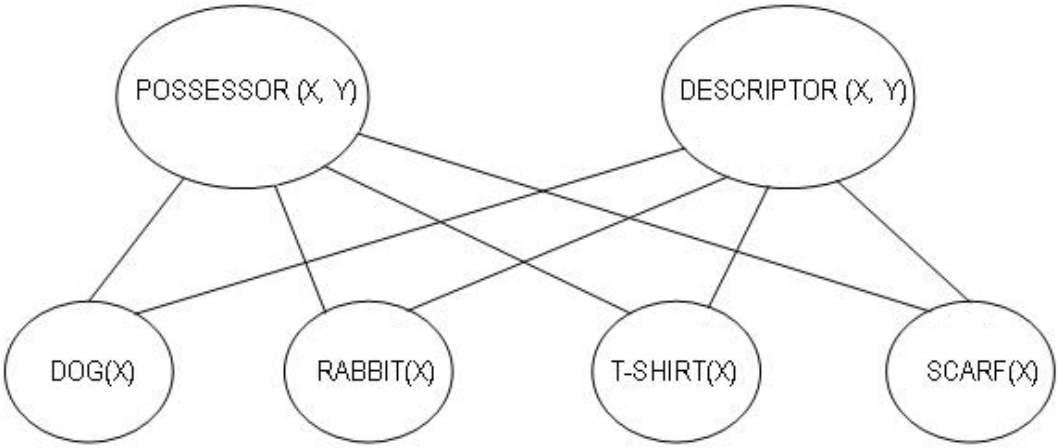
Taken together, these experiments cast new light on the influence of modifier and head constituents in the interpretation of novel combinations. The pattern of results is not compatible with the CARIN model. Gagné and Shoben (1997) presented RT data to argue that modifiers have a privileged status: Relations are stored as part of each modifier's representation, such that processing a combination involves mediated retrieval of the relevant relation via the modifier with which it is associated; relations have no independent existence in the semantic network. Thus priming of a semantic relation should only occur if the modifier constituent, which acts as the key to relation retrieval, appears in both prime and target. But the current set of experiments showed reliable priming (of choice of interpretation) when prime and target contained different modifiers. The results therefore show no evidence for the special status of the modifier, suggesting that modifiers do not have greater access to relational information than do head nouns. However, given that the CARIN model was proposed on the basis of RTs, the above data discrepencies might relate to the different form of response data; this issue is addressed in Experiment 4.

In contrast, the current findings are more compatible with some aspects of Estes' (2003; Estes & Jones, 2006) model. This model accords no privileged status to the modifier, and proposes that relations are represented independently in the semantic

network. Processing a combination involves direct (unmediated) retrieval of the relevant relation. Because relations are independent, they can be primed through prior use in the absence of repetition of modifier or head, in keeping with the current findings. The results therefore suggest that when people process nominal combinations they retrieve a conceptual relation, and that this process of retrieval is at least partly independent of the retrieval of information associated with the modifier and the head. However, one aspect of the current results is not predicted by Estes' model: Priming was stronger when either the head or the modifier was repeated than when neither the head nor the modifier was repeated. If relations were simply independently represented, there would be no reason to expect such a difference.

The finding of greater relation priming in the presence of lexical repetition converge with the findings for syntactic priming in language production, and suggest that a similar type of explanation may be appropriate. Such studies show priming in the absence of lexical repetition but enhanced priming in the context of such repetition (e.g., Branigan et al., 2000; Cleland & Pickering, 2003; Pickering & Branigan, 1998). Pickering and Branigan interpreted such results in terms of the Levelt et al. (1999) model of lexical representation, in which lexical entries are split into a conceptual stratum (that captures the meaning of words), a lemma stratum (that captures their syntactic properties), and a word-form stratum (that captures their phonological properties) (see Section 2.3.1). They constructed a network model of the lemma stratum in which the syntactic component of lexical entries (i.e., their lemmas) is associated with nodes corresponding to grammatical constructions. For example, transitive verbs such as *kick* and *drink* are linked to nodes corresponding to the active and passive constructions. Use of *kick* in the passive, for example, activates the *kick* node and the passive node, and their coactivation leads to a strengthening of the link between them. Activation does not decay immediately. The activation of the passive node thereby increases the chances of subsequently using a passive, and the strengthening of the link leads to a particularly strong tendency to subsequently use the passive with the verb *kick*.

Figure 3-9: The representation of relations within the conceptual stratum



I therefore propose a comparable account of relation priming, with the main difference being that the account is localized at the conceptual stratum rather than the lemma stratum. Let us assume that the concepts associated with each word are linked to particular relations, as shown in Figure 3-9. To capture the overall preference for DESCRIPTOR over POSSESSOR relations, the initial activation of the DESCRIPTOR(X, Y) node is greater than the activation of the POSSESSOR(X, Y) node (just as the initial activation of the ACTIVE node is greater than the initial activation of the PASSIVE node in English). Because relations constitute components of the meaning of lexical entries, the network forms part of the conceptual stratum rather than the lemma stratum, but the organizational principles are similar. Note that lexical entries are not decomposed into semantic features in Levelt et al.'s (1999) account. The associations between concepts and relational nodes hold equally for heads and modifiers, because the association between concepts such as DOG(X) or SCARF(X) and relations such as POSSESSSOR or DESCRIPTOR does not depend on how those concepts are used within an expression (i.e., whether they are used as heads or modifiers). Interpretation of *dog scarf* as meaning a dog wearing a scarf activates the DOG(X) node, the SCARF(X) node, and the POSSESSOR(X, Y) node. The simultaneous activation of the three leads to a strengthening of the connections between DOG(X) and POSSESSOR(X, Y) and between SCARF(X) and POSSESSOR(X, Y). Activation of the POSSESSOR(X, Y) node increases the likelihood of using the POSSESSOR relation to link a subsequent combination (of two new concepts). The strengthening of the connections between DOG(X) and POSSESSOR(X, Y) further increases the likelihood

of using the POSSESSOR relation if the DOG(X) concept is activated again, as in the subsequent comprehension of *dog T-shirt*. Likewise, the strengthening of the connections between SCARF(X) and POSSESSOR(X, Y) further increases the likelihood of using the POSSESSOR(X, Y) relation if the SCARF(X) concept is activated again, as in the subsequent comprehension of *rabbit scarf*.

In conclusion, relations appear to be represented in a partly independent and partly lexically-bound manner, just as syntactic information appears to be (Pickering & Branigan, 1998). The lexically-bound component does not appear to be modifier-specific. Instead, the associations between heads and relations and between modifiers and relations appear to be equally strong. I have argued that these findings can be integrated with accounts drawn from the literatures concerned with concept combination and psycholinguistics.

3.9 Summary

This chapter reported three priming experiments designed to evaluate competing theoretical accounts of conceptual combination, by focusing on the influences of head and modifier constituents on the comprehension of novel ambiguous combinations. Experiment 1 found evidence for relation priming, both when the modifier was repeated, and when the head was repeated. Experiment 2 replicated this finding in the absence of lexical repetition. A comparison analysis showed evidence for a lexical boost effect; priming was stronger in the context of repetition. Experiment 3 confirmed that the effects observed in the first two experiments were indeed linguistic, rather than visual. Taken together, the results of Experiments 1–3 argue against the CARIN model of conceptual combination and are more consistent with the account put forward by Estes and Jones (2006). I discussed how these findings might be interpreted in terms of a model of relational representation in the conceptual stratum based on Levelt et al. (1999).

Chapter 4

The time course of relation priming

4.1 Overview

In Chapter 3, we saw that listeners can be primed to repeatedly interpret ambiguous noun-noun combinations in the same way, reflected in the tendency to choose more POSSESSOR target pictures following POSSESSOR primes than DESCRIPTOR target pictures following POSSESSOR primes, and vice versa. This was argued to be clear evidence of relation priming in contexts not predicted by the CARIN model of conceptual combination (Gagné & Shoben, 1997). This chapter turns to the question of whether relation priming affects response times as well as choice of picture. Experiment 4 is therefore a follow-up study that used the same paradigm as the previous experiments to test whether the priming effect was reflected in faster response times. The experiment revealed a null result; there was no evidence for faster response times when prime and target pictures disambiguated the combinations in the same way. Possible reasons for this finding are discussed.

4.2 Introduction

Chapter 2 reviewed some of the theoretical assumptions underlying and empirical evidence for the main recent approaches to conceptual combination. Specifically, the CARIN model (Gagné & Shoben, 1997) was contrasted with schema-based approaches (Estes, 2003; Estes & Jones, 2006; Wisniewski, 1996, 1997) with respect to the key representational and processing assumptions underlying the two accounts. CARIN was the first theory of conceptual combination to extensively investigate reaction time (RT) data (but see Murphy, 1990). Indeed, notwithstanding converging *accuracy* measures of comprehension (Gagné, 2001; Gagné & Shoben, 2002), CARIN rests squarely on evidence consistently captured in RT terms: The theory's basic claim is that comprehension of a combination involves finding a relation to link the modifier and head concepts, and that relation frequency of the modifier, but not that of the head noun, predicts RTs in judging the sensicality of noun-noun combinations. (Gagné & Shoben, 1997; Gagné, 2001). Relation frequency (in technical terms, the *relational distribution*) refers to the frequency with which a relation has occurred in previous combinations involving a particular concept.

Recall from Chapter 2 the experiments presented in Gagné and Shoben (1997): Participants were made to judge the sensicality of combinations; these were of three different types, reflecting the frequency with which the relation instantiated by the combination was associated with the individual concepts. Thus a relation was high (H) or low (L) frequency for the modifier and head constituents respectively. The authors found that people were quicker to interpret HL combinations like *chocolate rabbit* (meaning *rabbit* MADE OF *chocolate*) and HH combinations like *chocolate utensils* (meaning *utensils* FOR *chocolate*) than LH combinations like *chocolate plant* (meaning *plant* MAKES *chocolate*). There was no reliable difference in RTs between the HH and HL conditions. On the basis of these results, Gagné and Shoben argued that ease of processing, reflected in RTs, was associated with the frequency of the relation associated with the modifier, while the frequency of the relation associated with the head did not affect processing.

There has been a recent flurry of published articles debating the validity of Gagné and Shoben's (1997) reported RT findings. Murphy and Wisniewski (2006; Storms & Wisniewski, 2005) raised concerns as to Gagné and Shoben's method for determining the relation frequencies of modifiers and heads in their materials (see also Maguire et al., in

press). They argued that the measure used in the original study was not representative of the true distributions of relations used with the words in the stimulus set as they occur in natural language. In constructing their materials, Gagné and Shoben selected 91 modifiers and 91 heads from 100 combinations collected by Levi (1978). Coupling every modifier with every noun yielded 8281 combinations, 3239 of which they judged as having sensible meanings. They then classified these according to the set of 15 relations (see Section 2.4.1). Next, they established the relation frequency for each modifier and each head by calculating the percentage of combinations involving that noun and relation. For example, the modifier *mountain* occurred 82% of the time with the LOCATED relation for interpretations of combinations involving *mountain* as the modifier. Murphy and Wisniewski suggested that frequency of relation type was confounded with familiarity and plausibility. They analyzed Gagné and Shoben's materials for plausibility (using participant ratings) and familiarity (measured in numbers of Google search hits) and found that these two factors were correlated with the RT patterns in Gagné and Shoben's results. So, they argued that the effects could have been due to plausibility or familiarity, and not relation frequency. The dialogue continues, with confusing results. Gagné and Spalding (2006) and Murphy and Wisniewski (2006) in turn debate the theoretical bases of the relationship between plausibility and familiarity, and relation frequency.

Priming studies conducted by Gagné (Gagné, 2001; Gagné, 2002; Gagné & Shoben, 2002) have all focused on RT measures. In all of these studies, target combinations were preceded by one of several prime combinations, and the dependent variable of interest was the time taken to interpret the target combination. For example, Gagné (2001) studied the effects of relation and repetition priming on sensicality judgements of unambiguous combinations like *murder film* (meaning *film* ABOUT *murder*). Comparing a same modifier, same relation condition (e.g., *murder investigation*) with a same modifier, different relation condition (*murder attempt*) and a different modifier, different relation control condition (*vocal range*), she found that repeating the modifier resulted in relation priming. Responses to *murder film* were faster and more accurate following *murder investigation* than following *murder attempt* or *vocal range*. A lexical effect was also evident in faster and more accurate responses to *murder attempt* than to *vocal range*. In a second experiment Gagné found different results when the repeated constituent was the head: Comprehension of the same relation (*poverty film*) and different relation (*foreign film*) conditions was faster and more accurate than the control condition (*vocal range*) but there

was no significant difference in RT or accuracy between same relation and different relation conditions. In contrast, using an identical task, Gagné and Shoben (2002) showed that comprehension of target combinations such as *adolescent doctor* was faster and more accurate following both *adolescent magazine* (where the modifier was repeated) and *animal doctor* (where the head noun was repeated) than following *country doctor*.

In contrast, Gagné (2002) reported RT data from a further priming study, which appears to be inconsistent with predictions made by CARIN. Participants were faster to respond to *student vote* when the prime combination used either a similar modifier with the same relation (e.g., *scholar accusation*) than when the prime used a similar modifier with a different relation (e.g., *scholar car*). But when primes contained similar heads, comprehension of the target *oil treatment* was not faster in the same relation condition (*surgery remedy*) than the different relation condition (*disease remedy*). This constitutes evidence of priming in the absence of lexical repetition. In the sections that follow, I report an experiment designed to examine the effects of priming on the time taken to choose between target pictures using the current set of materials.

4.3 Experiment 4: Does priming affect response latency?

Experiments 1–3 demonstrated that participants tended to interpret ambiguous combinations in the same way as they had interpreted a preceding (disambiguated) prime combination. That is, prior processing of a POSSESSOR relation increased the likelihood of using a POSSESSOR relation to interpret a subsequent combination, rather than the DESCRIPTOR alternative. Given the robust priming effects on choice of relation, an obvious question is whether priming affected the time taken to comprehend the target combination. Gagné (2001, Gagné & Shoben, 2002) reported RT evidence for relation priming, in contexts where relations were repeated between prime and target (although notably only for modifier repeated conditions). And there is also evidence from the syntactic priming literature for faster response times on target utterances that are structurally congruent with a previously comprehended prime (Branigan et al., 2005; Corley & Scheepers, 2002; Smith and Wheeldon, 2001). Branigan et al. (2005) showed that participants were faster to adopt an interpretation when they had just read a prime expression that was disambiguated to the same interpretation than when they had just read a prime expression that was disambiguated to the other interpretation.

To achieve a straightforward test of response times in the context of the current experimental design, Experiment 4 tested the effects of comprehending a disambiguated prime on the time taken to comprehend a disambiguated target. The critical manipulation was the prime-target pairing, specifically if relations were congruent or incongruent across the experimental item.

4.3.1 Predictions for the current study

As before, in testing for effects of relation priming in the interpretation of ambiguous combinations, we hypothesize that listeners will be faster to respond to target combinations that repeat the relation instantiated in the prime. That is, they should be faster to choose a picture of a dinosaur holding a flag (over the alternative picture of a dinosaur holding a present) as the match for *dinosaur flag*, if the preceding matching picture (for *dog T-shirt*) is a picture of a dog wearing a T-shirt (POSSESSOR), rather than if the preceding matching picture (for *rabbit T-shirt*) is a picture of a T-shirt with a rabbit on it (DESCRIPTOR). Based on the findings of Experiments 1–3, we can assume that comprehending the prime combination will lead to activation of one of the two relations (POSSESSOR or DESCRIPTOR). If the target picture matches the interpretation of the highly activated relation, comprehension should be facilitated. But if interpreting the target picture requires retrieval of the alternative relation, participants should take longer to select the matching picture.

4.3.2 Participants

Sixty-eight participants from the University of Edinburgh student community were paid to take part. All were native speakers of English with no reading difficulties, and none had taken part in Experiments 1–3.

4.3.3 Materials and design

The combinations and pictures (including fillers) for this experiment were identical to those in Experiment 3, with the exception that target combinations were disambiguated by the pictures. That is, like prime trials, target trials also comprised a matching and a nonmatching picture, such that only one of the pictures was a 'correct' depiction of the target combination. Hence, participants were forced to adopt either a POSSESSOR or a DESCRIPTOR interpretation. Thus there were four experimental conditions, as shown

in Table 4-1. Primes either depicted a POSSSESSOR or a DESCRIPTOR interpretation of the combination, and similarly, targets either depicted a POSSESSOR or DESCRIPTOR interpretation of the combination.

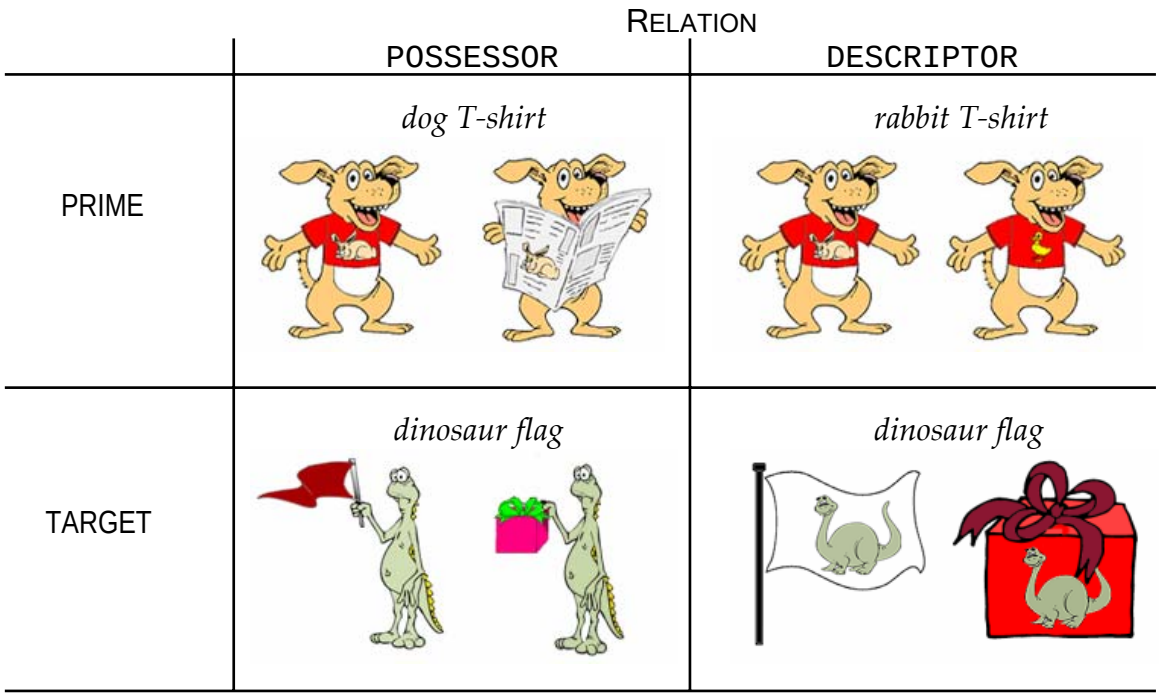
Table 4-1: Experiment 4 design showing the four experimental conditions

	TARGET RELATION	
PRIMING RELATION	POSSESSOR	DESCRIPTOR
POSSESSOR	P prime, P target	P prime, D target
DESCRIPTOR	D prime, P target	D prime, D target

Figure 4-1 shows a sample experimental item for Experiment 4. Congruent conditions (i.e., PP and DD) combined prime pictures in the top-left quadrant of the figure with target pictures in the bottom-left quadrant, and prime pictures in the top-right quadrant with target pictures in the bottom-right quadrant respectively. Similarly, incongruent prime-target conditions (i.e., PD and DP) combined prime pictures in the top-left quadrant of the figure with target pictures in the bottom-right quadrant, and prime pictures in the top-right quadrant with target pictures in the bottom-left quadrant respectively.

In the POSSESSOR prime condition the nonmatching pictures differed from the matches by having different heads (e.g., *dog newspaper* vs. *dog T-shirt*), whereas in the DESCRIPTOR prime condition the nonmatching pictures differed from the matches by having different modifiers (e.g., *duck T-shirt* vs. *rabbit T-shirt*). In the targets, half of the nonmatching pictures differed from the matches by having a different head (e.g., *dinosaur present* vs. *dinosaur flag*), and the other half differed from the matches by having a different modifier (e.g., *chimpanzee gloves* vs. *lizard gloves*). As in Experiments 2 and 3, the item set was organized so that there was no lexical repetition between prime and target phrases. The fillers were identical to those used in Experiment 3.

Figure 4-1: Experiment 4 sample experimental stimuli



The experimental items were organized into four lists, each including eight items per condition, such that one version of each item appeared in each list. Each list of 160 noun phrases and pictures (32 primes, 32 targets, and 96 fillers) was individually randomized for each participant, with the constraints that each prime immediately preceded the associated target and that at least two filler trials intervened between experimental trials.

4.3.4 Procedure

The procedure was identical to Experiments 1–3 (see Section 3.4.4), except that participants were explicitly instructed to respond as quickly as possible.

4.3.5 Coding and analysis

Each participant was presented with 32 targets, eight in each of the four priming conditions (PP, PD, DP, DD). Each target expression and corresponding pair of pictures were presented to all 68 participants, such that 17 participants saw any one version of an experimental item. Participants' choices and response times were recorded for prime and target pictures using Eprime software.

Both accuracy and outlier response times were taken into account in preprocessing the data. Nine participants were eliminated on the grounds that they had

five (15%) or more incorrect prime responses; it was assumed that they did not understand the task. These participants were unevenly spread across the four lists. Therefore, to counterbalance this procedure, three further participants were removed at random from the other list groups, two from list A and one from list C respectively. This left 56 participants' data for analysis. Next, trials on which a participant failed to select the matching prime picture were eliminated from the analysis (110 trials). If a participant failed to select the matching target picture, the response time for that item was removed from the target picture responses only (33 target trials). For the remaining trials, any response time over 4000 ms was excluded (9 prime trials, 1 target trial). In the participants analysis, any datum more than 2 standard deviations above or below the grand mean of a participant was replaced with the cut-off value (210 prime trials; 90 target trials). Similarly in the items analysis, any datum more than 2 standard deviations above or below the grand mean of an item was replaced with the cut-off value (80 prime trials; 67 target trials). ANOVAs were carried out on the data, with Prime (POSSESSOR vs. DESCRIPTOR) and Target (POSSESSOR vs. DESCRIPTOR) as factors, and separate analyses treating participants (F_1) and items (F_2) as random effects. Both factors were treated as within participants and items.

4.3.6 Results

Participants correctly identified the matching prime picture on 1682 trials (93.9%). Nine prime trials with responses over 4000 ms were also excluded. Of these 1682 trials, 1649 (98.0%) target pictures were correctly identified. There was one target trial with a response time over 4000 ms; this was excluded from the target response analysis. Table 4-2 shows the breakdown of errors across the four conditions for prime and target trials respectively. Table 4-3 lists the mean response times and standard deviations across the four conditions for prime and target trials respectively.

Table 4-2: Number of errors per condition in Experiment 4

	NUMBER OF ERRORS	
PICTURES	POSSESSOR target	DESCRIPTOR target
Prime		
Prime		
POSSESSOR	30	46
DESCRIPTOR	19	15
Target		
Prime		
POSSESSOR	8	7
DESCRIPTOR	11	7

Table 4-3: Means and standard deviations in milliseconds for response times in each condition in Experiment 4 (based on participant analyses)

	POSSESSOR target		DESCRIPTOR target	
PICTURES	Mean	SD	Mean	SD
Prime				
POSSESSOR prime	1113	312	1158	299
DESCRIPTOR prime	1238	203	1306	250
Target				
POSSESSOR prime	903	169	888	149
DESCRIPTOR prime	922	185	890	162

To determine whether participants were faster to interpret POSSESSOR or DESCRIPTOR relations with no prior prime combination, ANOVAs were carried out on the prime picture response times. Results revealed a significant effect of Prime (F_1 (1, 55) = 33.463, $p < .001$; F_2 (1, 31) = 8.281, $p < 0.01$); participants were faster to interpret POSSESSOR relations than DESCRIPTOR relations in the absence of priming. Target was not included as a factor in the analysis of prime responses; given that the target

pictures had not been seen when participants made their prime choice, any effect of Target on prime response would be spurious.

Two-way ANOVAs on the target response times revealed no significant main effects (*F*s < 1), with the exception of a marginal effect of Target in the participants analysis; F_1 (1, 55) = 3.054, p = 0.08). In addition, there was no interaction between Prime and Target (both *F*s < 1), indicating that participants were not quicker to respond whether the prime and target relations were congruent or incongruent.

4.4 Discussion

Using an expression-picture matching task, Experiment 4 investigated whether participants were faster to respond to targets that disambiguated a combination in the same way as a preceding prime picture. Results showed no effect of priming on target RTs; participants were not faster to select pictures when the target relation was congruent than when the target relation was incongruent. There was a main effect of Prime on the prime trials; participants were faster to select POSSESSOR pictures than DESCRIPTOR pictures. In short, while the results of Experiments 1–3 showed that priming affects choice of analysis, the current results suggest that it does not affect speed of response.

While the current null results are inconsistent with previous studies reporting RT measures of relation priming (Gagné, 2001; Gagné, 2002; Gagné & Shoben, 2002), there may be sound methodological reasons for this discrepancy. RT data are notoriously susceptible to influences from unplanned-for factors. Indeed, Gagné and Shoben's (1997) findings have been called into question for this very reason (Murphy & Wisniewski, 2006), and Spellman and colleagues (2001) failed to obtain priming of RTs in some conditions. The fact that accuracy was high in the current experiment (93.9% for prime trials and 98% for target trials) means that participants did, on the whole, interpret the combinations using the relations intended. Recall that this experiment used the same prime materials as Experiment 3. The prime pictures contained both possible relations within the same picture, and the 'correct' picture was the same across conditions; the combinations themselves (and nonmatching pictures) differed. Thus, the matching picture across both prime conditions was a picture of a dog wearing a T-shirt with a picture of a rabbit on it, and in the POSSESSOR condition the accompanying combination was *dog T-shirt*, whereas in the DESCRIPTOR condition it was *rabbit T-shirt*.

Word frequency was not controlled for in the construction of materials. Perhaps then, the fact the prime combinations used different nouns across conditions had an influence on the comprehension time. Participants correctly interpreted *dog T-shirt* as meaning a dog wearing a T-shirt (POSSESSOR), and *rabbit T-shirt* as a T-shirt with a picture of a rabbit on it (DESCRIPTOR). But the word frequencies of *dog* and *rabbit* would have affected the time taken to interpret the respective combinations. While the (primary) analyses for this experiment were on target times, the fact that word frequency may have been a source of noise (affecting times taken to interpret primes) is a problem for a test of priming.

Two further issues to consider are familiarity and plausibility. Again, these were not controlled for in the construction of materials. The items were all novel ambiguous combinations with relatively extraordinary referents; most (if not all) of them were unlikely to have been encountered before, bar the remarkable exception of a participant who happened to own a cushion with a picture of a rhino on it (a *rhino cushion*). Certainly, comments passed by participants as they left the experiment suggested that they found the referents strange. So even if they were able to interpret the combinations using the correct relation, the fact that the referents of the phrases were unfamiliar or implausible might have meant that they hesitated in responding. This would not necessarily be a sign of processing difficulty. Rather, the decision might have been affected by the familiarity or plausibility of the referent. In short, familiarity and plausibility may have been further sources of noise affecting RTs in the current experiment.

It is important to note that the findings of Experiment 4 are not inconsistent with the account of relational representation put forward in Chapter 3. There are good reasons to assume that RTs are not an appropriate measure of priming for the current set of experimental stimuli. We would have to use the same combinations across the different conditions to be sure that there is no additional noise caused by word frequency, familiarity or plausibility that would affect RTs. On methodological grounds, then, it seems appropriate to consider conducting a more tightly controlled RT study within the current experimental paradigm, in order to gain insight into the time course of relation priming.

4.5 Summary

This chapter reported a priming experiment designed to measure relation priming with response times. Experiment 4 showed a null result; participants were not faster to respond to targets that instantiated the same relation as the prime.

Chapter 5

Priming the production of coerced expressions

5.1 Overview

This chapter reports three experiments designed to investigate whether speakers employ mechanisms of enriched semantic composition in producing coerced expressions such as *The commuter finished the newspaper*. All three experiments used a sentence completion/picture description priming paradigm, where participants completed sentence fragments (e.g., *The author began the*, *The penpal finished writing the*) to describe accompanying pictures. Experiment 5 investigated whether or not speakers could be primed to produce complement coercions, in which part of the meaning of the message (specifically, the event structure associated with the coercing verb) was encoded in elided semantic material. The results demonstrated robust and reliable priming, suggesting that speakers are susceptible to priming of abstract semantic structure in production. However, given the *syntactic* correspondences with the levels of semantic specification expressed in the two priming conditions, another possible account of the results is discussed, i.e., that the priming effect observed in Experiment 5 was driven by syntactic

mechanisms alone. Experiment 6 explored the effect of non-repetition of the coercing verb between prime and target sentence fragments. The results replicated the priming found in Experiment 5, but this effect was smaller, and significant only in the by-items analysis. The results of this experiment, and a comparison between the two experiments, are interpreted in terms of the *lexical boost* effect. Experiment 7 was designed to address the syntactic-semantic distinction that was impossible to isolate in Experiments 5 and 6. Besides replicating the findings of the previous two experiments, this experiment established syntactic and semantic components to the priming effect. Taken together, these experiments constitute an initial investigation into the mechanisms of coercion in production. The results are interpreted in terms of a model of language production (based on Levelt et al., 1999) in which the combinatorial nodes connected to verb lemmas (in the lemma stratum) receive activation from conceptual nodes (in the conceptual stratum) via activation of abstract semantic nodes (in the conceptual stratum).

5.2 Introduction

Began the book can be interpreted as *began reading the book*, *began writing the book*, or even in other ways like *began binding the book* or *began editing the book*. This is because verbs like *begin*, *finish* and *enjoy* take on different meanings depending on their local syntactic context (see Section 2.5.1). In grammatical terms, this class of verbs requires an event complement; where the surface form contains an entity complement, the complement is type-shifted from an entity to an event (Pustejovsky, 1991, 1995) or, in McElree et al.'s (2001) terms, 'coerced' into an eventive reading. Importantly, the abstract event structure projected by such verbs is interpolated between *began* and *the book*, and recovering this material for interpretation requires an enriched form of composition (Jackendoff, 1997). Enriched composition refers to the underlying event structure that makes explicit the missing information in the expression. All other things being equal, the default interpretation for the coerced expression is determined by the (telic or agentive) qualia roles of the noun complement (Pustejovsky, 1991, 1995). So, assuming that the telic role of book is *read* and the agentive role is *write*, *began the book* is interpreted as *began reading the book* or *began writing the book*. Pustejovsky (1995) suggests that the telic role is the default role recovered, but Lapata and Lascarides (2003) argue against this; they claim that the default interpretation depends on the noun, e.g., whereas the telic role may be the default

role recovered in the case of *book*, *begin the tunnel* can only mean *begin building the tunnel* (agentive), not *begin going through the tunnel* (telic).

