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Relationships between grammatical encoding and decoding: an experimental psycholinguistic study

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Relationships between grammatical encoding and decoding

An experimental psycholinguistic study

Nomi Olsthoorn

Relationships between grammatical encoding and decoding
An experimental psycholinguistic study

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A note on the experimental set-up

All experiments reported in this thesis were conducted, that is prepared and executed, by means of the Nijmegen Experimental Set-Up (NESU) software and hardware, developed at the Max Planck Institute for Psycholinguistics in Nijmegen.

Introduction

Language is central to our behaviour. We use language all the time, but although speaking and understanding language seem so easy, automatic and effortless, the processes involved are by no means entirely clear and continue to be the subject of many studies. This thesis is no exception. It concerns sentences: how we build them, how we comprehend them. With words being the building stones of sentences, grammar is the mortar that glues together these bricks of meaning and ideas into firm and (usually) well-formed sentences. The bricks are important, but the mortar is essential. Without mortar the bricks are just a pile, but by means of the cement the meaningless pile can become a wall, a house, a church. Grammatical processing is the topic of this thesis. In particular, I will explore some relationships between grammatical production and comprehension processes, thus focussing on two aspects: the overlap between production and comprehension, and the mechanics of syntactic priming from comprehension to production.

Plan of this thesis

In Chapter 1, I will first introduce a widely accepted architecture of the language system. This architecture is based on the presumably distinct tasks of language production on the one hand, and language comprehension on the other. However, as far as grammatical processing is concerned, this duality is mainly motivated by theoretical arguments, rather than empirical data. In Chapter 2 some of the empirical implications of such a dual-processor model will be tested and alternative models will be discussed. I will report two experiments that aim to investigate the overlap between grammatical encoding

and decoding by means of two versions of a new paradigm, the Edited-Reading-Aloud (ERA) task: Pluralising and paraphrasing. At the end of Chapter 2, I will present preliminary comclusions about the relationship between syntactic comprehension and production.

Chapters 3 through 5 will subsequently consider another aspect of the relationship between grammatical encoding and decoding: syntactic priming. This phenomenon, the structural repetition of syntactic constructions, can offer more insight in the interplay between production and comprehension of sentences, and in the workings of grammatical processing in general, as it concerns representations that are shared between syntactic production and comprehension. In Chapter 3, I will therefore start out by giving an overview of syntactic priming studies, to be followed by two chapters in which the online dynamics of syntactic priming are investigated by means of experiments. More specifically, I was interested in studying reaction time effects of syntactic priming− effects that are predicted to occur by one of the dominant theories of syntactic priming. In order to rule out non-syntactic (lexical and conceptual) priming effects, we concentrated on word order as a possible target of syntactic priming mechanisms. However, the research took a special turn, because, although we did manage to replicate response tendency priming, we failed to find any reaction time effects of word order priming. This thesis ends with a concluding chapter in which I hope to integrate the results of all of the above.

Chapter 1
The architecture of grammatical processing

A dual-processor architecture of language processing

A feature of language is that not only are we able to produce it, we are also capable of understanding it. The standard architecture of the language system reflects this bi-modality of production and comprehension (see also Figure 1.1 below). Most models of language processing distinguish a number of stages in the processes of language use. In language production these stages are: conceptualisation, formulation and articulation (e.g. (Garrett, 1980; Dell, 1986; Levelt, 1989; Bock & Levelt, 1994; Levelt, Roelofs & Meyer 1999). According to Levelt's blueprint of the speaker, first, speakers decide what it is they like to express: in the Conceptualizer a preverbal message is generated. This preverbal message is the result of several processes, involving the conception of an expressive intention, selection of the relevant information, ordering this information, and keeping track of the conversation. In order to do this, the Conceptualizer accesses declarative knowledge available from long term memory and uses working memory to deposit all information currently accessible to the speaker.

Next, the preverbal message is translated in two steps from a conceptual structure into a linguistic structure in the Formulator. First, the proper words corresponding to the meaning of the concepts to be expressed are retrieved from the Mental Lexicon in the form of lemmas and put into a syntactic frame resulting in a surface structure; this is called *grammatical encoding*. The declarative knowledge represented at the lemma level is twofold: it consists of

information about the meaning of the lemma, the concept that goes with the word, and it also specifies the way in which the word can be used in combination with other words, the syntax. For instance, the conceptual information represented with the lemma *give* is that it involves some actor X who causes some possession Y to go from actor X to recipient Y. The syntactic information represented with the lemma *give* is that it is a verb (V) which can take a subject, corresponding to actor X, a direct object corresponding to the possession Y and an indirect object corresponding to the recipient Z, among other possibilities. Activation of a lemma occurs when part of the preverbal messages matches its conceptual information, causing the syntactic information to become available. According to Levelt (1989), this syntactical lemma information in turn calls syntactic building procedures stored in the Grammatical Encoder. For instance, the syntactic category V connected to the lemma give calls the verb-phrase building procedure. Other syntactic categories activate other phrase-building procedures, resulting in noun-phrases, prepositional phrases and so forth.

Some models of grammatical processing furthermore distinguish between a functional and a positional level of grammatical production (e.g. Garrett, 1975; Bock & Levelt, 1994). At the functional level, lemmas are selected and assigned to syntactic functions such as subject, object or modifier. Given this functional representation, the constituent structure is then built at the positional level. Although there are influential theories such as Government and Binding theory (Chomsky, 1981) that view word order (linear) relations as intrinsically related to hierarchical structure and constructed together with the hierarchical structure, in other theories, word order is now thought to be computed at a separate positional level (Garrett, 1975; Kempen & Hoenkamp, 1987; De Smedt, 1990; Pollard & Sag, 1994; Kempen & Harbusch, 2002). In the formalized computational models by De Smedt (1990), and Kempen and Hoenkamp (1987) two stages were accordingly separated. The first, functional, stage generates a structure containing functional relations (such as subject, object etc.) as well as hierarchical relations (such as S with daughter nodes NP and VP) between lemmas. The linear order of the resulting constituents however is not yet specified. The result can be conceived of as a "mobile" in which the vertical relations are already specified, but the horizontal ordering is to be determined. In the second, positional, stage, this horizontal word order is generated through

a linearisation process, determining the order of the constituents and subconstituents in the sentence.
During the second step of formulation, phonological encoding, the sounds (lexemes) and stress patterns are selected that accompany the string of lemmas produced by the previous stage. The end result of the Formulator is an articulatory, or phonetic plan, used in the final stage of language production. In the Articulator, the resulting speech plans are translated into movements of the speech organs, resulting in overt speech.

In language comprehension, similar stages are distinguished (Ferreira & Clifton, 1986; Frazier & Rayner, 1982; Rayner, Carlson & Frazier, 1983): during speech recognition, the physical speech signal is processed. In the subsequent parsing stage words, word groups and their syntactic relationships are being identified from this speech pattern and syntactic tree assembly takes place: *grammatical decoding*. Finally, the recognised words (lemmas) in their sentential context are translated into a meaning. In most cases this meaning is the conceptual message intended by the speaker.

Figure 1.1 is an illustration of this standard model of language processing, based upon Levelt (1989). Levelt assumed that the processing components are informationally encapsulated (Fodor, 1983). This means that (1) components use the output of the previous component as their characteristic input, and (2) the component's mode of operation is only minimally affected by the output of other components (except for their characteristic input). As to the seriality of the model, views differ. Levelt's original model is strictly serial in nature. This assumption of strict seriality has been motivated by theoretical parsimony rather than empirical evidence (Bock & Levelt, 1994). Others have argued that in sentence comprehension the grammatical decoder and the conceptualizer do not operate strictly sequentially, but in interaction (Kempen, 1977; McRae, Spivey-Knowlton & Tanenhaus, 1998). Decoding decisions may be affected by conceptual constraints, such as plausibility of the message. Some evidence however indicates that in parsing there exists an early stage that is in fact immune to conceptual influences (Mitchell, Corley & Garnham, 1992). Similarly, in sentence production, there may be a two-way flow of information between the Formulator and Conceptualizer (Kempen, 1977). Conceptual modifications may occur because of (temporary) capacity problems or word-

retrieval difficulty in the Formulator or when additional information is required by a selected lemma in order to satisfy all constraints it imposes.

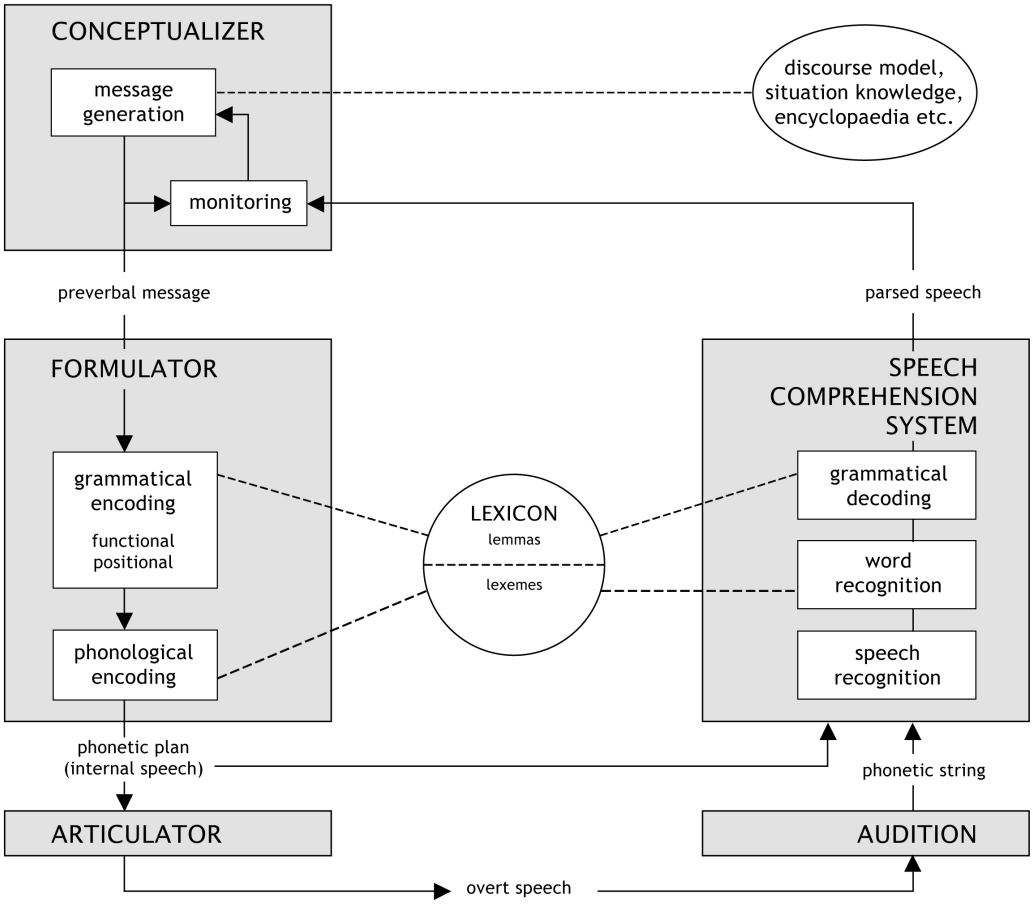

Figure 1.1 Standard architecture of the language processing system, based on Levelt's Blueprint for the Speaker (1989). Boxes represent processing components; circle and ellipse represent stores of declarative knowledge.

Speakers usually do not wait until the entire sentence is finished before they start articulating. Instead, as soon as part of a sentence is encoded on one processing level, another level begins to process it. This piecemeal production is called incremental processing (Kempen, 1977). Similarly, in sentence comprehension, the unfolding of a string of lemmas guides the parsing process, resulting in left-to-right construction of the syntactic tree (Kaplan, 1972; Marlson-Wilson, 1973).

Arguments for a dual- processor model

Although no one doubts the physical necessity of separate peripheral stages for language production and comprehension, the assumption that grammatical encoding and decoding also make use of entirely independent processing resources is merely motivated by (often implicit) theoretical arguments, discussed below.

Task Requirements

Grammatical encoder and decoder are said to fulfill essentially different tasks (e.g. Branigan, 1995; Thornton & MacDonald, 2003). Although they both are concerned with the assembly of syntactic structures, they concentrate on different aspects of this task and face different problems. For instance, the grammatical decoder is concerned with the task of dealing with lexical and syntactic ambiguity. It has to derive the conceptual structure from the given words and their left-to-right order. Wasow (1996, p. 354) observes that the grammatical decoder hence benefits from "early points of commitment. For the listener, the more predictable the remainder of the sentence, the better, for fewer possible continuations compatible with the string at any point entail less load on memory and less work for the parser later on". The grammatical encoder has no such disambiguation troubles[1]: the input conceptual messages are simply given. Finding lemmas that fit together grammatically and determining word order are among the encoder's main concerns, because it permanently runs the risk of 'talking itself into a corner' (syntactic deadlock, De Smedt & Kempen, 1987). According to Wasow (ibid.) the grammatical encoder thus prefers a late point of commitment in order to "postpone decision making which reduces the amount of planning needed and gives the speaker more time to formulate and articulate thoughts. This in turn, should minimize the chances of having to correct or abort an utterance."

However, this is not to say that in principle both task requirements mentioned in the beginning of this section could not be subserved by common cognitive processing resources. After all, the task of syntactic structure formation is a

[1] An exception would be listener modelling. However, current evidence suggests that speakers may not have the resources to take the listener's need into account constantly (e.g. Horton & Keysar, 1996). Furthermore, as far as it exists, listener modelling requires activation of the decoding system.

common cause for both components. A possibility is that the same cognitive resources are employed for encoding and decoding of syntactic structures, for instance by making only minimal adjustments to the process to provide for the specific characteristics of either encoding or decoding, and keeping all other things equal.

Language Acquisition

The productive and receptive language abilities of children are unbalanced. Grammatical production skills tend to be acquired at a much lower rate than grammatical comprehension skills. Children can understand much more complex and varied constructions than they can produce, and correlations between the two tend not to be very high (Bates, Bretherton & Snyder, 1988; Bates, Dale & Thal, 1995). There are three possible explanations for the dissociation between grammatical production and comprehension: First, the problem may not be the processing of syntactic information as such, but rather the accessibility of the information which is used in language production. Lemma retrieval given certain concepts might be harder than concept retrieval given certain lemmas (c.f. Hirsh-Pasek & Golinkoff, 1991). Furthermore, according to Bates, Dale and Thal (1995, p.114), in language acquisition production and comprehension are linked to different cognitive abilities: "In particular rate of progress in comprehension appears to be associated with a wide range of non-linguistic measures. […] By contrast, variations in production have fewer non-linguistic correlates". Finally, comprehension in children can be shallow, based on surface cues (i.e. which word comes first) and word meanings, especially in predictable contexts, whereas in sentence production no shortcuts are possible in which grammatical processing is circumvented[2].

Neurolinguistics

According to traditional views, language production and language comprehension are processed by different parts of the brain and are associated with different neurological symptoms. In particular a double dissociation was believed to exist, with language production deficits typically connected to

[2] However, recent research has revealed some local exceptions to the rule that language comprehension precedes language production. Specifically this is the case for pronoun comprehension. Children make errors in interpreting pronouns as late as age 6-7 while correctly producing them from age 2-3 (see Hendriks & Spenader, 2005/2006).

frontal cortical lesions in Broca's Area, and language comprehension problems usually associated with temporal lesions in Wernicke's Area. However, the neurological arguments with regard to this double dissociation do not hold. Literature surveys by Zurif and Swinney (1994) and Blumstein (1995) report that most agrammatic patients with lesions in Broca's Area not only have language production deficits, but also have problems with syntactic comprehension (Garrett, 2000; see also Grodzinsky, 2000). Additionally, in neuroimaging studies and electrophysiological research, it has been shown that perisylvian areas in the left hemisphere cortex (in particular the left inferior frontal gyrus) not only subserve syntactic comprehension, as is normally assumed, but also syntactic production (Hagoort, Brown & Osterhout, 1999). Neural network simulations of language processing employing Hebbian cell assemblies have furthermore demonstrated that double dissociations are not necessarily caused by separate underlying systems: a single system can cause similar effects (Pulvermüller, 2002).