As detailed in Chapter 2, there is a substantial body of evidence for mechanisms of coercion in language processing, but, crucially, this is exclusively in the domain of comprehension. Written comprehension studies involving self-paced reading and eye-tracking have repeatedly found that readers have greater difficulty processing complement coercions than various kinds of control expressions (McElree et al., 2001; McElree et al., 2006; Pickering et al., 2005; Traxler et al., 2002; Traxler et al., 2005). That is, when people read the sentence *The author began the book*, they are able to retrieve a meaning for the event expressed, but there are increased processing costs involved with interpreting such expressions. For example, people take longer, and make more regressive eye movement when reading sentences like *The author began the book* than when reading non-coerced controls like *The author wrote the book*, *The author began writing the book*, *The author saw the book*, *The author began the lecture*, and *The author saw the lecture*. Consistent with linguistic accounts of coercion (Pustejovsky, 1991, 1995; Jackendoff, 1997), the critical factor from a processing point of view is the *combination* of an event-taking verb like *began* with an entity-denoting noun like *book*. Importantly, it is not type-shifting per se that causes the cost, but the repair of the type-mismatch between an event-selecting verb and an entity-denoting object (Traxler et al., 2002). The work of McElree, Pickering, Traxler, and colleagues has focused mainly on complement coercion, but similar cost effects have been shown for other types of coercion, e.g., aspectual coercion, involving the combination of a telic verb with an atelic aspectual (adverbial phrase) modifier (Piñango et al., 1999).

It has been argued, then, that listeners employ mechanisms of enriched composition in comprehension, but do speakers rely on enriched composition in production? Specifically, how do speakers encode the missing semantic structure associated with coerced structures like *The author began the book*? Highlighting the differences between the respective processing challenges of comprehension and production, Bock (1991, p. 142) contends that 'a very general problem for a theory of production is to explain how speakers create linguistic structure at all levels'. Accounting for coercion in production is inextricably linked with an explanation of how speakers combine semantic and syntactic information when they formulate utterances. In Chapter 2 we saw that the standard psycholinguistic model of language production comprises the three levels of conceptualization (the message level), formulation (involving lexical

selection and grammatical encoding), and articulation (resulting in output forms) (Levelt, 1989; Bock & Levelt, 1994; Dell, 1986). Within this framework, the domain of enquiry for the present study is the meaning-to-form mapping processes that straddle the levels of conceptualization and formulation, i.e., the interaction of semantic and syntactic mechanisms in the generation of linguistic representations.

From pre-linguistic communicative intentions created at the conceptual (message) level, individual lexical items are combined to form larger, syntactically-specified structures according to the grammatical rules of the language (Bock & Levelt, 1994; Garrett, 1980, 1988; Levelt, 1989). As reviewed in Chapter 2, there is an extensive body of work demonstrating that these meaning-to-form mapping procedures are, or can be, affected by conceptual features of the underlying message (Bock & Warren, 1985; Bock & Loebell, 1990; Bock et al., 1992; McDonald et al., 1993; Ferreira, 1994; Griffin & Weinstein-Tull, 2003; Chang, Bock, & Goldberg, 2003). Most of the evidence centres on the influence of conceptual factors such as animacy, concreteness, and prototypicality (captured in the notion of 'conceptual accessibility'; Bock & Warren, 1985) on the mapping of the argument structure projected by verbs. The core debate has focused on the degree to which syntactic structure (specifically, grammatical function assignment and word order) is independent of conceptual factors. Some studies have found that conceptual accessibility influences the assignment of grammatical roles (e.g., subject, object) but not the mapping of word order (Bock & Warren, 1985; Bock & Loebell, 1990; Bock et al., 1992). But more recent (cross-linguistic) evidence suggests that word order preferences may be influenced by animacy (Tanaka et al., 2005). Importantly, however, the empirical work on meaning-to-form mapping in production has been restricted to conceptual features that are overtly realised in surface syntactic structures, and does not extend to conceptual representations that remain abstract and unexpressed, as in the case of event structure in complement coercion. Enriched composition has been shown to underlie the comprehension of complement coercion, such that interpreting such expressions is taxed by the generation of abstract event structure associated with recovering the eventive reading of an entity complement. But do similar abstract representations underlie the production of complement coercions? And, assuming it does exist, how might such abstract structure influence the meaning-to-form mapping mechanisms?

In the sections that follow, I report three experiments designed to examine the effects of priming on the production of complement coercions. The aim of the

experiments was to explore the workings of coercion in production by looking for evidence of enriched composition via semantic priming. The collective findings are interpreted in the light of Pickering and Branigan's (1998) lemma-level extension to Levelt et al.'s (1999) model of lexical representation. The model proposed connects the syntactic alternations associated with discrete combinatorial nodes at the lemma level to a common message-level conceptual representation that underlies the production of both complement coercions (e.g., *The author began the book*) and their fully-specified (non-coerced) alternatives (e.g., *The author began writing the book*).

5.3 The sentence completion/picture description priming paradigm

The experiments reported in this chapter use a combined sentence completion/picture description task to investigate priming of abstract semantic structure. Sentence completion and picture description tasks have been used in a wide range of previous production studies (e.g., Branigan et al., 2000; Bock, 1986; Bock, 1990). In the 'combined' paradigm, participants are presented with a written sentence fragment to complete in a way that best describes a picture; the dependent variable of interest is the form of the sentence completion. In the context of the questions that the current set of experiments seek to address, the pictures are critical in constraining possible responses, in that participants are directly prompted to produce completions that include noun phrase complements expressing entities (Experiments 5 and 6), which are potential candidates for semantic type coercion, and noun phrase complements expressing events (Experiment 7), which offer a further invaluable priming contrast.

As an empirical tool, priming has had an enduring influence on language processing research, not least in production studies (beginning with Bock, 1986). Placing the above experimental task in a priming paradigm sheds light on whether abstract semantic structure, such as that underlying elided material in complement coercions, is relevant to the language processor. If coercion occurs in production, the abstract event representations that are generated by enriched composition should be susceptible to the effects of semantic priming. Unlike Meyer and Schvaneveldt's (1971) original demonstration of semantic priming effects (which were interpreted in terms of semantic relatedness and therefore had implications for categorization), semantic priming in the

context of the production of coerced expressions will have implications for the mapping of conceptual representations onto syntactic structure.

5.4 Experiment 5: Coercion in sentence production

The first of the three experiments is a straightforward priming study of complement coercion in production. Can speakers be primed to repeatedly express the same level of semantic specification? In other words, after producing *The author began the book*, are they more likely to say *The bricklayer began the wall* or *The bricklayer began building the wall*? More specifically, is there evidence for enriched composition in the production of complement coercions? That is, do speakers generate abstract event structure when they produce utterances like *The author began the book*? In the context of production, enriched composition would involve generating abstract representations at an early (conceptual or message) level that are not subsequently realized grammatically in the syntax. Moreover, following proposals by Pustejovsky (1991, 1995) and Jackendoff (1997), these abstract representations would mediate the interaction of the coercing verb and its complement.

5.4.1 Predictions for the current study

In priming the production of complement coercions, where speakers have the option of either spelling out the missing predicate or leaving it unexpressed, the enriched composition hypothesis predicts an effect of prime sentence fragment type (*The author began the* vs. *The author began writing the*). Producing the completion *book* following *The author began the* implies the generation of abstract event structure after the coercing verb *began*, whereas this semantic representation is mapped onto the surface syntactic form where the verb phrase includes the explicit event argument (cf. the completion *book* following *The author began writing the*). If coercion occurs in production, then we would expect to see evidence of priming of abstract event structure, i.e., we would expect participants to be primed to produce coerced structures. Therefore, the enriched composition hypothesis predicts that production of *The author began the book* should prime *The bricklayer began the wall* and *The author began writing the book* should prime *The bricklayer began building the wall*. That is, prime and target should express the same level of semantic specification.

5.4.2 Participants

Thirty-two undergraduate students from the University of Edinburgh community were paid to participate. They were all native English speakers and had no reading difficulties.

5.4.3 Materials and design

Sixteen experimental item sets were created around eight coercing verbs. The full stimulus set is listed in Appendix C. Each critical item comprised a prime sentence fragment and corresponding picture, and a target sentence fragment and corresponding picture.

All pictures were created using Art Explosion ClipArt software and depicted an action involving an agent and an object undergoing the action. Typical actions involved creating and consuming (writing, reading, eating, drinking, making, and sculpting) in the context of events such as a woman drinking champagne, a bartender making cocktails, a grandmother knitting a sock, and a commuter reading a newspaper. Pictures were presented in colour on a white background.

Prime sentence fragments consisted of the following sequence: a noun phrase, a critical (coercing) verb (e.g., *began*) and condition-dependent post-verbal material. Primes were in two conditions, as shown in Figure 5-1. In the coerced condition the post-verbal material consisted of the definite determiner *the*. In the full-VP condition the verbal complement comprised a progressive verb (e.g., *writing*) followed by the definite determiner *the*. The contrast, then, was between *The author began the* and *The author began writing the*. The prime picture was the same for both conditions. Target sentence fragments consisted of a noun phrase and a critical (coercing) verb (e.g., *began*). A target picture depicted the target sentence fragment.

The qualia roles of the nouns to be elicited in the picture descriptions were taken into account in the design of the materials set. Experimental items were counterbalanced such that each coercing verb occurred once expressing an agentive role and once expressing a telic role (of the noun complement). The verb *enjoy* was the exception to this, since no examples could be found where it would occur naturally with an agentive reading (Lascarides & Copestake, 1998).

In addition to the 16 experimental item sets, there were 48 filler sentence fragments and associated pictures. Of these, 32 pictures depicted transitive actions, and the corresponding sentence fragments consisted of the following sequence: a noun phrase, an auxiliary verb, a transitive verb and a definite determiner, e.g., *The butcher was*

preparing the. The remaining 16 filler pictures showed intransitive actions, and the matching sentence fragments consisted of a noun phrase and an auxiliary verb, e.g., *The rocker was*. Verbs were in the past tense across the entire experiment e.g., *was, began drinking*. Experimental items used the simple past (coerced condition) or past progressive (full-VP condition); similarly, filler items used the simple past (intransitive) or past progressive (intransitive).

Both coerced and full-VP prime sentence fragments were displayed with the same picture. Thus *The author began the* (coerced) and *The author began writing the* (full-VP) were displayed with the picture at the top of Figure 5-1. The target sentence fragment *The bricklayer began* is shown at the bottom of Figure 5-1, with the corresponding picture. Figure 5-2 shows exemplars of transitive and intransitive filler sentence fragments and pictures respectively.

The experimental items were arranged into two lists, each made up of eight items per condition, with one version of each item appearing in each list. Each list of 80 pictures and sentence fragments (16 primes, 16 targets, and 48 fillers) was individually randomized for each participant, such that each prime was immediately followed by its associated target, and critical trials were separated by at least two filler trials.

5.4.4 Procedure

The materials were presented to participants on a computer screen using E-Prime software. At the beginning of the experiment oral instructions were given; participants then took part in a practice session consisting of eight trials to accustom them to the task. Practice trials comprised one exemplar of each prime type as well as six filler-type sentence fragments. The set of practice trials was counterbalanced, such that half of the participants saw a coerced exemplar first, and a full-VP exemplar three trials later, while for the other half of the participants the full-VP and coerced exemplars appeared in the practice session in the reverse order.

Figure 5-1: Experiment 5 sample experimental stimuli

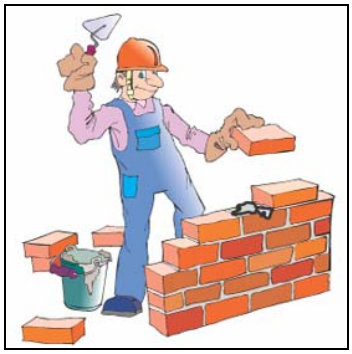
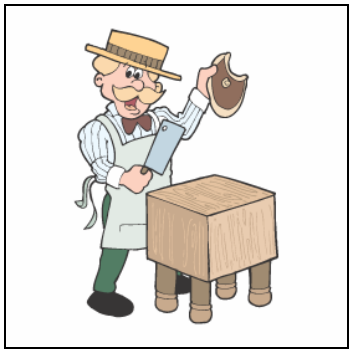
	SENTENCE FRAGMENTS	PICTURES
PRIMES		
Coerced	*The author began the*	
Full-VP	*The author began writing the*	
TARGET		
	The bricklayer began	

Figure 5-2: Experiment 5 sample fillers

	SENTENCE FRAGMENTS	PICTURES
FILLERS		
Transitive	*The butcher was preparing the*	
Intransitive	*The rocker was*	

A single trial (prime, target, or filler) comprised a fixation cross, a sentence fragment displayed in the centre of the screen for 1500 ms, and then a picture, again displayed in the middle of the screen (see Figures 5-3 and 5-4 for sample prime and target trials respectively). Each screen was separated by a 500 ms interval. Participants were instructed to read the sentence fragment silently to themselves, and on seeing the picture, to say the fragment aloud and complete it appropriately. Each item was viewed once, with the entire session lasting approximately 15 minutes.

Figure 5-3: A sample prime trial in Experiment 5 (coerced condition)

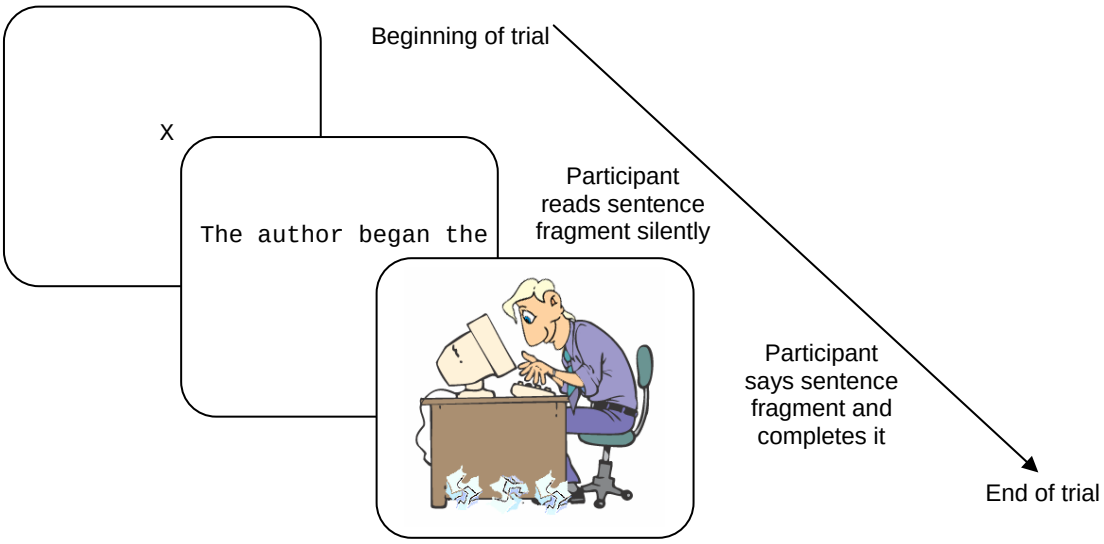
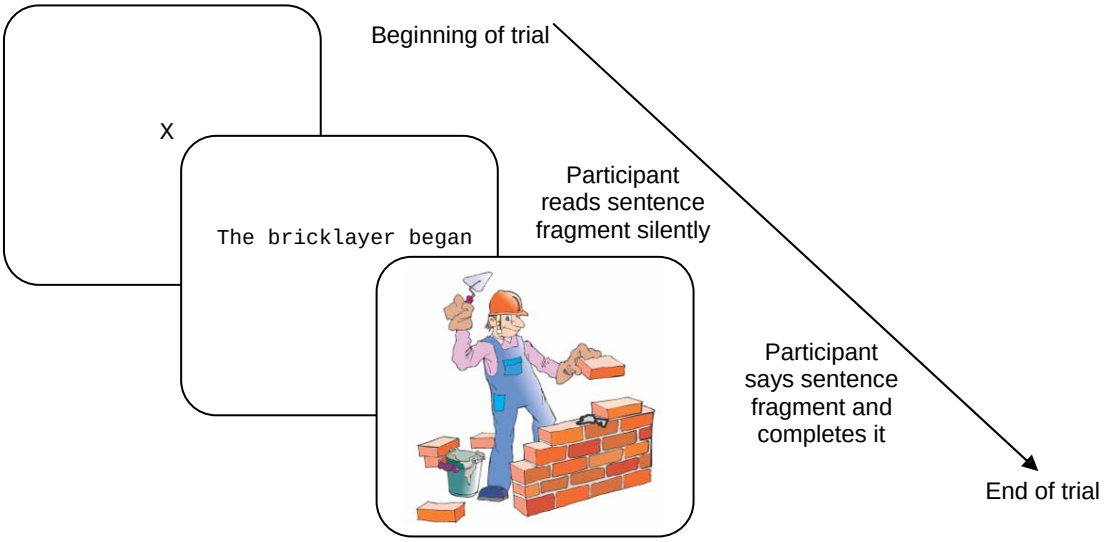


Figure 5-4: A sample target trial in Experiment 5



The experimental sessions were recorded on audiotape and subsequently transcribed to obtain a written record of the descriptions of the experimental pictures.

5.4.5 Coding and analysis

Every participant saw 16 experimental prime pictures and produced 16 target utterances, eight in each of the two priming conditions (coerced and full-VP). Every target sentence fragment and corresponding picture was presented to all 28 participants, such that 14 participants saw any one version of an experimental item.

The transcribed descriptions of the experimental pictures were coded as Coerced, Full-VP, Event-NP or Other. A prime picture description was coded as Coerced if the participant's response comprised a noun phrase subject, the coercing verb, and an entity-NP complement (e.g., *The author began the book*). Similarly, a prime picture description was coded as Full-VP if the participant's response comprised a NP subject, the coercing verb, and a VP complement, with the latter made up of a progressive verb and an entity-NP (e.g., *The author began writing the book*). A prime picture description was coded as Event-NP if the participant's completion comprised an event-NP (e.g., *The author began the work*). NP completions that were ambiguous between entity and event readings (e.g., *The schoolboy completed the reading*) were assumed to be events and coded accordingly. Prime completions that did not fall into one of the above categories, as well as responses that involved inaccurate repetition of any part of the prime fragment, were coded as Other.

Target picture descriptions were coded according to identical criteria. A target picture description was coded as Coerced if the participant's response contained an entity-NP as the complement of the coercing verb (e.g., *The bricklayer began the wall*). Similarly, a target picture description was coded as Full-VP if the complement of the coercing verb was a VP, headed by a verb in progressive or infinitival form and containing an entity-NP as the complement of that verb (e.g., *The bricklayer began building the wall*, *The bricklayer began to build the wall*). A target response was coded as Event-NP if the participant's completion comprised an event-NP (e.g., *The bricklayer began the job*), or an NP that was ambiguous between an entity and an event reading (e.g., *The grandmother completed the knitting*.) Finally, target completions that did not match any of the above were coded as Other.

Trials containing responses that were not completed as intended (i.e., as a coerced prime or as a full-VP prime, depending on the condition) were eliminated from the analysis. Subsequent calculations were based on a measure designed to determine the relative proportions of coerced and full-VP target responses in each of the two priming conditions (e.g., Branigan et al., 2000; Pickering et al., 2005). This measure (the coerced target ratio) was equal to the sum of coerced target responses in a particular priming condition divided by the sum of coerced target responses and full-VP target responses in that priming condition. Using this measure allowed for the comparison of priming between conditions in cases where the proportions of Other and event-NP responses were not equivalent. If a participant (or item) showed zero coerced or full-VP target descriptions in a given condition, then this would result in a divide-by-zero error in the

coerced target ratio calculation. In this case, the missing value was replaced with the grand mean of the coerced target ratio across all conditions.

How likely were participants to produce a coerced picture description immediately after producing a coerced description compared with after producing a full-VP description? To address this question, a primary analysis was carried out on the coerced target proportions across both priming conditions. (Note that reporting the results in terms of the coerced target proportion is arbitrary; the proportion of full-VP target completions is complementary, given the exclusion of Other and event-NP responses.) Once Others were removed, one participant had an empty cell; this was replaced with the grand mean for the following analyses. ANOVAs were carried out on the data, with separate analyses treating participants (F_1) and items (F_2) as random effects. The analyses were within-participants and within-items.

5.4.6 Results

Application of the coding criteria yielded 412 trials where the prime fragment was completed as either Coerced or Full-VP (92% of all responses). Of these, 197 (48%) were coerced trials, and 215 (52%) were full-VP trials. In these 412 trials, participants produced 90 (22%) coerced and 79 (19%) full-VP picture descriptions respectively. Table 5-1 shows the number of coerced, full-VP, event-NP, and Other forms produced in each of the two conditions.

Table 5-1: Raw figures per type of target completion produced in the two priming conditions of Experiment 5

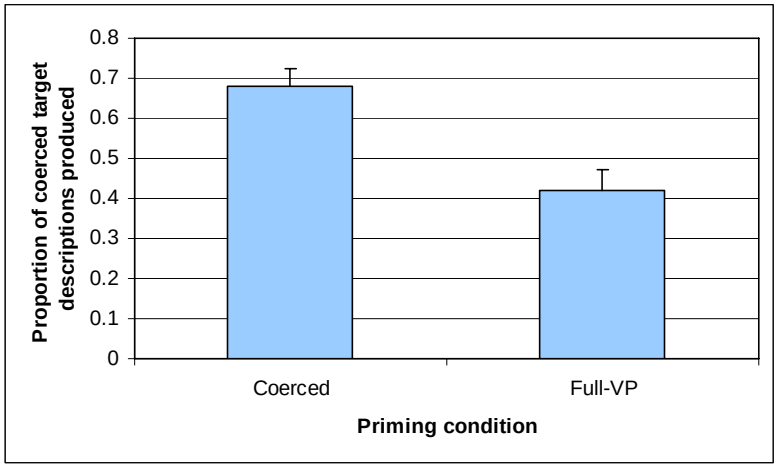
	TARGET COMPLETION			
PRIMING CONDITION	Coerced	Full-VP	Event-NP	Other
Coerced	90	43	22	42
Full-VP	49	79	5	82

Coerced versus full-VP descriptions

The overall proportions of coerced descriptions produced in the two priming conditions are presented in Figure 5-5. (All graphs represent data from participant analyses, with error bars showing standard error by participants.) Figure 5-5 shows that participants produced more target completions that were of the same type (coerced or full-VP) than

target completions that were of the alternative type to the prime completions. Specifically, after producing a coerced prime picture description, participants produced a coerced description of the target picture 69% of the time. After producing a full-VP structure, participants produced a coerced target description 42% of the time. Thus, there was an overall priming effect of 27%. In other words, participants produced 27% more target picture descriptions that were of the same type as the prime picture description than target descriptions that were of the alternative type.

Figure 5-5: Proportions of coerced target completions produced in the two experimental conditions of Experiment 5



One-way ANOVAs on the coerced target ratio revealed a significant effect of Prime (F_1 (1, 27) = 23.02; $p < .001$; F_2 (1, 15) = 21.655; $p < .001$); the proportion of coerced target descriptions was reliably higher when they were preceded by a coerced prime than when they were preceded by a full-VP prime.

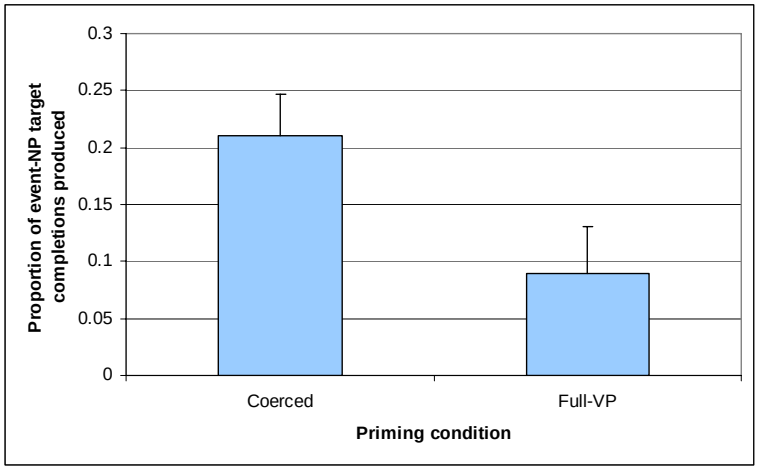
Event-NP completions

How likely were participants to produce event-denoting noun phrases after producing a coerced description compared with after producing a full-VP description? A secondary analysis of the data focused exclusively on noun phrase target completions, in order to further explore the influence of the priming manipulation on the mapping of event structure to syntactic form. In the context of the materials presented in this experiment, coercion only occurred where participants produced an entity-denoting noun phrase complement (e.g., *wall*) to complete the target fragment. Producing a noun phrase that

expresses an event (e.g., *work*) satisfies the event complement requirement of the coercing verb, and in this case there is no missing event structure underlying the surface form. The proportion of event-NP target completions was compared with the proportion of coerced (i.e., entity-NP) target completions across the two priming conditions. These proportions were calculated by dividing the number of event-NP completions produced following a coerced prime by the sum of event-NP targets and coerced (entity-NP) targets in that condition. Similarly, the number of event-NP completions produced following a full-VP prime was divided by the sum of event-NP targets and coerced (entity-NP) targets in that condition. (Having produced zero NP completions in the full-VP condition, three participants had empty event-NP target ratio cells, and these were replaced with the grand mean for this analysis.) ANOVAs were carried out on these data, with separate analyses treating participants (F_1) and items (F_2) as random effects. The analyses were within-participants and within-items.

The proportions of event-NP target completions produced in the two priming conditions are presented in Figure 5-6. Out of all target completions that took the form of an NP, participants produced an event-NP 21% of the time following a coerced prime and 9% of the time following a full-VP prime, reflecting an overall priming effect of 11%.

Figure 5-6: Proportions of event-NP target completions (of all NP target completions) produced in the two experimental conditions of Experiment 5



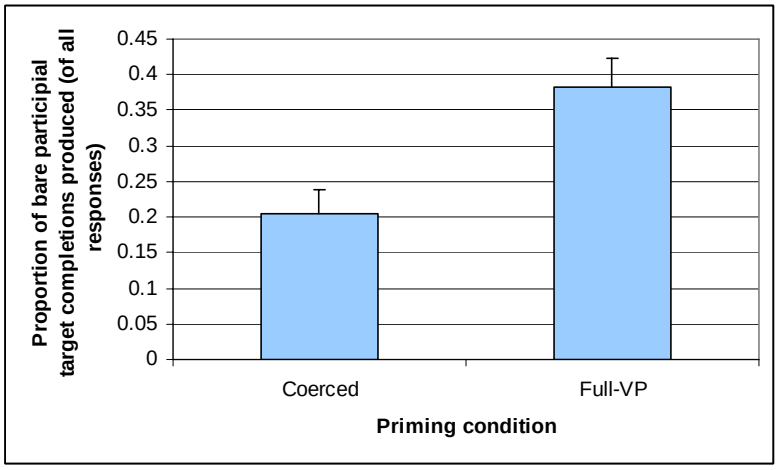
One-way ANOVAs on the event-NP target ratio revealed that the effect of Prime was marginal both by participants and by items. (F_1 (1, 27) = 3.454; p = .07; F_2 (1,

15) = 4.137; p = .06). Of all the NPs produced in target completions, there were more event-NP responses produced following coerced primes than following full-VP primes.

Other responses

One hundred and twenty-four target responses out of 412 primed descriptions in total (or 30% of the data) were coded as Other and were excluded from the analyses reported above. Of the 124 descriptions coded as Other, 122 (or 98%) were bare participial completions (e.g., *The bricklayer began building*). Figure 5-7 shows the mean proportions of bare participial target picture descriptions produced across the two experimental conditions. The results showed that after producing a coerced prime picture description, participants produced a bare participial completion (e.g., *building*) to complete the target fragment (*The bricklayer began*) 21% of the time. After a full-VP prime, they produced a bare participial completion 38% of the time.

Figure 5-7: Proportions of bare participial target completions produced in the two experimental conditions of Experiment 5



One-way ANOVAs on the proportions of bare participial target completions (out of all target completions) revealed a main effect of Prime (F_1 (1, 27) = 11.752; $p < 0.05$; F_2 (1, 15) = 20.583; $p < 0.001$); the proportion of bare participial target descriptions was reliably higher when they were preceded by a full-VP prime than when they were preceded by a coerced prime.

5.4.7 Discussion

In Experiment 5, participants were presented with sentence fragments to complete in a way that best described a corresponding picture. When producing target completions, they repeatedly expressed the same level of semantic specification in their description as that of a preceding prime picture description. That is, they were more likely to produce a coerced picture description after having just produced a coerced description than after having just produced a description that included the fully specified event structure connecting the coercing verb with its noun complement. These results can be taken as evidence of semantic priming of abstract event structure, and more specifically as evidence for coercion in production, complementing the extensive body of work demonstrating the phenomenon in processes of comprehension (McElree et al., 2001; McElree et al., 2006a; Pickering et al., 2005; Traxler et al., 2002; Traxler et al., 2005).

However, a straightforward semantic account of the priming effect is problematic. Choosing between expressing two distinct levels of semantic specification (i.e., coerced vs. full-VP) to describe the pictures also involves generating distinct *syntactic* structures. A coerced completion like *the book* in *The author began the book* is a noun phrase, while the fully specified version, *writing the book*, is a verb phrase. An obvious question to address, then, is whether the priming effect observed in this experiment is simply a reflection of syntactic mechanisms rather than of residual activation of an abstract semantic representation. Results of the analysis of Other responses showed that participants produced significantly more bare participial completions (e.g., *The bricklayer began building*) following full-VP primes (*The author began writing the book*) than following coerced primes (*The author began the book*): This suggests that production of a verb primed production of another verb. Furthermore, previous findings of syntactic priming in production (e.g., Bock, 1986; Branigan et al., 2000; Pickering & Branigan, 1998) report similar magnitudes of priming as found in this study, thus taken in this light the results would be consistent with other studies. If there is a semantic component to the priming effect, this coincides with a syntactic alternation. In order to isolate the semantic component, we need to tease apart the two types of effects.

It is clear, then, that a shortcoming of the current experimental design is the fact that we cannot distinguish semantic priming from syntactic priming; Experiment 7 addresses this issue by developing the experimental design. However, by focusing exclusively on completions that took the form of an NP, it becomes possible to tease apart event structure from syntactic structure, because both event- and entity-NPs have

the same syntactic structure. Recall that for the purposes of the primary analysis, event-NP target completions were eliminated from the calculation. But the results of the event-noun analysis showed that out of all NP completions produced, participants were more likely to produce an event-NP completion to describe a target picture following a coerced prime than following a full-VP prime. This finding is consistent with what the enriched composition hypothesis predicts in the context of a basic syntactic effect, i.e., over and above a structural preference. When participants produced a coerced structure, abstract event structure was salient to the processor, resulting in more event-NPs following a coerced prime than following a full-VP prime. Underlying event structure must, then, be associated with coerced structures. The fact that of out of the overall target NP completions produced, the coerced condition primed the production of significantly more event-NPs than the full-VP condition does at least constitute indirect evidence of enriched composition in production. If the effect was purely syntactic, with the production of noun phrases priming the production of noun phrases, and similarly for verb phrases, then we would not expect to find a difference between the proportions of event-NP target completions in the coerced compared with the full-VP priming condition.

The results of Experiment 5 show that speakers can be primed to produce coerced structures, and suggest that this effect may have a semantic component. However, because the semantic effect is only revealed indirectly, the enriched composition explanation cannot be wholly accepted. It is possible that the priming effect may be due exclusively to activation of syntactic structures, with no contribution of abstract event structure. Before addressing this concern, however, I turn to another potential influence on the priming effect obtained in this experiment, namely the effect of repeating the coercing verb between prime and target. Experiment 6 was designed to explore whether the priming observed in Experiment 5 affected representations that are independent of specific lexical items versus representations that are localized to specific coercing verbs. As Experiment 5 showed priming when the coercing verb was repeated between prime and target, we cannot distinguish between these possibilities.