Self-monitoring

The fact that speakers are capable of monitoring their own speech for appropriateness and grammaticality is often used as an argument in favour of an independent-resources model. According to the Perceptual Loop Hypothesis (Levelt, 1983, 1989), self-monitoring is accomplished by the same language comprehension system that normally performs the analysis of utterances produced by interlocutors. Speakers "listen" to their own inner speech, that is, to the phonological code which is the output of the formulator (Levelt, Roelofs & Meyer, 1999) and analyse it with the mechanisms that are also used for analysing overt speech, thus making an internal loop through the sentence comprehension part of the language system (see also Figure 1.1, above). Although the psychological reality of the internal and external perceptual loop and the role of the comprehension system in self-monitoring are empirically confirmed (cf. Postma, 2000; Oomen & Postma, 2001; Hartsuiker & Kolk, 2001; Pickering & Garrod, 2004), the simultaneity of these processes in self-monitoring is only an assumption. It is this supposed parallel functioning of the grammatical encoder and decoder in monitoring that is used as an argument in favour of an independent-resources, dual-processor model. However, the same monitoring function can be fulfilled by a model that switches between production and comprehension processes. The results of the experiments reported in Chapter 2 also corroborate this possibility of *time-sharing*.

Commonalities between production and comprehension

There are at least five substantial similarities between syntactic production and comprehension which lead us to speculate that both modalities may be subserved by shared cognitive resources. They fall into two categories: similarities pertaining to control structures and empirical similarities. I will discuss them below.

Similar control structures

First of all, most current models of sentence production and sentence parsing work on the basis of lexical guidance. Lexical entries corresponding to either conceptual structures (in formulating, c.f. Kempen & Hoenkamp, 1987) or to words recognized in the input sentence (in parsing, c.f. MacDonald, Pearlmutter & Seidenberg, 1994) are retrieved from the Mental Lexicon and combined into syntactic structures.

Furthermore, grammatical encoding and decoding are both responsive to conceptual factors. Thematic relations as specified in the conceptual structure are used to assign grammatical functions and relations in formulation. Top down information about conceptual plausibility guides the interpretation process of parsing sentences (e.g. McRae, Spivey-Knowlton & Tanenhaus, 1998). In line with this, a direct mapping between conceptual and syntactic relations was demonstrated in both modalities. For instance no active-to-passive transformations are performed in sentence generation (Bock, Loebell & Morey, 1992), nor are passive-to-active transformations necessary in parsing (Slobin, 1966).

Third, in formulating (Kempen, 1977) as well as in parsing (Kaplan, 1972; Marslen-Wilson, 1973) syntactic trees are processed incrementally. That is, they grow from left to right, in tandem with the unfolding of a conceptual message (in formulating) or a string of words (in parsing).

Fourth, both processes work on a nearly deterministic basis: Although language is highly ambiguous on almost all levels, only a small part of the total space of structure formation alternatives is explored, and a single structure is selected as output. This property is responsible for the fact that the grammatical decoder can be “led up the garden path” and in grammatical encoding may cause

syntactic deadlock — i.e. the inability to continue the structure in a grammatically well-formed manner, leading to backtracking and repair or revision (De Smedt & Kempen, 1987).

Similar empirical profiles

Apart from the control structures similarities, there is a vast body of performance data suggesting that grammatical encoding and decoding exhibit similar empirical profiles. Indirect evidence from priming experiments (Branigan et al., 1995; Branigan, Pickering & Cleland, 2000; Pickering & Garrod, 2004), attraction errors (Nicol, Forster & Veres., 1997; Bock & Miller, 1991; Vigliocco & Nicol, 1998), shadowing studies (Marslen-Wilson, 1973), lexical frame preferences (Clifton, Frazier & Connine, 1984; Shapiro, Nagel & Levine, 1993), from the structural complexity of sentences — as measured by working memory load (cf. Gibson, 1998)— and from speeded speech monitoring studies (Postma, 2000; Oomen & Postma, 2001) indicates that grammatical encoding and decoding work in a very similar manner. I will discuss this evidence briefly below.

Evidence from priming studies

In syntactic priming, the exposure to a sentence with a particular syntactic construction tends to affect the processing of a subsequent sentence that has the same or a similar syntactic structure but is unrelated semantically and lexically. Syntactic priming effects can be found in production-to-production priming: participants repeat sentences and subsequently describe pictures or complete sentences. It was found that subjects re-used the structure of the prime significantly more often than alternative structures (e.g. Bock, 1986; Branigan, 1995). For instance, participants will describe a picture more frequently with a prepositional dative (PO) sentence such as (3), after having repeated a prime sentence with that structure such as (1), than after a double-object dative prime such as (2):

(1)	The secretary bakes a cake for her boss.	(PO)
(2)	The secretary bakes her boss a cake.	(DO)
(3)	The boy gives a flower to the girl.	(PO)

Similar effects were reported in comprehension-to-comprehension priming experiments. This includes the understanding of sentences partially presented in

white noise (Mehler & Carey, 1967), attachment preferences in sentences with local ambiguities (Mehler & Carey, 1968; Mehler, Carey & Bever, 1970), shorter reading times (Frazier, Taft, Clifton, Roeper & Ehrlich, 1984; Branigan, 1995) and eye-movement studies (Arai, Van Gompel & Scheepers, 2006; Traxler & Pickering, 2004, 2005, Pickering & Traxler, 2005). However, see Chapter 4 for a critical review of reaction time data.

Although similarities between both empirical profiles give us an indication of the resemblance of the two processes, it actually means no more than that (at least) the same syntactic structures are used in production and in comprehension. As for the possibility of shared processing components, between-modality priming effects provide additional evidence. In a typical comprehension-to-production priming experiment (Branigan, Pickering, Liversedge, Stewart & Urbach, 1995; Pickering & Branigan, 1995) participants are presented with fragments to complete. The first sentence of the passage serves as the prime, the to-be-completed sentence is the target. Participants are more likely to complete the fragment in the same way as the prime. More between-modality priming effects were found in priming experiments that took place in a dialogue setting, in English (Branigan, Pickering & Cleland, 2000) and in Dutch (Bos, 1999). Long term between-modality priming was furthermore obtained in a picture description task (Bock, Dell, Chang & Onishi, 2006). (For an overview of syntactic priming studies see Chapter 3).

Apparently, production and comprehension of syntax tap into the same kind of resources. According to Branigan et al., the source of the priming is possibly either a process common to both comprehension and production, or a shared set of representations of syntactic knowledge.

Evidence from subject-verb agreement processes

Experiments on subject-verb agreement processes has revealed an additional correspondence between sentence production and sentence comprehension processes (Nicol, Forster & Veres, 1997; Pearlmutter, Garnsey & Bock, 1999). In the sentence *the label on the bottles are…* a subject-verb agreement error occurs. Instead of following the number of the head noun *label* (singular), the verb follows the number of the non-head noun *bottles* (plural). From earlier sentence production experiments (e.g. Bock & Miller, 1991) it was known that subject-verb agreement errors (a special type of so-called attraction errors) are

more likely to occur when a verb is required after a plural non-head noun following a singular head noun as in sentence (4), than when a plural head is followed by a singular non-head, as in (5).

(4) The producer of the adventure movies…(head sg. – non-head pl.)

(5) The students from the university… (head pl. – non-head sg.)

Interference from plurals seems to occur not only in sentence production, but in sentence comprehension as well, as was demonstrated in an experiment using the Maze task (Nicol, Forster & Veres, 1997). In this task, participants are presented with the first word of a sentence, followed by two alternative continuations, only one of which is grammatical. Participants have to decide quickly which of these words is the better continuation of the sentence, and indicate their choice by pressing one of two keys. Since agreement does not affect decision making until the verb (and the (in)congruence with the preceding subject) is encountered, the reaction time on the verb is the only dependent variable of interest. It should be noted that in the entire set of words used for one trial there is only one verb. In other words, participants do not have to attend to agreement per se, which would be the case if they were presented with a choice between a congruent verb and an incongruent verb. Instead, possible sentences consisted of all combinations of a singular (non-)head noun and a plural (non-)head, followed by a verb that always agreed with the actual subject of the sentence.

The results were clear. The same pattern of errors (as measured by increases in reaction times) emerged as in the production experiments. When subjects suspected incongruence, as in *the author of the speeches is here now*, the reaction times on the verb increased.

Similar results were obtained in a sentence classification task. In this task, participants were required to read a string of words that appeared on a computer screen, as in normal text, and to judge whether the words appeared in the proper order. Participants pressed a button as soon as they had decided whether the sentence contained an acceptable sequence of words. The exact same pattern of results was found as in the previous experiment.

Pearlmutter, Garnsey and Bock (1999) replicated these results measuring reading times in self-paced reading and eye-tracking experiments. They furthermore argued that the pattern of sensitivity to real and seeming agreement violations in comprehension as well as production results from an inadvertent overwriting process in which the head NP's number feature is replaced by the local NP's specification. The fact that these findings only obtain when the head NP is singular, not when it's plural is accounted for by the proposal (following Eberhard, 1997) that the plural head NP is explicitly marked, making it less likely to be overwritten, in favour of a non-marked local NP.

Thornton & MacDonald (2003) demonstrated that plausibility significantly mediates agreement processes in both production and comprehension, using a single set of stimulus sentences. In the production experiments, participants were asked to create a complete passive sentence given a verb and a noun phrase fragment consisting of a head and a non-head (e.g. *the album by the classical composers*). The plausibility of the verb was manipulated so that either both nouns could be plausible passive subjects (e.g. *praised*), or only the head noun could be a plausible subject (e.g. *played*). The comprehension task was self-paced reading with the same materials. In comprehension longer reaction times on the verb and in production higher agreement error rates were found when both nouns were plausible subjects than when only the head was plausible.

Evidence from shadowing studies

In the shadowing experiments participants are trained to repeat back (shadow) auditorily presented prose (Marslen-Wilson, 1973; 1985). After extensive training, certain participants are able to shadow speech input at extremely short delays: less than 300 ms on average, which is about as long as the time required to pronounce a syllable. These so-called 'close shadowers' reported that they were repeating the input words before they even knew what the words were (Marslen-Wilson, 1985). In some of the experiments single words of the input text were modified, so as to create syntactic or semantic violations. However, without being consciously aware of it, the close shadowers restored the anomalous words, without causing any prolongation of the shadowing delays.

These findings are interesting with regard to the architecture of the language system because restoration of lexical anomalies is a production task. Since the

shadowing delays are extremely short and participants are not aware of the anomalous words, nor of their own restorations, it follows that the parsed syntactic structure must be somehow *directly* available for production, suggesting an architecture comprising a close link between modalities, or at least a shared working memory. In a strict interpretation of the independent-resources model, however, one would expect the syntactic structures from the parser to be available to the formulator only via an indirect route, since the processing components are supposed to be informationally encapsulated. Presumably, any indirect route would at least require more time, and perhaps even conscious awareness.

Evidence from working-memory load studies

One of the factors determining working memory load is the structural complexity of sentences (cf. Gibson (1998) for complexity metrics). Structurally more complex sentences are harder to understand and occur less frequently in corpora of spoken and written language (Gibson & Pearlmutter, 1994). This seems to imply that the working memory load of a particular syntactical structure is a predictor of its frequency of occurrence in language production and of its perceived complexity.

Evidence from speeded self-monitoring studies

Additional indications for a shared-resources architecture come from speeded-up speech monitoring studies (Oomen & Postma, 2001; Hartsuiker & Kolk, 2001). In experiments investigating self-monitoring, participants were required to describe networks presented on a computer screen. The networks consisted of coloured pictures, connected by one or more lines. A dot moved trough the network, indicating the route that participants had to describe. This task was specifically designed to elicit many speech errors and self-repairs and therefore could provide insight in self-monitoring mechanisms. Increasing the rate of the dot created time pressure and speeded speech. Levelt's perceptual loop theory (Levelt, 1983, 1989) predicts that accelerated speech leaves less time and resources for monitoring. The results of these speeded network description tasks indicated, surprisingly, that the monitor (or rather the grammatical decoder) adjusted the speed of error detection to the faster speech output rate, without loss of accuracy (Oomen & Postma, 2001). Corroborating results were found in a simulation study by Hartsuiker and Kolk (2001) that used a computational approach to model self-monitoring in normal and speeded-up language

production. These findings suggest that production and comprehension modules are at least tightly linked, not only for as far as mental representations are concerned (as is demonstrated by priming studies), but also with respect to processing speed.

If the two modalities are indeed separate, it is to be expected that they can be employed independently from each other: using the one should not affect simultaneous use of the other. This implication of the dual-processor model will be investigated in Chapter 2.

Chapter 2
Testing the independent-resources model of the language system

Introduction

As described in the previous chapter, current theories of language processing usually distinguish between two independent resources of grammatical processing: Grammatical encoding for sentence production and grammatical decoding for sentence comprehension (e.g. Levelt, 1989). Although this duality is theoretically motivated, empirical evidence is scarce. In this chapter, we introduce a novel task, called "edited reading aloud" (ERA), which allows examining whether speakers are able to construct and maintain simultaneously two separate syntactic structures, as implied by the independent-resources theories, or only focus on the current sentence. The latter option would support a model in which grammatical encoding and decoding are subserved by shared cognitive resources.

The current independent-resources dual-processor model implies that grammatical encoder and decoder can function independently and simultaneously. In order to test this implication of the model we devised a novel task called Edited-Reading Aloud (ERA). In the experiments reported below, participants are presented with input sentences that need to be edited into output sentences. The editing operation is a grammatical manipulation of the input sentences, resulting in output sentences of a prespecified construction. The editing takes place online, phrase by phrase, enabling us to register voice onset times for the output phrases. We manipulated the grammaticality of the input sentences in a way that allowed voice onset times of the output fragments for

critical locations in the sentences to be compared under controlled conditions. Critical locations were defined as those fragments in which ungrammaticalities (if any) surface in the input sentence, In the ERA-task, reading input sentences involves grammatical decoding and editing output sentences, grammatical encoding (for detailed descriptions of experimental trials, see Figures 2.1 and 2.2 in the method sections of Experiment 1 and 2 reported below).

The ERA-task is based on the assumption that an independent-resources model should be able to maintain different syntactic structures for encoding and decoding simultaneously. Importantly, due to the purely grammatical manipulation, the meaning of the input sentence and the output sentence is the same, or very similar; therefore there is no need for participants to construct and maintain more than one conceptual structure.

There are two possible sources of delay in the ERA-task. Ungrammaticalities in the input sentence cause delay due to decoding problems; critical fragments that do not immediately fit into the output sentence cause delay due to encoding problems. We predict that in case of an independent-resources model, properties of both the input and output sentences will affect reaction times. In particular, we expect that both ungrammaticalities in the input sentences (decoding problems) as well as editing the input fragment to fit the output sentence (encoding problems) will result in longer reaction times at the critical location in the sentence. On the other hand, if the assumption that input and output structures can be processed concurrently is not correct, we predict that (1) ungrammaticalities in the input sentences will not delay reaction times if the fragments fit into the output sentence and (2) reaction times will be affected only by encoding problems. Longer reaction times will thus not stem from ungrammaticalities in the input sentence, but rather depend on whether the encountered input fragment fits grammatically into output sentence under construction, or not. If the fragment at hand does not immediately fit into the output sentence and has to be edited we expect longer reaction times. The latter pattern of reaction times is in accordance with a shared-resources, single-processor model of grammatical processing.

EXPERIMENT 1

The editing instruction in this experiment was to pluralize part(s) of Dutch input sentences, resulting in a plural subject and verb of the output sentences. The sentences are presented in fragments and voice onset times are registered. A typical pluralising ERA-trial is pictured in Figure 2.1. The number of the subject and number of the verb in the input sentences were systematically varied, leading to four conditions, like (1a-d) below: subject and verb both plural (condition PP) (1a), subject plural and verb singular (condition PS) (1b), subject singular and verb plural (condition SP) (1c) and subject and verb both singular (condition SS) (1d). Note that condition PP is identical to the desired output sentence and that conditions SP and PS are incongruent sentences, containing an error of agreement between subject number and verb number.