Lexical boost effects have been reported in syntactic priming studies (e.g., Branigan & Pickering, 1998, Branigan et al., 2000; Cleland & Pickering, 2006; Corley & Scheepers, 2002). In production, priming has been shown when the verb is not repeated (Bock, 1986; Pickering & Branigan, 1998) as well as when it is repeated (Pickering & Branigan, 1998), although the effect is significantly stronger when it is repeated

(Pickering & Branigan, 1998). The same holds for nouns (Cleland & Pickering, 2003). These findings suggest that the syntactic representations used in production may be at least partly, though not entirely, localized to lexical items. Indeed, Levelt and Kelter (1982) interpreted their priming effect as a tendency to reuse specific words, i.e., as lexical rather than syntactic priming. What role did lexical overlap play in the priming effect obtained in Experiment 5? The aim of Experiment 6 was to address this question, by varying the coercing verb between prime and target. A replication of the results would strengthen the conclusions concerning coercion in production as well as contributing to the findings concerning lexical influences on priming.

5.5 Experiment 6: Priming without repetition of the coercing verb

Experiment 6 was designed to provide further evidence of complement coercion in production, and specifically to investigate whether priming of abstract meaning-to-form mapping mechanisms occurred in the absence of lexical repetition between prime and target. As discussed in previous chapters, the lexical boost effect is well-established in syntactic priming studies, both in comprehension (Branigan et al., 2000, Pickering et al., 2005) and in production (Pickering & Branigan, 1998, Pickering et al., 2000; Cleland & Pickering, 2003), and the effect has been shown in the context of verb repetition (Pickering et al., 2005) and noun repetition (Cleland & Pickering, 2003). Enhanced syntactic priming in the context of lexical overlap has been explained in the context of combinatorial information linked to specific lexical items. But lexical boost effects have also been shown to influence relation priming. Experiments 1 and 2 of this thesis have demonstrated the lexical boost effect on relation priming in comprehension, and this was argued to support the partial independence of relational representations. If speakers can be primed to produce complement coercions in the absence of repeated constituents between prime and target, this would similarly constitute evidence of the partial independence of abstract event representations. I explore this possibility in Experiment 6, in which prime and target sentence fragments contained different coercing verbs. In other respects, it was identical to Experiment 5.

5.5.1 Predictions for the current study

Following findings in the syntactic priming literature concerning the influence of lexical repetition on the magnitude of priming (Pickering & Branigan, 1998; Cleland &

Pickering, 2003; Branigan et al., 2000; Branigan et al., 2005), as well as the findings concerning relation priming reported in Chapter 3, we would expect the absence of lexical overlap between prime and target to have a similar influence on the priming of semantic structure. The enriched composition hypothesis again predicts an effect of prime sentence fragment type, i.e., production of *The author began the book* should prime production of *The bartender mastered the cocktail* and production of *The author began writing the book* should prime production of *The bartender mastered making the cocktail*. That is, prime and target picture descriptions should express the same level of semantic specification. However, without the lexical boost to priming contributed by repetition of the coercing verb, the effect is likely to be smaller than in Experiment 5.

5.5.2 Participants

Twenty-eight volunteers from the University of Edinburgh student community were paid to take part. All were native speakers of English with no reading difficulties, and none had taken part in Experiment 5.

5.5.3 Materials and design

The sentence fragments and pictures (including fillers) for this experiment were identical to those in Experiment 5. However, the assignment of prime to target combinations was rotated, such that the coercing verb was not repeated across prime-target pairs. Each item comprised a prime sentence fragment such as *The author began the* together with a picture, and a target sentence fragment such as *The bartender mastered*, together with a corresponding picture. Additionally, items were rotated with the constraint that coercing verbs were not paired with synonyms or antonyms. There was one exception to this, where prime and target coercing verbs were semantically related; *The penpal finished*/*The penpal finished writing* were the primes for *The bricklayer began*. Such a pairing for one item was unavoidable; given a set of eight verbs, four of which are semantically related, it is impossible to arrive at an arrangement that does not include one semantically related pair of prime-target verbs.

5.5.4 Procedure

This was the same as in Experiment 5 (see Section 5.4.4).

5.5.5 Coding and analysis

The dependent measure of interest was again whether participants produced a coerced or full-VP target picture description. Coding of participant responses and calculations of coerced target ratios were therefore identical to those employed in Experiment 5.

5.5.6 Results

Coding revealed that one item (item 12 in Appendix C-4) had elicited exclusively Other responses. This item was therefore removed for the purposes of the following analyses. After this item was removed, application of the coding criteria yielded 377 trials where the prime fragment was completed as either Coerced or Full-VP (90% of all responses). Of these, 179 (43%) were coerced trials, and 198 (47%) were full-VP trials. In these 377 trials, participants produced 75 (20%) coerced and 51 (14%) full-VP picture descriptions respectively. Table 5-2 shows the number of coerced, full-VP, event-NP, and Other completions produced in each condition.

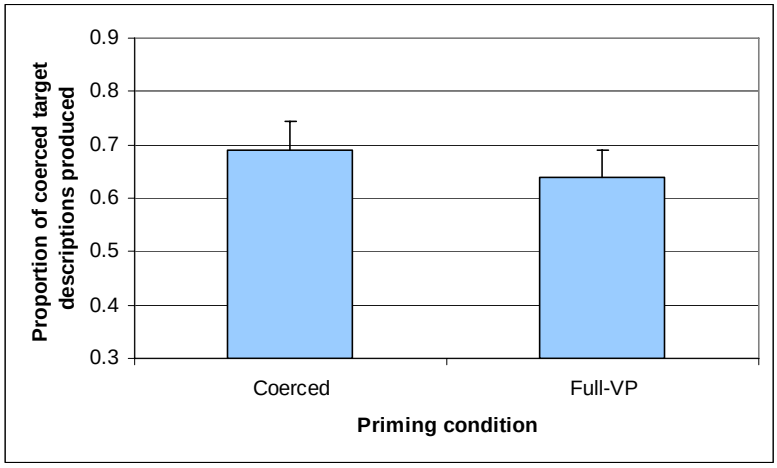
Table 5-2: Raw figures per type of target completion produced in the two priming conditions of Experiment 6

	TARGET COMPLETION			
PRIMING CONDITION	Coerced	Full-VP	Event-NP	Other
Coerced	75	32	20	52
Full-VP	81	51	14	52

Coerced versus full-VP responses

Figure 5-8 shows the proportions of coerced target picture descriptions in the two experimental conditions. The results showed that when participants produced a coerced prime picture description, they produced a coerced completion to describe the target picture 64% of the time. When participants produced a full-VP structure to describe the prime picture, they produced a coerced completion in a subsequent target picture description 69% of the time. Thus, there was an overall priming effect of 5%. In other words, participants produced 5% more target picture descriptions that were of the same type as the prime picture description than target descriptions that were of the alternative type.

Figure 5-8: Proportions of coerced target completions produced in the two experimental conditions of Experiment 6

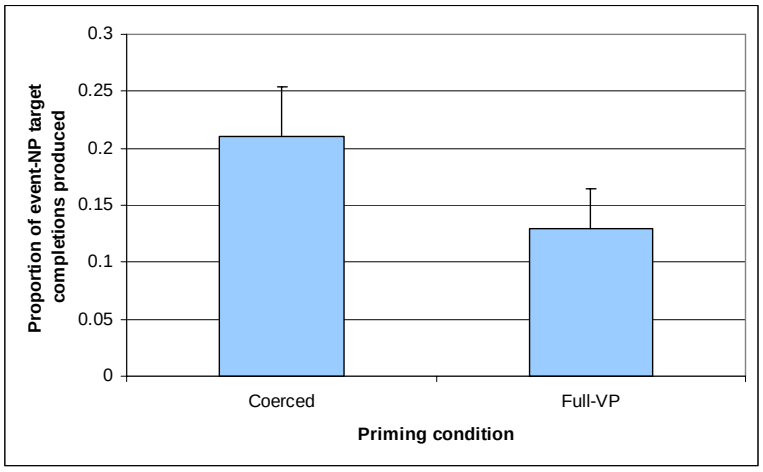


One-way ANOVAs carried out on this data revealed an effect of Prime that was significant by items only ($F_1 < 1$; F_2 (1, 14) = 5.632; $p < .05$); when items was included as the random factor, the percentage of coerced target descriptions was reliably higher when they were preceded by a coerced prime than when they were preceded by a full-VP prime.

Event-NP completions

The proportions of event-NP target completions produced in the two priming conditions are presented in Figure 5-9. Out of all target completions that took the form of an NP, participants produced an event-NP 21% of the time following a coerced prime and 13% of the time following a full-VP prime, reflecting an overall priming effect of 8%.

Figure 5-9: Proportions of event-NP target completions (of all NP target completions) produced in the two experimental conditions of Experiment 6

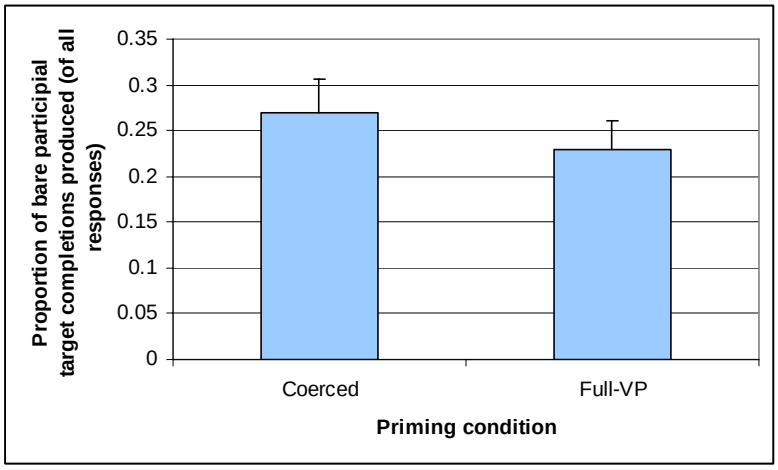


One-way ANOVAs on the event-NP target ratio revealed that the effect of Prime was not significant (F_1 (1, 27) = 2.056; p = .16; F_2 < 1).

Other responses

One hundred and four target responses out of 377 primed descriptions in total (or 27.6% of the data) were coded as Other and were excluded from the analyses reported above. Of the 104 descriptions coded as Other, 94 (or 68%) were participial completions (e.g., *The clerk began reading*). Figure 5-10 shows the mean proportions of bare participial target picture descriptions produced across the two experimental conditions. The results showed that after producing a coerced prime picture description, participants produced a bare participial completion (e.g., *building*) to complete the target fragment (*The bricklayer began*) 27% of the time. After a full-VP prime, they produced a bare participial completion 23% of the time.

Figure 5-10: Proportions of bare participial target completions produced in the two experimental conditions of Experiment 6



One-way ANOVAs on the proportions of bare participial target completions (of all target completions) revealed no main effect of Prime (both *F*s < 1); the percentage of bare participial target completions did not depend on the form of the prime sentence fragment.

5.5.7 Discussion

The results of Experiment 6 failed to yield strong evidence that abstract event structure can be primed in the production of picture descriptions. In the absence of repetition of the coercing verb between prime and target, participants tended to express the same level of semantic specification as they had just done on a preceding prime trial, but this effect of Prime was significant by items only. Furthermore, the event-NP analysis did not yield any significant results for this experiment.

The diminished priming effect observed in Experiment 6 reveals some suggestion that abstract event structure can be primed independently of the coercing verb, but that the level of activation that a given event representation receives is substantially weakened in the absence of lexical repetition. But given previous production evidence that priming with head repetition is approximately double the magnitude of priming without head repetition (Branigan et al., 2000; Cleland & Pickering, 2003; Pickering & Branigan, 1998), it may be that the effect is too weak to detect in this sample size. On the basis of the results of Experiment 6, it is impossible to draw a clear conclusion about verb-

independent priming. A direct comparison of the magnitude of priming across Experiments 5 and 6 will elucidate this finding.

5.6 Comparison of Experiments 5 and 6

There is substantial evidence for the influence of lexical repetition on priming in studies of syntactic priming (Pickering & Branigan, 1998; Branigan et al., 2000; Cleland & Pickering, 2003). If priming of event structure is similar to priming of syntactic structure, then lexical repetition should enhance priming in the context of the current experiment. To this end, a combined analysis of Experiments 5 and 6 was carried out in order to determine whether priming of abstract semantic structure was enhanced by lexical repetition of the coercing verb. Given that one item (item 12 in Appendix C-4) proved problematic in Experiment 6 (see Section 5.5.6 above) and was removed in the analysis of that experiment, it was also removed from Experiment 5 for the purposes of the following comparison.

One-way ANOVAs were carried out on the coerced target proportions. Prime was within-participants and within-items; Experiment was between participants but within items. The analysis revealed a main effect of Prime (F_1 (1, 54) = 15.713; $p < .001$; F_2 (1, 28) = 26.215; $p < .001$); across experiments there was a 16% tendency to produce target descriptions that expressed the same level of semantic specification as the prime description than target descriptions that were of the alternative type to the target description. More importantly, there was an interaction between Prime and Experiment, although this failed to reach significance in the by-items analysis (F_1 (1, 54) = 6.616; $p < .05$; F_2 (1, 28) = 3.306; $p = .09$). Comparing the two experiments by participants showed that the 27% priming effect in Experiment 5 (i.e., when the coercing verb was repeated between prime and target sentence fragments) was significantly larger than the 5% priming effect in Experiment 6 (i.e., when the coercing verb was different between prime and target fragments). In other words, lexical repetition enhanced priming. That is, priming occurs whether the coercing verb is repeated or not, but stronger priming occurs if the coercing verb is repeated. This finding is presented with the following caveat: While Experiments 5 and 6 were designed and set up with a view to carrying out the above analysis, there are clearly potential methodological problems associated with cross-experiment comparisons, e.g., if participants for the two experiments came from different populations.

5.7 Experiment 7: Is the priming effect syntactic or semantic?

Experiment 7 employed the same technique as that used in the previous two experiments, with a new set of pictures and sentence fragments. As before, in testing whether speakers employ mechanisms of enriched composition in production, we hypothesize that speakers can be primed to produce abstract event structure. But recall from the discussion in Section 5.4.7 that a syntactic explanation for the above results cannot be ruled out, on the grounds of structural correspondences between primes and targets. That is, coerced complements take the form of NPs and non-coerced complements take the form of VPs. At best, so far the findings can be presented as indirect evidence of coercion in production (based on the event-NP target response analysis; see Section 5.4.6).

To achieve a straightforward test of semantic priming without the confounding influence of syntactic structure, Experiment 7 introduced a third priming condition in which the elicited complement was an event-denoting noun, e.g., *speech*. The alternative syntactic form of the event in this case (NP rather than VP) allows us to carry out a direct comparison between event-denoting complements and entity-denoting complements of coercing verbs (e.g., *began the book* vs. *began the speech*), while keeping syntactic structure constant. Critically, only the first of the two examples (i.e., *began the book*) involves coercion, yet both expressions have the syntactic structure of a verb followed by a noun phrase. It follows that priming of the structural configuration should not differ between the two, thus any difference in priming can be attributed to a semantic effect. In contrast, the full-VP condition (*began reading the book*) has the same semantic (event) status as the event-NP condition (*began the speech*) but different syntactic structure; a comparison between these two conditions will verify the semantic effect by ruling out the null hypothesis.

5.7.1 Predictions for the current study

In the context of the materials presented in this experiment, semantic type coercion only occurs where the complement elicited in completing the sentence fragment is an entity-denoting noun phrase (e.g., *book*). Producing an event-denoting noun phrase (e.g., *speech*) satisfies the semantic requirements of the coercing verb, and in this case there is no abstract event structure underlying the surface syntactic form. Similarly, the complement

in the full-VP condition (e.g., *writing the book*) satisfies the event-hood requirement, therefore there should be no abstract event structure in this case either.

Experiments 5 and 6 have shown that production of an expression like *The author began the book* primes production of *The bricklayer began the wall*, and that production of *The author began writing the book* primes production of *The bricklayer began building the wall*. In Experiment 7, contrasting the above two prime types with an event-NP prime like *The author began the speech* leads the way to the following two predictions: If the priming effect is semantic, then *The author began the speech* (event-NP) should prime *The bricklayer began building the wall*, i.e., the event-NP and coerced conditions should differ. If the effect is *syntactic*, then *The author began the speech* (event-NP) should prime *The bricklayer began the wall*, i.e., the event-NP and full-VP conditions should differ. In other words, a syntactic account predicts coerced target responses following event-NP primes, while a semantic account predicts full-VP target responses following event-NP primes. A third possibility is that there are syntactic *and* semantic components to the priming effect. In this case, the event-NP condition should differ from both the coerced and the full-VP conditions respectively.

5.7.2 Participants

Thirty-six further participants from the University of Edinburgh student community were paid to participate. They were all native English speakers, had no reading difficulties, and none had taken part in the previous two experiments.

5.7.3 Materials and design

The experimental items used in Experiments 5 and 6 were extended to a set of 24, created around the same eight coercing verbs as before. Additionally, items that had produced high proportions of Other completions in the previous two experiments (in either prime or target) were modified. The full stimulus set is listed in Appendix E. As before, each critical item comprised a prime sentence fragment and corresponding picture, and a target sentence fragment and corresponding picture.

Prime sentence fragments took the same form as in Experiments 5 and 6, i.e., a noun phrase, a coercing verb (e.g., *began*) and then either the definite determiner *the* (e.g., *The celebrity began the*; coerced and event-NP), or a progressive verb followed by the definite determiner *the* (e.g., *The celebrity began drinking the*; full-VP). Primes were in three conditions, as shown in Figure 5-11. The three-way prime contrast, then, was between

The celebrity began the (coerced, with accompanying picture of an elegantly dressed woman drinking from a champagne glass), *The celebrity began drinking the* (full-VP, with the same picture as in the coerced condition), and *The celebrity began the* (event-NP; here the picture shows a similarly glamorous figure poised to speak in front of an array of microphones, in the typical physical format of a public speech or press conference). Target sentence fragments had the same form as in Experiments 5 and 6. The example target *The clerk began* is shown at the bottom of Figure 5-11, with the corresponding picture.

Thus, pictures in the coerced and full-VP conditions depicted actions involving an agent and an object undergoing the action, whereas pictures in the event-NP condition depicted an agent involved in an activity that could be described with an event-denoting noun phrase, i.e., there was no clear object undergoing an action. As before, typical actions in the coerced and full-VP conditions involved creating and consuming objects (e.g., writing, reading, eating, drinking, making, and sculpting) whereas actions depicted in the event-NP condition were unspecified as regards (semantic) patients (e.g., a fight, a lecture, and a race). Pictures were presented in colour on a white background.

The set of filler sentence fragments and pictures used in Experiments 5 and 6 was extended to maintain the 3:1 filler-item ratio. This resulted in 72 fillers for this experiment, comprising 48 transitives (e.g., *The mother was feeding the*) and 24 intransitives (e.g., *The director was*). As before, tense was held constant across all experimental items and fillers; verb phrases were in the past or past progressive form, e.g., *was*, *began drinking*. Randomised lists were prepared as in the previous two experiments, containing the 24 experimental item pairs and 72 fillers.

5.7.4 Procedure

This was the same as in Experiments 5 and 6 (see Section 5.4.4). The experimental sessions were recorded on audiotape and subsequently transcribed to obtain a written record of the descriptions of the experimental pictures.

5.7.5 Coding and analysis

Every participant saw 24 experimental prime pictures and produced 24 target utterances, eight in each of the three priming conditions (coerced, full-VP, and event-NP). Every target sentence fragment and corresponding picture was presented to all 36 participants, such that 12 participants saw any one version of an experimental item.

Figure 5-11: Experiment 7 sample experimental stimuli

	SENTENCE FRAGMENTS	PICTURES
PRIMES		
Coerced	*The celebrity began the*	
Full-VP	*The celebrity began drinking the*	
Event-NP	*The celebrity began the*	
TARGET		
	The clerk began	

Transcribed prime and target descriptions of the experimental pictures were coded according to the same criteria as those used in Experiments 5 and 6, yielding four code categories: Coerced, Full-VP, Event-NP, and Other. Trials containing responses that were not completed as intended (i.e., as a coerced prime, as a full-VP prime, or as an event-NP prime, depending on the condition) were eliminated from the analysis. Coerced target proportions were calculated as per the calculation described in Section 5.4.4. ANOVAs were carried out on the data, with separate analyses treating participants (F_1) and items (F_2) as random effects. The analyses were within-participants and within-items.

I again undertook an analysis of only NP target completions to assess whether the three conditions led to different proportions of event-NP target completions. This was done by calculating proportions of event-NP targets produced across the three conditions. (One participant produced zero NP target completions in the coerced condition, while another produced zero NP target completions in the full-VP condition; for the purposes of this analysis, their empty cells were replaced with the grand mean.) ANOVAs were carried out on these data, with separate analyses treating participants (F_1) and items (F_2) as random effects.

5.7.6 Results

Application of the coding criteria yielded 732 trials where the prime fragment was completed as either Coerced or Full-VP (85% of all responses). Of these, 207 (28.3%) were coerced trials, 274 (37.4%) were full-VP trials, and 251 (34.3%) were event-NP trials. In these 732 trials, participants produced 123 (16.8%) coerced, 102 (13.9%) full-VP, and 131 (17.9%) event-NP picture descriptions respectively. Table 5-3 shows the number of coerced, full-VP, event-NP, and Other completions produced in each condition.

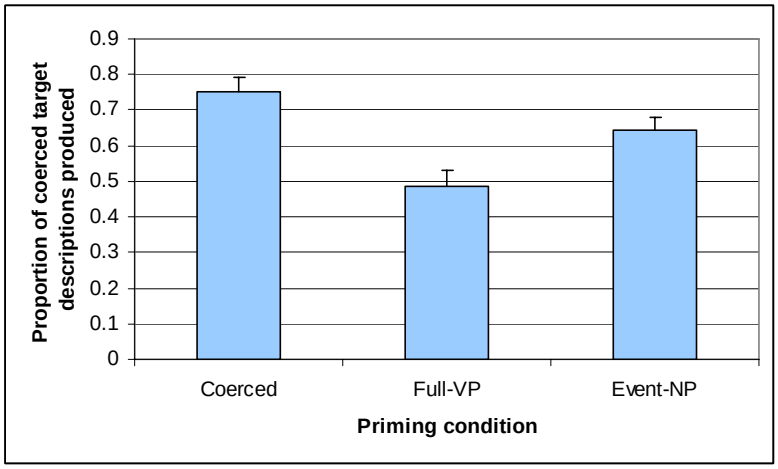
Table 5-3: Raw figures per type of target completion produced in the three priming conditions of Experiment 7

	TARGET COMPLETION			
PRIMING CONDITION	Coerced	Full-VP	Event-NP	Other
Coerced	123	30	12	42
Full-VP	102	92	10	70
Event-NP	131	45	25	50

Coerced versus full-VP responses

Figure 5-12 shows the proportions of coerced target descriptions for the three priming conditions. The proportion means are as follows: after producing a coerced prime picture description, participants produced a coerced description of the target picture 75% of the time. After producing a full-VP prime, participants produced a coerced target description 49% of the time. After producing an event-NP prime, they produced a coerced target description 65% of the time.

Figure 5-12: Proportions of coerced target completions produced in the three experimental conditions of Experiment 7

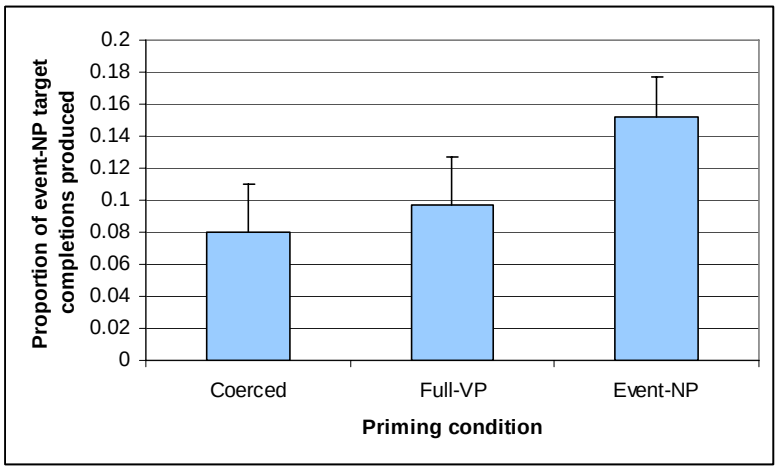


One-way ANOVAs on the proportions of coerced target descriptions revealed a significant main effect of Prime (F_1 (2, 70) = 27.97; $p < .001$; F_2 (2, 46) = 22.52; $p < .001$); the percentage of coerced target descriptions depended reliably on the form of the prime construction. Planned comparisons showed that there were significantly more coerced responses in the coerced condition than the event-NP condition (t_1 (35) = -1.73; $p < .05$; t_2 (23) = -2.83; $p < .05$). Furthermore, there were significantly more coerced responses in the event-NP condition than the full-VP condition (t_1 (35) = 6.23; $p < .0001$; t_2 (23) = 4.05; $p < .0001$).

Event-NP completions

The proportions of event NP target completions produced in the three priming conditions are presented in Figure 5-13. Out of all target completions that took the form of an NP, participants produced an event NP 8% of the time following a coerced prime, 10% of the time following a full-VP prime, and 15% following an event-NP prime.

Figure 5-13: Proportions of event-NP target completions (of all NP target completions) produced in the three experimental conditions of Experiment 7

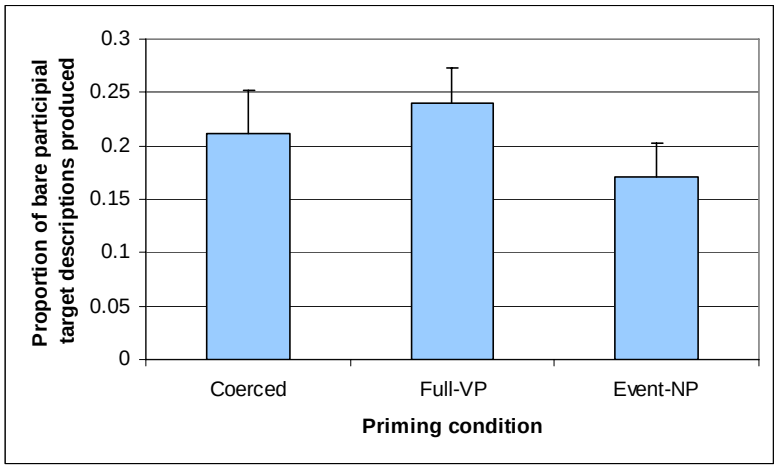


One-way ANOVAs on the event-NP target ratio revealed that the effect of Prime was not significant in both the by-participants and by-items analyses. (F_1 (2, 70) = 1.889; p = .16; F_2 (2, 46) = 3.272; p = .07).

Other responses

One hundred and sixty-two target responses out of 732 primed descriptions in total (or 22% of the data) were coded as Other and were excluded from the analyses reported above. Of the 162 descriptions coded as Other, 150 (or 92.6%) were bare participial completions (e.g., *The clerk began reading*). Figure 5-14 shows the mean proportions of bare participial target picture descriptions produced across the three experimental conditions. The results showed that after producing a coerced prime picture description, participants produced a bare participial completion (e.g., *building*) to describe the target picture (*The bricklayer began*) 21% of the time. After a full-VP prime, they produced a bare participial completion 24% of the time. And after an event-NP prime, they produced a bare participial completion 17% of the time.

Figure 5-14: Proportions of bare participial target completions produced in the three experimental conditions of Experiment 7



One-way ANOVAs on the proportions of bare participial target completions (of all target completions) revealed no main effect of Prime (F_1 (2, 70) = 1.64; p = .20; F_2 (2, 46) = 1.383; p = .26); the percentage of bare participial target completions did not depend on the form of the prime sentence fragment.

5.7.7 Discussion

Experiment 7 replicated the finding that experimental participants were significantly more likely to produce a target picture description with the same level of semantic specification as the prime description than with the alternative level of specification. Given that the coercing verb was repeated between prime and target, the contrast between coerced and full-VP conditions in this experiment was consistent with that in Experiment 5, which used a slightly different experimental set (and completely different prime-target pairings). More importantly, however, this experiment directly addressed the major shortcoming of the previous two experiments. Because of the syntactic correspondences between primes and targets across the two conditions, i.e., that different levels of semantic specification corresponded to different structural configurations, priming could be argued to be purely a syntactic effect. But the third priming condition in Experiment 7 demonstrated that the effect has at least semantic and syntactic components, because priming in this condition (Event-NP) differed significantly from each of the other two conditions. That is, abstract event structure affected choice of syntactic structure.

These results are consistent with previous findings of abstract semantic priming in the production literature. Watson et al. (2004) found that participants who had interpreted an expression using a particular reference frame (e.g., relative to the speaker's perspective) tended to use the same reference frame in their subsequent utterance. Cleland and Pickering (2003) found that the semantic relatedness of nouns enhanced syntactic priming. And semantic influences have been shown to operate on the mapping to sentence-level syntax. Chang et al. (2003) showed enhanced syntactic priming in the context of order of thematic roles, and Griffin and Weinstein-Tull (2003) found that semantic similarity enhanced syntactic priming. The current study constitutes the first evidence for semantic priming of abstract event structure (that remains unexpressed in the surface syntactic structure), and specifically for the occurrence of semantic type coercion in production. In the following section I interpret the combined data from Experiments 5, 6, and 7 in terms of a model of conceptual and lemma strata in the production system.

5.8 General discussion

The above set of experiments was conducted with the aim of investigating whether speakers employ mechanisms of enriched composition in production. This was tested through the priming of coerced expressions in a sentence completion/picture description task. In Experiment 5, speakers produced a higher proportion of target utterances with the same level of semantic specification as the prime utterance than with the alternative level of semantic specification. Speakers repeatedly expressed the same level of semantic specification, and this effect occurred even when the coercing verb was not repeated between prime and target. In Experiment 6, priming was not significant. This is consistent with the well-established lexical boost effect (Pickering & Branigan, 1998; Branigan et al., 2000). Experiments 5 and 6 provided indirect evidence for priming of abstract event structure in production. Experiment 7 demonstrated that this priming effect has both semantic and syntactic components; the combination of a coercing verb and an event-NP complement differentially primes coerced and full-VP structures. Taken together, the results of the three experiments constitute evidence of priming of event structure and enriched composition in production.

The above findings can be interpreted in terms of Levelt et al.'s (1999) framework for linguistic representation (see also Roelofs, 1992, 1993), coupled with

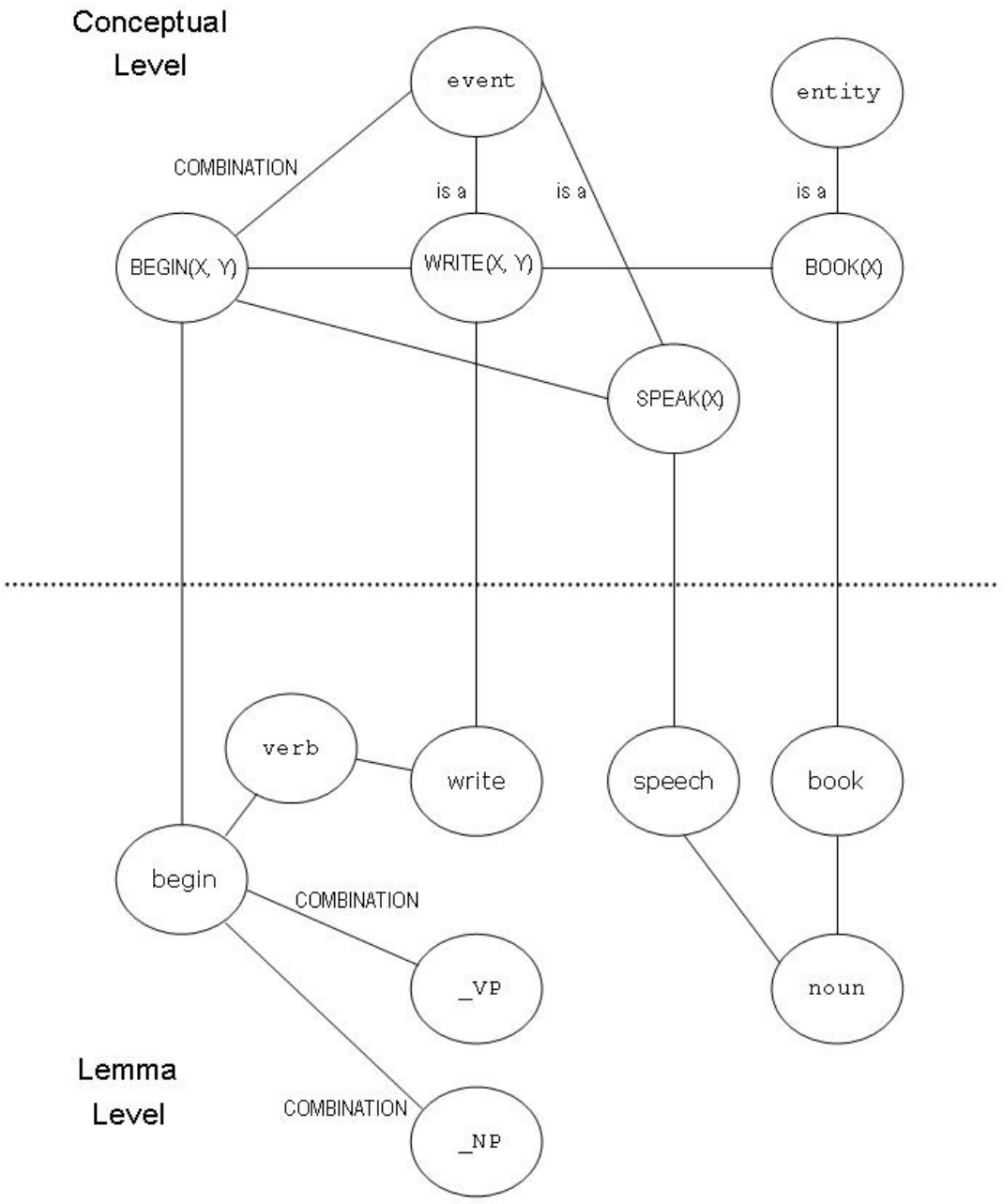
Pickering and Branigan's (1998) proposals for the lemma stratum (see Section 2.3.1 and Figure 2-2). According to Levelt et al., the representation of lexical entries is split across three distinct levels: a conceptual stratum, a lemma stratum, and a word-form stratum. The conceptual stratum contains information relating to the meaning of a word. The lemma stratum contains information relevant to the process of grammatical encoding. The word-form stratum is the site of phonological representations. According to Pickering and Branigan, lemma nodes (e.g., *punch*) are connected to nodes representing grammatical information, including word class (e.g., verb), grammatical features (e.g., singular, past tense, progressive aspect), and combinatorial information (specifying how the lemma can be combined with other words in phrasal structures). Lemmas can be connected with a number of different combinatorial nodes, which are activated when a verb is used in a particular construction. For example, the verb *punch* is linked to grammatical nodes corresponding to the active and passive constructions. Use of *punch* in the passive, e.g., *The referee was punched* would activate the *punch* node and the passive node, and their coactivation would lead to a strengthening of the connection between them. Importantly, activation patterns do not decay immediately. Activation of the passive node increases the likelihood of reusing a passive, thus, on a subsequent utterance involving *punch*, the speaker will be more likely to use the passive construction than the alternative active construction. Since the combinatorial nodes are shared between different lemmas (e.g., *punch* and *kick*), priming occurs in the absence of lexical overlap, but repeating the lemma between prime and target increases the magnitude of priming. If the lemma is repeated, then residual activation of both the passive node and the link will bias reusing the passive. But if a different lemma linked to the same combinatorial node is used (e.g., *kick*), there is no *lexical boost* effect of the link between the lemma node and the passive node. In sum, residual activation of combinatorial nodes and their connections with lemma nodes are the source of syntactic priming effects, which have been demonstrated cross-linguistically for a range of different constructions and experimental paradigms (Bock, 1986; Bock et al., 1992; Branigan et al., 2000; Hartsuiker & Kolk, 1998; Hartsuiker & Westenberg, 2000; Pickering & Branigan, 1998).

The current findings point to a comparable account that incorporates the event structure priming evidence. Critically, this account cuts across the conceptual and lemma strata in capturing the mapping of abstract event structure onto alternating syntactic configurations. The relevant details of the model proposed are presented graphically in Figure 5-15. The top half of the diagram shows the conceptual stratum. I assume that the

concepts associated with each word are represented at this level in a similar network organization as that proposed for lemmas in the lemma stratum (Roelofs, 1992, 1993; Pickering & Branigan, 1998). Event structure forms a part of the meaning of lexical entries, therefore this is represented at the conceptual level. In Figure 5-15 the conceptual node BEGIN(X, Y) is connected via a COMBINATION link with the semantic node event, capturing the fact that BEGIN(X, Y) combines with an event. The predicates WRITE(X, Y) and SPEAK(X) are connected to the same node event via is a relations, capturing the fact that these have the semantic status of events. Similarly, the concept BOOK(X) is connected to the semantic node entity, capturing the fact that it has the semantic status of an entity. BEGIN(X, Y) is connected to both predicates WRITE(X, Y) and SPEAK(X). Being a transitive event, WRITE(X, Y) is in turn connected to the entity concept BOOK(X). The lower half of the model shows the lemmas associated with the respective lexical concepts. Following Pickering and Branigan, these lemmas (begin, write, speech, and book) are each connected to a syntactic category node, capturing their grammatical class, and combinatorial nodes, capturing how they combine with other categories to form phrasal projections. Capturing word class information, the lemmas begin and write are both connected to the verb node, and the lemmas speech and book are connected to the noun node. Furthermore, the lemma begin connects to two combinatorial nodes (_VP and _NP), specifying that it can combine with a VP complement or an NP complement.

Let us consider how the proposed model can account for the priming evidence obtained in the current set of experiments. When speakers produce a coerced expression like *The author began the book*, the event node associated with the concept BEGIN(X, Y) is part of the prelinguistic message that is generated. That is, '*what* the author began doing' is necessarily part of the propositional content of the speaker's communicative intention, which is in turn fed forward for lexical access. Thus, production of *The author began the book* with the meaning 'began writing the book' starts with the activation of the conceptual nodes BEGIN(X, Y), WRITE(X, Y), BOOK(X), and the connections between them. Figure 5-15 shows that the concept BEGIN(X, Y) does not link directly with the concept BOOK(X); rather their connection is mediated by the concept WRITE(X, Y) (along with a number of other possible predicates not represented here; we will return to this point in Chapter 6).

Figure 5-15: A partial model of the representation of semantic and syntactic information associated with coercing verbs in the production lexicon



Activation flows from the conceptual level to the lemma level. Activation of the conceptual nodes BEGIN(X, Y), WRITE(X, Y), and BOOK(X) spreads to their associated lemma nodes in proportion to their levels of activation. As the lemmas become activated, syntactic information associated with them becomes available, such that their associated grammatical and combinatorial nodes become activated. Lexical access follows, whereby lemmas are selected and mapped onto syntactic structures,

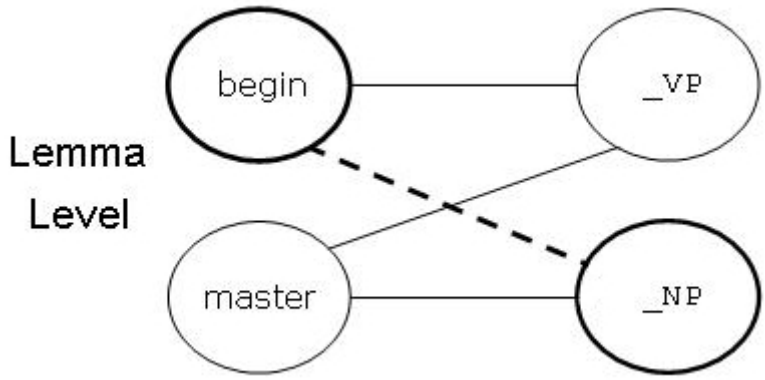
according to the relative levels of activation of the applicable alternatives. In producing *The author began the book*, the speaker does not express the concept WRITE(X, Y), causing the lemma write to be suppressed. This in turn leads to inhibition of the verb node. Since the verb node is inhibited, the VP phrasal projection associated with the combinatorial _VP node cannot be built, therefore this combinatorial node is itself inhibited, along with the connection between the lemma begin and the _VP node. In contrast, the alternative combinatorial _NP node and the connections between begin and _NP are not suppressed. Consequently, higher activation of the _NP node (relative to activation of the _VP node), and activation of the connection between begin and the _NP node, as well as activation of the lemma book, are associated with the coerced form *The author began the book*. Importantly, this difference in levels of activation between the alternate combinatorial nodes (and their connections with the lemma begin) are a result of inhibition triggered by non-selection of the lemma write.

Now compare the flow of activation associated with production of the non-coerced expression *The author began the speech*. The conceptual nodes BEGIN(X, Y) and SPEAK(X) are activated, together with the connection between them. Activation spreads to the lemma level, with the concept SPEAK(X) being realized grammatically as the noun *speech* via activation of the lemma speech. In this case all lexical concepts survive to the lemma level and there are no patterns of inhibition at this level caused by non-retrieval of a particular lemma. Since the noun node is activated, the NP phrasal projection associated with the combinatorial _NP node can be built, therefore this combinatorial node is activated, along with the connection between the lemma begin and the _NP node. As in the case of *The author began the book*, then, production of *The author began the speech* is associated with higher activation of the _NP node (relative to activation of the _VP node), as well as activation of the connection between begin and the _NP node. However, the relative difference in levels of activation of the _NP and _VP nodes (and their connections with the lemma begin) is not of the same magnitude in both cases. Because production of *The author began the book* involves inhibition of the _VP node (via non-retrieval of the lemma write), the difference between activation of _NP and _VP is greater in this case than in the case of *The author began the speech*. Residual patterns of activation reflecting these relative differences account for the different priming effects obtained following *The author began the book* versus *The author began the speech*.

Let us consider how residual patterns of activation affect processing of a subsequent target. Following both *The author began the book* and *The author began the speech* the strengthening of the connection between begin and the _NP node increases the likelihood of using the NP complement structure if the begin lemma is activated again, as in the subsequent production of *The celebrity began the champagne*. However, because the difference in levels of residual activation between the _NP and _VP nodes is smaller following *The author began the speech* than following *The author began the book*, the priming effect in the latter case is greater. In other words, speakers will be more likely to say *The celebrity began the champagne* following *The author began the book* than following *The author began the speech*. This is because speakers will select the _VP node more of the time following *The author began the speech* (thereby producing the alternative form *The celebrity began drinking the champagne*)

Finally, let us consider how the model accounts for the difference in the effect on the production of *The bartender mastered the cocktail* of prior production of *The author began the book* compared with *The amateur mastered the sculpture*. Although the current experiments show no clear evidence for verb-independent priming, statistically significant effects have been reported for syntactic priming in comprehension (Branigan et al., 2005). Tentatively, then, Figure 5-16 shows how patterns of activation at the lemma level might occur in the context of repetition (vs. no repetition) of the coercing verb. The finding that priming was significantly influenced by lexical overlap of the coercing verb is suggestive of residual activation of the link between the lemma begin and the _NP node, as shown by the heavy dotted arc in the figure. This residual activation contributes to the syntactic component of the overall priming effect. Thus, if the coercing verb is repeated between prime and target, residual activation of both the _NP node and the link between the lemma begin and _NP will contribute to the priming effect. In contrast, if the coercing verb differs (as in *The bartender mastered the cocktail*) then only the _NP node will contribute to the priming effect. This is consistent with Pickering and Branigan's (1998) account, in which they claim that priming is due to activation of the connections between nodes at the lemma level as well as the nodes themselves.

Figure 5-16: Patterns of activation at the lemma level in the context of repetition of the coercing verb



5.9 Summary

This chapter reported three priming experiments designed to elicit coerced expressions during a spoken picture description/sentence completion task. This was motivated by the palpable gap in psycholinguistic research of evidence for coercion in production, in the face of comprehension evidence (centred on the costs of coercion to the processor). Experiment 5 found evidence for priming of coerced expressions, and this was interpreted as evidence for priming of abstract semantic content, specifically event structure. Experiment 6 showed that priming was not fully significant in the absence of lexical overlap (reaching significance in the by-items analysis only). A comparison analysis across Experiments 5 and 6 showed that priming was stronger when the coercing verb was repeated; speakers are more likely to reuse semantic structure when the coercing verb is held constant between prime and target. This was interpreted in line with the effects of lexical boost. Experiment 7 found evidence of semantic and syntactic components to the priming effect. Taken together, the results of Experiments 5–7 are consistent with the hypothesis that speakers make use of abstract semantic representations in production, analogous to that shown for comprehension. I discussed how these findings might be interpreted in terms of a model of the conceptual and lemma strata based on Levelt et al. (1999), with reference to enriched composition in the production system, and how syntactic encoding is affected by semantic influences.

Chapter 6

Local and global influences on the production of coerced expressions

6.1 Overview

Based on the findings of Experiments 5, 6, and 7 reported in Chapter 5, it has been argued that speakers do employ mechanisms of enriched semantic composition in producing coerced expressions. This chapter presents an experiment that further explores the representation and processing of complement coercions, by focusing on *contextual* influences on the meaning-to-form mapping mechanisms underlying their production. Specifically, Experiment 8 was designed to explore the contrast between the influences on priming of the coerced complement and the sentential subject respectively. Apart from replicating the priming results of the previous three experiments, this experiment showed no evidence for differing local and global contextual influences on the production of complement coercions.

6.2 Introduction

It is well established that contextual information influences how individual words in a sentence are processed (see Section 2.2.2); over the past two decades debate has focused on issues such as the precise source of contextual effects and what stages in processing are affected. Diverse studies have highlighted more than one source of contextual influence on lexical processing of both ambiguous and unambiguous target words. Specifically, many researchers have distinguished between local and global influences on interpretation, measured in terms of eye movements (Binder & Morris, 1995; Kambe, Rayner, & Duffy, 2001; Morris, 1994; Rayner et al., 1994), lexical decision (Kintsch & Mross, 1985; Schwanenflugel & White, 1991), and naming latencies (Hess et al., 1995). Evidence suggests that both local and global contexts can influence interpretation to differing degrees. For example, Schwanenflugel and White (1991) found that both local and discourse-level context influenced word recognition. Similarly, Morris (1994) showed that reading times on an unambiguous word (e.g., *mustache*) were affected both by local and by global context. In contrast, Hess et al. (1995) found that local context effects on the naming of unambiguous targets (e.g., *poem*) were overridden by global context. And in a series of studies on the interpretation of biased ambiguous words (e.g., *band*, which has the dominant meaning 'music group' and the subordinate meaning 'bracelet'), Rayner and colleagues (Duffy et al.,1988; Kambe et al., 2001; Rayner et al., 1994) found evidence for a *subordinate bias effect*. This refers to the finding that a word (e.g., *band*) is harder to process than an unambiguous control (e.g., *gold*), whether global or local context supported the subordinate meaning. But contrary to the findings of Hess et al., global context did not override local context. This chapter is concerned with different sources of contextual influence on the processing of coerced expressions. I first consider the evidence from comprehension of complement coercions before reporting an experiment that investigated contextual influences on their production.

Recall from the previous chapter (and the literature review) that interpreting complement coercions like *began the book* involves interpolating abstract semantic structure (between *began* and *the book*) that encodes the event meaning associated with the entity-NP *book*. This is because verbs such as *begin* and *enjoy* semantically select for event complements. The eventhood requirement is satisfied in cases like *began reading the book* or *began the fight*. But where these verbs occur with entity-denoting nouns (as in *began the book*), the NP complement is type-shifted from an entity to an event and the elided

predicate is recovered by means of enriched composition (Jackendoff, 1997). Coercion depends on retrieving an event sense from the qualia structure of the noun complement (Pustejovsky, 1991, 1995). Qualia structures are lexical representations capturing the essential attributes of an entity noun, including its telic role (i.e., its purpose or function), and agentive role (i.e., its typical means of coming into existence). For example, the telic role for *book* is *read*, and its agentive quale is *write* (or arguably *print* or *bind*).When a noun phrase like *the book* is type-shifted from an entity to an event, the telic or agentive qualia role is retrieved to generate a predicate equivalent to the underlying event (e.g., *began reading/writing the book*). Importantly, coercion involves selecting a property that is most compatible with the discourse context. If the subject in this case is *the author* (as in *The author began the book*), the agentive qualia role will be retrieved, whereas if the subject is *the student* (as in *The student began the book*) the telic qualia role will be selected. Thus, context plays a role in which qualia role is selected.

Evidence of contextual influences on the interpretation of coerced expressions has been provided by Lapata et al. (2003), who investigated the influence of the sentential subject on the interpretation of complement coercions in German. Using a sentence completion task, Lapata et al. manipulated the subjects of sentences containing coerced complements, and tested which qualia role (telic or agentive) of the complement noun was recovered in the construction of the eventive reading, as expressed in participants' completions. Thus for a complement coercion like *began* ____ *the book* (in German, *begann das Buch* ____) the experimental contrast was between a telic subject (*the critic*), an agentive subject (*the author*) and a neutral subject (*Peter*). Participants' completions showed that telic subjects elicited telic event readings, and agentive subjects elicited agentive readings. Furthermore, the neutral subject condition elicited telic event readings, providing evidence for Pustejovsky's (1995) claim that a telic interpretation is the default reading recovered. Exploring the influence of the discourse context using an eye-tracking paradigm, Traxler et al. (2005) examined the effect of varying prior contextual information on the difficulty of interpreting complement coercions. They found that introducing the understood activity before a target coerced expression did not eliminate the processing cost (e.g., *The contractor had been building in the suburbs. That spring he began a condominium*.), but introducing the entire event sense associated with the coerced complement did (e.g., *The student read a book in his dorm room. Before he started the book about the opium trade*...). Importantly, readers still experienced difficulty at the noun complement

of the coerced expression, even when the preceding sentence explicitly provided the missing predicate.

Lascarides and Copestake (1998) argued that Pustejovsky's (1995) qualia representations are not always sufficient to account for interpretation, as the coerced event reading may not be recoverable from the telic or agentive qualia roles. Their proposal is that if the interpretation of a coerced complement involves an event that is not a telic or agentive role in the complement noun's qualia structure, then a restricted local interpretation (i.e., one based on the interaction of the semantics of the coercing verb and the NP complement; Pustejovsky, 1995) can be overridden in favour of information from the broader context. Focusing on the interpretation of complement coercions with non-conventional interpretations, Lascarides and Copestake proposed a formalism that extends the purely lexical approaches to complement coercion (Jackendoff, 1997; Pustejovsky, 1991, 1995), by incorporating contextual influences on the recovery of a coerced event interpretation. They discussed the following example: *My goat eats anything. He really enjoyed your book*. Here the event reading recovered is *eating the book*, rather than the telic default *reading the book*. Lascarides and Copestake argue that lexical defaults (represented in qualia structure) persist beyond the lexicon into the pragmatic component, where they may be overridden by default pragmatic information. This idea is captured in two axioms: `Defaults Survive`, and `Discourse Wins`. `Defaults Survive` holds that lexical generalizations (i.e., Pustejovsky's qualia structures) normally apply in discourse. `Discourse Wins` holds that conflicting discourse information overrides lexical defaults in determining interpretation. These axioms explain why the reading of *He really enjoyed your book* above is equivalent to *The goat enjoyed eating your book*, rather than *The goat enjoyed reading your book*. The telic quale of book is *read* by default, but this conflicts with pragmatic reasoning, which dictates that goats cannot read books (but can eat them). In this way, discourse constraints take precedence over lexical generalizations, and license the interpretation *The goat enjoyed eating your book*.

In the comprehension literature local and global contexts have been typically defined with reference to sentence-internal versus sentence-external material. That is, local context refers to (closely) preceding words within the same sentence, and global context refers to any text preceding the sentence, i.e., the previous sentence(s) or paragraph(s). By analogy, for complement coercions like *The boy began the book* we can make local and global distinctions in interpretation; however, in this case both are within the sentence. A local interpretation of *The boy began the book* relies solely on the interaction

of the semantics of the noun (*book*) and coercing verb (*began*); this reading can be recovered without reference to the subject of the coercing verb (i.e., *the boy*). Thus the local interpretation of *The boy began the book* is equivalent to *The boy began reading/writing the book*. In contrast, a global interpretation relies on reference to the subject of the sentence; in this case the local reading is overridden in favour of a less plausible interpretation. For example, *The goat began the book* cannot mean *The goat began reading/writing the book*, since world knowledge dictates that goats cannot read nor write. The only way that *the goat* can be plausibly associated with *the book* is via an eating event. Since *eating* is not captured in the qualia structure of the noun *book*, this is a global interpretation: It depends on VP-external material. To summarize, in exploring contextual influences on coerced complements, we can draw a clear distinction between cases of local coercion, which rely on properties of the complement noun and cases of global coercion, which cannot be plausibly associated with these properties.

The experiments reported in Chapter 5 showed that speakers can be primed to produce coerced expressions like *The author began the book*. That set of experiments relied solely on local complement coercions (i.e., ones that relied on either the telic or the agentive qualia roles of the complement nouns to encode the missing predicate). But what would happen to the production priming effect observed in those experiments under the influence of global context (as in *The goat began the book*)? That is, can speakers be primed to produce local complement coercions after producing global complement coercions? Addressing this question would reveal whether the mapping procedures used by speakers to produce coerced expressions remain constant, irrespective of the properties of the sentential subject. Do the same basic operations underlie the construction of coerced meanings, irrespective of global and local differences, or does the construction of coerced representations differ in the two cases? The present experiment examined the effects of global and local context on the processing of complement coercions by recording speakers' sentence completions as they completed picture descriptions in which these two types of context were manipulated.

6.3 Experiment 8: Global versus local coercion

Experiment 8 was designed to assess the relative influences of local versus global contexts on the priming effects observed in Experiments 5–7. The complement coercions elicited in the previous experiments all relied on local coercions, i.e., where the

recovered event sense corresponded to either the telic or agentive role of the complement noun. The experimental paradigm was consequently further developed to include a manipulation of the coerced complement and sentential subject. This allowed us to test whether priming of event structure occurred in the context of local complement coercion, global complement coercion, or both, and facilitated direct comparison of the effects of local and global context.

6.3.1 Predictions for the current study

As in Experiments 5–7, when completing a target sentence fragment participants have the option of either spelling out the missing predicate (e.g., *The bricklayer began building the wall*) or leaving it unexpressed (e.g., *The bricklayer began the wall*). Consistent with the findings of the previous experiments, a coerced fragment like *The author began the* should prime *The bricklayer began the wall*, and the fully-specified alternative *The author began writing the* should prime *The bricklayer began building the wall*. Notice that the above complement coercions are all examples of local coercion. A further prime contrast in the following experiment is between a global coerced fragment like *The goat began the*, and the fully-specified alternative *The goat began eating the*. On the basis of the syntactic component (established in Experiment 7), we predict some priming from global to local coercions: *The goat began the* should prime *The bricklayer began the wall* and *The goat began eating the* should prime *The bricklayer began building the wall*. If global and local coercions are semantically different, then we predict more priming from local primes to local targets than from global primes to local targets. That is, priming from *The author began the* to *The bricklayer began the wall* should be greater than from *The goat began the* to *The bricklayer began the wall*. Similarly, priming from *The goat began eating the* to *The bricklayer began building the wall* should be greater than from *The author began writing the* to *The bricklayer began building the wall*. In sum, if local and global context influences the meaning-to-form mapping mechanisms underlying the production of complement coercions, then we would expect to see an interaction between the two prime factors.

6.3.2 Participants

Thirty-two volunteers from the University of Edinburgh student community were paid to take part. All were native speakers of English with no reading difficulties, and none had taken part in previous experiments in the series.

6.3.3 Materials and design

Twenty-four experimental item sets were created around eight coercing verbs. The full stimulus set is listed in Appendix D. As in Experiments 5–7, each critical item comprised a prime sentence fragment and corresponding picture, and a target sentence fragment and corresponding picture. Primes expressed either a global or a local complement coercion. In addition, primes were either in the coerced or full-VP form. Thus primes were in four conditions, as shown in Figure 6-1. In the LC (i.e., local, coerced) condition, a prime sentence fragment such as *The author began the* was displayed with the picture in the top-left quadrant of the primes in Figure 6-1. In the LF (i.e., local, full-VP) condition, the corresponding prime fragment *The author began writing the* was displayed with the same picture, shown in the bottom-left quadrant of the primes in figure 6-1. In the GC (global, coerced) and GF (global, full-VP) conditions, the prime fragments *The goat began the* and *The goat began eating the* were displayed with the same picture, shown in the top-right and bottom-right quadrants respectively of the primes in Figure 6-1. The target sentence fragment *The bricklayer began* was displayed with the picture at the bottom of Figure 6-1.

All pictures were created using Art Explosion ClipArt software and depicted an action involving an agent and an object undergoing the action. Typical actions depicted were the same as in Experiments 5–7, except that that half of the agents were animals, engaged in activities that were not plausibly associated with the complement of the action (e.g., a goat eating a book, a mouse climbing a cupboard). Animal agents were necessary in order to achieve global readings. Pictures were presented in colour on a white background.

To check that the pictures depicted the intended prime fragment completions, participants were presented with the set of prime and target pictures, and accompanying picture descriptions to complete (e.g., *The author began*, *The goat began*; see Appendix D). Seventy-two fragments (i.e., 48 prime fragments and 24 target fragments) were randomised to produce 12 lists, with one participant completing each list. Seven items yielded highly varied or vague descriptions; e.g., *fix*, *nail*, *put*, *take aim*, *hammer*, and *finish* were events used in completions for *The carpenter started*. The pictures for these items were altered and pretested a second time; again, 12 randomised lists were created, with one participant completing each list. The set of pictures was finalised based on descriptions involving events that occurred with a mean of 8.4 times (out of 12), ranging from 2 to 11 times. Items which showed low counts also showed a high proportion of coerced completions; e.g., while *The expert enjoyed* registered a count of two common events (*sniff*),

this represented 50% of the overall number of explicit events for that item. That is, eight of the 12 completions for this item were entity-NPs, e.g., *The expert enjoyed a fine glass of wine*.

Figure 6-1: Experiment 8 sample experimental stimuli

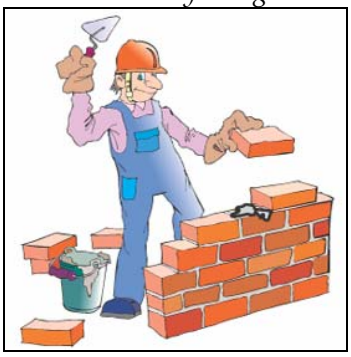
PRIMES

COERCION TYPE

	Local	Global
	The author began the 	*The goat began the* 
Coerced FORM Full-VP	*The author began writing the* 	*The goat began eating the* 

TARGET

The bricklayer began



A second pretest was conducted to establish default (i.e., 'local') preferences for the understood predicate in the complement coercions (see Appendix D). Participants were asked to provide fill-in-the-blank responses to the 48 complement coercions (devoid of subjects) that would be depicted in prime and target pictures in the experiment (e.g., *began* _____ *the book*). The order of the test sentences was randomised to produce 12 lists, with one participant completing each list. On the basis of the responses gathered, verbs were selected for the local, full-VP condition (e.g., *The author began writing the*). These verbs (or synonyms, e.g., *fix* and *mend*) occurred with a mean of 8.0 times (out of 12), ranging from 4 to 11 times. In addition, verbs selected for the global, full-VP condition (e.g., *The goat began eating the*) never appeared in the completions elicited. That is, according to the default verb preferences, these verbs were not plausibly associated with the noun complements expressed.

As an additional means of checking that the local and global complement coercions involved plausible and implausible associations between the underlying events and their corresponding noun complements respectively, similarity measures were derived from Latent Semantic Analysis (LSA) (Landauer, Foltz, & Laham, 1998). LSA offers a method for inducing the contextual-usage meaning of words by statistical computations applied to large text corpora; by calculating cosines between pairs of texts, it captures the degree to which constituents appear in similar contexts. The LSA Matrix comparison was used to control for semantic similarity between coerced predicates and their noun complements. For example, I compared the noun *book* with the verb *write* (local) and the verb *eat* (global) respectively, in order to make sure that the probability of the object NP appearing with the coerced predicate (*write* or *eat*) was significantly different across local and global conditions. More specifically, it was important that the probability was low for the global pairs and high for the local ones. Accordingly, using a 300-factor LSA database, the mean cosine for the locally coerced and globally coerced NPs was estimated at 0.27 (SD = 0.179) and 0.08 (SD = 0.056) respectively. The mean cosine indices were reliably different between the global and local conditions ($t(24) = 4.679$; $p < .001$).

In addition to the 24 experimental item sets, there were 72 filler sentence fragments and associated pictures. Of these, 48 pictures depicted transitive actions, and the corresponding sentence fragments consisted of the following sequence: a noun phrase, an auxiliary verb, a transitive verb and a definite determiner, (e.g., *The butcher was preparing the*). The remaining 24 filler pictures showed intransitive actions, and the

matching sentence fragments consisted of a noun phrase and an auxiliary verb, (e.g., *The rocker was*). Half of the fillers involved human subjects and the other half involved animal subjects. Tense was held constant across all critical and filler items; verb phrases were in the past or past progressive form, (e.g., *was, began drinking*).

The set of practice trials presented before the start of the experiment included one exemplar of each prime type as well as eight filler-type sentence fragments. For each of the four experimental lists, half of the practice trials included prime type exemplars in one order, and the other half of the practice trials included prime type exemplars in the reverse order. Thus, across all experimental lists there were eight practice trial lists.

The experimental items were arranged into four lists, each made up of six items per condition, with one version of each item appearing in each list. Each list of 120 pictures and sentence fragments (24 primes, 24 targets, and 72 fillers) was individually randomized for each participant, such that each prime was immediately followed by its associated target, and critical trials were separated by at least two filler trials.