(1a) Input condition PP: subject plural, verb plural
Desired output sentence in all conditions
De drukke straten zijn gevaarlijk voor kleine kinderen.
The busy streets are dangerous for small children.

(1b)* Input condition PS: subject plural, verb singular
De drukke straten is gevaarlijk voor kleine kinderen.
The busy streets is dangerous for small children.

(1c)* Input condition SP: subject singular, verb plural
De drukke straat zijn gevaarlijk voor kleine kinderen.
The busy street are dangerous for small children.

(1d) Input condition SS: subject singular, verb singular
De drukke straat is gevaarlijk voor kleine kinderen.
The busy street is dangerous for small children.

Given these conditions and this task, the critical location is the finite verb, since that is where agreement errors surface. With respect to the voice onset latencies to the verb fragment we therefore predict the following patterns of reaction times. For the independent-resources model we expect the reaction times to be affected by both the grammaticality of the input sentence and the fit of the input verb in the output sentence. We expect it takes time to change a singular verb to

a plural verb in conditions SS and PS, due to new lexeme activation (encoding problem). In conditions that contain an agreement error, the processor needs to deal with the feature mismatch between the subject of the sentence and the verb (decoding problem). Thus, condition PP is predicted to be fastest, followed by conditions SS (new lexeme activation) and SP (dealing with feature mismatch in the input), although it is difficult to foretell which of the latter will be faster.

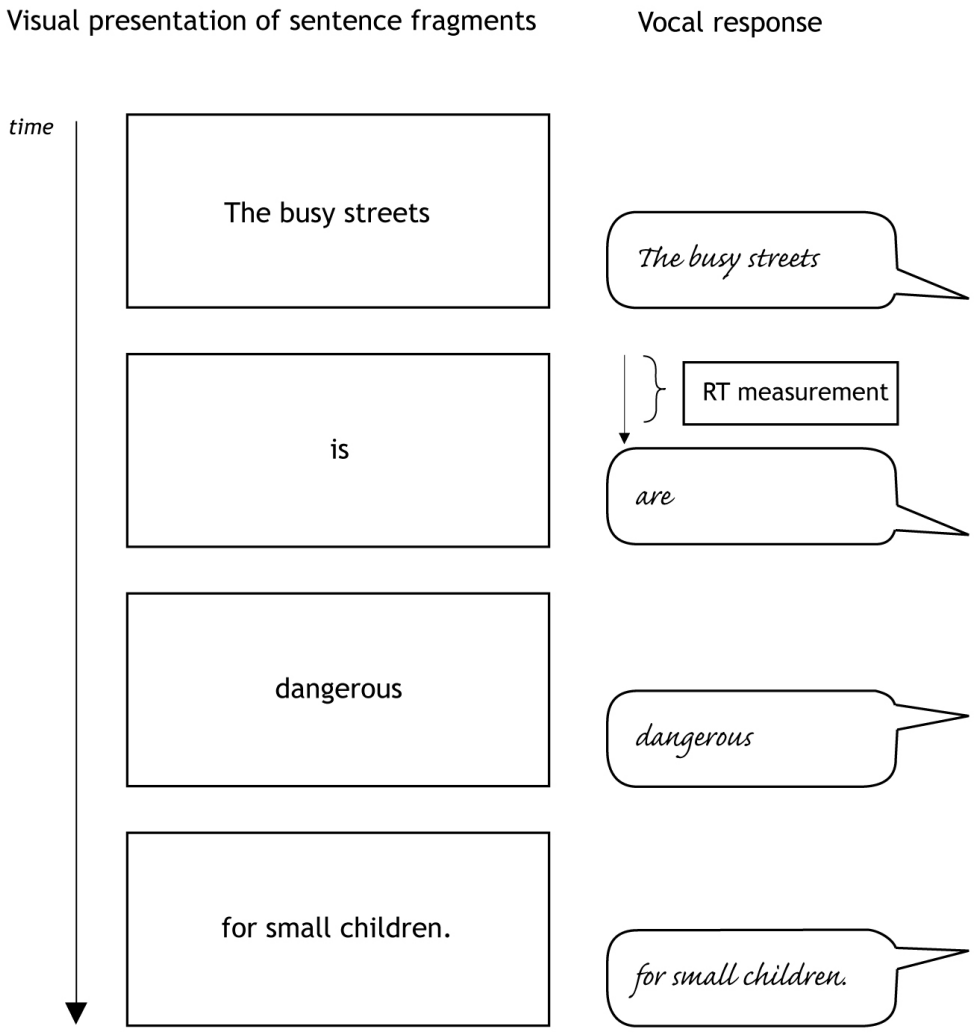

Figure 2.1 Sample Pluralising ERA-trial for condition PS

Finally, condition PS should require the longest processing time due to the fact that here the processor needs to deal with both decoding and encoding problems: the feature mismatch in the input, and activation of the new (plural) lexeme. Alternatively, if the implications of the independent-resources model

are incorrect and resources are shared between production and comprehension, we expect the two input conditions with a singular verb to be slower than the conditions containing a plural verb, since the former require pluralisation (activation of a new, plural lexeme: encoding problem) whereas the latter can be incorporated into the output sentence without problems. Crucially, no difference is expected between conditions PP and SP. To sum up, for a shared-resources model we expect: PP = SP < SS = PS and for the independent-resources model we expect PP< [SS, SP] < PS.

Method

Pre-test

Prior to the experiment we conducted a pre-test to confirm that reading incongruous sentences in which subject number and verb number do not agree, as in conditions SP and PS, indeed requires more time than reading the grammatical, congruent sentences. We used the same procedure and the same materials as in the main experiment below with this exception: Instead of having to pluralise the sentences, participants were instructed simply to read the fragments aloud. In both experiments, each voice onset triggered the next sentence fragment to appear on screen. Ten participants took part in the pre-test. Two of them were excluded from the analyses because their data reflected a high percentage of voice key malfunctioning.

Table 2.1 shows the mean response times for the four conditions. The means suggest that, as expected, the incongruent conditions PS and SP were read on average 18 ms slower than the grammatical, congruent conditions SS and PP. Two separate 2 x 2 Repeated Measures analyses (subject number x verb number) in which participants and items, respectively, were treated as random variables, yielding F1 and F2 statistics, confirmed this. In the subject analysis no significant main effects were obtained, nor was the main effect of subject number in the item analysis significant (all F's < 1.5). The main effect of verb number in the item analysis was marginally significant ($F2\ (1, 57) = 3.99$, $p = .051$). Crucially though, the interaction between subject number and verb number was highly significant in subject ($F1\ (1, 7) = 23.74$, $p < 0.001$) and item ($F2\ (1, 57) = 16.5$, $p < .001$) analyses, confirming the prediction that reading the verb in incongruent sentences in which subject number and verb number

mismatch is more difficult, as reflected by longer reading times, than reading the verb in congruent, grammatical sentences.

Table 2.1 Reading task pilot mean verb response voice onset latencies in milliseconds, standard deviations in brackets.

Subject number in input sentence	Verb number in input sentence	
	plural	singular
plural	481 (17.9)	507 (14.8)
singular	497 (14.6)	487 (20.3)

Main Experiment

Participants

Sixteen participants were paid in course credits or euros to take part in the experiment. All of the participants in the study were native-Dutch-speaking members of the Leiden University community and had normal or corrected-to-normal vision. No one participated in more than one experiment reported in this article. Four further participants were excluded because their sessions failed to be recorded properly due to system malfunctioning.

Materials

We constructed 60 items like (1) above (see Appendix A for the complete list). All items consisted of a subject noun phrase, either including an adjective or followed by a post- nominal modifier, a verb phrase, and a sentence-final adverbial phrase, a prepositional phrase or an object noun phrase. The number of the subject noun phrase and the number of the verb phrase varied systematically to create four conditions: two of which grammatical: subject and verb both plural (condition PP), subject and verb both singular (condition SS), and two of which ungrammatical (incongruent): subject plural and verb singular (condition PS) and subject singular and verb plural (condition SP). Each sentence was presented in four or five fragments, indicated below by slashes, for instance (2):

(2) De drukke straten / zijn / gevaarlijk / voor kleine kinderen.
The busy streets / are / dangerous / for small children

The fragments corresponded to the noun phrase, the post nominal modifier if applicable, the finite verb, the past participle in case of (auxiliary / past participle constructions) and the sentence final phrase. Note that the finite verb was always presented in isolation, enabling measurement of latencies to the verb directly.

Design

Four lists of items were constructed, with all conditions of all items appearing in each list, totalling 240 trials per session. The lists thus only differed with respect to the order in which the items were presented. The order of the items within each list was random with the restriction that the same condition could not occur within three consecutive trials and the same sentence could not within ten trials. Six participants were assigned randomly to each list. Eight practice sentences, two of each condition, preceded the experimental session. The practice trials were of the same format as the experimental trials.

Procedure

Participants were tested individually facing a computer screen positioned about 80 cm away from them. In front of the participant, a microphone was placed in order to register vocal responses. The experimenter was also present in the room. Reaction times were measured from the appearance of the sentence fragment on the screen until voice onset. Each fragment was presented for 1200 ms, with a 10 ms interval between fragments and a 1000 ms interval between sentences.

Prior to the experiment participants were instructed to edit aloud the sentences fragment-by-fragment so that their response would be a grammatical, sentence containing a plural subject and finite verb, regardless of the number of the input words. They were instructed to speak clearly and were given the opportunity to ask questions before the experiment commenced.

Results

The data of interest in this experiment are the reaction times on the verb, since this is where effects of number mismatch can be noticed. In the following we will therefore restrict our analyses to verb response onset latencies. Due to an error two sentences were not presented in all four conditions and were thus

eliminated from the dataset. We removed all extreme data points from the remaining data. Extreme data points were defined as reaction times that deviated more than two times the standard deviation from the mean per subject and per condition. This resulted in the removal of 6.8% of all data points, evenly distributed across conditions and subjects.

Table 2.2 shows the mean latencies (averaged across participants and items after filtering) per condition. Latencies for conditions with a plural input verb are on average 26 ms shorter than for conditions with a singular input verb. To determine if this is significant we conducted 2 x 2 Repeated Measures analyses (subject number x verb number) yielding significant main effects of verb number [$F1\ (1, 15) = 77.46$, $p < 0.001$; $F2\ (1, 57) = 28.44$, $p < 0.001$] but no effect of subject number, nor, importantly, of subject number by verb number (all F's < 1.5).

Table 2.2 Experiment 1. Pluralising-task mean verb response voice onset latencies in milliseconds (standard deviations in brackets).

Subject number in input sentence	Verb number in input sentence	
	plural	singular
plural	500 (56.4)	530 (51.2)
singular	500 (60.0)	523 (60.0)

Discussion

Experiment 1 demonstrates that in the pluralising ERA-task voice response latencies to plural verbs are significantly faster than latencies to singular verbs, irrespective of the congruence between number of the subject and number of the verb in the input sentence. The self-paced reading pre-test, however, showed that in reading the same set of sentences, the incongruous sentences did cause a slowing effect. This pattern of results provides evidence against the independent-resources model which predicts that participants can build up and maintain two separate syntactic constructions simultaneously, one for comprehension and one for production. The model predicts that in the pluralising ERA-task voice response latencies on the verb should be affected by both the grammaticality of the input sentence (as defined by agreement between subject number and verb number) and by the number of the verb, leading to a

predicted pattern of reaction times of PP< [SS, SP] < PS. If this were the case we should have found at least an interaction effect of subject number and verb number, and possibly an effect of verb number. However, the pattern obtained (PP=SP < SS=PS) only displayed an effect of verb number. This is in accordance with the predictions of the alternative model in which grammatical encoding and decoding are not separate but operate on shared cognitive resources, implying that at any point in time, participants can only maintain one syntactic structure. In case of the ERA-task, this structure is the edited, output sentence. The pre-test demonstrated that this effect was not due to a lack of detectability of the ungrammaticalities in the input, as this self-paced reading task showed that the (verbs of the) ungrammatical (incongruent) sentences were read significantly slower than the grammatical sentences.

However, one could argue that the pluralising task was too general, causing confusion for the participants as to which fragments were to be edited and which were not. To reduce this risk, the stimuli were specifically constructed to minimize confusion over which fragments needed to be pluralised. When properly processed semantically no confusion should arise as to which fragments needed to be pluralised, and hardly any did. As a result (and providing evidence that semantic processing indeed took place), participants were pretty good in pluralising only the subject and the verb while leaving the other fragments intact (mistakes were made in only 4% of the sentences). Nevertheless, there is no way of telling if participants might just have employed a strategic approach to the sentences and pluralised everything on a word-by-word basis, regardless of the input or of the sentence context, without actually syntactically processing either the input or output sentence. Another issue is the fact that we did not directly measure the degree of awareness of the ungrammaticalities of the input sentences. To address these concerns, we employed another editing instruction in Experiment 2, namely paraphrasing direct to indirect speech. This operation enabled us to be more specific regarding the to-be-edited fragments and it also ruled out the possibility of a simple word by word response strategy. In addition to this, we included a question after each sentence to monitor the degree of awareness of input grammaticality.

EXPERIMENT 2

The aim of Experiment 2 is to replicate the effect obtained in Experiment 1, using a grammatically more demanding editing task, where adopting a simple word-by-word response strategy is minimised. The experiment consists of two parts, a paraphrase task, and a correction task. The paraphrase task in particular calls for a substantial alteration of the sentence structure. Both tasks require participants to read input sentences fragment by fragment and edit these to produce output sentences as the input sentence unfolds. All sentences contain a reflexive pronoun. Grammaticality of the input sentences is manipulated by providing a reflexive pronoun that does or does not correspond to its antecedent with respect to the person feature. Importantly, the input reflexive either does or does not match the antecedent of the intended output sentence. This generates two reflexive conditions per task: one in which the input reflexive can remain the same (condition SAME), the other in which it needs to be changed to fit the output sentence (condition CHANGE).

In the paraphrase part, the editing instruction is to paraphrase direct to indirect speech, like example (3), below. Participants have to produce output sentences such as (3c) (*The headmaster complained that he had seen a nasty cartoon of himself in the hall*), given one of two input sentence conditions, in which grammaticality is manipulated by variation of the person feature of the reflexive pronoun. The paraphrase is cued by the presentation of the word *dat* (that), see Figure 2.2.

Condition PARA-CHANGE consists of grammatical input sentences, like (3a) (*The headmaster complained "I have seen a nasty cartoon of myself in the hall"*), and contains the correct reflexive pronoun (corresponding to the antecedent) (i.e. *mezelf* [myself], 1st person singular), In order for the reflexive to suit the indirect speech output sentence, however, it needs to be edited to *zichzelf* (himself) (3rd person singular).

In condition PARA-SAME the sentences are ungrammatical, like (3b) (The *headmaster complained "I have seen a nasty cartoon of himself in the hall"*): The third person property of the reflexive does not correspond to the first person property of the antecedent in the input sentence. Instead, the reflexive fits the desired output sentence as it is, and need not be edited.