6.3.4 Procedure

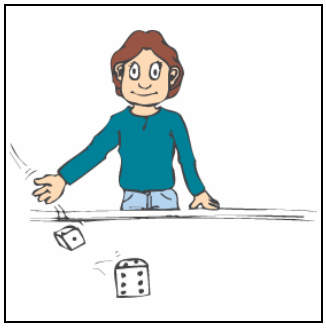
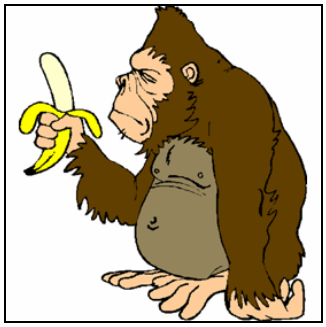
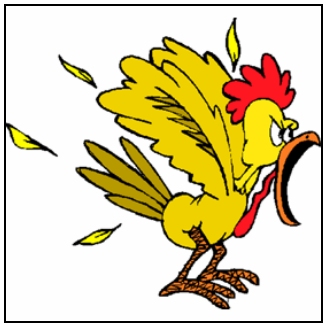
This was the same as in Experiments 5–7 (see Section 5.4.4).

6.3.5 Coding and analysis

Every participant saw 24 experimental prime pictures and produced 24 target utterances, six in each of the four priming conditions (GC, GF, LC, and LF). Every target sentence fragment and corresponding picture was presented to all 32 participants, such that eight participants saw any one version of an experimental item.

The dependent measure of interest was again whether participants produced a coerced or full-VP target picture description. Transcribed prime and target descriptions of the experimental pictures were therefore coded according to the identical criteria as those used in Experiments 5–7 (see Section 5.4.5), yielding four code categories: Coerced, Full-VP, Event-NP, and Other. Trials containing responses that were not completed as intended (i.e., as a GC prime, as a GF prime, as LC prime, or as a LF prime, depending on the condition) were eliminated from the analysis. Coerced target proportions were calculated as per the calculation described in Section 5.4.4. ANOVAs were carried out on the data with Form (coerced vs. full-VP) and Coercion Type (global vs. local) as factors, with separate analyses treating participants (F_1) and items (F_2) as random effects. Both factors were treated as within-participants and within-items.

Figure 6-2: Experiment 8 sample fillers

	SENTENCE FRAGMENTS	PICTURES
FILLERS		
Transitive	*The player was rolling the*	
	The gorilla was holding the	
Intransitive		
	The relative was	
	The chicken was	

There was a large proportion of 'missing data' in this experiment (caused by high numbers of Other responses on prime trials) and this was not distributed evenly across the four conditions (37.5%, 3%, 24.5%, and 3% for GC, GF, LC, and LF conditions respectively). This would have the effect of skewing the coerced target proportions calculated in the primary analysis. A second analysis of the data was therefore carried out; this time, rather than proportions, the statistical analyses were computed on absolute cell frequencies, using a log ratio measure. Additionally, in order to deal with zero cell counts, 0.125 was added to each cell before calculating the log-ratio (Arai, van Gompel, & Scheepers, in press). (This was akin to adding a quarter of a count to each condition per participant, equally divided between the two response categories.) As in the primary analysis, ANOVAs were carried out on the data with Form (coerced vs. full-VP) and Coercion Type (global vs. local) as factors, with separate analyses treating participants (F_1) and items (F_2) as random effects. As before, both factors were treated as within-participants and within-items.

6.3.6 Results

Coding revealed that one item (item 20 in Appendix D-1) had elicited exclusively Other responses; it was therefore removed for the purposes of the following analyses. After this item was removed, application of the coding criteria yielded 611 trials where the prime fragment was completed as either Coerced or Full-VP (83% of all responses). Of these, 139 (23%) were LC trials, 179 (29%) were LF trials, 115 (19%) were GC trials, and 178 (29%) were GF trials. In these 611 trials, participants produced 225 (42%) coerced and 308 (58%) full-VP picture descriptions respectively. Table 6-1 shows the number of coerced, full-VP, event-NP, and Other completions produced in each condition.

Table 6-1: Raw figures per type of target completion produced in the four priming conditions of Experiment 8

	TARGET COMPLETION			
PRIMING CONDITION	Coerced	Full-VP	Event-NP	Other
Local, Coerced	81	42	6	10
Local, Full-VP	49	106	1	23
Global, Coerced	63	37	3	12
Global, Full-VP	32	123	2	21

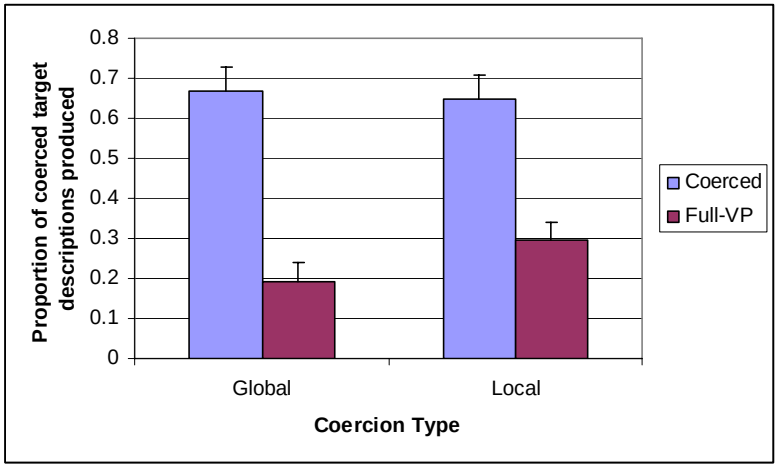
Other and Event-NP responses

Sixty-six target responses out of 611 primed descriptions in total (or 11% of the data) were coded as Other and were excluded from the analysis reported below. Of the 66 descriptions coded as Other, 55 (or 83%) were participial completions (e.g., *The clerk began reading*). Of the 611 primed descriptions, 12 target responses (or 2% of the data) were coded as Event-NP (e.g., *The celebrity started the party*). This was judged to be too few completions of this kind to merit statistical analysis.

Coerced versus full-VP responses

The overall proportions of coerced descriptions produced in the four priming conditions are presented in Figure 6-3. Figure 6-3 shows that participants produced more target completions that were of the same Form (coerced or full-VP) than target completions that were of the alternative Form to the prime completions. Collapsing over Coercion Type, after producing a coerced prime picture description, participants produced a coerced description of the target picture 66% of the time. After producing a full-VP structure, participants produced a coerced target description 25% of the time. Thus, there was an overall priming effect of 41%. In other words, participants produced 41% more target picture descriptions that were of the same Form as the prime picture description than target descriptions that were of the alternative Form. In contrast, the figure shows that collapsing over the two Form types reveals similar proportions of coerced target descriptions in global and local conditions.

Figure 6-3: Proportion of coerced target completions produced in the four experimental conditions of Experiment 8



Two-way ANOVAs carried out on this data revealed a main effect of Form (F_1 (1, 31) = 68.78; $p < .001$; F_2 (1, 22) = 53.11; $p < .001$). There was a significant overall tendency to repeatedly express the same level of event structure, manifested as a priming effect of 41%; that is, participants produced 41% more target responses that were of the same type (coerced or full-VP) as the prime response than target responses that were of the alternative type to the prime response. In addition, the effect of Coercion Type was significant in the by-items analysis only (F_1 (1, 31) = 1.277; $p = .27$; F_2 (1, 22) = 5.43; $p < .05$). There were 4% more coerced responses in the local condition than in the global condition (0.43 vs. 0.47). There was no interaction between Form and Coercion Type (both Fs < 1), indicating that priming did not differ whether the context of coercion was global or local. Priming occurred both in the context of global coercion (0.48) and in the context of local coercion (0.35).

Log ratio analysis

The log ratios of coerced to full-VP target descriptions produced in the four priming conditions are presented in Table 6-2.

Table 6-2: Log ratios of coerced to full-VP target completions in Experiment 8

PRIMING CONDITION	TARGET LOG RATIO
Local, Coerced	.9503
Local, Full-VP	-1.2016
Global, Coerced	.9803
Global, Full-VP	-1.9213

Two-way ANOVAs carried out on the log ratios revealed the same pattern of significant effects as the primary analysis. There was a main effect of Form (F_1 (1, 31) = 68.75; $p < .001$; F_2 (1, 22) = 52.93; $p < .001$), supporting the above finding of a significant overall tendency to repeatedly express the same level of event structure. In addition, the effect of Coercion Type was significant in the by-items analysis only (F_1 (1, 31) = 2.21; ns; F_2 (1, 22) = 4.60; $p < .05$), consistent with the primary analysis. Finally, there was again no interaction between Form and Coercion Type (both Fs < 1). The log ratio analysis also showed that priming did not differ whether the context of coercion was global or local.

6.4 Discussion

In Experiment 8, participants were presented with sentence fragments to complete in a way that best described accompanying pictures. When producing target completions, they repeatedly expressed the same level of event structure in their description as that of a preceding prime description. That is, they were more likely to produce a coerced picture description after having just produced a coerced description than after having just produced a full-VP description. These results replicate the findings of Experiments 5–7 in Chapter 5. More importantly, Experiment 8 showed that priming of event structure occurred regardless of whether the coercion was influenced by local or global context, i.e., the complement noun or the sentential subject. There was no indication that priming in the context of global coercion was any stronger than priming in the context of local coercion, suggesting that there is no semantic difference between global and local complement coercions. However, a possible explanation for this finding is that the intra-sentential context manipulation is simply too weak to have an effect.

The patterns of 'missing data' on prime trials in this experiment merit a brief comment. Across Experiments 5–7, coerced conditions showed higher proportions of Other responses than full-VP conditions. We can take this as evidence that, in the absence of priming, full-VP complements were the default picture description preference. Experiment 8 showed a higher proportion of Other responses for the global coerced condition than for the local coerced condition. This suggests that local coercions are the preferred default over global coercions, in the absence of priming.

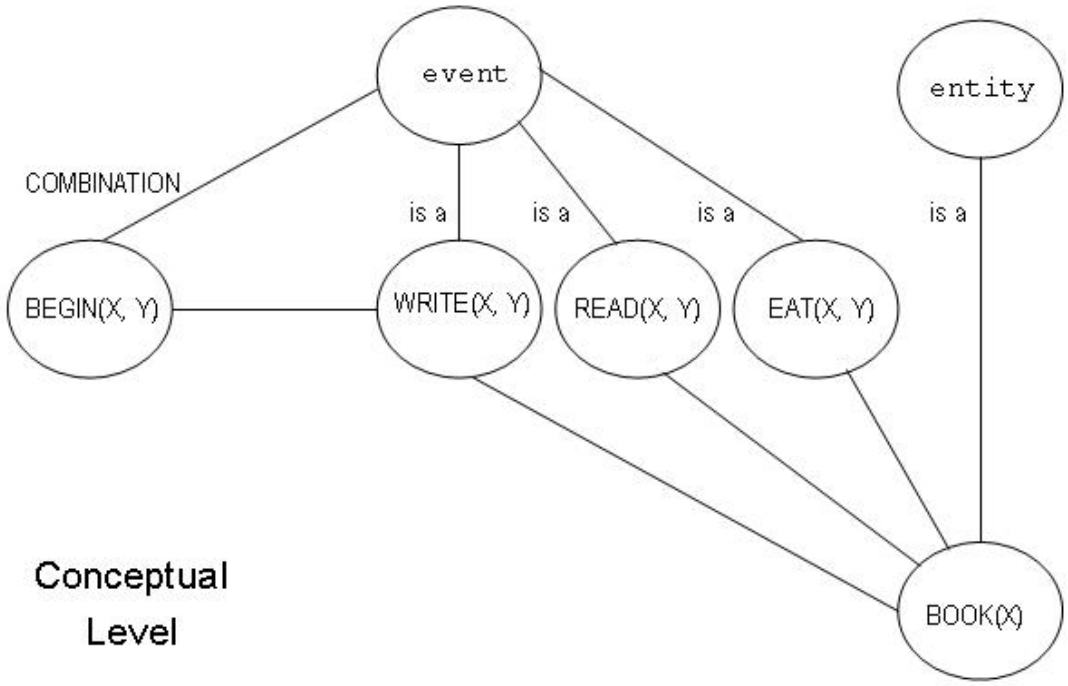
We can now incorporate the current set of results into the model proposed in Section 5.8 (see Figure 5-15). Figure 6-4 depicts the relevant further details. As in Figure 5-15, Figure 6-4 shows that the conceptual node BEGIN(X, Y) is connected via a COMBINATION link to the semantic node `event`, capturing the fact that BEGIN(X, Y) combines with an event. For the purposes of the discussion in Section 5.8, Figure 5-15 showed only the predicate WRITE(X, Y) mediating the concepts BEGIN(X, Y) and BOOK(X). Figure 6-4 extends the representation to include other possible predicates (WRITE(X, Y), READ(X, Y), and EAT(X, Y)), capturing local and global readings. These three predicates are connected to the node `event` via is a relations, reflecting the fact that they have the semantic status of events. Similarly, the concept BOOK(X) is connected to the semantic node `entity`, capturing the fact that it has the semantic status of an entity. BEGIN(X, Y) is connected to the predicates WRITE(X, Y),

READ(X, Y), and EAT(X, Y) and these are in turn connected to the entity concept BOOK(X). The predicate EAT(X, Y) is global whereas WRITE(X, Y) and READ(X, Y) are local with respect to BOOK(X); this information is captured in the network by default levels of activation of the connections between the concept BOOK(X) and the respective predicates: Reflecting the fact that *eat the book* is an implausible event, the connection between EAT(X, Y) and BOOK(X) will show a low base activation.[5] In contrast, *read* and *write* are telic and agentive qualia roles of *book*, therefore the connection between READ(X, Y) and BOOK(X), and the connection between WRITE(X, Y) and BOOK(X) will both have higher base levels of activation. The levels of activation of these last two relative to each other will reflect the default preference for the particular coercing verb-entity complement combination. If the default local reading is the telic qualia role, then the connection between READ(X, Y) and BOOK(X) will have a higher base activation than the connection between WRITE(X, Y) and BOOK(X), or vice versa.

The priming results suggest that once the speaker has produced a global or local coercion, patterns of residual activation on a subsequent target trial equally favour a local or a global coercion. That is, priming in this case is purely syntactic, reflecting a choice of combinatorial node at the lemma level. Crucially, there is no difference in the influences of local and global contexts on priming.

[5] By extension, all conceptual node predicates are connected to all noun concepts, with the default weights of the connections between verb-noun pairs capturing plausibility constraints (and, in the case of complement coercions, global versus local readings). The model has the potential to be unconstrained given the proliferation of connections; the values of default weights have an important role to play in offsetting this.

Figure 6-4: The conceptual level, showing local and global predicate concepts



In sum, the results of Experiment 8 suggest that the mapping of event structure onto syntactic structure in the production of complement coercions may draw on more than the lexically localised qualia representations proposed by Pustejovsky (1995). While speakers appear to resist producing globally coerced complements (reflected in the proportion of 'missing' prime data in the GC condition), the results do suggest that speakers are able to map event representations that depend partly on the sentential subject, rather than on properties of the complement noun alone. That is, speakers use their knowledge that *authors* may be connected with *books* through *writing*, but *goats* may not. Thus, while producing a coerced expression like *The author began the book* may rely (at least partly, if not entirely) on the lexical properties of the noun *book*, the mapping of event structure in producing a global coercion like *The goat began the book* depends much more heavily on the properties of the noun *goat*. In this sense, the current data provide psycholinguistic evidence for Lascarides and Copestake's (1998) pragmatic account of coercion operations, in which lexical defaults may be overridden by discourse information.

6.6 Summary

The aim of this chapter was to explore contextual influences on complement coercion, specifically the difference between local and global contexts. The results of Experiment 8 were consistent with the findings of the previous three experiments, and demonstrated that global and local context does not influence the production of complement coercion.

Chapter 7

Conclusions

7.1 Overview

This thesis set out to investigate the mental representation and online processing of abstract conceptual structure during language processing using priming. It explored two issues: First, it examined some of the processing mechanisms underlying the comprehension of conceptual combinations. Second, it examined some of the processing mechanisms underlying the production of coerced expressions. A number of conclusions can be drawn from the findings of the eight experiments reported here. Additionally, the two studies open the way for diverse possibilities for further research on the respective topics of investigation. In the sections that follow, I summarise the main findings of each study, and highlight some unanswered questions and directions for future research in each of the two areas.

7.2 Conceptual combination

The experiments reported in Chapters 3 and 4 used a forced-choice expression-picture matching paradigm to investigate relation priming during the comprehension of novel ambiguous noun-noun combinations. The motivations for this study were two-fold.

First, the two dominant theoretical approaches to conceptual combination make very different predictions with respect to the influences of modifier and head constituents on comprehension. Second, the recent relevant studies on relation priming have reported highly discrepant results. The current set of experiments was designed to shed light on the determinants of relation priming by using an experimental procedure that had not yet been exploited in this area, thereby informing the theoretical debates on conceptual combination.

The three experiments reported in Chapter 3 assessed the relative influences of modifier and head constituents on relation priming. Experiment 1 examined the effects of lexical repetition and semantic relation. Results showed reliable relation priming; participants tended to choose target pictures that instantiated the same relation as a preceding prime picture. Furthermore, in addressing the issue of whether recovery of the linking relation relied on the modifier or the head, results showed statistically equivalent priming in the context of repetition of the modifier and head respectively. Experiment 2 demonstrated significant priming when neither noun constituent was repeated. This finding is important because previous demonstrations of relation priming in the absence of lexical repetition have been open to alternative explanations. Given the current experimental design, we can be confident that the priming effect observed in Experiment 2 was due to repetition of the conceptual relation between prime and target, rather than to other (e.g., contextual) factors. A comparison analysis across Experiments 1 and 2 demonstrated that priming was significantly stronger in the context of lexical repetition. Experiment 3 showed significant priming when each picture contained both relations, arguing against a possible visual-priming account.

The findings of Experiments 1–3 were interpreted with respect to relation- and schema-based theories of conceptual combination, as captured in Gagné and Shoben's (1997) CARIN model and Estes and Jones' (2006) account. First, the findings of equivalent priming for modifier and head repetition, as well as priming in the absence of repetition, constitute convincing evidence against two core tenets of the CARIN model. The first is the 'primacy of the modifier', i.e., the notion that modifier constituents have semantic privilege in conceptual combination, and the second is that relations have bound representations. Importantly, the finding of relation priming in the absence of repetition suggests that Estes and Jones' independent model, according to which relations are independent representations in the semantic network, may not be entirely accurate either. The lexical boost effect that emerged from the combined analysis of

Experiments 1 and 2 suggests that relational representations are at least partly localized to the individual concepts that are combined. In sum, the data from Experiments 2 and 3 suggest that relations have representations that are partly independent from the head or modifier; whereas the combined analysis of Experiments 1 and 2 suggest that these representations are not entirely independent.

Based on the pattern of results observed across these experiments, I proposed a partial model (based on Levelt et al., 1999) of how relation priming might work in the comprehension of noun-noun combinations. In brief, the model localized the account in the conceptual stratum, where lexical concepts are linked to relations. Activation of a relation node increases the likelihood of reusing the relation to interpret a subsequent combination. Moreover, residual activation of the connection between that relation and a conceptual node further boosts the likelihood of using that relation if that lexical concept is activated again. Thus, residual activation of concept nodes and relation nodes, as well as the connections between them, accounts for priming.

Experiment 4 (reported in Chapter 4) used a slightly altered experimental design to measure the time participants took to select a matching picture, thereby assessing whether the priming of response choice observed in Experiments 1–3 converged with patterns of reaction-time data. In this case the experimental manipulation centred on congruent versus incongruent relations between prime-target pairs. Results showed that participants were not faster to respond to targets that instantiated prime-congruent relations than ones that instantiated prime-incongruent relations. That is, there was no priming of response times. I considered possible explanations for this null result, and argued on methodological grounds that the finding is not inconsistent with the previous experiments. Taken together, the current set of experiments on conceptual combination provides convincing evidence against the relation-based approach proposed by the CARIN model (Gagné & Shoben, 1997), and supports aspects of Estes and Jones' (2006) account.

A few issues that have not been addressed in the current study merit consideration, and point to areas for further research. First, the current set of experiments used just two relations on the grounds that this allowed a considerable degree of experimental control. This study was inspired by the methodology used in syntactic priming studies (both in production and comprehension), which typically allow participants to produce one of two forms or comprehend one utterance in two ways, and have two priming conditions that correspond to these two possibilities. We cannot of

course be certain that the current findings generalize to other pairs of relations, just as it is not possible to be certain that findings of structural priming with actives and passives (say) generalize to other constructions.

Second, the critique of CARIN presented here has not addressed the question of whether the taxonomy of relations is the right one; indeed, this is a matter of considerable debate (see Wisniewski & Murphy, 2002, for a discussion). For the purposes of the current study, it was important to use relations assumed by one of the models whose predictions were under scrutiny. The set of relations that the CARIN model assumes are themselves derived from the linguistic taxonomy developed by Levi (1978). But there is reason to believe that this small set of basic relations underestimates the richness of people's knowledge by being too general in nature, and that people derive much more specific relations between the constituents of combinations than those captured in this set. Further work needs to be done to establish what the most appropriate taxonomy of semantic relations might be.

Finally, the question of whether property compounds require a different process of interpretation (cf. the distinction proposed by dual-process theory between relation linking and property mapping mentioned in Section 2.4.2) is contentious. Some research has suggested that property interpretations are a last resort, and that property compounds are relatively rare, and more difficult to interpret than relation compounds. Gagné (2000) suggested that property compounds are in fact simply another kind of relational compound, which instantiate the LIKE/RESEMBLANCE relation. Given that the current experiments were designed to test a specific set of predictions made by the CARIN model, I have chosen to steer clear of these questions, but they clearly need to be addressed in future work.

7.3 Complement coercion

The experiments reported in Chapters 5 and 6 used a combined sentence completion/ picture description paradigm to investigate whether speakers employ mechanisms of enriched composition during the production of complement coercions. This was motivated by the paucity of psycholinguistic studies concerning coercion in production, in the face of extensive evidence from comprehension (centred on the costs of coercion to the processor). The aim of the experiments was to explore the workings of coercion in production by looking for evidence of enriched composition via semantic priming.

The three experiments reported in Chapter 5 tested whether speakers can be primed to produce complement coercions, in which the event structure projected by the coercing verb is missing. Experiment 5 found that speakers were influenced by the level of semantic specification of a preceding utterance in producing coerced complements. When producing target picture descriptions, they produced more coerced complements following coerced primes than following primes that included the fully-specified event structure, and more full-VP completions following full-VP primes than following coerced primes. Experiment 6 explored verb-independent priming but failed to yield strong evidence of priming in this case. Experiment 7 extended the experimental design to include a third critical priming condition, in order to tease apart syntactic and semantic components to the priming effect. The combination of a coercing verb and an event-NP yielded different levels of priming compared with both other (coerced and full-VP) priming conditions. This experiment confirmed that abstract event structure affected choice of syntactic structure, and established syntactic and semantic components to priming.

The combined results of Experiments 5–7 were interpreted in terms of a model (based on Levelt et al., 1999) of the conceptual and lemma strata, in which coercing verbs are linked to combinatorial nodes corresponding to alternate syntactic structures. Drawing on the account proposed by Pickering and Branigan (1998) for syntactic priming, the model shows that priming arises as a result of residual activation of combinatorial nodes, as well as residual activation of the links between the coercing verb node and the combinatorial node. Activation of these links accounts for the lexical boost effect, evident in the comparison between priming across Experiments 5 and 6. In sum, the model captures the mapping of abstract event structure onto alternating syntactic configurations.

Chapter 6 reported a follow-up experiment designed to investigate contextual influences on the meaning-to-form mapping mechanisms underlying the production of complement coercions. Experiment 8 compared global and local influences on priming, using the same experimental procedure as that used in Experiments 5–7. Results showed evidence of the syntactic component to priming observed in the previous three experiments, but no semantic component. That is, the coerced complement (local) and sentential subject (global) conditions had equivalent influences on priming. This data was discussed in relation to the model proposed in Chapter 5. The representations in the conceptual stratum were extended to include nodes capturing local and global underlying

predicates, and preferences were explained in terms of default patterns of activation at this level in the network. In sum, the mental representations and processing mechanisms underlying semantic type coercion are issues that have only recently begun to receive serious attention in psycholinguistics. This thesis adds to the growing body of literature suggesting that people use mechanisms of enriched composition in language processing, and extends previous experimental evidence to processes in production.

It is clear that further work needs to be done to clarify several key assumptions underlying theoretical accounts of coercion such as that proposed by Pustejovsky (1991, 1995). For example, the current set of experiments does not offer any insight as to a *psycholinguistic* account of the details of qualia representations. Indeed, apart from being counterbalanced in Experiments 5 and 6, qualia roles were not taken into consideration in this study. Moreover, the information that they encode is only very crudely captured in the network model depicted in Figures 5-15 and 6-4. Further research is needed to elaborate the precise nature of these lexically localized structures, in order to integrate linguistic and psycholinguistic accounts of complement coercion. Another issue to address in future work is the nature of default interpretations of complement coercions. Pustejovsky (1995) claims that the telic role is the default event recovered in interpretation, but this should be investigated experimentally. Finally, given that complement coercion (as well as other types of coercion) has not been studied in production, there are a wide range of possible experimental manipulations which logically follow from the studies reported here. For example, a further prime contrast would be to consider the effects of repetition of the underlying (coerced) predicate.

On a more general and speculative note, it may be worth considering other phenomena that exhibit similar meaning-to-form mapping properties as complement coercions. How general is the model proposed in Chapter 5? I have argued that it captures the priming evidence for how syntactic alternations are linked to common message-level representations. There are other cases where conceptual representations are not mapped onto syntactic structures (e.g., *The man ate*), which may be explained by similar means.

In summary, this thesis has offered fresh and convincing relation priming evidence to the ongoing debate between proponents of competing theoretical models of conceptual combination. Additionally, it has presented priming evidence suggesting that people use mechanisms of enriched composition in language processing, thereby extending previous psycholinguistics accounts of coercion to processes in production.

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Appendix A

Materials used for the experiments reported in Chapter 3

A-1: Experimental items for Experiment 1

The combinations in parentheses describe the distracter prime pictures.

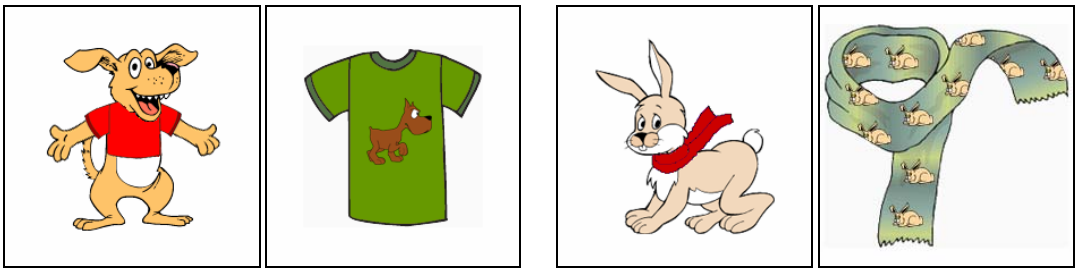
	PRIMES		TARGET
	Modifier Repeated	Head Repeated	
1.	dog T-shirt (dog newspaper)	rabbit scarf (duck scarf)	dog scarf
2.	bear mug (bear pillow)	doll umbrella (clown umbrella)	bear umbrella
3.	dinosaur lamp (dinosaur sofa)	porcupine flag (goose flag)	dinosaur flag
4.	frog bucket (frog boat)	baby hat (grandfather hat)	frog hat
5.	mouse bed (mouse trophy)	cyclist fan (dancer fan)	mouse fan
6.	pig teapot (pig candle)	grandmother book (boy book)	pig book
7.	gorilla sign (gorilla basket)	fox tent (tortoise tent)	gorilla tent
8.	elephant parachute (elephant tambourine)	penguin boots (beaver boots)	elephant boots
9.	ant shoes (ant flippers)	goat chair (bird chair)	ant chair
10.	eagle handbag (eagle pot)	monkey shorts (squirrel shorts)	eagle shorts
11.	cat purse (cat crown)	pelican bottle (kangaroo bottle)	cat bottle
12.	snake table (snake desk)	octopus cap (sheep cap)	snake cap
13.	rat cookie (rat cupcake)	seal bracelet (rooster bracelet)	rat bracelet
14.	fish car (fish canoe)	crane balloon (crow balloon)	fish balloon
15.	hippo bath (hippo plane)	turtle suitcase (vulture suitcase)	hippo suitcase
16.	flamingo ice-cream (flamingo plate)	grasshopper bell (koala bell)	flamingo bell
17.	lion pipe (lion skirt)	butterfly can (chicken can)	lion can
18.	dragon dress (dragon waistcoat)	king guitar (pirate guitar)	dragon guitar
19.	wizard iron (wizard teacup)	elf sweet (hunchback sweet)	wizard sweet
20.	raccoon backpack (raccoon wheelbarrow)	parrot horn (snail horn)	raccoon horn
21.	puppy cot (puppy pram)	cow jug (lobster jug)	puppy jug
22.	cowboy bowl (cowboy pan)	fairy saw (mermaid saw)	cowboy saw
23.	turkey apron (turkey helmet)	angel vase (gnome vase)	turkey vase
24.	kitten bow (kitten sombrero)	bull mittens (rhino mittens)	kitten mittens
25.	caterpillar cushion (caterpillar stool)	bee wallet (owl wallet)	caterpillar wallet
26.	giraffe earring (giraffe pendant)	ape tie (horse tie)	giraffe tie
27.	shark bandage (shark plaster)	mosquito belt (panda belt)	shark belt
28.	leopard poncho (leopard scale)	donkey socks (camel socks)	leopard socks
29.	tiger pyjamas (tiger bathrobe)	ostrich trousers (stork trousers)	tiger trousers
30.	alligator coat (alligator cardigan)	ladybird trainers (lamb trainers)	alligator trainers
31.	lizard brush (lizard hanger)	mole gloves (panther gloves)	lizard gloves
32.	pilot jeans (pilot overalls)	monk jacket (knight jacket)	pilot jacket

A-2: Experimental pictures for Experiments 1 and 2

PRIMES

Modifier Repeated | Head Repeated

1.



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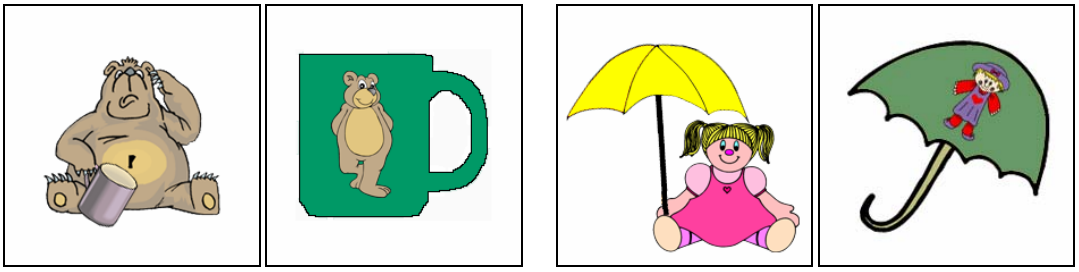

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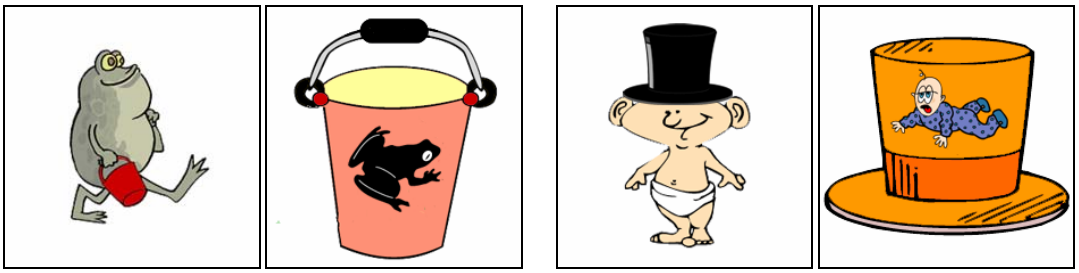
4.