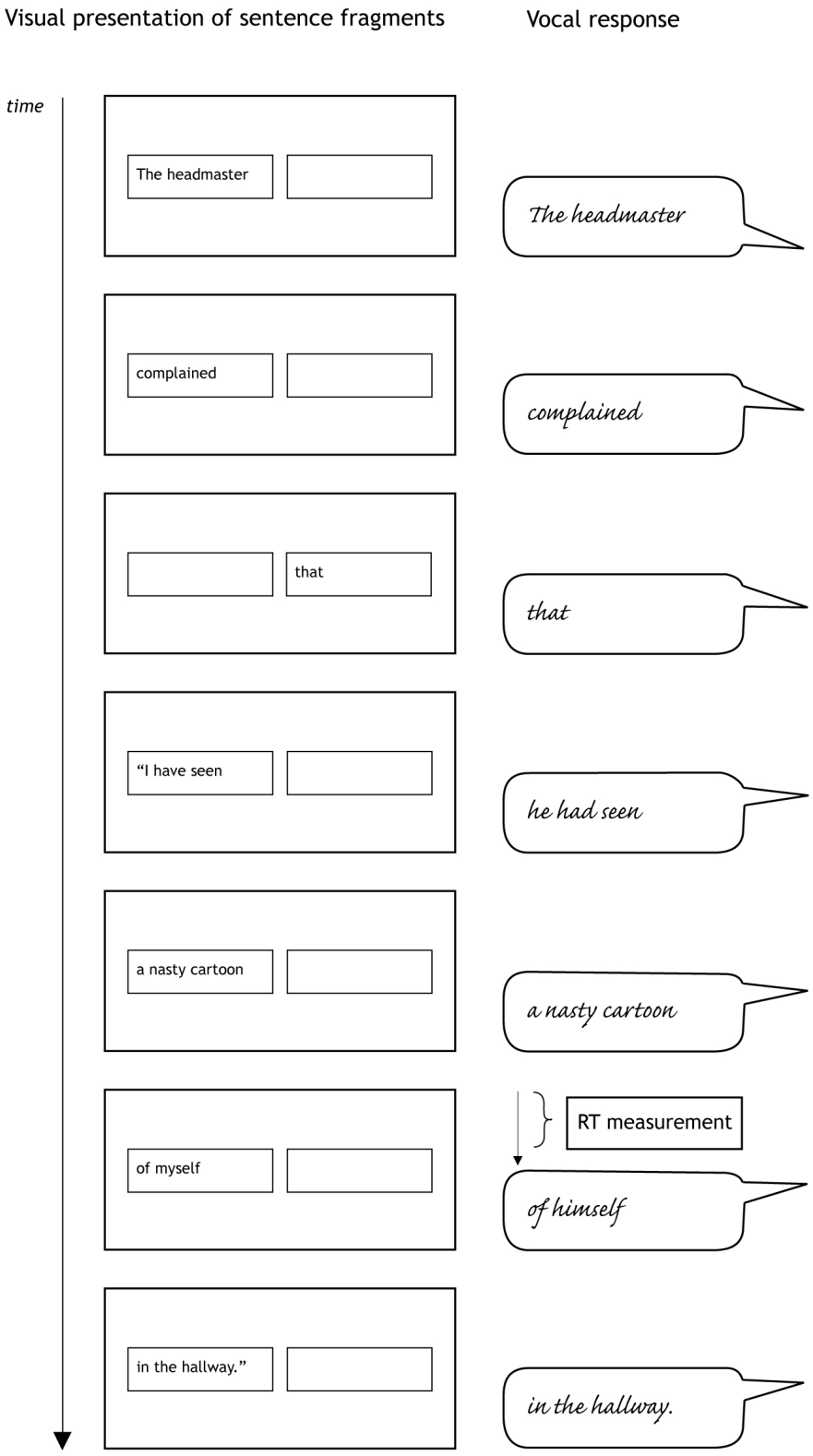

Figure 2.2 Sample paraphrasing ERA-trial

(3a) Input in condition PARA-CHANGE

The headmaster complained “I have seen a nasty cartoon of myself in the hall”.

(3b)* Input in condition PARA-SAME

The headmaster complained “I have seen a nasty cartoon of himself in the hall”.

(3c) Desired output

The headmaster complained that he had seen a nasty cartoon of himself in the hall.

Thus, grammaticality of the input sentence in the paraphrase part is manipulated by providing a reflexive pronoun whose person feature matches either the antecedent in the input sentence (*mezelf*, 1st person singular) as in condition PARA-CHANGE, or the output sentence (*zichzelf*, 3rd person singular), as in condition PARA-SAME.

In the correction part of the experiment, we use the indirect speech versions of the same set of sentences as in the paraphrase task. Participants are instructed to read sentences like (4) below and to correct mistakes. The sentences are presented in fragments, and are either grammatical or ungrammatical. The grammatical input sentences are identical to the desired output sentences (4a, 4c)): (*De lottowinnaar zei dat hij had besloten een rode auto te kopen voor zichzelf* [The lottery winner said that he had decided to buy a red car for himself]) and do not require a correction, but can simply be read aloud (condition CORR-SAME).

The ungrammatical sentences contain a reflexive pronoun that does not correspond to the antecedent with respect to the person feature, like in (4b): (*De lottowinnaar zei dat hij had besloten een rode auto te kopen voor mezelf* [The lottery winner said that he had decided to buy a red car for myself]). The reflexive in these ungrammatical sentences needs to be corrected so that it matches its antecedent (condition CORR-CHANGE), resulting in the intended output sentence (4c).

(4a) Input in condition CORR-SAME, desired output

De lottowinnaar zei dat hij had besloten een rode auto te kopen voor zichzelf.

The lottery winner said that he had decided a red car to buy for himself.

‘The lottery winner said that he had decided to buy a red car for himself.’

(4b)* Input in condition CORR-CHANGE

De lottowinnaar zei dat hij had besloten een rode auto te kopen voor mezelf.

` *The lottery winner said that he had decided a red car to buy for myself.*

'The lottery winner said that he had decided to buy a red car for myself.'

(4c) Desired output

De lottowinnaar zei dat hij had besloten een rode auto te kopen voor zichzelf.

The lottery winner said that he had decided a red car to buy for himself.

'The lottery winner said that he had decided to buy a red car for himself.'

The reaction times of interest in both tasks are those on the reflexive pronoun, since that is where possible ungrammaticalities surface. Condition CHANGE reflexives always require grammatical encoding: the number of the reflexive needs to be brought in accordance with the number of the antecedent in the desired output sentence. Only ungrammatical input sentences (irrespective of the task or the condition) can present a decoding problem.

Independent-resources theories predict that response latencies on the reflexive are both affected by the grammaticality of the input as well as by the condition of the reflexive. Condition CORR-SAME is expected to be fastest in this model, since it neither presents a decoding problem — the sentence is grammatical — nor an encoding problem, as the reflexive can be reused. PARA-CHANGE and PARA-SAME, both encounter one problem and are thus expected to be somewhat slower. PARA-CHANGE involves an encoding problem (producing the correct reflexive), PARA-SAME a decoding problem (dealing with the ungrammatical input sentence). Sentences in condition CORR-CHANGE involve both encoding and decoding problems and are therefore expected to generate the longest reaction times.

A shared-resources model predicts that, like in Experiment 1, we do not expect participants to notice the ungrammaticalities in the input sentences, nor to be affected by them in terms of voice response latencies. We do predict latencies to be influenced by the condition of the input reflexive, however, with conditions PARA-CHANGE and CORR-CHANGE that involve an encoding problem resulting in longer reaction times than those of conditions PARA-SAME and CORR-SAME.

In sum, the independent-resources model predicts: CORR-SAME < [PARA-SAME, PARA-CHANGE] < CORR CHANGE and the shared-resources model predicts: [CORR-SAME, PARA-SAME] < [CORR-CHANGE, PARA-CHANGE] (See table 2.3).

In addition to the ERA-tasks, in order to monitor the degree of awareness of the manipulation, participants receive a brief question following each trial, about whether the input sentence was grammatical. Since the independent-resources model predicts that encoding and decoding structures can be maintained simultaneously, it follows that grammaticality judgements in both the paraphrase task and the correction task should be near perfect. The shared-processor model however implies that only one structure can be maintained at the time. As the ERA-tasks call for encoding of a desired output structure specifically, we expect that ungrammaticalities in the input structures will not even be noticed.

Table 2.3 Model predictions of difficulties per editing task and reflexive condition

Task	Input reflexive condition	Grammatical	Independent-resources model		Shared-resources model	
			decoding problem	encoding problem	decoding problem	encoding problem
PARA	SAME	-	+	-	-	-
	CHANGE	+	-	+	-	+
CORR	SAME	+	-	-	-	-
	CHANGE	-	+	+	-	+

Method

Paraphrase task

Participants

Twenty-two members of the Leiden University community were paid in course credits or euros to participate in this experiment. All were Dutch native speakers and had normal or corrected-to-normal vision.

Materials

We constructed twelve experimental items in Dutch, eighteen fillers and five practice items, like (5) below (See Appendix B). The experimental sentences

consisted of a subject noun phrase, a finite verb followed by a colon and opening quotation marks (“), a sentence in direct speech, containing a reflexive pronoun that either did or did not correspond in person with the antecedent (the subject), and closing quotation marks (”), like (5 a/b). As reflexive pronouns that did not correspond to the antecedent in the input sentence we used the reflexive matching the person feature of the antecedent in the output sentence. This yielded two reflexive conditions: PARA-CHANGE (the reflexive needs to be modified in order to suit the desired output sentence (5a)) and PARA-SAME (the reflexive does not have to be modified in order to fit into the output sentence (5b)). The position of the reflexive pronoun in the sentence varied. In half of the experimental sentences, the reflexive took sentence final position; in the other half it preceded the sentence final infinitive.

(5a) Condition PARA-CHANGE

De lottowinnaar zei: (dat) “ik heb besloten een rode auto te kopen voor mezelf”

The lottery winner said: (that) “I have decided a red car to buy for myself”

‘The lottery winner said, (that), “I have decided to buy a red car for myself”.’

(5b)* Condition PARA-SAME

De lottowinnaar zei (dat): “ik heb besloten een rode auto te kopen voor zichzelf”.

The lottery winner said: (that) “I have decided a red car to buy for himself”

‘The lottery winner said, (that) “I have decided to buy a red car for himself”.’

(5c) Desired output

De lottowinnaar zei dat hij had besloten een rode auto te kopen voor zichzelf.

The lottery winner said that he had decided a red car to buy for himself

‘The lottery winner said that he had decided to buy a red car for himself.’

Each sentence was presented in fragments, like (6) below:

(6) De lottowinnaar/ zei:/“ ik /heb besloten/ een rode auto/ te kopen/ voor mezelf”.

(The lottery winner/ said:/ “I/ have decided/ a red car/ to buy/ for myself”.)

‘The lottery winner said: “I have decided to buy a red car for myself”.’

Two rectangular frames were shown on the monitor, one on the right, the other on the left of the centre. The sentence fragments were presented one by one in

the left-hand frame. To elicit the paraphrase, the word *dat* (that) was presented in the right-hand frame immediately after the finite verb of the main sentence.

The practice sentences and fillers also were in direct speech. Two out of five practice sentences contained reflexive pronouns, one of which was incorrect. One-third of the filler sentences contained a subject verb agreement error or idiomatic error rendering the sentence ungrammatical. None of the fillers contained a reflexive pronoun.

Design

The experiment started with the practice sentences, followed by the experimental sentences and the fillers in random order with the restriction that no more than two experimental items would occur in consecutive trials. To avoid possible learning effects, participants received only each sentence in one condition only, according to a Greek-Latin square, with half of the sentences embodying condition PARA-SAME and the other half condition PARA-CHANGE.

Procedure

Participants were tested individually with the experimenter present, facing a computer screen positioned about 80 cm away and a microphone to register vocal response time. Reaction times were measured from the appearance of the sentence fragment on the screen until voice onset. Each sentence fragment was presented for 1200 ms, with a 10 ms break between fragments and a 1000 ms break between sentences. Immediately following each trial a grammaticality question was presented for 1000 ms.

Prior to the experiment, participants were instructed explicitly and by means of examples that their task was to paraphrase the sentences such that their response would be a grammatical sentence in indirect speech. Participants were furthermore asked to judge the grammaticality of each input sentence at the end of the trial, by giving a vocal response. They were instructed to speak clearly and were given the opportunity to ask questions prior to the experiment.

Correction task

Participants

Fifteen members of the Leiden University community were paid in course credit or euros to participate. All were Dutch native speakers and had normal or corrected-to-normal vision.

Materials

The experiment consisted of twelve experimental sentences, like (7) below, 24 fillers and five practice items. Indirect speech versions of the same experimental sentences as in the paraphrase task were used in the correction task. Each experimental sentence contained either a third person reflexive pronoun that corresponded to the antecedent (condition SAME (7a)), or a first person reflexive which did not correspond to the antecedent (condition CHANGE (7b)).

(7a) Input in condition CORR-SAME, desired output
De lottowinnaar zei dat hij had besloten een rode auto te kopen voor zichzelf
The lottery winner said that he had decided a red car to buy for himself
'The lottery winner said that he had decided to buy a red car for himself.'

(7b)* Input in condition CORR-CHANGE
De lottowinnaar zei dat hij had besloten een rode auto te kopen voor mezelf.
The lottery winner said that he had decided a red car to buy for myself
'The lottery winner said that he had decided to buy a red car for myself.'

(7c) Desired output
De lottowinnaar zei dat hij had besloten een rode auto te kopen voor zichzelf
The lottery winner said that he had decided a red car to buy for himself
'The lottery winner said that he had decided to buy a red car for himself.'

The practice sentences and fillers also were also in indirect speech but did not contain reflexive pronouns. Three out of five practice sentences and halve of the filler sentences contained a subject-verb agreement error or idiomatic error rendering the sentence ungrammatical.

Design

Participants saw half of the experimental items in condition CORR-SAME, the other half in CORR-CHANGE, according to a Greek-Latin square. The experiment started with the practice sentences, randomly followed by the experimental items and the fillers with the restriction that no more than two experimental items would occur in consecutive trials

Procedure

The experimental procedure was the same as in the paraphrase task, with the exception that after each trial no grammaticality judgement had to be made. Participants were instructed to correct mistakes as they read the sentences fragment by fragment and respond clearly and as quickly as possible.

Results

Participants with more than four voice key errors on the experimental items were excluded from analysis, leaving twelve participants in each task. All extreme data points were removed from the remaining data. Extreme data points were defined as reaction times that were either shorter than 300 ms or longer than 1000 ms. This resulted in the removal of 13 data points (9%) for the paraphrase task and 19 data points (13%) for the correction task, evenly distributed across conditions and subjects.

Table 2.4 shows the mean latencies (averaged across participants and items after filtering) per reflexive pronoun condition. Latencies for conditions with reflexives matching the desired output sentence (condition SAME) are on average 52 ms shorter than for conditions with reflexives that needed to be modified (condition CHANGE).

Table 2.4 Experiment 2. Mean response onset latencies in milliseconds on the reflexive pronoun.

	Task	
Input reflexive condition	Paraphrase	Correction
SAME	604	607
CHANGE	645	670

We conducted two repeated measures analyses; an analysis by subjects with task type (paraphrase vs. correction) as between-participants factor and reflexive condition (SAME vs. CHANGE) as within-participants factor, and an analysis by items with task type (paraphrase vs. correction) and reflexive condition (SAME vs. CHANGE) both treated as within factors.

Reflexive condition yielded a significant main effect within subjects ($F1 (1, 22) = 8.844$, $p < 0{,}005$) and a marginally significant main effect within items ($F2 (1, 11) = 8.914$, $p = 0.012$). No interaction effect of task type and reflexive condition was found, neither within subjects ($F1 (1, 22) = 0.374$, $P > 0.5$), nor within items ($F2 (1, 11) = 1{,}265$, $p > .25$).

The grammaticality judgements yielded six (4%) incorrect answers for the correction task and 36 (25%) for the paraphrase task. Corrected for chance, this means that in the paraphrase task only half of the questions were answered correctly, whereas in the correction task 82% of the grammaticality judgements were accurate.

Discussion

Experiment 2 was set up to determine if the results from Experiment 1 could be replicated in a more grammatically demanding setting where adopting a simple word-by-word response strategy was ruled out. The independent-resources model predicts that both decoding problems such as ungrammatical input sentences, and encoding problems such as modification of the input reflexive pronoun to make it fit the output structure should cause delay. Hence, if the independent-resources assumption is right we expect: CORR-SAME < [PARA-SAME, PARA-CHANGE] < CORR CHANGE. In contrast, the shared-resources model predicts that decoding problems do not affect reaction times, leading to: [CORR-SAME, PARA-SAME] < [CORR-CHANGE, PARA-CHANGE].