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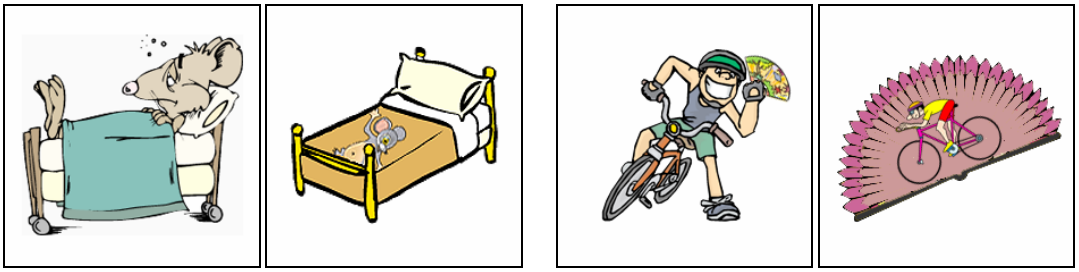

PRIMES

Modifier Repeated Head Repeated

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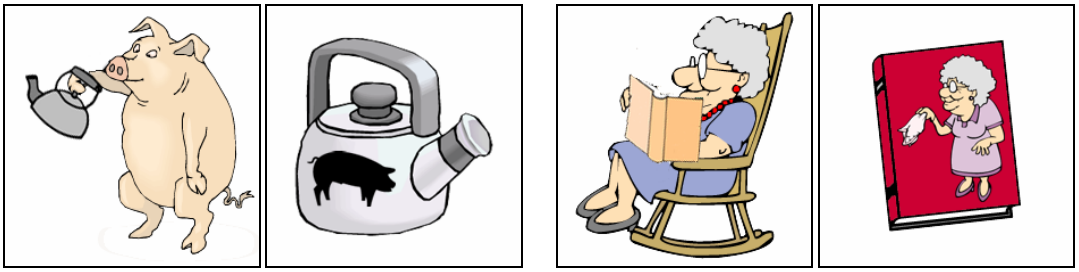

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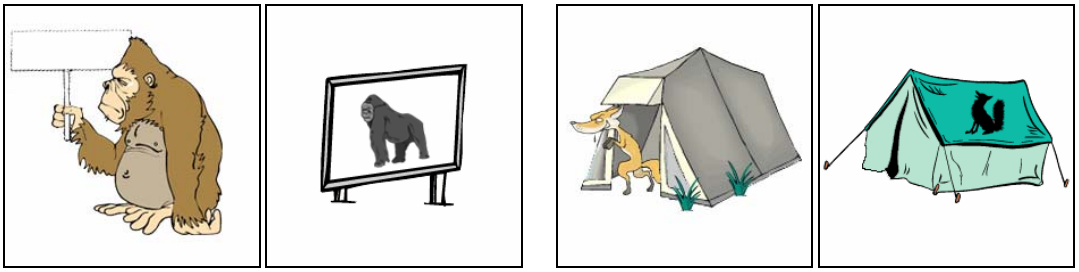

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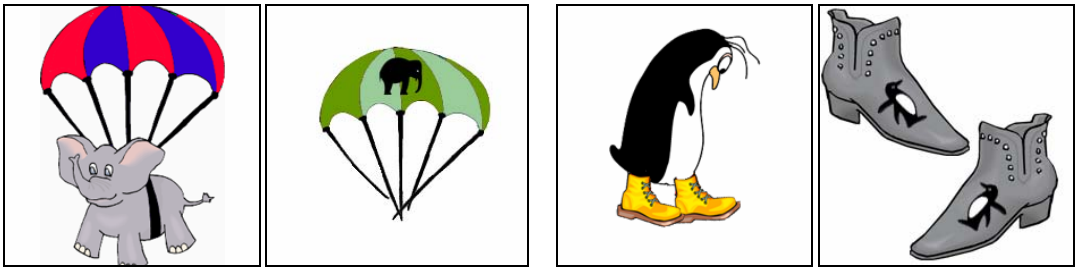

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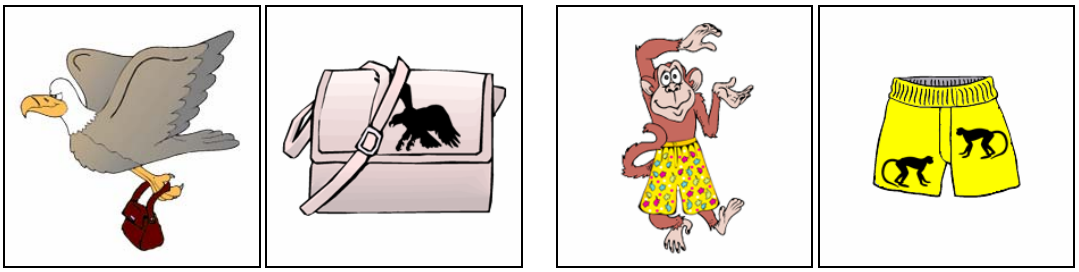

PRIMES

Modifier Repeated Head Repeated

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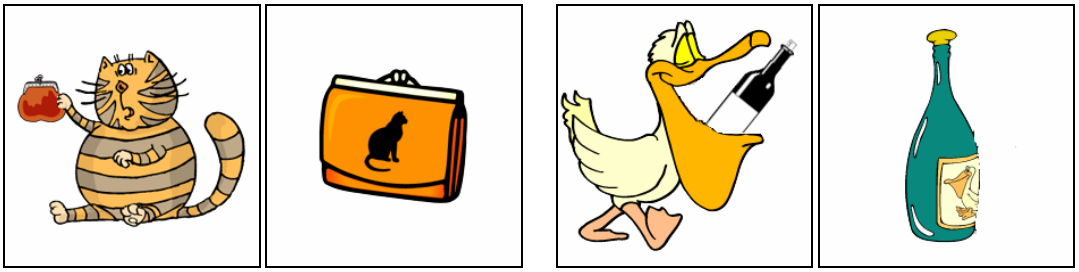

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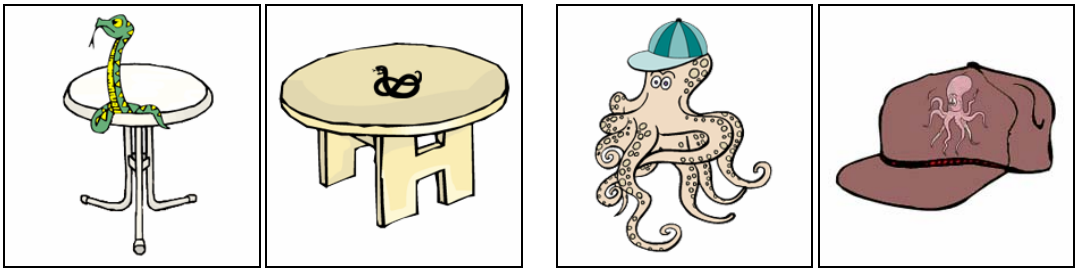

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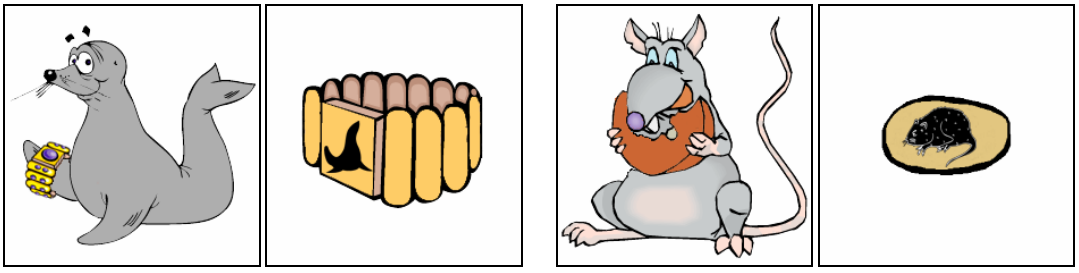

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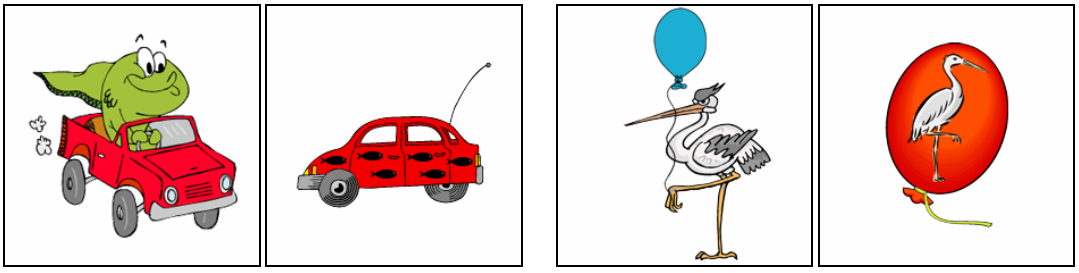

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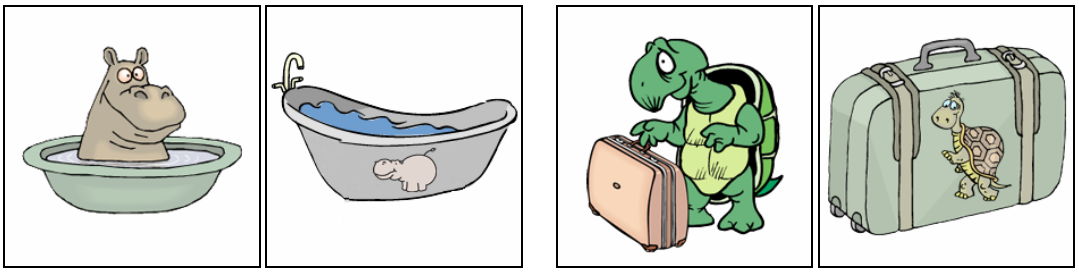

PRIMES

Modifier Repeated Head Repeated

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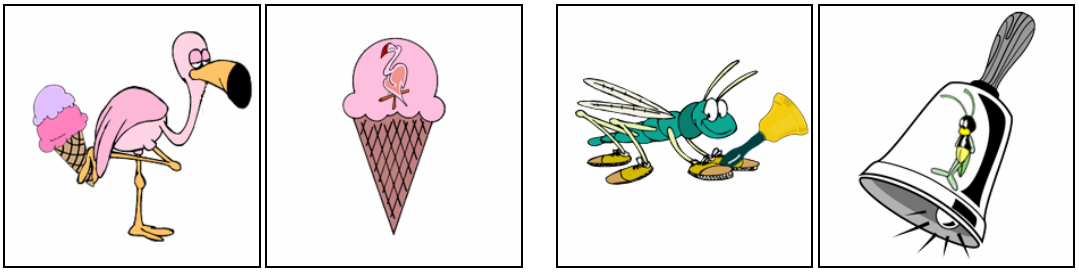

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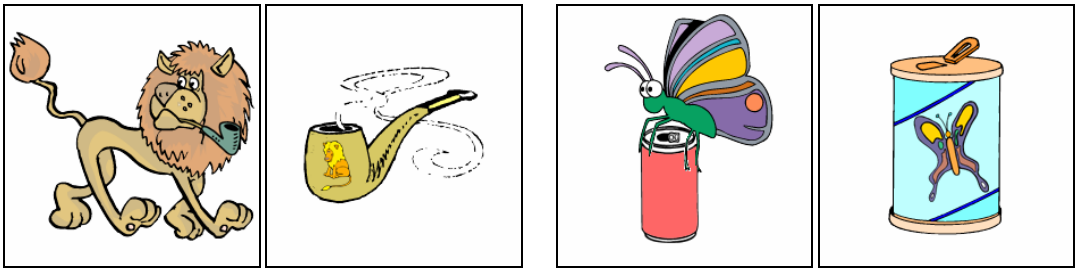

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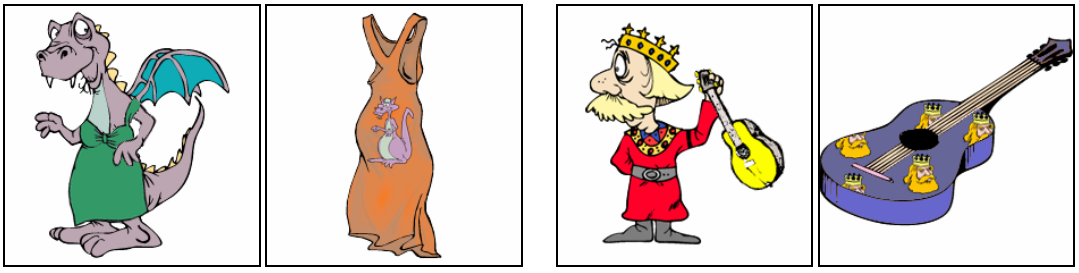

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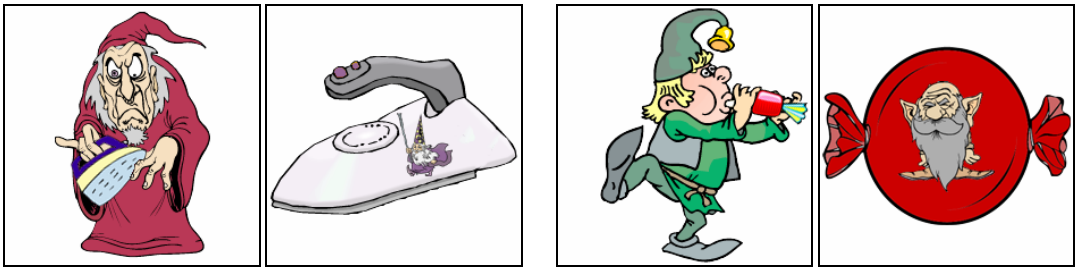

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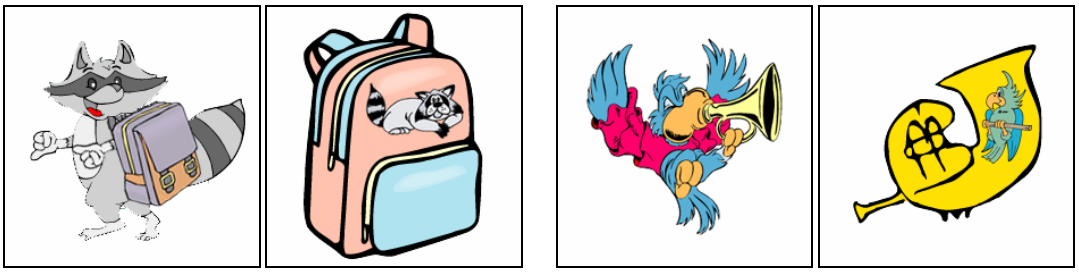

PRIMES

Modifier Repeated		Head Repeated	

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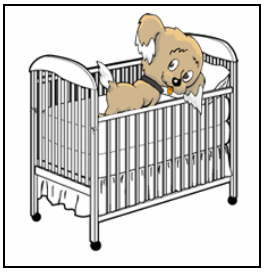
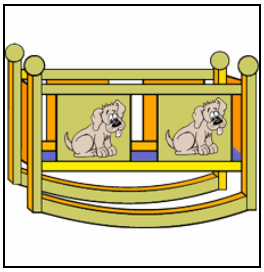

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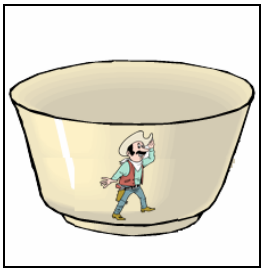
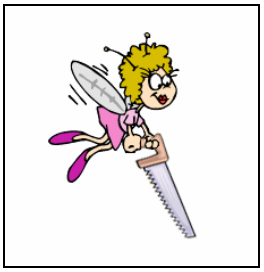
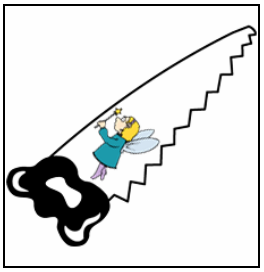

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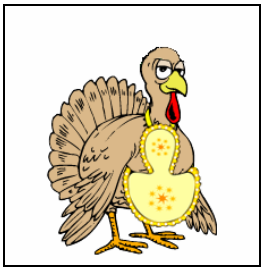
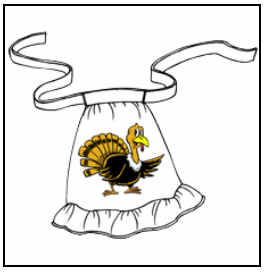

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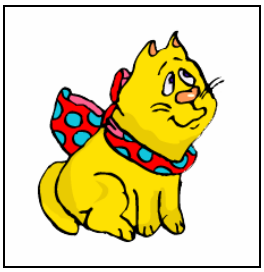
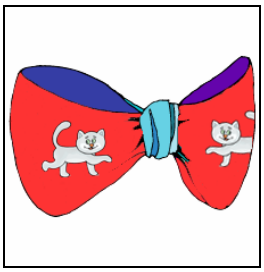

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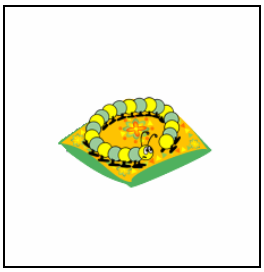
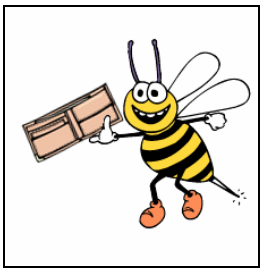
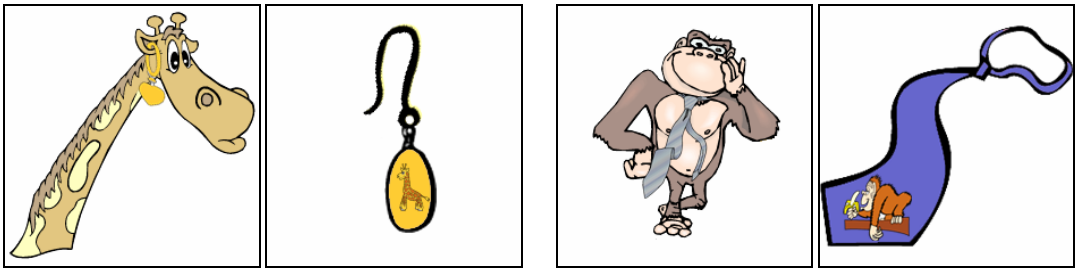





PRIMES

Modifier Repeated | Head Repeated

26.



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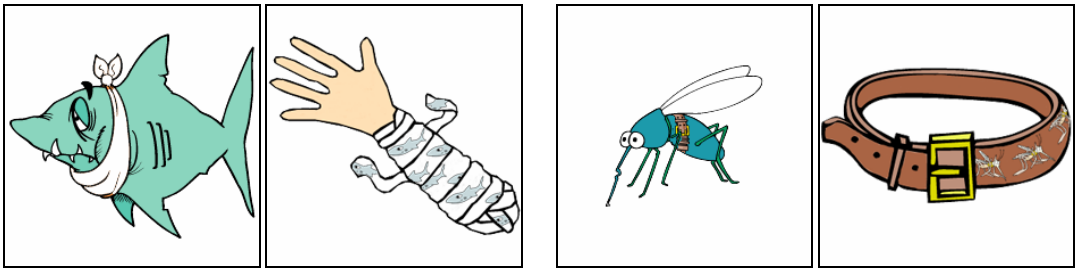

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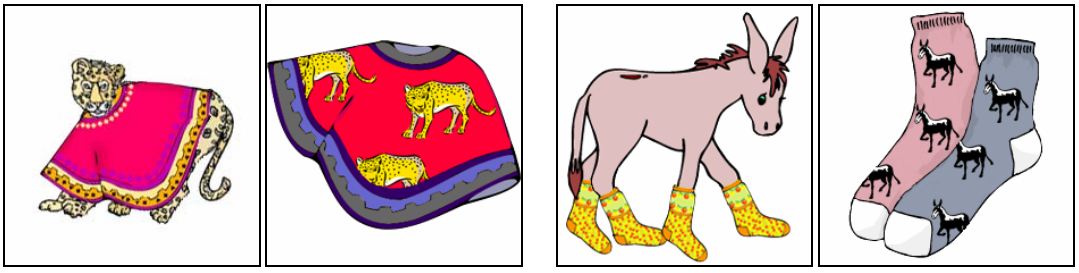

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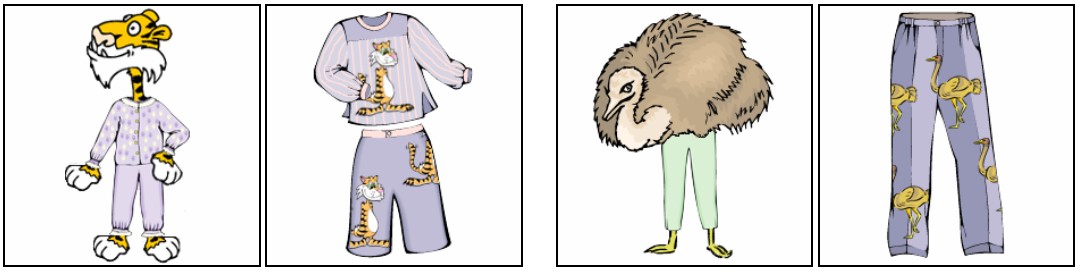
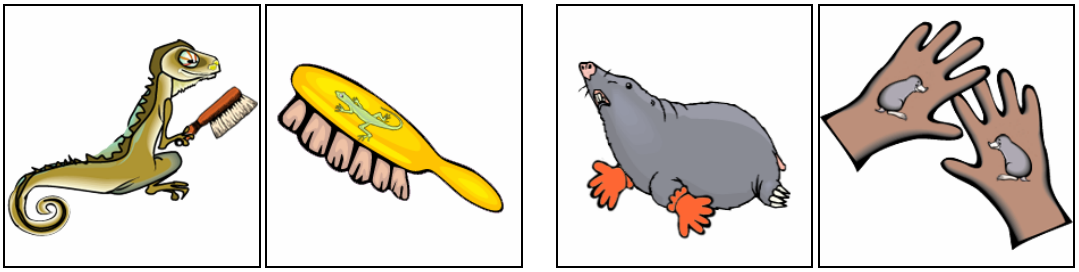


30.

PRIMES

Modifier Repeated Head Repeated

31.



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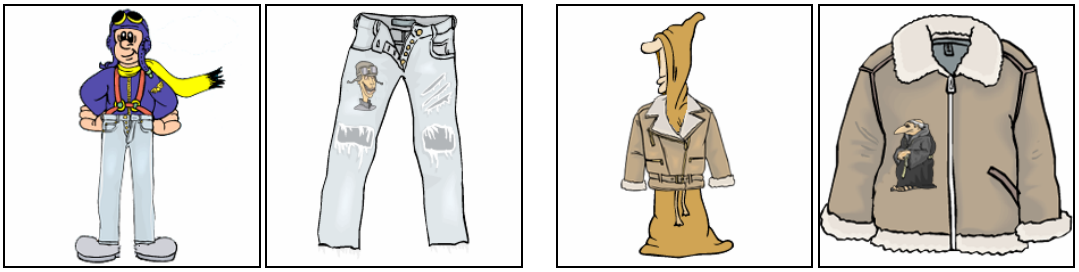

TARGETS

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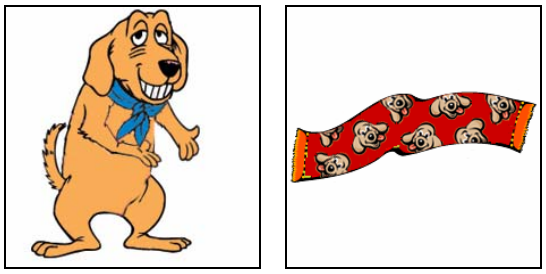

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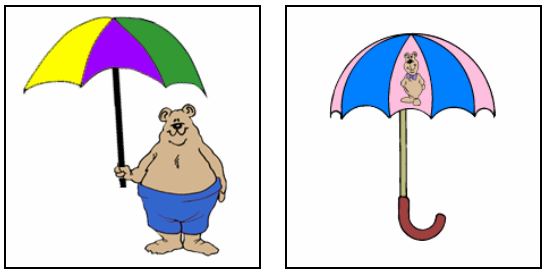

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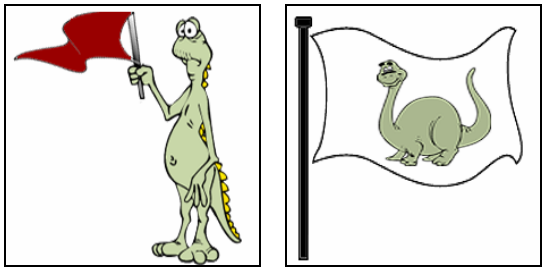
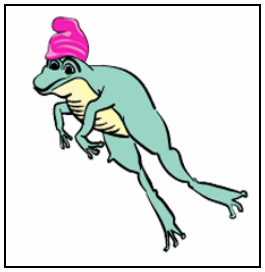


TARGETS

4.

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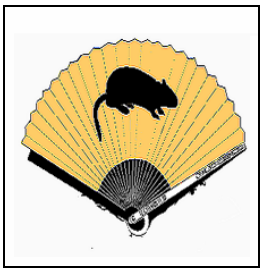

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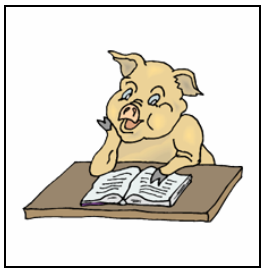
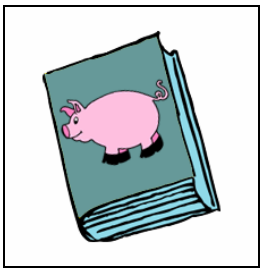

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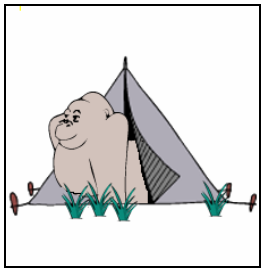
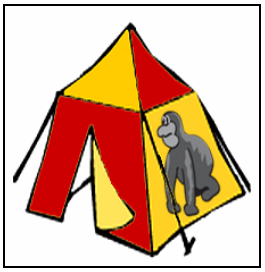

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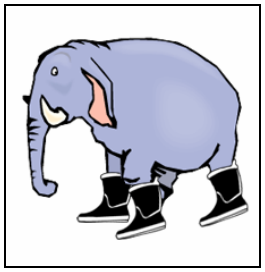


TARGETS

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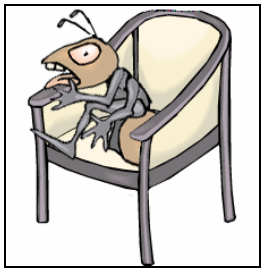
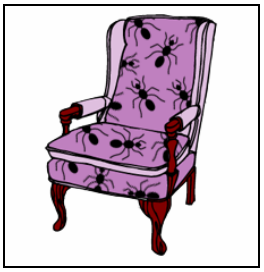

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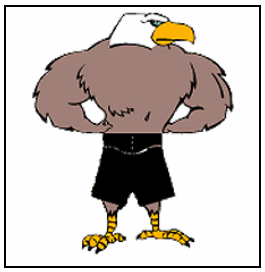


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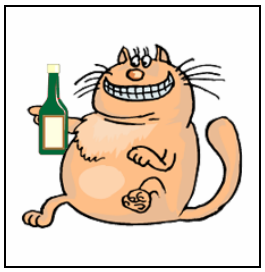


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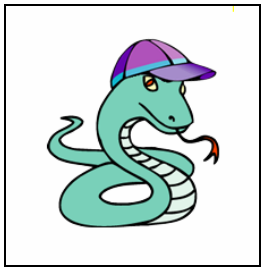


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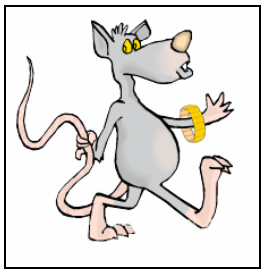
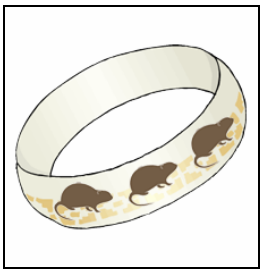

TARGETS

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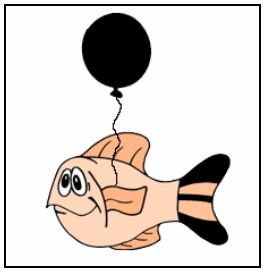
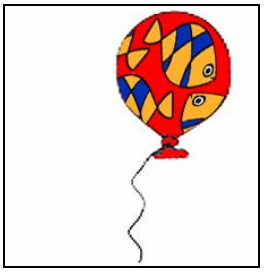

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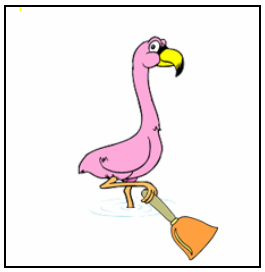


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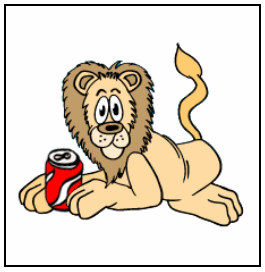
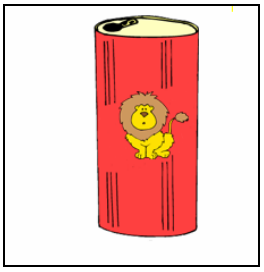

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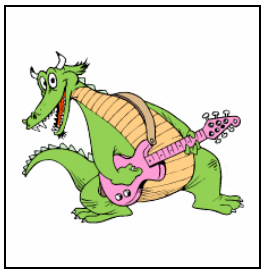


TARGETS

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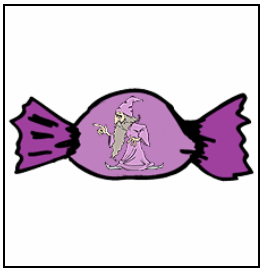

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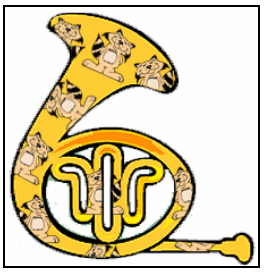

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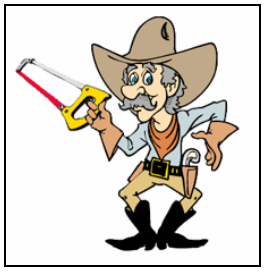
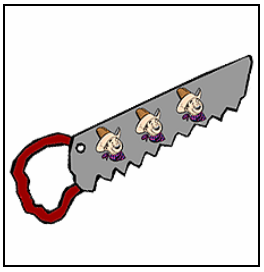

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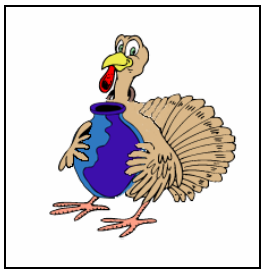


TARGETS

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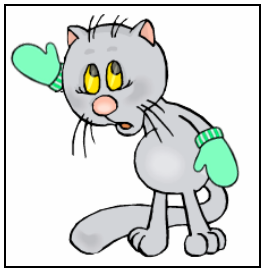
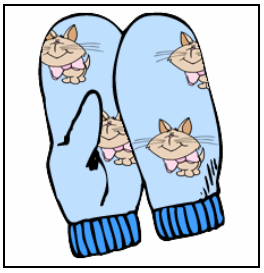

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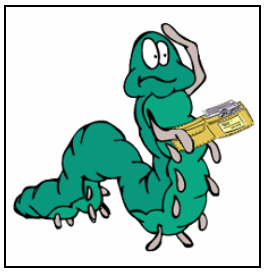
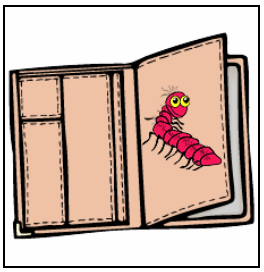

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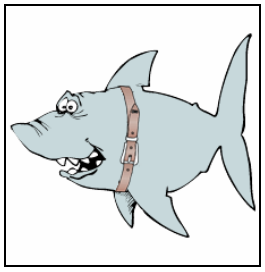
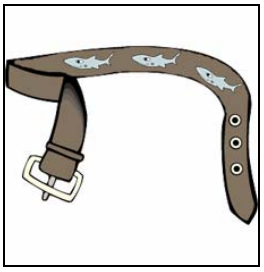

28.