The results show, in agreement with the results of Experiment 1 and contrary to what the independent-resources model would predict, that also in a more grammatically demanding task participants are not maintaining the input and the output syntactic structures simultaneously. Instead, as was the case with the

verbs in Experiment 1, reaction times on the critical word, the reflexive pronouns, are merely affected by how well they fit in the output sentence, not by the grammaticality of the input sentence. Reaction times are considerably faster for conditions PARA-SAME and CORR-SAME in which the reflexive presented in the input fits the output sentence, that is, when it already corresponds to the antecedent in the output sentence, than for conditions PARA-CHANGE and CORR-CHANGE. This picture is confirmed by the grammaticality judgement data: in 25% of the cases participants could not determine correctly whether the input sentence was grammatical or not. This contradicts the implication of the dual processor assumption that grammatical encoder and decoder should be able to work independently from and parallel to each other.

General discussion

The current experiments were conducted with the aim of testing the implications of the standard independent-resources model of syntactic processing that grammatical encoding and decoding can function simultaneously and independently from each other. To achieve this we utilized a new technique, the Edited Reading Aloud (ERA) task in which participants were presented with input sentences that needed to be edited into output sentences of a prespecified construction. Editing took place online, fragment by fragment, and voice onset times for the output phrases were recorded. Grammaticality of the input sentences was manipulated and we compared voice onset times on critical locations in the sentences for conditions in which the critical word grammatically fit either the input sentence, or the output sentence, or both. We argued that having a separate grammatical encoder and decoder implies that syntactic structures for production can be maintained simultaneously with syntactic structures for comprehension. Hence, the independent-resources model predicts that ungrammaticalities in input as well as in output sentences should affect response latencies. On the other hand, if grammatical encoding and decoding are not as separate as often assumed, a shared-resources model would predict that reaction times are not affected by grammaticality of both input and output structures, since these cannot be maintained simultaneously, but rather only by the grammaticality of the sentence under construction, that is, the output structure.

In Experiment 1, the desired output was a sentence with plural subject and verb; the input consisted of sentences in which subject number and verb number systematically varied. The reaction times on the verb did not reflect the grammaticality of the input sentence but only the fit of the verb in the output sentence, with plural verbs producing shorter latencies than singular verbs, indicating that participants do not process the subject-verb disagreement in the input but rather focus on the output sentence alone.

In Experiment 2, we replicated this finding using two variations on the ERA-task. In a paraphrase ERA-task, the editing instruction was to paraphrase direct to indirect speech. This operation was grammatically more demanding and less likely to be accomplished strategically, on a word-by-word basis, without building a syntactic structure. A correction ERA-task required participants to correct errors in the input sentence, so as to produce a grammatical output sentence. Grammaticality of the input sentence in both variants was manipulated by providing a reflexive pronoun that, with respect to the person feature, corresponded either to the antecedent in the input sentence, or to the antecedent in the output sentence. Again, reaction times were only affected by the fit of the reflexive in the output sentence, not by the grammaticality of the input sentence. The percentage of errors in the grammaticality judgements on the input sentences further supported the assumption that proper parsing of the input sentence alone did not take place. The results of Experiment 2 were replicated in a second study (Kempen, Olsthoorn & Sprenger, in preparation).

The ERA-task does not require separate conceptual structures to be maintained. In both experiments the meaning of the input and output sentences is the same (in Experiment 2) or very similar (Experiment 1). The obtained results are therefore unlikely to be due to the fact that the speaker cannot deal with multiple meanings at the same time. On the basis of these experiments we can therefore conclude that the standard model of language processing featuring separate processors for grammatical encoding and decoding is insufficiently specific. The independent-resources model as it stands implies that the informationally encapsulated processors should be able to work simultaneously and independently, and the ERA-experiments have demonstrated that this is not the case.

Conclusions

Given the current findings there are several theoretical possibilities with regard to the architecture of grammatical processing. The first is a modification of the current independent-resources model. We have demonstrated that no two syntactic structures are maintained simultaneously, suggesting that grammatical encoding and grammatical decoding do not take place in parallel. This in turn suggests that encoder and decoder at a minimum share a common working memory. A shared working memory implies that grammatical encoding and decoding cannot take place concurrently, because at one point in time only one syntactic structure can be assembled and maintained. The two processors sharing the working memory may be homogeneous in nature (essentially reduplicating each other) or heterogeneous (each with its own characteristics).

Based upon the theoretical and empirical commonalities between grammatical production and comprehension as well as the current data, another, more extreme option is a shared-resources model in which at least the strict separation of grammatical encoding and decoding is reduced. It assumes that syntactic processing in general is a modality a-specific task which can be executed by shared cognitive resources (a single Grammatical Coder), using a single, shared working memory.

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Further research into the relationship between grammatical encoding and decoding would have to include experimental set-ups that embody both production and comprehension tasks. Between-modality syntactic priming experiments offer such an environment, based on the assumption that if the processing of a stimulus affects the subsequent processing of another stimulus, then the two stimuli must be related along a dimension that is relevant to the cognitive system (Branigan, Pickering, Liversedge, Stewart & Urbach., 1995). In the case of syntactic priming, this common dimension must be of a syntactic nature, since that is the only dimension on which prime and target sentences are related. The next chapters will therefore concern syntactic priming.

Chapter 3
Syntactic priming: a survey

Introduction

Language is productive. Speakers and listeners are able to generate and understand an in principle unlimited, in practice a very large number of different sentences. This creativity and novelty of language have often been emphasised by linguists and psycholinguists. However, although productivity is doubtlessly an important characteristic in language competence, language performance studies such as corpus analyses have demonstrated our speech to be highly repetitious (see Kempen 1977; Miller & Weinert, 1998, for an overview). Almost 70% of the language contained in the London-Lund corpus of spoken English, for instance, was repetitious (Altenberg, 1990). This tendency to repeat seems to affect all populations of speakers (cf. Smith & Wheeldon, 2001 for an overview) and all aspects of language: the lexicon (Altenberg, 1990), phrases and lexemes (Levelt & Kelter, 1982), formulaic language (Vihman, 1982; Kuiper, 1996), syntactic frames (Nattinger & DeCarrico, 1992) and syntactic structures, such as the short-term repetition of passives (Weiner & Labov, 1983).

The syntactic repetition effect is also called syntactic persistence or syntactic priming: referring to the phenomenon where the use of a syntactic structure in a sentence increases the likelihood of the use of the same structure in a new (subsequent) sentence. Syntactic persistence has been extensively investigated, not only in corpora, but also in experimental settings (e.g. Bock, 1986, 1989; Bock & Loebell, 1990; Branigan, Pickering, Liversedge, Stewart & Urbach,

1995; Fox-Tree & Meijer, 1999; Hartsuiker, Kolk & Huiskamp, 1999; Hartsuiker & Westenberg, 2000; Smith & Wheeldon, 2001) using written and spoken texts and in a variety of languages. The reason for this enthusiastic exploration of the syntactic priming phenomenon is that it opens a window onto the mental representation and workings of grammatical knowledge and processes. For if the processing of a sentence affects the processing of another sentence, and the sentences are similar in one dimension only, it can be assumed that the cognitive system is sensitive to that particular dimension. Although in principle priming effects can be inhibitory as well as facilitatory, in general the prime facilitates the processing of the related target.

A distinction can be made between syntactic priming within modalities (production-to-production priming and comprehension-to-comprehension priming) and priming between modalities (from comprehension to production or vice versa). Within-modality priming effects can provide information about modality-specific knowledge and procedures, between-modality priming on the other hand can give insight into the kind of information that is shared between modalities[3]. In the following sections I will give an overview of both within-modality priming studies and between-modality priming studies. I will focus on syntactic priming evidence reflected in increased response tendencies. Studies of the online effects or syntactic priming will be discussed in Chapter 4.

Production-to-production priming

The first to establish production-to-production syntactic persistence effects in an experimental setting was Bock (1986). She investigated whether repeating a sentence with a particular structure affected the subsequent description of a picture. Under the guise of a memory test, participants repeated aloud an auditory presented prime sentence containing either a double-object (NP-NP) dative construction as in Example (1) (DO), or a prepositional-object (NP-PP) dative construction as in Example (2) (PO).

[3] Although the dichotomy production-to-production and comprehension-to-production priming is not always evident, as even a production-to-production experiment usually involves some form of comprehension, for instance in repeating or reading the prime sentence, the main distinction here is not in terms of the underlying sources of priming, but the task with which participants were presented.

(1) The rock star sold the undercover agent some cocaine. (DO)

(2) The rock star sold some cocaine to the undercover agent. (PO)

Next, a picture was shown representing an action involving an agent, a patient and a recipient, for instance: a girl handing a paintbrush to a man. These target pictures could all be described with both a prepositional-object and a double-object dative sentence. Participants were instructed to describe the picture using a single sentence featuring no pronouns. Bock demonstrated a significant tendency for the syntactic structure employed in the priming trial to be re-deployed more frequently during the target picture description task. Thus, participants were more likely to describe the picture with a double-object construction (*The girl hands the man a paintbrush*) after having repeated a double-object priming sentence than after a prepositional priming sentence. After a prepositional-object prime they would describe the picture with a PO sentence like *The girl hands the paintbrush to the man*. Similarly, after a passive sentence, more pictures were described in passive voice than after an active sentence.

Subsequent research by Bock and colleagues showed that the syntactic priming effect is insensitive to three kinds of similarities between prime and target. Firstly, syntactic priming effects were not affected by thematic similarities between prime and target sentences. In picture description, it did not matter whether the prime sentence was conceptually similar as well as syntactically similar or rather syntactically similar but conceptually dissimilar. Thus, a picture description such as *The girl handed the paintbrush to the man* was just as likely to occur after the conceptually similar *The wealthy widow gave her Mercedes to the church* as after the conceptually different (but syntactically similar) *The wealthy widow drove her Mercedes to the church*. The syntactic similarity between prime and target sentences still gave rise to the syntactic priming effect (Bock & Loebell, 1990).

Secondly, lexical similarities between prepositions do not affect syntactic priming. The syntactic priming effect is equally likely to occur in describing a picture like The *waiter brings a tray of drinks to the customers* after a prime sentence with the same preposition (*The secretary took a cake to her boss*), as after a prime sentence using a different preposition (*The secretary baked a cake for her boss*) (Bock, 1989). It should be noted, however, that in the above

mentioned study by Bock and Loebell (1990) it was found that participants were equally likely to describe a picture in the passive voice after a full passive prime (*The construction worker was hit by the bulldozer*) as after a prepositional locative (*The construction worker was digging by the bulldozer*), suggesting a lexical source (repetition of the pronoun *by*) of the persistence effect after all.

Thirdly, syntactic priming is not affected by metrical or phonological similarities between primes and targets. This was also investigated by Bock and Loebell (1990) when they presented participants with sentences that looked like (but in fact were not) true NP-PP syntactic primes because of their metrical and phonological structure, for instance *Susan brought a book to study*. However, prime sentences like these did not have the same effect as genuine syntactic primes, such as *Susan brought a book to Stella*.

Apart from picture description, similar production-to-production priming effects have been found using sentence completion (e.g. Pickering & Branigan, 1998; Hartsuiker & Westenberg, 2000) and sentence recall (Potter & Lombardi, 1998) paradigms.

Comprehension-to-comprehension priming

Like sentence production, sentence comprehension is also repetition prone. Intuitively, the way in which we comprehend sentences can be affected by previously encountered sentences. Consider classic garden path sentences such as *The horse raced past the barn fell*. Although normally virtually incomprehensible at first pass, these reduced relatives can become oddly familiar to anyone who has read theoretical linguistic or psycholinguistic papers. Overexposure to this particular type of construction rapidly leads to a loss of one's normal intuitions concerning grammaticality. This was also experimentally established by Matthews (1979, in Branigan, 1995), who found that sentences like (3) containing a reduced relative were more likely to be judged grammatical if they were judged after a related (but structurally not quite identical) sentence such as (4) rather than if they preceded it.

(3) The canoe floated down the river sank.

(4) The man that was thrown down the stairs died.

If grammaticality judgements reflect in part difficulty of parsing, these findings can be interpreted as evidence of a syntactic priming effect: comprehension of a previous sentence with a related structure apparently facilitates the subsequent processing of a structurally similar sentence that is usually difficult to process.

A more direct method to measure comprehension-to-comprehension priming involves explicit sentence interpretation (Mehler & Carey, 1968; Carey, Mehler & Bever, 1970; Branigan, Pickering & McLean, 2005). Mehler and Carey (1968) showed participants a series of pictures and asked them to judge whether a sentence correctly described a picture. The sentences used contained a copular verb and a predicate NP with an intransitive verb, as exemplified in sentence (5), or were progressive transitive structures such as sentence (6).

(5) These are conflicting desires

(6) They are forecasting cyclones.

Five sentences of one type were followed by a sixth sentence, which was either of the same type or the other type. When the last sentence correctly described the picture, it was responded to faster if it had the same structure as the preceding five items than if it had a different structure. However, no effect was found when the sentence did not correctly describe the picture. In a subsequent experiment by Carey, Mehler & Bever (1970) a similar task was employed. Again participants were asked if a sixth sentence correctly described a picture. The five preceding prime sentences again were all of one type, either with a copular construction or with a progressive transitive construction. However, this time the target sentence was always globally ambiguous and could be analysed as either a copula or a progressive structure. For instance, in *They are lecturing doctors*, *lecturing doctors* can be an NP functioning as predicate or a VP (with a transitive verb). There were four picture conditions: compatible with the copular structure; compatible with the progressive-transitive reading; compatible with both readings; compatible with neither reading. In addition to deciding whether or not the target sentence was compatible with the picture, participants were also asked to paraphrase the sentence. This allowed Carey et al. to determine which interpretation of the target sentence the participant had made.

The results indicated no difference between response latencies for pictures that were compatible with the primed interpretation and pictures that were compatible with both interpretations. If the picture was compatible with the unprimed reading however, responses were significantly slowed, suggesting a relative priming effect. Furthermore, in the paraphrase task, the primed reading was significantly more often reported than the unprimed reading. These findings suggest that syntactic priming can affect the processing of ambiguous sentences in such a way that the ambiguity goes unnoticed and the reaction times are no different from equivalent unambiguous sentences.

Another method to test comprehension-to-comprehension priming is by means of reading times. In the whole-sentence self-paced reading paradigm employed by Branigan (1995) participants were instructed to read a prime sentence followed by a target sentence. Priming in comprehension should manifest itself as a reduction in reading time for a sentence in the primed condition compared to the unprimed condition. For instance, using transitives with early-closure subordinate clauses and intransitives with late-closure subordinate clauses such as sentences (7) and (8) below, reading times were considerably shorter in primed conditions, in which two sentences of the same type were paired, than in unprimed conditions, where a transitive prime preceded an intransitive target sentence or vice versa.

(7) While the woman was eating the creamy soup the pudding went cold.

(8) While the woman was eating the creamy soup went cold.

Strong and reliable priming effects were also found with complement/relative clause ambiguities and with main clause/reduced relative ambiguities. Overall, Branigan (1995) only found priming effects with locally ambiguous sentences where one continuation produces a strong garden path effect. The effect was syntactic in nature, since primes and targets were controlled for alternative origins of the effect such as lexical and semantic similarity, number of syllables and metrical structure[4].

Using a range of syntactic structures that varied in grammaticality from moderately grammatical to very grammatical, Luka and Barsalou (2005)

[4] As Branigan used a whole-sentence self-paced reading paradigm, it is unclear whether these data reflect initial syntactic analysis, or rather later syntactic reanalyses.

demonstrated a structural facilitation effect in comprehension by means of grammaticality ratings. Participants rated sentences more grammatical (as compared to novel sentences) if they had read them earlier. Increased grammaticality ratings were also observed for sentences that shared syntactic structure, but not content words with the sentences read earlier. This effect occurred after even a single exposure to the structure, but was enhanced by more exposures.