TARGETS

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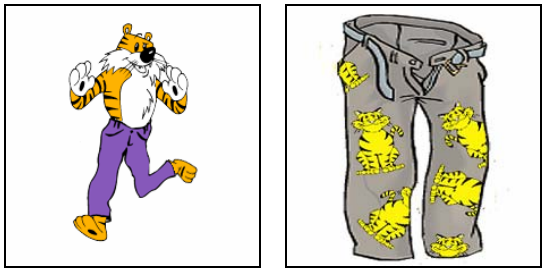

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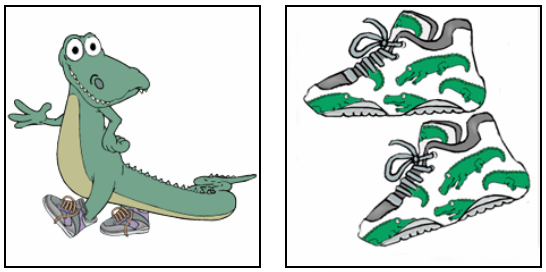

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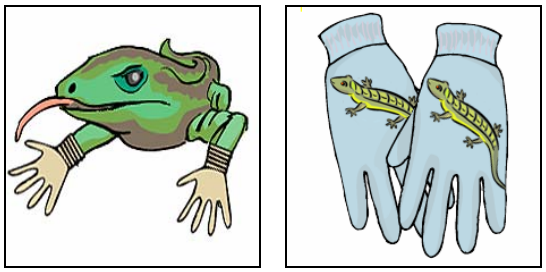

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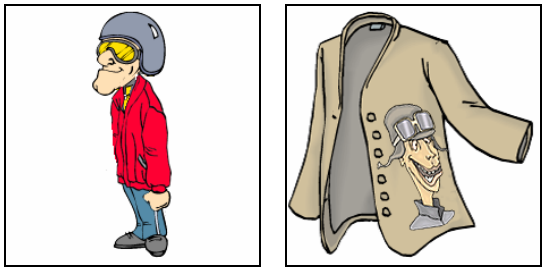


A-3: Filler items for Experiments 1 and 2

Match	Nonmatch
acrobat	surgeon
angel	doll
apes	ducks
apron	bathrobe
archeologist	judge
backpack	sofa
bandage and brush	stool and scale
bath and cushion	crown and plate
beds	tambourines
bee and mole	koala and gnome
beetle	moth
beetle and spider	moth and spider
bikini	loafer
bowls	cupcakes
bows	hangers
bulls	owls
butchers	carpenters
butterflies	chickens
calendar	clipboard
calendar and typewriter	typewriter and computer
carpenter	exterminator
cars	desks
scientist	detective
clown	dancer
cobra	moose
computer	ruler
conductor and guitarist	archeologist and butcher
cookies	sombreros
cow and cyclist	stork and rhino
crane	panther
cricket	jester
crickets	dragonflies
detective and judge	scientist and exterminator
dress and poncho	skirt and overalls
earrings	canoes
elf	snail
envelope and punch	gramophone and punch
fairy	squirrel
florist	mechanic
florist and singer	conductor and singer
fox	vulture
glue and eraser	key and glue
goat	lamb
gramophone	camera
grandmothers	mermaids
guitarists	mechanics
handbag	helmet
harp and violin	trumpet and harp
iron	pot
jeans	candle
jesters	acrobats
keys	cameras

Match	Nonmatch
kings	knights
ladybird and donkey	kangaroo and tortoise
lamps	flippers
loafer and slipper	sandal and slipper
mask and sharpener	sharpener and watch
masks	presents
mirror	sandal
mirrors	bikinis
monk and baby	pirate and hunchback
monkey	rooster
mosquito and ostrich	bird and boy
mug and sign	boat and trophy
notebook and folder	notebook and clipboard
octopus and parrot	sheep and crow
parachute and cot	plane and pram
pencil and stapler	stapler and stamp
pencils	folders
penguin and pelican	grandfather and goose
pipe and ice-cream	newspaper and basket
porcupine and grasshopper	beaver and panda
puffins	pigeons
purse	waistcoat
pyjamas and coat	plaster and cardigan
rabbits	lobsters
rulers	erasers
seahorse and swordfish	pigeon and worm
seahorses	whales
seals	horses
shoes	teacups
stamps	calculators
swordfish and whale	reindeer and puffin
table	wheelbarrow
teapot and bucket	pillow and pan
television	calculator
televisions	trumpets
T-shirt	pendant
turtles	camels
walrus and cobra	moose and walrus
watch	violin
wolf and woodpecker	reindeer and dove
wolves	doves
woodpeckers	worms
wreath	present
wreaths	envelopes

A-4: Experimental items for Experiment 2

The combinations in parentheses describe the distracter prime pictures.

	PRIMES		TARGET
1.	dog T-shirt (dog newspaper)	rabbit scarf (duck scarf)	alligator trainers
2.	bear mug (bear pillow)	doll umbrella (clown umbrella)	ant chair
3.	dinosaur lamp (dinosaur sofa)	porcupine flag (goose flag)	bear umbrella
4.	frog bucket (frog boat)	baby hat (grandfather hat)	cat bottle
5.	mouse bed (mouse trophy)	cyclist fan (dancer fan)	caterpillar wallet
6.	pig teapot (pig candle)	grandmother book (boy book)	cowboy saw
7.	gorilla sign (gorilla basket)	fox tent (tortoise tent)	dinosaur flag
8.	elephant parachute (elephant tambourine)	penguin boots (beaver boots)	eagle shorts
9.	ant shoes (ant flippers)	goat chair (bird chair)	dragon guitar
10.	eagle handbag (eagle pot)	monkey shorts (squirrel shorts)	dog scarf
11.	cat purse (cat crown)	pelican bottle (kangaroo bottle)	elephant boots
12.	snake table (snake desk)	octopus cap (sheep cap)	fish balloon
13.	rat cookie (rat cupcake)	seal bracelet (rooster bracelet)	flamingo bell
14.	fish car (fish canoe)	crane balloon (crow balloon)	frog hat
15.	hippo bath (hippo plane)	turtle suitcase (vulture suitcase)	giraffe tie
16.	flamingo ice-cream (flamingo plate)	grasshopper bell (koala bell)	gorilla tent
17.	lion pipe (lion skirt)	butterfly can (chicken can)	hippo suitcase
18.	dragon dress (dragon waistcoat)	king guitar (pirate guitar)	kitten mittens
19.	wizard iron (wizard teacup)	elf sweet (hunchback sweet)	leopard socks
20.	raccoon backpack (raccoon wheelbarrow)	parrot horn (snail horn)	lion can
21.	puppy cot (puppy pram)	cow jug (lobster jug)	lizard gloves
22.	cowboy bowl (cowboy pan)	fairy saw (mermaid saw)	mouse fan
23.	turkey apron (turkey helmet)	angel vase (gnome vase)	pig book
24.	kitten bow (kitten sombrero)	bull mittens (rhino mittens)	pilot jacket
25.	caterpillar cushion (caterpillar stool)	bee wallet (owl wallet)	puppy jug
26.	giraffe earring (giraffe pendant)	ape tie (horse tie)	raccoon horn
27.	shark bandage (shark plaster)	mosquito belt (panda belt)	rat bracelet
28.	leopard poncho (leopard scale)	donkey socks (camel socks)	shark belt
29.	tiger pyjamas (tiger bathrobe)	ostrich trousers (stork trousers)	snake cap
30.	alligator coat (alligator cardigan)	ladybird trainers (lamb trainers)	tiger trousers
31.	lizard brush (lizard hanger)	mole gloves (panther gloves)	turkey vase
32.	pilot jeans (pilot overalls)	monk jacket (knight jacket)	wizard sweet

A-5: Experimental items for Experiment 3

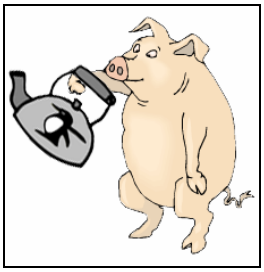
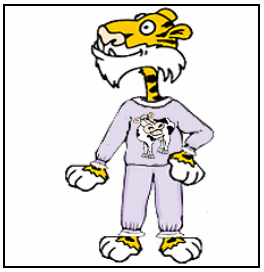
The combinations in parentheses describe the distracter prime pictures.

	PRIMES		TARGET
	POSSESSOR	DESCRIPTOR	
1.	dog T-shirt (dog newspaper)	rabbit T-shirt (duck T-shirt)	dinosaur flag
2.	frog boat (frog bucket)	ladybird boat (goose boat)	elephant boots
3.	eagle handbag (eagle pot)	mermaid handbag (hunchback handbag)	hippo suitcase
4.	pig teapot (pig candle)	penguin teapot (beaver teapot)	dog scarf
5.	tiger pyjamas (tiger bathrobe)	cow pyjamas (lobster pyjamas)	bear umbrella
6.	gorilla basket (gorilla sign)	panda basket (crane basket)	frog hat
7.	dragon dress (dragon waistcoat)	elf dress (angel dress)	mouse fan
8.	hippo plane (hippo bath)	kangaroo plane (pelican plane)	pig book
9.	ant flippers (ant shoes)	butterfly flippers (seal flippers)	gorilla tent
10.	kitten bow (kitten sombrero)	baby bow (doll bow)	ant chair
11.	cat purse (cat crown)	sheep purse (octopus purse)	eagle shorts
12.	rat cupcake (rat cookie)	cockerel cupcake (tortoise cupcake)	cat bottle
13.	fish car (fish canoe)	grasshopper car (bee car)	snake cap
14.	alligator cardigan (alligator coat)	monkey cardigan (squirrel cardigan)	rat bracelet
15.	flamingo plate (flamingo ice-cream)	owl plate (bull plate)	fish balloon
16.	bear mug (bear pillow)	parrot mug (snail mug)	flamingo bell
17.	mouse trophy (mouse blanket)	cyclist trophy (dancer trophy)	lion can
18.	pilot jeans (polot overalls)	fairy jeans (clown jeans)	dragon guitar
19.	dinosaur sofa (dinosaur lamp)	grandmother sofa (knight sofa)	wizard sweet
20.	giraffe pendant (giraffe earring)	monk pendant (gnome pendant)	raccoon horn
21.	snake desk (snake table)	stork desk (koala desk)	puppy jug
22.	shark bandage (shark plaster)	boy bandage (grandfather bandage)	cowboy saw
23.	leopard poncho (leopard scale)	ostrich poncho (camel poncho)	turkey vase
24.	puppy cot (puppy pram)	donkey cot (ape cot)	kitten mittens
25.	raccoon backpack (raccoon wheelbarrow)	panther backpack (vulture backpack)	caterpillar wallet
26.	caterpillar cushion (caterpillar stool)	rhino cushion (crow cushion)	giraffe tie
27.	lizard brush (lizard hanger)	mosquito brush (turtle brush)	shark belt
28.	turkey apron (turkey helmet)	pirate apron (king apron)	leopard socks
29.	lion pipe (lion skirt)	fox pipe (goat pipe)	tiger trousers
30.	cowboy bowl (cowboy pan)	hedgehog bowl (bird bowl)	alligator trainers
31.	elephant parachute (elephant tambourine)	mole parachute (lamp parachute)	lizard gloves
32.	wizard teacup (wizard iron)	chicken teacup (horse teacup)	pilot jacket

A-6: Experimental prime pictures for Experiment 3

Note that POSSESSOR and DESCRIPTOR primes were displayed with the same picture. For example, picture no. 1 appeared with the combination *dog T-shirt* in the POSSESSOR condition, and with the combination *rabbit T-shirt* in the DESCRIPTOR condition. Target pictures for this experiment were the same as in Experiments 1 and 2 (See Appendix A-2).

PRIMES

1. 
2. 
3. 
4. 
5. 
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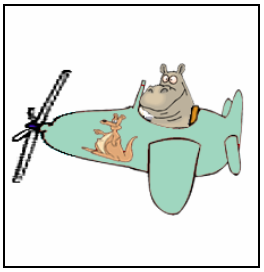
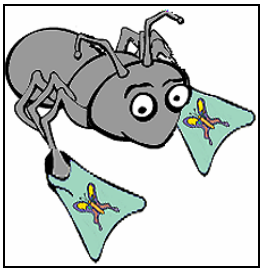
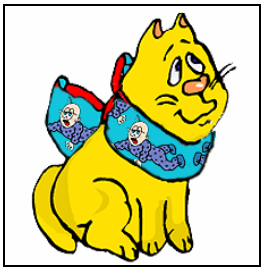
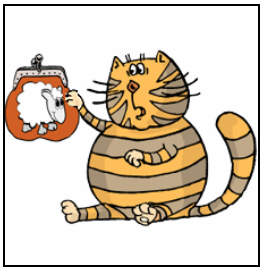
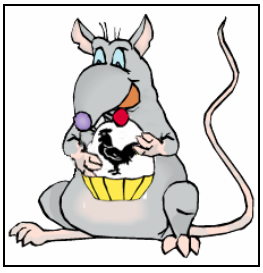
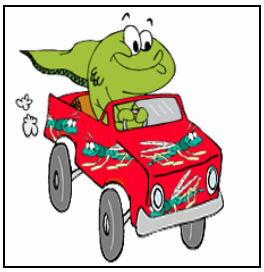
7. 
8. 
9. 
10. 
11. 
12. 
13. 
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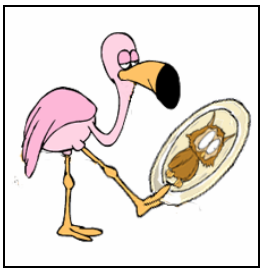
15. 

PRIMES

16.

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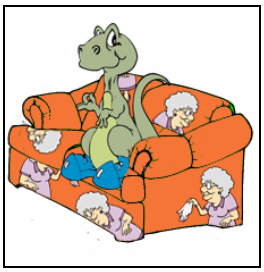
19.



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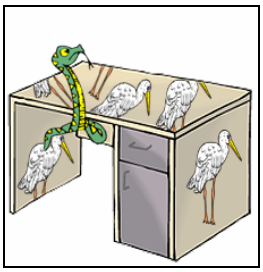

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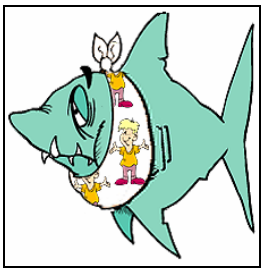
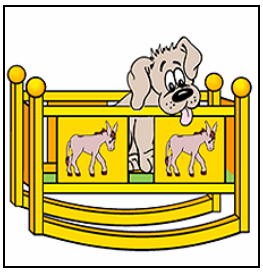


23.

24.



25.

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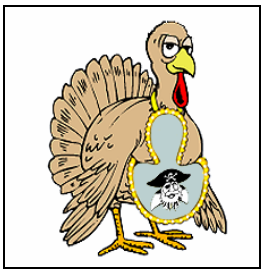
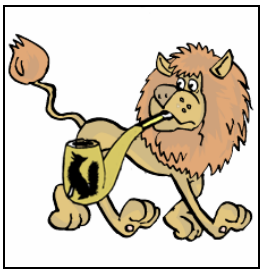
28.



29.



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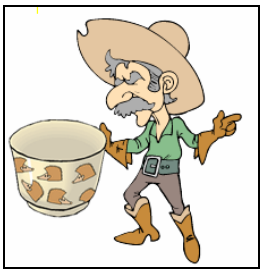
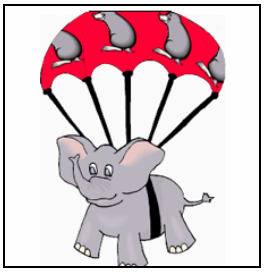


PRIMES

31.



32.

A-7: Filler items for Experiment 3

Match	Nonmatch
acrobat	surgeon
mermaid	doll
panthers	ducks
apron	bathrobe
archeologist	judge
backpack	lamp
bandage and brush	stool and scale
plane and cushion	crown and ice-cream
beds	tambourines
grandfather and mole	koala and gnome
beetle	moth
beetle and spider	moth and spider
bikini	loafer
bowls	cookies
bows	hangers
owls	bulls
butchers	carpenters
butterflies	chickens
calendar	clipboard
calendar and typewriter	typewriter and computer
carpenter	exterminator
cars	tables
scientist	detective
stork	dancer
cobra	moose
computer	ruler
conductor and guitarist	archeologist and butcher
cupcakes	sombreros
cow and cyclist	clown and turtle
panda	ape
cricket	jester
crickets	dragonflies
detective and judge	scientist and exterminator
dress and poncho	skirt and overalls
pendant	canoes
elf	snail
envelope and punch	gramophone and punch
fairy	squirrel
florist	mechanic
florist and singer	conductor and singer
fox	vulture
glue and eraser	key and glue
pirate	lamb
gramophone	camera
grandmothers	angels
guitarists	mechanics
handbag	helmet
harp and violin	trumpet and harp
teacup	pot
jeans	candle
jesters	acrobats
keys	cameras

Match	Nonmatch
kings	knights
ladybird and donkey	pelican and tortoise
sofas	shoes
loafer and slipper	sandal and slipper
mask and sharpener	sharpener and watch
masks	presents
mirror	sandal
mirrors	bikinis
monk and baby	goat and hunchback
monkey	seal
mosquito and ostrich	bird and boy
mug and basket	bucket and trophy
notebook and folder	notebook and clipboard
sheep and parrot	octopus and crow
parachute and cot	bath and pram
pencil and stapler	stapler and stamp
pencils	folders
penguin and kangaroo	bee and goose
pipe and plate	newspaper and sign
hedgehog and grasshopper	beaver and crane
puffins	pigeons
purse	waistcoat
pyjamas and cardigan	plaster and coat
rabbits	lobsters
rulers	erasers
seahorse and swordfish	pigeon and worm
seahorses	whales
roosters	horses
flippers	irons
stamps	calculators
swordfish and whale	reindeer and puffin
desk	wheelbarrow
teapot and boat	pillow and pan
television	calculator
televisions	trumpets
T-shirt	earring
rhinos	camels
walrus and cobra	moose and walrus
watch	violin
wolf and woodpecker	reindeer and dove
wolves	doves
woodpeckers	worms
wreath	present
wreaths	envelopes

Appendix B

Materials used for the experiments reported in Chapter 4

B-1: Experimental items for Experiment 4

The combinations in parentheses describe the distracter prime and target pictures.

	PRIMES POSSESSOR	DESCRIPTOR	TARGET
1.	dog T-shirt (dog newspaper)	rabbit T-shirt (duck T-shirt)	dinosaur flag (dinosaur present)
2.	frog boat (frog bucket)	ladybird boat (goose boat)	elephant boots (elephant skateboard)
3.	eagle handbag (eagle pot)	mermaid handbag (hunchback handbag)	hippo suitcase (hippo ice-skates)
4.	pig teapot (pig candle)	penguin teapot (beaver teapot)	dog scarf (dog bikini)
5.	tiger pyjamas (tiger bathrobe)	cow pyjamas (lobster pyjamas)	bear umbrella (bear blouse)
6.	gorilla basket (gorilla sign)	panda basket (crane basket)	frog hat (frog glasses)
7.	dragon dress (dragon waistcoat)	elf dress (angel dress)	mouse fan (mouse parasol)
8.	hippo plane (hippo bath)	kangaroo plane (pelican plane)	pig book (pig radio)
9.	ant flippers (ant shoes)	butterfly flippers (seal flippers)	gorilla tent (gorilla bib)
10.	kitten bow (kitten sombrero)	baby bow (doll bow)	ant chair (ant violin)
11.	cat purse (cat crown)	sheep purse (octopus purse)	eagle shorts (eagle gun)
12.	rat cupcake (rat cookie)	cockerel cupcake (tortoise cupcake)	cat bottle (cat pencil)
13.	fish car (fish canoe)	grasshopper car (bee car)	snake cap (snake telephone)
14.	alligator cardigan (alligator coat)	monkey cardigan (squirrel cardigan)	rat bracelet (rat bandana)
15.	flamingo plate (flamingo ice-cream)	owl plate (bull plate)	fish balloon (fish headphones)
16.	bear mug (bear pillow)	parrot mug (snail mug)	flamingo bell (flamingo wellingtons)
17.	mouse trophy (mouse blanket)	cyclist trophy (dancer trophy)	lion can (baboon can)
18.	pilot jeans (pilot overalls)	fairy jeans (clown jeans)	dragon guitar (slug guitar)

	PRIMES POSSESSOR	DESCRIPTOR	TARGET
19.	dinosaur sofa (dinosaur lamp)	grandmother sofa (knight sofa)	wizard sweet (wizard binoculars)
20.	giraffe pendant (giraffe earring)	monk pendant (gnome pendant)	raccoon horn (jester horn)
21.	snake desk (snake table)	stork desk (koala desk)	puppy jug (dragonfly jug)
22.	shark bandage (shark plaster)	boy bandage (grandfather bandage)	cowboy saw (witch saw)
23.	leopard poncho (leopard scale)	ostrich poncho (camel poncho)	turkey vase (skunk vase)
24.	puppy cot (puppy pram)	donkey cot (ape cot)	kitten mittens (robin mittens)
25.	raccoon backpack (raccoon wheelbarrow)	panther backpack (vulture backpack)	caterpillar wallet (anteater wallet)
26.	caterpillar cushion (caterpillar stool)	rhino cushion (crow cushion)	giraffe tie (werewolf tie)
27.	lizard brush (lizard hanger)	mosquito brush (turtle brush)	shark belt (seahorse belt)
28.	turkey apron (turkey helmet)	pirate apron (king apron)	leopard socks (armadillo socks)
29.	lion pipe (lion skirt)	fox pipe (goat pipe)	tiger trousers (moose trousers)
30.	cowboy bowl (cowboy pan)	hedgehog bowl (bird bowl)	alligator trainers (zebra trainers)
31.	elephant parachute (elephant tambourine)	mole parachute (lamb parachute)	lizard gloves (chimpanzee gloves)
32.	wizard teacup (wizard iron)	chicken teacup (horse teacup)	pilot jacket (ghost jacket)

Appendix C

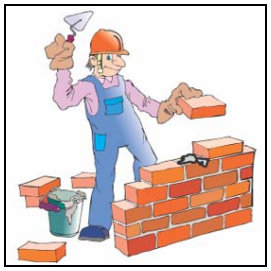
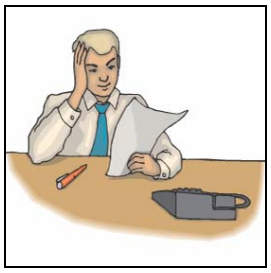
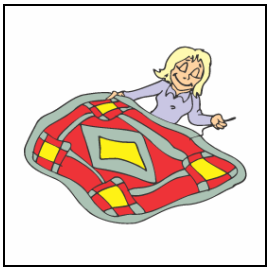
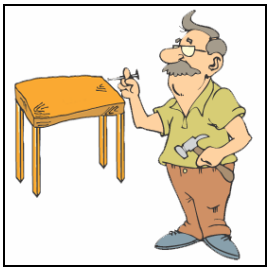
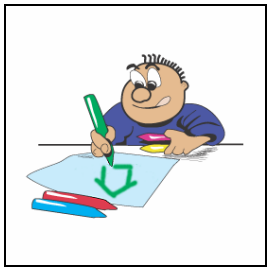
Materials used for the experiments reported in Chapter 5

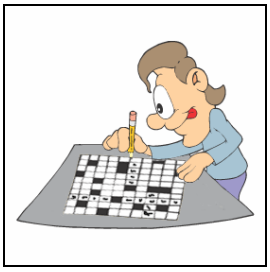
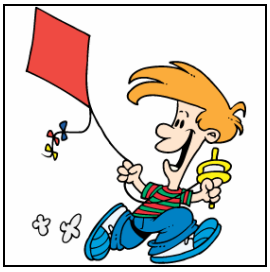
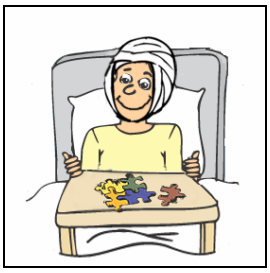
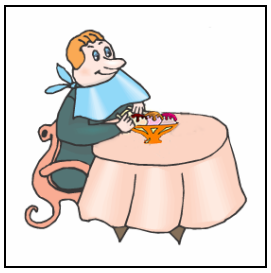
C-1: Experimental items for Experiment 5

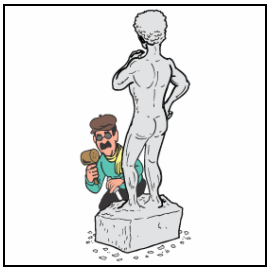
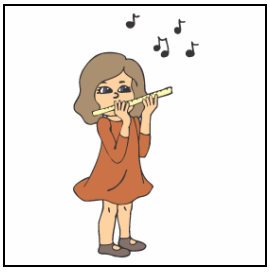
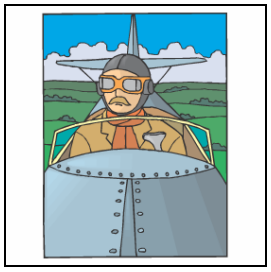
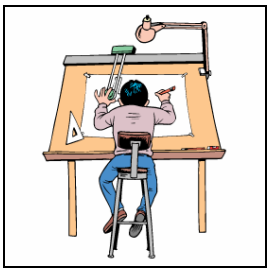
The two prime types are separated by slashes. Both primes had the same subject. The first verb phrase appeared in the Coerced condition; the second verb phrase appeared in the Full-VP condition.

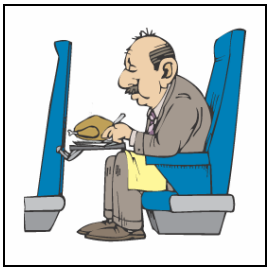
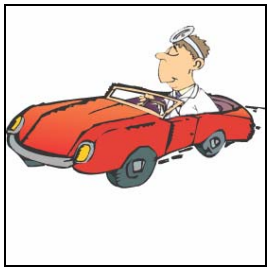
	PRIMES Coerced/Full-VP	TARGET
1.	The author began the/began writing the	The bricklayer began
2.	The celebrity began the/began drinking the	The clerk began
3.	The woman completed the/completed sewing the	The grandmother completed
4.	The schoolboy completed the/completed reading the	The teacher completed
5.	The carpenter continued the/continued constructing the	The child continued
6.	The nerd continued the/continued doing the	The walker continued
7.	The boy enjoyed the/enjoyed flying the	The expert enjoyed
8.	The patient enjoyed the/enjoyed doing the	The customer enjoyed
9.	The penpal finished the/finished writing the	The cook finished
10.	The teenager finished the/finished reading the	The banker finished
11.	The amateur mastered the/mastered sculpting the	The bartender mastered
12.	The genius mastered the/mastered playing the	The pilot mastered
13.	The architect started the/started designing the	The potter started
14.	The diner started the/started eating the	The commuter started
15.	The artist tried the/tried painting the	The pupil tried
16.	The passenger tried the/tried eating the	The doctor tried

C-2: Experimental pictures for Experiments 5 and 6

PRIMES Coerced/Full-VP	TARGET
1. 	
2. 	
3. 	
4. 	
5. 	

PRIMES Coerced/Full-VP	TARGET
6. 	
7. 	
8. 	
9. 	
10. 	

PRIMES Coerced/Full-VP	TARGET
11. 	
12. 	
13. 	
14. 	
15. 	

PRIMES Coerced/Full-VP	TARGET
16. 	

C-3: Filler items for Experiments 5 and 6

The accountant was calculating the
The archeologist was brushing the
The detective was examining the
The fishmonger was cutting the
The postman was delivering the
The mechanic was fixing the
The milkman was delivering the
The beekeeper was collecting the
The handyman was moving the
The scientist was testing the
The butcher was preparing the
The workman was unrolling the
The camper was pitching the
The cleaner was mopping the
The monk was playing the
The mother was feeding the
The director was
The maid was
The chauffeur was
The nun was
The rocker was
The man was
The eccentric was
The backpacker was
The professor was
The onlooker was
The salesman was
The guest was
The announcer was
The pensioner was
The escapee was
The tourist was
The visitor was
The baby was
The toddler was
The athlete was
The cameraman was
The waiter was
The relative was
The schoolgirl was
The grandchild was
The sportsman was
The girl was
The youth was
The oceanographer was
The father was
The contestant was
The adventurer was

C-4: Experimental items for Experiment 6

Primes are separated by slashes. The first prime was used in the coerced condition; the second prime was used in the full-VP condition.

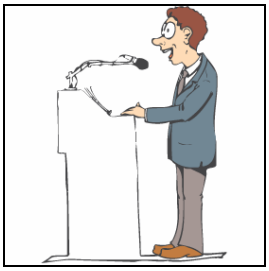
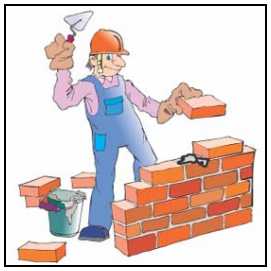
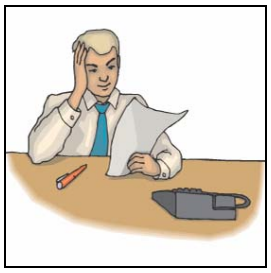
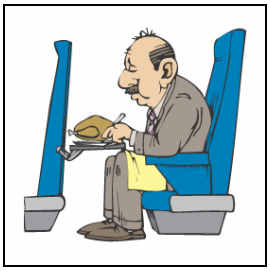
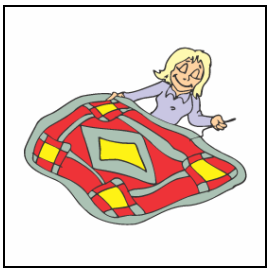
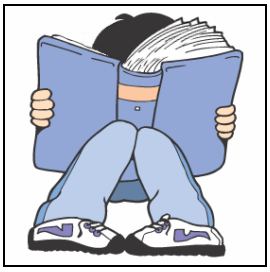
	PRIMES Coerced/Full-VP	TARGET
1.	The author began the/began writing the	The bartender mastered
2.	The celebrity began the/began drinking the	The customer enjoyed
3.	The woman completed the/completed sewing the	The pupil tried
4.	The schoolboy completed the/completed reading the	The expert enjoyed
5.	The carpenter continued the/continued constructing the	The cook finished
6.	The nerd continued the/continued doing the	The clerk began
7.	The boy enjoyed the/enjoyed flying the	The banker finished
8.	The patient enjoyed the/enjoyed doing the	The commuter started
9.	The penpal finished the/finished writing the	The bricklayer began
10.	The teenager finished the/finished reading the	The doctor tried
11.	The amateur mastered the/mastered sculpting the	The grandmother completed
12.	The genius mastered the/mastered playing the	The walker continued
13.	The architect started the/started designing the	The child continued
14.	The diner started the/started eating the	The pilot mastered
15.	The artist tried the/tried painting the	The potter started
16.	The passenger tried the/tried eating the	The teacher completed

C-5: Experimental items for Experiment 7

Primes are separated by slashes. The first prime was used in the coerced and event-NP conditions; the second prime was used in the full-VP condition.

	PRIMES Coerced; Event-NP/Full-VP	TARGET
1.	The author began the/began writing the	The bricklayer began
2.	The celebrity began the/began drinking the	The clerk began
3.	The passenger began the/began eating the	The man began
4.	The woman completed the/completed sewing the	The penpal completed
5.	The schoolboy completed the/completed reading the	The pupil completed
6.	The surgeon completed the/completed writing the	The brat completed
7.	The carpenter continued the/continued constructing the	The builder continued
8.	The lawyer continued the/continued reading the	The nerd continued
9.	The professor continued the/continued writing the	The artist continued
10.	The boy enjoyed the/enjoyed flying the	The expert enjoyed
11.	The patient enjoyed the/enjoyed doing the	The customer enjoyed
12.	The girl enjoyed the/enjoyed eating the	The teenager enjoyed
13.	The actress finished the/finished smoking the	The cook finished
14.	The specialist finished the/finished reading the	The banker finished
15.	The journalist finished the/finished writing the	The diner finished
16.	The professional mastered the/mastered sculpting the	The bartender mastered
17.	The genius mastered the/mastered playing the	The pilot mastered
18.	The kid mastered the/mastered throwing the	The chef mastered
19.	The architect started the/started designing the	The potter started
20.	The guest started the/started eating the	The commuter started
21.	The seamstress started the/started making the	The youth started
22.	The novice tried the/tried riding the	The traveller tried
23.	The sufferer tried the/tried using the	The doctor tried
24.	The student tried the/tried using the	The hostess tried

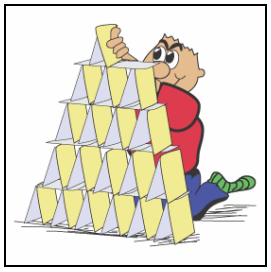
C-6: Experimental pictures for Experiment 7

	PRIMES		TARGET
	Coerced/Full-VP	Event-NP	
1.			
2.			
3.			
4.			
5.			

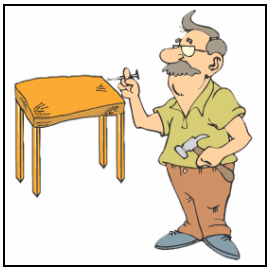
PRIMES Coerced/Full-VP	Event-NP	TARGET

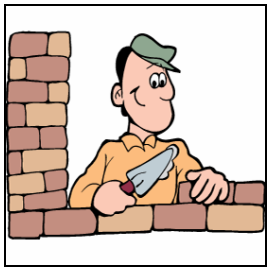
6.





7.





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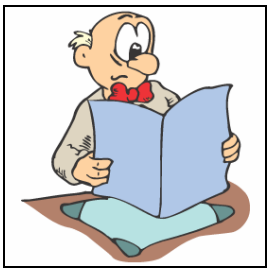
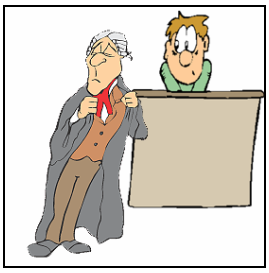
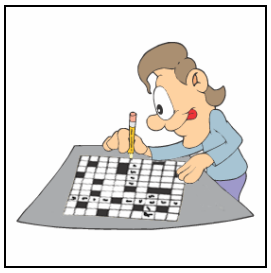
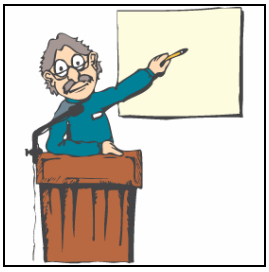
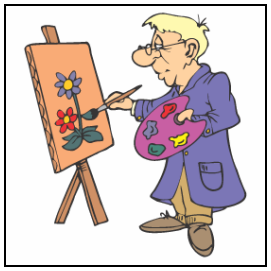
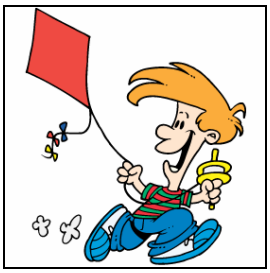
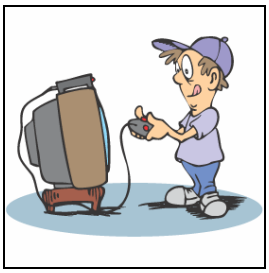




9.

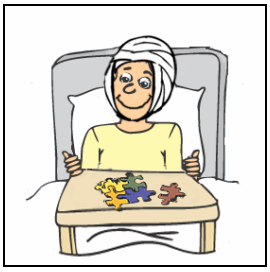




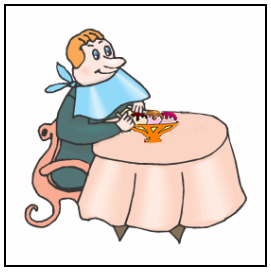
10.

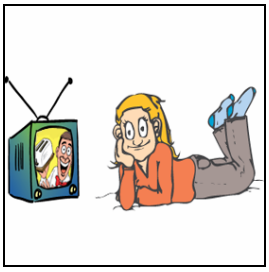

PRIMES Coerced/Full-VP	Event-NP	TARGET

11.





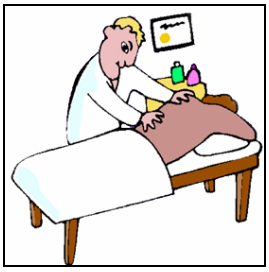
12.

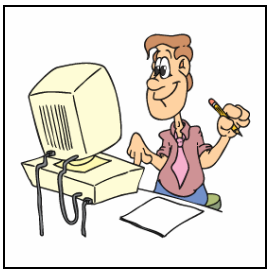

13.

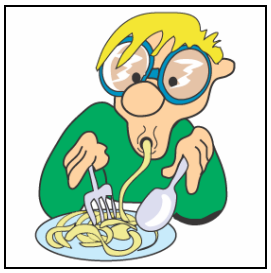


14.

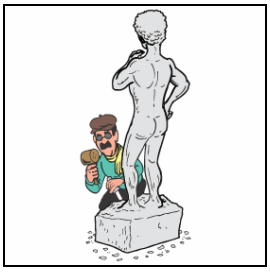

15.



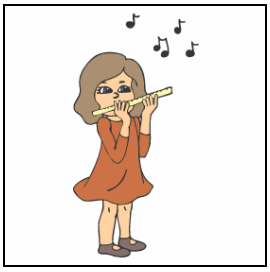
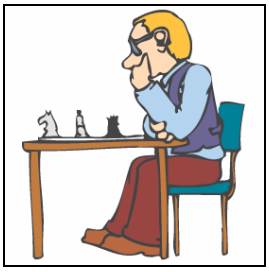
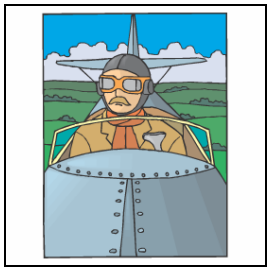


PRIMES		TARGET
Coerced/Full-VP	Event-NP	

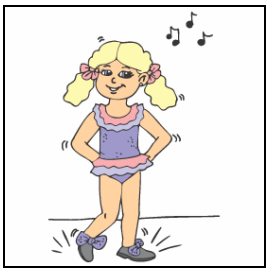
16.



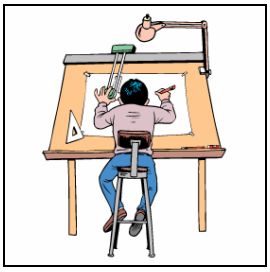
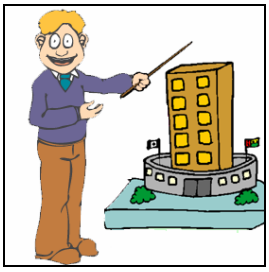
17.

18.


19.

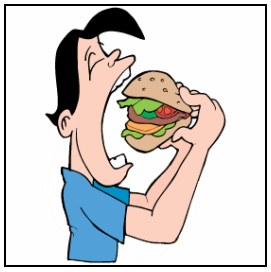

20.



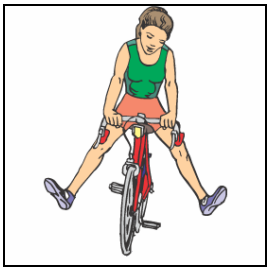
PRIMES		TARGET
Coerced/Full-VP	Event-NP	

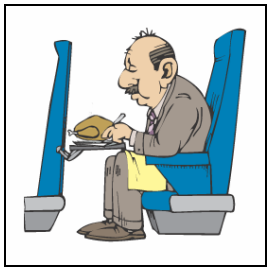
21.



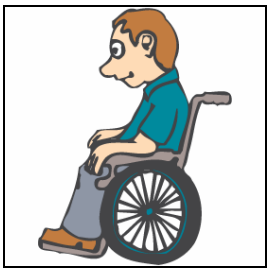
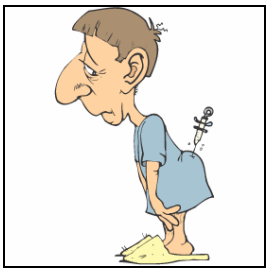
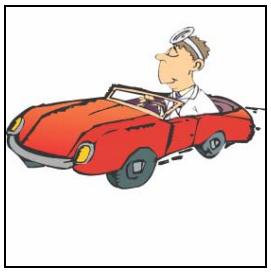


22.





23.

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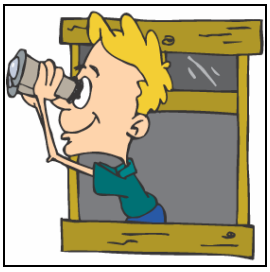
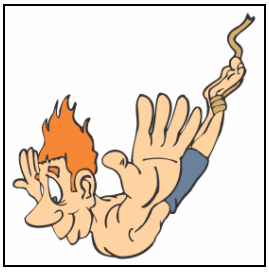




C-7: Filler items for Experiment 7

The accountant was calculating the
The archeologist was brushing the
The detective was examining the
The fishmonger was cutting the
The postman was delivering the
The mechanic was fixing the
The milkman was delivering the
The beekeeper was collecting the
The handyman was moving the
The scientist was testing the
The butcher was preparing the
The workman was unrolling the
The camper was pitching the
The cleaner was mopping the
The monk was playing the
The mother was changing the
The caretaker was sweeping the
The porter was opening the
The air hostess was serving the
The gardener was shovelling the
The volunteer was collecting the
The player was rolling the
The miner was drilling the
The babysitter was pushing the
The director was
The maid was
The chauffeur was
The nun was
The rocker was
The man was
The eccentric was
The backpacker was
The professor was
The onlooker was
The salesman was
The guest was
The announcer was
The pensioner was
The escapee was
The tourist was
The visitor was
The baby was
The toddler was
The athlete was
The cameraman was
The waiter was
The relative was
The schoolgirl was
The grandchild was
The sportsman was
The girl was
The youth was
The oceanographer was
The father was

The contestant was
The adventurer was
The businessman was
The holidaymaker was
The writer was
The student was
The diner was
The tramp was
The entertainer was
The traveller was
The diva was
The doctor was
The grandfather was
The widow was
The secretary was
The lad was
The clown was
The performer was

Appendix D

Materials used for the experiments reported in Chapter 6

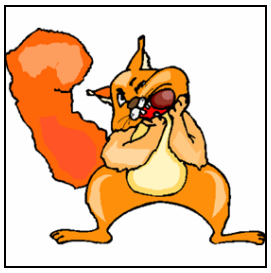
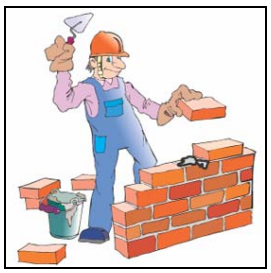
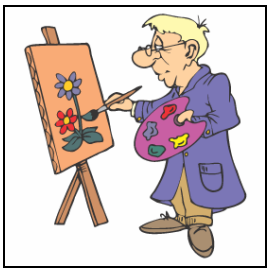
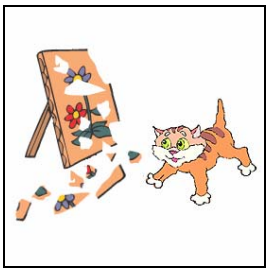
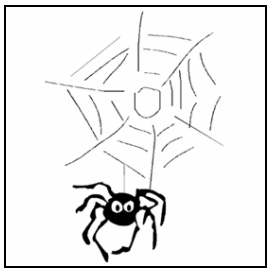
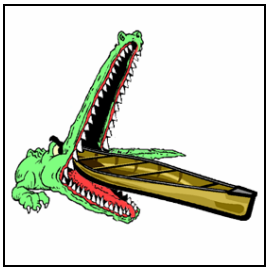
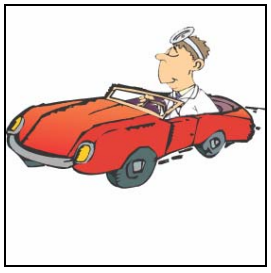
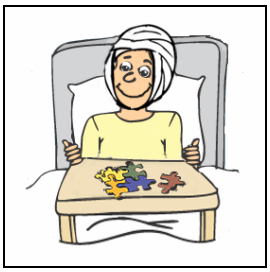
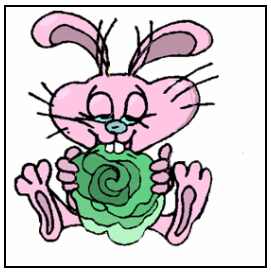
D-1: Experimental items for Experiment 8

Primes are separated by slashes. The first prime was used in the coerced conditions; the second prime was used in the full-VP conditions.

	PRIMES		TARGET
1.	Local	The potter attempted the/attempted to make the	The squirrel attempted
	Global	The ant attempted the/attempted to carry the	The squirrel attempted
2.	Local	The author began the/began writing the	The bricklayer began
	Global	The goat began the/began eating the	The bricklayer began
3.	Local	The artist finished the/finished painting the	The spider finished
	Global	The kitten finished the/finished destroying the	The spider finished
4.	Local	The grandfather tried the/tried paddling the	The doctor tried
	Global	The alligator tried the/tried eating the	The doctor tried
5.	Local	The patient enjoyed the/enjoyed doing the	The rabbit enjoyed
	Global	The puppy enjoyed the/enjoyed chewing the	The rabbit enjoyed
6.	Local	The woman continued the/continued sewing the	The brat continued
	Global	The dog continued the/continued chewing the	The brat continued
7.	Local	The carpenter started the/started fixing the	The raccoon started
	Global	The woodpecker started the/started pecking the	The raccoon started
8.	Local	The woodworker began the/began building the	The banker began
	Global	The beaver began the/began chewing the	The banker began
9.	Local	The farmer tried the/tried driving the	The monkey tried
	Global	The bull tried the/tried charging the	The monkey tried
10.	Local	The professor continued the/continued writing the	The nerd continued
	Global	The hamster continued the/continued nibbling the	The nerd continued
11.	Local	The camper attempted the/attempted pitching the	The worm attempted
	Global	The rhino attempted the/attempted to charge the	The worm attempted
12.	Local	The boy started the/started reading the	The penpal started
	Global	The caterpillar started the/started eating the	The penpal started
13.	Local	The mechanic finished the/finished fixing the	The bird finished
	Global	The bear finished the/finished throwing the	The bird finished

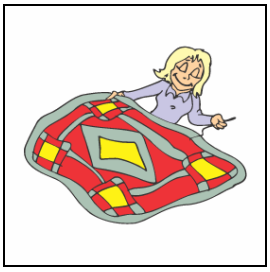
	PRIMES		TARGET
14.	Local	The novice tried the/tried riding the	The bartender tried
	Global	The hippo tried/tried eating the	The bartender tried
15.	Local	The girl mastered the/mastered catching the	The seal mastered
	Global	The bee mastered the/mastered riding the	The seal mastered
16.	Local	The builder attempted the/attempted to make the	The chef attempted
	Global	The bulldog attempted the/attempted to push the	The chef attempted
17.	Local	The handyman tried the/tried repairing the	The giraffe tried
	Global	The woodpecker tried the/tried pecking the	The giraffe tried
18.	Local	The commuter enjoyed the/enjoyed reading the	The expert enjoyed
	Global	The gerbil enjoyed the/enjoyed eating the	The expert enjoyed
19.	Local	The farmer finished the/finished building the	The mouse finished
	Global	The fox finished the/finished raiding the	The mouse finished
20.	Local	The man began the/began reading the	The actress began
	Global	The bug began the/began eating the	The actress began
21.	Local	The apprentice attempted the/attempted to fix the	The rat attempted
	Global	The mouse attempted the/attempted to climb the	The rat attempted
22.	Local	The pensioner tried the/tried riding the	The hostess tried
	Global	The shark tried the/tried eating the	The hostess tried
23.	Local	The boy enjoyed the/enjoyed flying the	The walrus enjoyed
	Global	The vulture enjoyed the/enjoyed ruining the	The walrus enjoyed
24.	Local	The seamstress started the/started sewing the	The celebrity started
	Global	The moth started/started eating the	The celebrity started

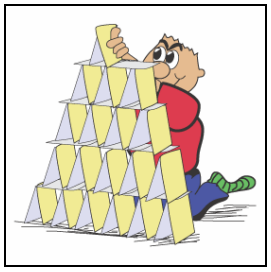
D-2: Experimental pictures for Experiment 8

	PRIMES		TARGET
	Local	Global	
1.			
2.			
3.			
4.			
5.			

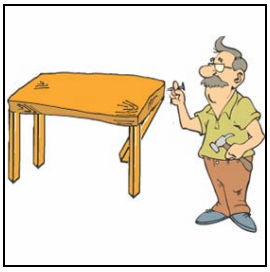
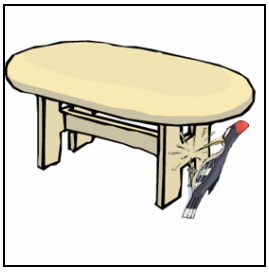
PRIMES		TARGET
Local	Global	

6.

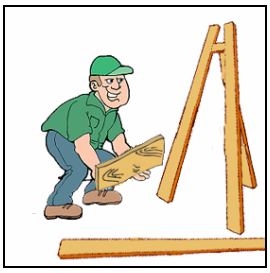




7.


8.

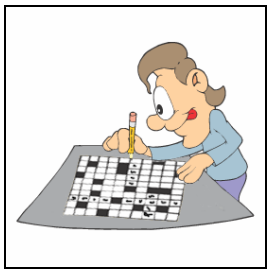


9.



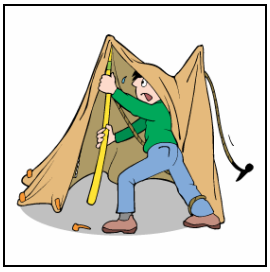
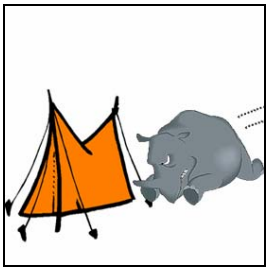
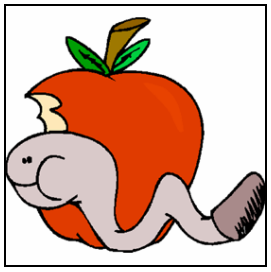
10.





PRIMES		TARGET
Local	Global	

11.

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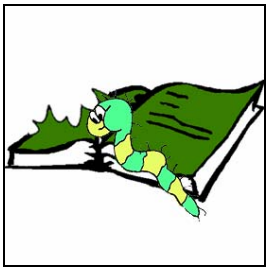


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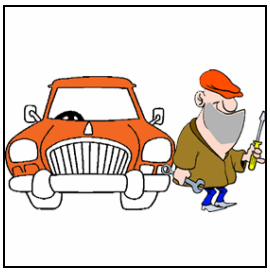
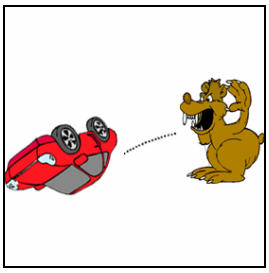


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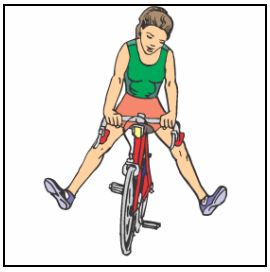
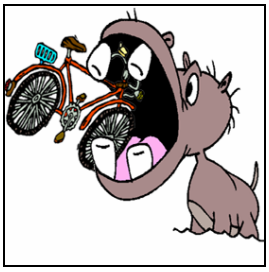


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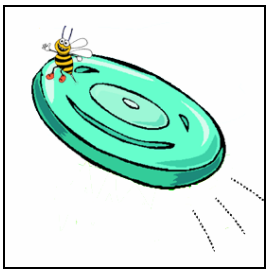
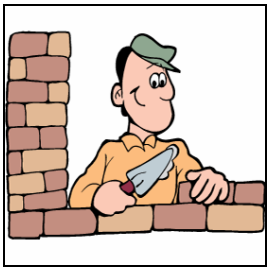
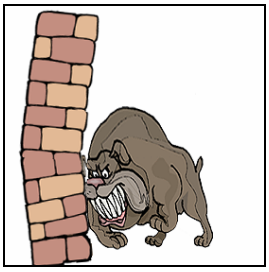



PRIMES		TARGET
Local	Global	

16.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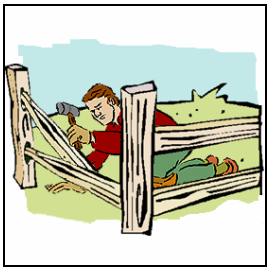
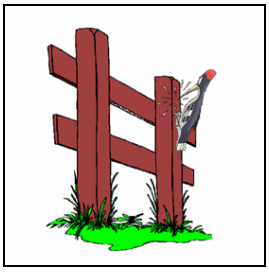
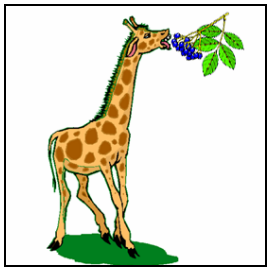




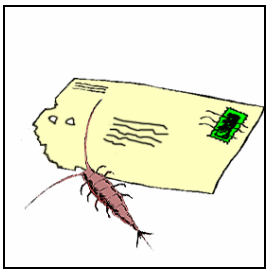
18.



19.



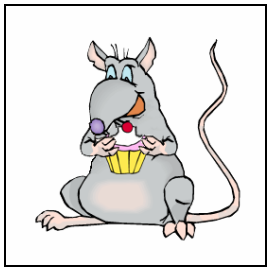
20.


PRIMES		TARGET
Local	Global	

21.





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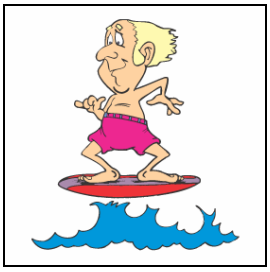
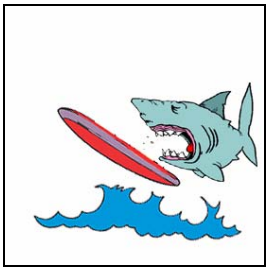


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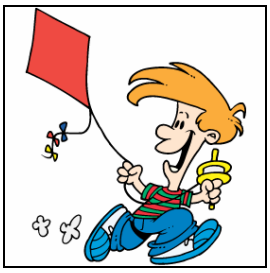

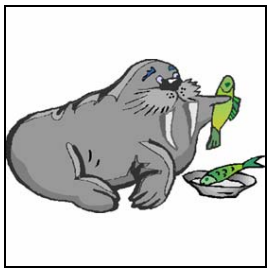

24.



D-3: Filler items for Experiment 8

The miner was drilling the
The fishmonger was cutting the
The player was rolling the
The gardener was shovelling the
The beekeeper was collecting the
The babysitter was pushing the
The butcher was preparing the
The workman was unrolling the
The cleaner was mopping the
The mother was changing the
The caretaker was sweeping the
The porter was opening the
The bird was feeding the
The koala was hugging the
The hen was laying the
The cat was searching the
The bear was fleeing the
The gorilla was holding the
The cat was unravelling the
The puppy was trailing the
The rabbit was chasing the
The piglet was splashing the
The fish was pursuing the
The toad was smelling the
The director was
The maid was
The chauffeur was
The nun was
The rocker was
The man was
The eccentric was
The backpacker was
The onlooker was
The salesman was
The guest was
The announcer was
The escapee was
The tourist was
The visitor was
The baby was
The toddler was
The athlete was
The cameraman was
The waiter was
The relative was
The grandchild was
The girl was
The youth was
The dinosaur was
The bat was
The bird was
The chick was
The chicken was
The cat was

The lion was
The orangutan was
The ostrich was
The owl was
The wolf was
The turtle was
The tortoise was
The snake was
The goose was
The cub was
The eagle was
The donkey was
The flamingo was
The horse was
The monkey was
The rooster was
The calf was
The duck was

D-4: Experiment 8 Pretest 1

Participants were instructed to complete the sentences in a way that best described the accompanying picture.

1	The potter attempted	_____
2	The ant attempted	_____
3	The apprentice attempted	_____
4	The mouse attempted	_____
5	The author began	_____
6	The goat began	_____
7	The man began	_____
8	The bug began	_____
9	The woodworker began	_____
10	The beaver began	_____
11	The woman continued	_____
12	The dog continued	_____
13	The professor continued	_____
14	The hamster continued	_____
15	The boy enjoyed	_____
16	The vulture enjoyed	_____
17	The patient enjoyed	_____
18	The puppy enjoyed	_____
19	The commuter enjoyed	_____
20	The gerbil enjoyed	_____
21	The artist finished	_____
22	The kitten finished	_____
23	The mechanic finished	_____
24	The bear finished	_____
25	The farmer finished	_____
26	The fox finished	_____
27	The builder mastered	_____
28	The kangaroo mastered	_____
29	The girl mastered	_____
30	The bee mastered	_____
31	The camper started	_____
32	The rhino started	_____
33	The boy started	_____
34	The caterpillar started	_____
35	The seamstress started	_____
36	The moth started	_____
37	The carpenter started	_____
38	The woodpecker started	_____
39	The novice tried	_____
40	The hippo tried	_____
41	The grandfather tried	_____
42	The alligator tried	_____
43	The farmer tried	_____
44	The bull tried	_____
45	The pensioner tried	_____
46	The shark tried	_____
47	The handyman tried	_____
48	The frog tried	_____
49	The squirrel attempted	_____
50	The brat attempted	_____

51	The bricklayer began	_____
52	The rabbit began	_____
53	The banker began	_____
54	The rat continued	_____
55	The nerd continued	_____
56	The walrus enjoyed	_____
57	The hostess enjoyed	_____
58	The expert enjoyed	_____
59	The spider finished	_____
60	The bird finished	_____
61	The mouse finished	_____
62	The chef mastered	_____
63	The seal mastered	_____
64	The bartender started	_____
65	The penpal started	_____
66	The celebrity started	_____
67	The raccoon started	_____
68	The worm tried	_____
69	The passenger tried	_____
70	The monkey tried	_____
71	The doctor tried	_____
72	The giraffe tried	_____

D-5: Experiment 8 Pretest 2

Participants were instructed to fill in the blank in a way that clarified the meaning of the phrase, as in the two examples given.

E.g.	***finished the house***		**=**	***finished***	***building***	***the house***
	started the portrait		**=**	***started***	***to paint***	***the portrait***

1	attempted	the vase	=	attempted	_____	the vase
2	attempted	the cupboard	=	attempted	_____	the cupboard
3	attempted	the tent	=	attempted	_____	the tent
4	began	the book	=	began	_____	the book
5	began	the letter	=	began	_____	the letter
6	began	the easel	=	began	_____	the easel
7	continued	the quilt	=	continued	_____	the quilt
8	continued	the letter	=	continued	_____	the letter
9	enjoyed	the kite	=	enjoyed	_____	the kite
10	enjoyed	the jigsaw puzzle	=	enjoyed	_____	the jigsaw puzzle
11	enjoyed	the newspaper	=	enjoyed	_____	the newspaper
12	finished	the picture	=	finished	_____	the picture
13	finished	the car	=	finished	_____	the car
14	finished	the henhouse	=	finished	_____	the henhouse
15	mastered	the wall	=	mastered	_____	the wall
16	mastered	the frisbee	=	mastered	_____	the frisbee
17	started	the book	=	started	_____	the book
18	started	the table	=	started	_____	the table
19	started	the dress	=	started	_____	the dress
20	tried	the bicycle	=	tried	_____	the bicycle
21	tried	the canoe	=	tried	_____	the canoe
22	tried	the tractor	=	tried	_____	the tractor
23	tried	the surfboard	=	tried	_____	the surfboard
24	tried	the fence	=	tried	_____	the fence
25	attempted	the nut	=	attempted	_____	the nut
26	attempted	the cake	=	attempted	_____	the cake
27	attempted	the apple	=	attempted	_____	the apple
28	began	the wall	=	began	_____	the wall
29	began	the cigarette	=	began	_____	the cigarette
30	began	the coffee	=	began	_____	the coffee
31	continued	the house of cards	=	continued	_____	the house of cards
32	continued	the crossword	=	continued	_____	the crossword
33	enjoyed	the fish	=	enjoyed	_____	the fish
34	enjoyed	the lettuce	=	enjoyed	_____	the lettuce
35	enjoyed	the wine	=	enjoyed	_____	the wine
36	finished	the web	=	finished	_____	the web
37	finished	the nest	=	finished	_____	the nest
38	finished	the cheese	=	finished	_____	the cheese
39	mastered	the pizza	=	mastered	_____	the pizza
40	mastered	the ball	=	mastered	_____	the ball
41	started	the letter	=	started	_____	the letter
42	started	the crisps	=	started	_____	the crisps
43	started	the champagne	=	started	_____	the champagne
44	tried	the cocktail	=	tried	_____	the cocktail
45	tried	the car	=	tried	_____	the car
46	tried	the ice-cream	=	tried	_____	the ice-cream
47	tried	the beer	=	tried	_____	the beer
48	tried	the berries	=	tried	_____	the berries