Between-modality Priming

So far, only within-modality syntactic priming experiments have been discussed. Since the same modality is used in both prime and target, it is possible that priming taps into some modality-specific process, rather than the syntactic knowledge itself. Evidence for common syntactic representations or processes becomes stronger when syntactic persistence is found between processing modes. In principle, between-modality priming should occur in two directions: from production to comprehension and from comprehension to production, and studies of between-modality priming could reflect this. In the first case we might expect comprehension of a structure to be facilitated if a sentence with the same structure had just been produced. In the second case we would expect that participants are more likely to produce a sentence with a particular structure following comprehension of a sentence with that structure. In practice however, most between-modality priming experiments focus on comprehension-to-production priming. The reason is that comprehension primes are more easily controlled by the experimenter than production primes. This stems from the fact that a considerable part of priming seems to be linked to competition between alternative structures. If priming is competitive in nature, this means that in order to find a priming effect, the prime sentence needs to correspond to one of the alternatives structures of the target sentence. Although eliciting an appropriate and specific to-be-produced prime structure is not impossible, it is difficult. Comprehension-to production priming, on the other hand, is easier to investigate, since the experimenter can control the structure of the prime sentence. The between-modality priming experiments presented below therefore all deploy priming from sentence comprehension to production, to demonstrate shared syntactic knowledge and information or processes between these modalities.

Levelt and Kelter (1982) already demonstrated that the grammatical form of a question could affect the form of an answer. They registered a strong tendency with shopkeepers to answer to the question posed (in Dutch): *At what time does your shop close?* with *At five o'clock*, rather than with *Five o'clock*, whereas the question *What time does your shop close?* elicited more *Five o'clock* responses than *At five o'clock* responses. The effect disappeared when an additional clause was added to the question, proving it to be short-lived. Nevertheless, the results of this study suggest syntactic priming from comprehension to production. However, it is very well possible that the source of this priming effect is not syntactic in nature, but rather lexical, originating from repetition of the preposition. In addition, it is difficult to generalise on the basis of this study since the circumstances were quite specific, with the prime sentence being semantically related to the target. This makes the Levelt and Kelter results difficult to interpret as strong evidence for between-modality syntactic priming.

Comprehension-to-production priming in a written sentence completion experiment without semantic relationship between prime and target, was found by Branigan et al. (1995). Participants were asked to complete the final sentence in passages like (9) and (10) below:

(9) A soldier was in court, accused of attacking a young man. The victim showed his injuries to the judge. The judge gave…

(10) A soldier was in court, accused of attacking a young man. The victim showed the judge his injuries. The judge gave…

After having read passage (9) which contains a prepositional-object dative construction, participants were more likely to complete it with a prepositional-object construction, whereas after having read (10), containing a double-object construction, the written sentence completions tended to consist of more double-object constructions. Although the priming effect occurred only with respect to the double-object completions and did not obtain when participants used pronouns, the results of this study demonstrate a clear syntactic priming effect that cannot be explained in terms of lexical repetition of the pronoun.

The sentence recall or intrusion paradigm (Potter & Lombardi, 1990, 1998; Lombardi & Potter, 1992) provides another example of comprehension-to-production priming. Participants in these experiments had to read and

subsequently recall sentences whilst performing concurrent tasks. Potter and Lombardi found that sometimes "lure" words slipped into the recalled sentence, causing the surface structure of the sentence to change if the intruding word did not fit with the sentence that was read. These lures were semantically similar to words from the original sentence, but brought with them an alternative sub-categorisation frame. For instance *give* in the original sentence could have been replaced with *donate* in the recalled sentence, changing the DO structure in the source sentence to a PO structure in the goal sentence. Other clauses could syntactically prime the target sentence so that it was sometimes misremembered as having the structure of the prime sentence. On the basis of these experiments Potter and Lombardi argued that the meaning of a sentence, rather than its surface form, is remembered and used to reproduce the sentence in recall.

A recall-based sentence-production task was also used by Ferreira (2003) to determine the effect of function word repetition in structural persistence. Three experiments served to measure whether the presence of an optional *that* in a sentence-complement structure such as *The mechanic mentioned (that) the car could use a tune-up* can be primed by the prior production (by recall) of a sentence that included a lexically similar *that* (transitive primes with determiner *that*, such as *The company insured that farm for…* or noun-complement primes with complementizer *that*s like *The theory that…*) or a lexically and syntactically similar *that* (sentence-complement primes with and without *that*s). It was found that only primes that were both lexically and syntactically similar, could lead to priming of the sentence-complement. Furthermore, compared to neutral primes, sentence-complement primes without *that* decreased target *that*-mention more than sentences-complement primes with *that*s increased it. Ferreira thus concluded that lexical priming does not facilitate syntactic priming, but rather the other way around.

A more ecologically valid way of studying between-modality priming is in a natural (spoken) dialogue between two speakers. This was realised in English by Branigan, Pickering and Cleland (2000) who designed a cunning experimental set-up to manipulate and study syntactic priming (co-ordination) in dialogue. To accomplish this, they had pairs of speakers describe pictures to each other, in such a way that, while being unable to see each other, the listeners had to select, on the basis of the speaker's description, a matching picture from a set laid out in front of them. One of the interlocutors was actually a

confederate of the experimenter, who produced scripted responses that systematically varied in syntactic structure (DO and PO datives), thus serving as prime sentences. It was found that the syntactic structure of the confederate's descriptions affected the syntactic structure of the other speaker's subsequent description. If the verbs differed between prime sentence and response, 26% more coordinated (where the structure of the target response repeated the prime structure) than non-coordinated responses (target responses where no such repetition occurred) were produced; if the verb remained the same, the percentage coordinated responses was even 55%. These results were later replicated in Dutch (Bos, 1999).

Thus, syntactic priming between modalities was empirically established, within language users both in writing and in sentence recall, and between language users in dialogue. This suggests that the knowledge or representations that are involved in priming are not modality-specific, but rather reflect something that is common to syntactic processing in general. In the next section I will briefly explore possible explanations for the syntactic priming phenomenon.

Explanations of syntactic priming

Locus of the priming effect

Although syntactic priming is clearly a robust effect, uncertainty remains as to the precise stage of language processing at which it originates. Initial studies provided support for the view that the effects are located at the level of grammatical processing, with some effects occurring during functional encoding, when lemmas are retrieved and assigned grammatical function roles, and others from positional encoding when constituent assembly processes are executed and word order is determined (Bock, 1986; Bock & Loebell, 1990; Bock, Loebell & Morey, 1992). For instance, Bock and Loebell (1990), argued that since dative sentences that contained a location (*The wealthy widow drove her Mercedes to the church*) primed datives that did not contain such a location (*A rock star sold some cocaine to an undercover agent*), the effect could not stem from the priming of thematic roles during the conceptual planning stage and must therefore be grammatical in origin. Additionally, they observed that passive targets were less frequent after active primes than after locatives, with which they shared constituent structure, but not grammatical or thematic role

structure. This lead them to conclude that the effect must clearly be explained in terms of positional, rather than functional processing. In a later study, the fact that participants produced more active sentences with inanimate subjects following passive primes with inanimate subjects than following passive primes with animate subjects, Bock et al. (1992) did attribute this particular effect to the level of functional encoding, as priming of the assignment of an animate lemma to a grammatical role.

More recently however, a number of researchers have begun to argue that the effects of structural persistence can indeed result from the priming of functional and conceptual structures (Hare & Goldberg, 1999; Hartsuiker, Kolk & Huiskamp, 1999; Chang, Dell, Bock & Griffin, 2000; Heydel & Murray, 2000). Hartsuiker et al. (1999) argue that the effects found by Bock et al. (1992) should be attributed to the conceptual and functional stages of speech production after all. For instance, the animacy effects attributed by Bock et al. to the level of functional processing should be relocated to the conceptual level; after all, animacy is a conceptual rather than grammatical aspect of language. In their modelling study (see below), Chang et al. (2000) also locate these effects in the mapping from conceptual to functional encoding.

Hare and Goldberg (1999) attribute their priming effect to the conceptual level as well. They had participants produce either a prepositional dative object sentence (11), a double object (12), or a *provide with*- sentence (13) as primes, and subsequently describe target pictures using either a prepositional object dative sentence or a double object dative

(11) His editor promised the hot story to Bob.

(12) His editor offered Bob the hot story.

(13) His editor credited Bob with the hot story.

Although the *provide with*-prime matches the prepositional object sentence in terms of syntactic structure (i.e. both are NP V NP PP) but not the double object sentence (which is NP V NP NP), in terms of conceptual structure it matches the double object sentence, placing the recipient immediately after the verb, in contrast to the prepositional object sentence in which the verb is followed by the theme. The fact that an equal proportion of double object targets was produced after double object primes as after *provide with*-primes, and that this proportion was significantly higher than the proportion produced after prepositional object

primes suggests that the priming effect in this study originates in the conceptual similarities between prime and target.

Finally, evidence for a priming effect unequivocally originating at the positional level was demonstrated by Hartsuiker and Westenberg (2000), who primed the word order of auxiliary verb and past participle in Dutch subordinate clauses (see also Chapter 4). In Dutch, this word order of past participle constructions varies freely, and is not affected by functional of conceptual aspects. Additionally, Smith and Wheeldon (2001) argue for an effect of phrase structure priming on sentence production latencies and attributed it to the level of positional encoding rather than early conceptual or functional processes (however, see also Chapter 4).

Of course, it is likely that the above mentioned effects and explanations do not exclude, but rather complement each other, and that syntactic processing can be independently facilitated by repetition at any of its constituent processing stages (c.f. Bock et al., 1992; Hartsuiker et al. 1999).

Apart from the locus of the priming effect, researchers have focused on the precise mechanisms that lead to structural priming. There are two hypotheses that can be distinguished on the basis of the temporal characteristics of empirical priming data. I will discus them in the next subsections.

Priming as residual activation

Priming effects in general are usually explained in terms of activation levels: upon encountering the first stimulus (the prime), the mental representations that are associated with it become activated. The representations accumulate activation until a certain threshold is reached, after which the representation becomes active for a short period of time. In terms of neural network models, from which this activation metaphor is derived, it is said that the active node(s) that form(s) the representation fire(s). Afterwards, the activation levels decrease again, but it takes some time until the activation levels are back to base rate. Thus, even after responding to the stimulus, the representations (the nature of which I will discuss later) retain some of their activation so that when the second stimulus (the target) comes across, the representations associated with the prime are still partly activated (provided that the time elapsed between the

first and the second stimulus is not longer than the time it takes for the representations to decay to base rate). If the prime stimulus and the target stimulus are sufficiently alike, then some (or all) of the representations they activate overlap. Thus, when the target stimulus is similar to the prime stimulus, the representations activated by the target may still have some residual activation from the prime. Therefore, these overlapping representations require less additional activation to reach a threshold in order to become active.

Now let's explore an example of syntactic priming. Let's say that the first stimulus is a sentence with a prepositional object dative construction, for instance: Humbert *bought a dress for Dolores*. We have seen above that it does not matter in which modality the prime sentence is processed: comprehension and production of a sentence can both produce reliable priming effects. Processing this sentence activates the mental representations associated with it in such a way that even after having processed this sentence, the representations that correspond to the prepositional object structure preserve some of their activation. Assume the prime stimulus is followed by a second stimulus: a picture that must be described, for instance a cartoon depicting how Jerry is handing a bomb to Tom. The picture can thus be described with a dative construction: a prepositional object construction like in the prime (*Jerry gives the bomb to Tom*) or a double object construction (*Jerry gives Tom a bomb*). Since the prepositional object representations are already more activated by the prime, and the double object structure is not, it is likely that the picture will also be described with a prepositional object construction. In other words, when subsequently confronted with multiple alternative structures to express a desired message (in case of a production target) or to interpret a given string of words (in case of a comprehension target), the representations corresponding to the alternative recently activated by the prime (here the prepositional object construction) have an advantage over those that correspond to the other alternative (the double object construction). The primed representations are more readily available, and win. This explains the response tendency effects of syntactic priming that were described in this chapter.

The precise nature of these representations has been a source of debate: what kind of information is it exactly that priming taps into? Until between-modality priming was established it was in principle possible that the representations that become activated are associated with modality-specific processes. In case of the

example above, this could mean that not the syntactic structure information about prepositional object constructions was primed, but rather the processes that are involved in actually processing (either comprehending or producing) the structure (Bock & Loebell, 1990). However, the fact that it was possible to prime from comprehension to production, has been interpreted as proof that the mental representations that became activated by the prime could not be particular to the modality at hand, but had to be connected to the syntactic information shared by the prime and target, in this case the prepositional dative construction. Following Levelt, Roelofs and Meyer (1999), Pickering and Branigan (1998) and Branigan, Pickering, Liversedge, Stewart and Urbach (1995) postulated that this syntactic information is information about the allowed subcategorisation frames or syntactic frames that specify how a certain verb can be used in a grammatical structure. For instance, the verb lemma *give* is linked to (at least) two subcategorisation frames: a double object frame specifying that it can be used as : X [give] Y to Z, and a prepositional object frame that specifies that X [give] Z Y (Branigan et al.,1995; Pickering & Branigan 1998; Branigan, Pickering & Cleland, 2000; Melinger & Dobel, 2005). Recently used subcategorisation frames retain higher levels of residual activation than their competitors and therefore require less additional activation to become reactivated. This has led some researchers to believe that priming effects should be found not only in terms of response tendency, but also in terms of shorter reaction times (Smith & Wheeldon, 2001; Wheeldon & Smith, 2003). Since less additional activation is necessary to reach threshold, less time is needed to accumulate the required amount of activation (see also Chapters 4 and 5). In fact, in other domains, such as lexical retrieval, the effect of priming is usually measured in terms of response speed-up

The priming as residual activation account explains why sentences tend to resemble their immediate predecessors, as far as their grammatical construction is concerned. The mental representations used just a minute ago are still somewhat active. If so, syntactic priming should dissipate with time or interference. In fact, it is rather desirable that priming should be transient. For instance at the level of phrase structure building, the on-line generation of surface syntactic structure requires rapid switching between different but frequently used phrase structures. Persistent activation of such structures could therefore inhibit rather than facilitate fluent speech production. There is some evidence that priming is indeed a short lived effect (Levelt & Kelter, 1982;

Branigan, Pickering & Cleland, 2000; Wheeldon & Smith, 2003). As we already saw, the repetition effect found by Levelt and Kelter (1982) disappeared as soon as an additional clause was included in the question. Wheeldon and Smith (2003), extend these findings to the effect of phrase structure priming on sentence production latencies and demonstrate that no priming survived the addition of even a single intervening unrelated trial (see also Chapter 4).

Priming as implicit learning

However, there are also studies that prove that syntactic priming can last for a fairly long time. For instance, Bock and colleagues found that structural priming persisted for over ten intervening sentences, both from production to production (Bock & Griffin, 2000) and from comprehension to production (Bock, Dell, Chang & Onishi, 2006). Luka and Barsalou (2005) report a persisting structural facilitation effect, pertaining to 40 to 50 intervening sentences (in addition to a five minute distractor task) in rating grammatical acceptability that can be interpreted as syntactic priming in comprehension. Others found priming effects over even longer periods of time: when primes and targets were separated by 20 minutes (Boyland & Anderson, 1998), or over as long as a week for aphasic patients (Saffran & Martin, 1997).

It is unlikely that these long term priming effects are also the result of residual activation. Instead, it has been argued that syntactic priming is a form of implicit learning which affects the mapping from conceptual to syntactic structure. (Bock & Griffin, 2000; Chang, Dell, Bock & Griffin, 2000). The persistence of priming over time and intervening sentences implicates a longer-term change to the production system, whose function may be to tune the system to experience. Chang et al. follow Seger (1994), in defining implicit learning as something that involves incidental learning of complex, abstract relations during the performance of a task, yielding knowledge that is inaccessible to consciousness. To test their hypothesis, Chang et al. developed a model of structural priming based upon the best working models for implicit learning: simple recurrent networks. The basic idea is that the model learns to be sensitive to stimuli that follow certain patterns, because it can use its past experiences as the context for predictions about the current state the model is in. When the predictions fail, the model reacts by making changes to the weights between the conceptual and syntactic level, using backpropagation. These

weight changes are the hypothetical basis for implicit learning. The results of their tests suggest that similar architectural features may be applied in accounting for the mechanisms of structural priming in language production.

Of course, the implicit learning account and the residual activation hypothesis are not mutually exclusive. In fact, it is likely that they both affect the syntactic properties of our sentences. Future research could focus on determining the factors that sometimes cause the effects of priming to be transient, and sometimes more persistent. These could include (but are not limited to) the experimental paradigm used, the syntactic structures in question, but also the time course of the effects in terms of reaction time changes of primed versus unprimed sentences.

Functional benefits and implications of syntactic priming

Syntactic priming is assumed to be an automatic effect, occurring unbeknownst to the language user. However although not exercised consciously, there may well be a functional benefit from syntactic co-ordination to speaker and/or listener. There are three common accounts of the functions of syntactic priming (Ferreira & Bock, 2006): implicit learning, fluency and alignment. In line with the implicit learning theory of priming, one account is that priming effects reflect the longer term process of learning how the syntactic constructions in a speaker's language map onto the features of meaning that they express (Bock & Griffin, 2000; Chang et al. 2000). Production or comprehension of a linguistic expression causes the language user to link certain syntactic configurations in certain orders to relational structures in their message representations. The grammatical-encoding process is henceforth tuned to compute those linkings of message structures and syntactic configurations again (Bock, Dell, Chang & Onisi, 2007), resulting in a tendency to reuse recently processed structures.

For both the fluency and the alignment accounts it is important to realise that language has evolved not in isolation within single speakers but in interaction with other speakers. The alignment account (Pickering & Garrod, 2004) views syntactic priming as a process that benefits the coordination between speakers. It helps interlocutors to coordinate their representations of the current situation (their *situation models*). By reflecting each others lexical and syntactic information, using the same words and structures, alignment of the situation

model is more likely as a result. Evidence for this hypothesis is for instance the fact that priming effects obtained in dialogue studies (Branigan, Pickering & Cleland, 2000) are substantially larger than priming effects that have been observed in memory-based, isolated syntactic priming paradigms (Bock, 1986; Bock & Griffin, 2000).

According to the fluency account, reuse of grammatical structures can help reduce the speaker's computational load associated with the syntactic processing of their utterances. Normally, speakers have a choice of grammatical structures to convey a meaning. Choosing one and performing the mental processes to generate it puts a certain computational load upon the system. Reducing this load by reusing a previously processed structure benefits mental resources for other aspects of language use: message generation, choice of words and pragmatics. This so called effort reduction hypothesis (Smith & Wheeldon, 2001) assumes that syntactic priming is a transient, short-term effect and thus builds mainly on the residual activation explanation. If syntactic priming functions to reduce processing load and to promote fluency, it should in principle be possible to measure this in terms of reduced processing times for primed constructions in comparison to unprimed constructions. However, the implicit learning account does not rule out reaction time effects either. According to this account, structural priming effects are the result of a longer term change in preference of one syntactic alternative over another. Assume that the initial proportion of alternative A and alternative B is 50-50, that is, both constructions are equally likely to be chosen. In terms of reaction times, the two alternatives are involved in a fair competition, and that may take a while to produce a winner. Now say that with experience, this proportion changes to 80-20. This will cause the time it takes to resolve the competition to be shorter. However, if the initial proportion of A and B is already unequal, e.g. 80-20, and priming affects the dispreferred structure, this may cause the proportion to change to 50-50, resulting in longer competition times and thus longer reaction times. Hence the implicit learning account implies that priming will not necessarily result in shorter reaction times but may cause longer reaction times, or no reaction time difference at all (when the change in proportions is rather small).

The reaction time effects of priming will be examined in the next two chapters.

Chapter 4
Reaction time priming in cued picture description

Introduction

As described in the previous chapter, the effects of syntactic priming are usually measured in terms of response tendencies: does processing of a prime of a certain syntactic structure increase the probability of the subsequent use of that structure, even if alternative structures are available? Chapter 3 provided an overview of studies proving that this is indeed the case: After reading or producing a sentence with a particular construction, there is a significant increase of the probability that the same construction will be used again in a subsequent sentence.

This chapter and the next will investigate if syntactic priming effects can be measured, not only in terms of increased response tendencies, but also in terms of reaction times.

The priming as residual activation account predicts that syntactic priming should be measurable not only in terms of response tendencies that are affected but also in terms of a reaction time effect. According to this theory the effect of priming is assumed to originate from residual activation on the mental representations of recently used syntactic structures. One of the effects of this residual activation is that the representation in question requires less additional activation in order to reach threshold to become fully active and fire, i.e. release its activation so that the represented information becomes available (cf. also Chapter 3). Hence, since the activation necessary to trigger the representation of

a recently used structure is reduced in comparison to that of a structure that has not been recently used, it is expected that the primed representation reaches the threshold faster. This reasoning has led some researchers to believe that priming in general (and syntactic priming in particular) serves the purpose of ensuring fluency of speech (Smith & Wheeldon, 200).

The initial view was that speakers produce repetitious features of speech because these reduce the processing burden on the listener and render a text easier to understand (Pawley & Syder, 1983). Subsequent research, however, undermined this view and emphasised that not so much altruistic concerns of the speaker to reduce the processing load on the listener, but rather that self-interest on part of the speaker exerts a strong influence on the formulation process (Clark & Wasow, 1998; Keysar, Barr & Horton, 1999; Smith, 2000). This view was already put forward by Levelt and Kelter (1982), who stated that: "… reusing previous discourse elements has the function of facilitating the fluency of the formulation process itself. It may require less effort to reuse available surface materials wherever possible than to generate speech every time anew from a semantic base" (see also Bock, 1986). Another possibility that has been put forward is that syntactic priming benefits both speaker and listener, by promoting alignment of shared situation models for the speaker as well as the listener (Pickering & Garrod, 2004).

Some support for the effort reduction hypothesis of syntactic priming has been found in relation to formulaic language. Such language is comprised of phrases and clauses which can be retrieved prefabricated from the speaker's lexicon, without the need for syntactic planning (Kuiper, 1996). It is possible that the avoidance of syntactic planning is motivated by benefits in cost reduction for the speaker. In other words: if retrieving prefabricated 'standard' expressions also serves to reduce processing effort on part of the speaker, it is to be expected that formulaic language is unusually prevalent in speech contexts that require a lot of processing effort, for instance because of increased speech rate. Kuiper (1996) provided support for this hypothesis in an online study. He observed that the proportion of repetitious formulaic language in the speech of sports commentators and auctioneers indeed increased as the speed at which they generated utterances rose. This support for the effort reduction hypothesis, however, only pertains to the repetition and use of fixed expressions stored in

the lexicon of the speaker rather than the short-term repetition of syntactic structures as is found in syntactic priming.

In addition, the effort reduction hypothesis implies that reusing recently processed materials entails a reaction time benefit for the speaker. Reusing an already available syntactic structure, for instance one that has been just recently used, should take less time and effort than computing or retrieving an entirely new structure. This efficiency leaves room for other resources to deal with rather more interesting aspects of the conversation such as listening to what your interlocutor is saying or thinking of smart responses and retrieving the appropriate words. The effort reduction hypothesis of syntactic priming therefore predicts that syntactic priming effects should manifest themselves in shorter response times for primed target structures in comparison to unprimed targets.

As described in the previous chapter, the residual activation account is not the only explanation of syntactic priming. Long term priming effects, spanning up to ten intervening trials (Bock & Griffin, 2000), or over 20 minutes (Boyland and Anderson, 1992) cannot be sufficiently explained in terms of transient residual activation of recently used representations. These effects are better explained by implicit learning (Bock & Griffin, 2000; Chang, Dell, Bock & Griffin, 2000). According to this account, syntactic priming is the result of longer-term changes in the preference of one alternative over another. Reaction time effects are also possible within an implicit learning framework. However, compared to the residual activation account, which predicts a speed-up of primed sentences in comparison to unprimed sentences, the direction of the effect is less clear in the implicit learning view. Depending on the initial preference ratio of the competing alternatives, adding even more preference to the stronger alternative would indeed produce (even) shorter reaction times. Adding preference to the weaker alternative on the other hand, could cause it to resist the stronger alternative for a longer period of time, and thus produce longer reaction times (see also the end of Chapter 3).

Below, I will first outline three existing studies of the reaction time effects of syntactic priming, and then describe three new experiments that aim to find a reaction time effect of syntactic priming.

Smith & Wheeldon's picture description experiments

The explicit objective of Smith and Wheeldon (2001; Wheeldon & Smith, 2003) was to test the effort reduction hypothesis. They used a moving picture description paradigm where participants in the prime trials described situations starting with either a simple noun phrase (NP), opening a sentence-coordination (1a) or a conjoined NP (1b). In the subsequent target trials (1c) they always produced another conjoined NP.

(1a)	The eye moves up and the fish moves down	incompatible prime
(1b)	The eye and the fish move apart	compatible prime
(1c)	The spoon and the car move up	target

The different conditions of the prime were triggered by the visual display of the movements: horizontally diverging objects (1a) elicited the 'move apart' incompatible primes and vertically diverging objects (1b) cued the co-ordinated NP that functioned as compatible prime sentence.

Smith and Wheeldon measured the time elapsed from the presentation of the visual display on screen until voice onset, assuming that grammatical encoding of the internal structure of the initial phrase is conducted prior to speech onset. In their first experiment they found a structural repetition effect of compatible prime-target pairs over incompatible pairs of about 50 ms: target sentences commenced 50 ms faster following a syntactically related prime than after a syntactically unrelated prime. In subsequent experiments other factors contributing to the effect were systematically ruled out.

The cost of lemma access as a source of the effect was factored out using picture previewing prior to each trial. Although allowing participants to anticipate the objects used in the picture description and retrieve the appropriate lemmas from the lexicon was effective in removing the time dedicated to lemma access from the latencies, the 50 ms priming effect still obtained.

Visual picture movement priming as a source of the facilitation effect was ruled out by using the exact same movements for the compatible primes as for the incompatible primes. To ensure that the movement employed would be described in a manner compatible with the prime or incompatible with the

prime, Smith and Wheeldon tested compatible primes in one session and incompatible primes in another one, a week apart, with different instructions as to how to describe the movements. Again, latencies of compatible prime-target pairs were still some 50 ms faster than latencies of incompatible prime-target pairs. The observed priming effect can therefore not be attributed to visual movement priming. This was further strengthened in another experiment which used written prime sentences rather than a picture description task and still produced the facilitation effect. Finally, when participants were instructed to name the movements but not the objects in the visual display, the effect disappeared, arguing against conceptualization of the movement as the source of the priming effect.

In two additional experiments, Wheeldon and Smith (2003) replicated these findings. They also tested the duration of the effect, to test the implicit learning theory of priming, but found that no priming survived the insertion of even one intervening unrelated trial. Since the effect is short-lived, it seems that in this set up at least, the mechanism responsible for the priming effect is residual activation of some sort, and not implicit learning.

Evaluating Smith and Wheeldon's results

Although Smith and Wheeldon did find a robust 50 ms speed-up of compatible prime-target pairs over incompatible pairs, the question is whether this is a purely syntactic effect. Lexical sources of the effect, for instance those caused by the different syntactic position and function in which the compatible and incompatible prime sentences employed the conjunct *and* were excluded, however, despite such careful measures, not all lexical effects seem to have been prevented. Prime and target of compatible trials share the verb MOVE in plural form (*move*), whereas in the unrelated condition, prime and target do not share this identical verb form: the prime sentences contain the verb MOVE twice in third person singular (*moves*), the target contains the plural *move* again. Identity priming of the verb form therefore cannot be excluded as a source of the reaction time effect, with the identical (compatible prime-target) pairs being processed faster than the non-identical (incompatible prime-target) pairs. Corroborating this is the recent finding that, even with different verbs, number priming has been demonstrated to exist between prime and target, with plural primes eliciting more plural target sentence completion than do singular primes

(Desmet & Schoonbaert, 2005). This finding only pertains to response tendency priming however. So far, a reaction time speed-up has not yet been demonstrated for prime-target pairs with the same grammatical number in comparison to prime-target pairs that do not have the same number[5].

Corley & Scheepers internet based study

Corley and Scheepers (2002) did a web-based replication of the sentence completion task of Pickering and Branigan's (1998) Experiment 1, in which the priming of double object (DO) and prepositional object constructions (PO) was tested. Essentially, participants were to complete both prime and target sentences. The prime sentences were fashioned in such a way as to elicit either a PO response or a DO response. Each prime fragment consisted of a subject noun phrase (NP), a ditransitive verb, and an NP immediately following the verb. This second NP was either inanimate, rendering a PO completion more likely (2a), or animate, making it more probable that participants would complete the sentence using a DO construction (2b). Target fragments consisted of a subject NP and a ditransitrive verb (2c). Since no complement NPs were given, participants were free to complete these fragments as either PO or DO constructions.

(2a) The bank manager handed the cheque…

(2b) The bank manager handed the customer…

(2c) The junior surgeon handed…

The experiment was administered as a typewritten sentence completion task via the World-Wide Web. Response onset times were measured from sentence appearance on screen until the first key stroke, the assumption being that a complete response is generated before typing commences. Sixty-six self-reported native speakers of English participated in the experiment, twelve of which were removed before analysis because of evident lack of seriousness for the study: response times that were too slow or responses that consisted mainly of so called 'other' completions, i.e. completions that did not conform to either a PO structure or a DO structure.

[5] Our own results also support this: in the pluralising ERA-task of Chapter 2, transforming singular to plural verb forms took on average 26 ms.

Corley and Scheepers analysed both the response tendency data and the reaction time data. The response tendency priming data demonstrated an overall structure repetition effect: participants produced significantly more PO target completions following PO prime completions than following DO prime completions, and marginally more DO target completions following DO primes than following PO primes. However, this effect was mainly due to the conditions in which prime and target fragments contained the same verb.

As for the reaction time data, only PO and DO completions were included in the analysis. Significant reaction time effects of the compatible prime-target pairs compared to the incompatible pairs were merely obtained in the same verb condition, with compatible prime-target pairs on average 650 ms faster than incompatible prime-target pairs.

Evaluating Corley and Scheepers' results

There are a number of drawbacks to Corley and Scheepers' results as well. Since both the response tendency priming effect and the reaction time priming effect mainly obtained in the condition in which prime and target contained identical verbs, it is uncertain if this study can be taken as evidence for a reaction time effect of structure repetition. Instead, lexical priming seems to be the main source of the speed-up.

Furthermore, the legitimacy of typed responses as a valid measure for processing speed has not been demonstrated. For instance, given what we know about incremental sentence production, and the fact that phenomena signalling the piecemeal production of sentences (such as syntactic deadlock and so-called apokoinou constructions) occur in writing as they do in speech, and often go unnoticed by the writer, it is questionable if response generation is indeed completed before typing commences.

Traxler and Pickering's eye movement studies

Recently, a series of eye-tracking experiments by Traxler and Pickering (Traxler & Pickering, 2004; 2005; Pickering & Traxler, 2005) have investigated the effects of syntactic priming in sentence comprehension. In their

experiments, participants read prime-target sentence pairs that either maintained or changed grammatical form. In particular, Traxler and Pickering used reduced relatives like sentence (3a), as their target sentences and (varying over experiments) main clauses (3b), full (3c), short (3d) and reduced relatives (3e), passives (3f) and pluperfects (3g) as primes.

(3a) The doctor examined by the specialist was unreliable (target)

(3b) The defendant examined the bloody glove during the trial (main clause)

(3c) The defendant who was examined by the lawyer was unreliable (full relative)

(3d) The defendant who was examined was unreliable (short relative)

(3e) The defendant examined by the lawyer was unreliable (reduced relative)

(3f) The patient was examined by he doctor who drove a red car (passive)

(3g) The defendant had examined the glove during the trial (pluperfect)

Priming effects were measured in terms of reduced total reading times and fewer first pass regressions on the target sentences. Traxler and Pickering (2004, 2005) found that all types of relative clauses (full, short and reduced) primed the reduced relative targets, leading them to induce that neither verbatim repetition nor recovery from misanalysis during processing of the prime is necessary for priming to occur. Furthermore, the fact that short relatives and to a lesser degree also passives produced a priming effect on the reduced relatives suggests that the explicit presentation of the agentive by-phrase (absent with the short relative primes) and precise structural overlap (absent with the passive primes) are not required.

However, priming effects only obtained when the same verb was used in both prime and target. When the target sentence contained a verb different from the verb in the prime, even if both prime and target were reduced relative constructions, no priming occurred. Pickering and Traxler (2005) tested whether the priming effect originated either from processing of the past participle form of the verb (as in a lexical account of the effect), or from the verb-argument frames, accessed when the repeated past participle is recognized. To distinguish these accounts, they contrasted main-clause primes (the baseline) with reduced relative and pluperfect primes, all using the same verb as in the target sentences. If priming results from the processing of the past participle per se, the pluperfects are expected to prime the reduced relatives compared to the main clause primes. If the locus of the priming effect is the verb, together with its

implicit argument structure, however, no such facilitation from the pluperfect primes is to be expected.

Fifty-five participants took part in the experiment. Again, the reduced relative primes facilitated the comprehension of the reduced relative targets (compared to the main clause primes), but the pluperfect primes did not facilitate comprehension. According to Pickering and Traxler "these results provide evidence for a level of representation in language comprehension that is activated by comprehension of a particular word (the ambiguous verb), and which is sensitive to its implicit argument structure."

Evaluating Traxler and Pickering's results

Although Traxler and Pickering (2004, 2005) only obtained priming effects in sentence comprehension when the prime and the target sentence contain the same verb, their most recent results (Pickering & Traxler, 2005) suggest that simple repetition of the past participle (as in the pluperfect primes) or the surface verb form (as in the main clause primes) is insufficient to facilitate comprehension of reduced relatives. Instead, the results are compatible with an account in which the locus of the priming effect is not just the verb form, but the verb, together with its implicit argument structure.

Syntactic priming evidence from ERP's (Ledoux, Traxler and Swaab)

In order to identify the source of the priming effect obtained in the above mentioned studies, Ledoux, Traxler and Swaab (2007) monitored event-related potentials (ERP's) while participants read reduced relative target sentences that had been preceded by either a reduced relative prime or a main clause prime. While ERP's are sensitive enough to detect differences in processing that may not manifest behaviourally, and like eye-tracking, can be time-locked to different critical words, they can also dissociate lexical repetition priming and syntactic priming. Lexical repetition has been demonstrated to decrease the amplitude of the (negative) N400 component, as have words that can be easily integrated into the preceding context (e.g. Brown & Hagoort, 1993). Syntactic processing on the other hand has been found to affect the (positive) P600 component of the ERP signal (e.g. Hagoort, Brown, Groothusen, 1993).

Using the same stimulus materials as Traxler & Pickering (2004), Ledoux et al. presented same-verb prime sentences in either reduced relative or main clause constructions, followed by reduced relative target sentences. If prime structure facilitates the syntactic processing of the target structure, then participants' ERPs should show a decreased P600 when reduced relative primes precede reduced relative targets (relative to when those targets follow main clause primes). This was exactly what was found. Furthermore, comparing a given reduced relative when it appeared as a prime and as a target showed a reduced positivity for the targets, due to syntactic priming. Finally, a significant N400 verb repetition effect obtained after main clause primes, but not after reduced relative primes. Instead, a later decreased positivity (the Late Positive Component- LPC) was observed, which Ledoux et al. interpreted as evidence that some kind of information is maintained in working memory, from the first presentation of the verb to the second, possibly the syntactic properties of the verb.

Nopenney and Price's fMRI study

In a silent sentence reading task, Nopenney and Rice (2004) collected both fMRI data and reading times of target sentences preceded by structurally similar and dissimilar primes. Neural activity was measured by means of the blood oxygenation level-dependent (BOLD) signal in fMRI, which can provide insight into cognitive processes, even in absence of behavioral manifestations. Syntactic structures used in this study were late vs. early closure sentences (*Before the director left the stage the play began*, vs. *After the headmaster had left the school deteriorated rapidly*) and reduced relatives vs. main clauses (*The child left by his parents played table football*, vs. *The artist left his sculptures to the British Museum*). When consecutive sentences, presented word by word, were syntactically similar, activation levels in the left anterior temporal lobe were reduced in comparison to when sentences were dissimilar. The whole-sentence self-paced reading times displayed a similar adaptation effect with reduced reading times for primed vs. unprimed structures.

Evaluating Nopenney and Price's fMRI results

Since in this study, reading time data and neural activity were measured not

concurrently, but using different tasks (the reading times were collected in a whole-sentence self-paced reading paradigm whereas the physiological measures were obtained by presenting the sentences in a word –by-word fashion), Nopenney and Price remark that although both measures seem to reflect some sort of syntactic priming, the reduced reading times cannot clearly be linked to the decreased neural activity. In addition, like in Branigan's 2005 study, it is questionable whether whole-sentence reading times in fact do reflect initial syntactic processing, or rather later reanalysis of syntactic structure. Moreover, as in the studies reported above, prime and target sentences repeated the verb. Although both experimental primes and control primes contained the same verbs, it is possible that part of the reported priming effects (shorter reading times and reduced neural activity) is due to a lexical component. In this account (in line with Pickering and Traxler's 2005 interpretation) the verb, together with its implicit argument structure is activated, not just the syntactic information per se, rendering it less demanding for the speaker to assign thematic roles to the sentence arguments (Nopenney & Price, 2004).

Conclusions drawn from previous reaction time priming studies

In sum, to date there are several studies that claim to have found a reaction time effect of syntactic priming. However, a lot of these effects can be argued to originate from word identity priming. Smith and Wheeldon's (2001) picture description experiments do not exclude identity priming of the exact verb form, Corley and Scheepers (2002) sentence completion experiments only find a reliable reaction time effect in the same verb condition, rendering purely structural priming improbable as the main source of the effect, and also Traxler and Pickering (2004, 2005) only obtained a syntactic priming effect in their same verb condition. Pickering and Traxler's (2005), and Nopenney and Price's (2004) results, however, suggest that at least in sentence comprehension, not just repetition of the lexical identity of the verb form is the main source of the priming effect, but rather the verb together with its implicit argument structure. Whereas this interpretation is supported by recent ERP-data (Ledoux, Traxler & Swaab, 2007), it remains to be seen whether this explanation also holds for sentence production.

Any experiment that aims at testing the reaction time effects of syntactic priming should avoid the problems of the above mentioned studies. This presents two challenges: The first is to steer clear from lexical sources of priming. The second is that in language production research it is often difficult to control the types of structures that participants use. In order to establish a clear reaction time effect of syntactic priming, the response times of compatible prime-target pairs must be compared with the response times of the incompatible prime-target pairs. So, it is necessary to elicit sufficient numbers of compatible and incompatible pairs to make comparison possible. A particular challenge is to elicit target structures given a certain prime, especially since both compatible and incompatible prime-target pairs are required. Both challenges can be overcome by using lead-in words to trigger desired target word orders. By using word order variations as variable, it is possible to tap into syntactic processes involving linearization, but at the same time ensure that other variables, such as number of words and the words themselves are kept constant across primed and unprimed conditions. The use of lead-ins promotes equal numbers for all target word orders.

In Dutch, the basic word order of a main clause (subject-verb-object (SVO)) changes to verb-subject-object (SOV) in subordinate clauses; the verb moves to the end of the clause. For instance, the main clause *Buendía stichtte Macondo* (Buendia founded Macondo), has SVO word order, however, in a subordinate clause, the verb *stichtte* moves backward, rendering the SOV sentence …*dat Buendía Macondo stichtte* (…that Buendía Macondo founded / '…that Buendía founded Macondo'). Furthermore, Dutch is a V2 (verb second) language; declarative sentences always take the verb as the second constituent (*Uiteindelijk stichtte Buendía Macondo* (Finally founded Buendía Macondo / 'Finally, Buendía founded Macondo')), thus becoming verb-subject-object (VSO) word order. It is this contrast between the SOV word order of subordinate clauses and the VSO word order of declarative main sentences that will be used in our subsequent experiments. The advantage of using word order variations to investigate syntactic priming is that it allows both conditions of the target to consist of the exact same words; the only thing that changes is the order these words are put into for the target response.

To simplify the picture descriptions and keep reaction time variations due to word finding problems to a minimum, the experimental sentence will contain no

direct objects. The required target word order for the picture descriptions will be triggered by the lead-in word: the subordinate conjunction in case of the SV condition, an adverb in case of the VS declarative main clause condition. Naming latencies in a similar task have been shown to be equal for these word orders in Dutch (Van Wijk & Kempen, 1982).

In the remainder of this chapter, three experiments are presented which investigate the online dynamics of word order priming via the cued picture description task.

EXPERIMENT 1

Method

Participants

Twenty-four native speakers of Dutch participated. All of them were students at Leiden University who were paid in course credits or Euros. Each participant took part in only one of the experiments in this chapter.

Materials

A booklet containing 15 simple line drawings, all depicting multiple actors involved in an action intended to be described with an intransitive verb, was handed out to 50 respondents, who were asked to describe the pictures with the simplest sentence possible. All respondents were native speakers of Dutch who agreed to participate voluntarily and they did not participate in any of the experiments that used these stimuli.

After analysis of the responses, those pictures that were described uniformly with regard to noun and verb choice, by at least 95% of the respondents were selected to be included in the stimulus set of the experiments reported below, provided that the verb in question was intransitive. This resulted in the exclusion of four pictures.

The resulting set of target pictures consisted of 11 simple line drawings, each depicting two or more similar actors performing an action together, requiring picture descriptions consisting of a plural subject noun and an intransitive verb in third person plural (see figure 4.1 below for an example and Appendix C for

the complete set)[6]. Plural noun forms were used because, unlike singular nouns, in Dutch these do not require definite articles.

The pictures were preceded by a lead-in word: *omdat* (because) or *soms* (sometimes), cueing respectively subject-verb (SV) or verb-subject (VS) word order in the target sentence. Prime sentences varied across two dimensions: word order (SV vs. VS) and lexical identity (identical, non-identical and neutral). Lexically identical prime sentences comprised the same words as the intended target description and non-identical sentences consisted of a description of one of the other pictures from the set of target stimuli. The picture descriptions serving as non-identical primes were paired with the targets so as to maximise semantic distance. For instance, pictures depicting inanimate subjects (e.g. burning candles) were invariably paired with prime sentences containing animate subjects (e.g. waving girls). In addition to these primes, a neutral condition was included which consisted of two strings of five X's.

With respect to word order, prime-target pairs could be compatible (both prime and target SV or VS) or incompatible (SV prime with VS target, or VS prime with SV target). Prime sentences also contained a lead-in word to set their word order. To avoid lexical repetition priming in the compatible conditions, prime lead-ins were different from the target lead-ins. The VS prime sentences therefore started with *hier* (here), the SV primes started with *terwijl* (while).

Procedure and design

Prior to the experiment, participants were familiarised with the materials by studying a booklet containing all 11 pictures and the nouns and verbs required for their description. Participants were instructed to use only these words in their response and to respond as quickly and clearly as possible. Two practice blocks of 22 trials preceded the experiment. Each picture was presented twice (once for each lead-in) in a practice session. The practice blocks served to further familiarise participants with the pictures and the description task. The blocks were repeated until all pictures were named correctly. Prime sentences

[6] The comparatively low number of stimulus pictures is the result of the fact that it is difficult to construct pictures that reliably elicit descriptions of an intransitive verb, and unambiguous actors, without having to repeat the actors. However, the relatively low statistical power of the experimental design, due to the small number of stimulu items is counteracted by the fact that we consistently obtained the same pattern of results in both the experiments reported in this chapter and in all other experiments, not reported here.

were not part of the practice blocks. In the experimental session, participants were instructed to read the primes silently.

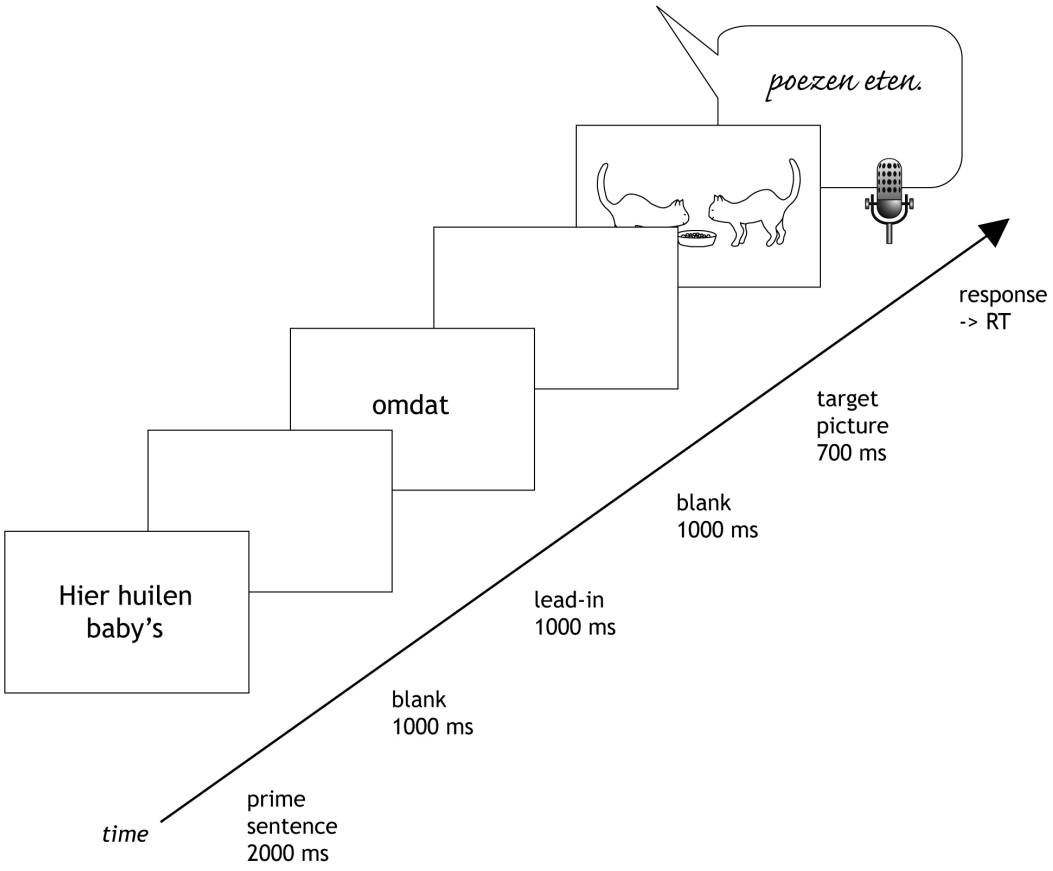


Figure 4.1 Trial set up for Experiment 1

Participants were tested individually with the experimenter present, facing a computer screen positioned about 80 cm away and a microphone to register vocal response time. Reaction time measurement commenced with the appearance of the target picture on the screen and stropped at voice onset. The prime sentences were presented for 2000 ms, followed by a blank screen for 1000 ms. Since the prime sentences were to be read in silence, no reaction to the prime was required. Subsequently the lead-in word was presented for 1000 ms, followed by a 1000 ms break and the target for 700 ms. Reaction time measurement started with the presentation of the target picture. After having registered a response or after 5000ms when no response was registered, the next trial would start after a 3000 ms inter trial interval.

The experiment was presented in one experimental block of 132 (lexical identity (2) x prime (3) x target word order (2) x pictures (11)) randomised trials, with a short break after 66 trials.

Results

Responses with latencies shorter than 300 ms and longer than 8000 ms were excluded from the analysis, as were trials in which technical errors occurred (0.8%). Trials on which the reaction time differed more than two standard deviations from the cell mean were replaced with the corresponding cut-off value (4.9%).

The data were analysed with 2 x 3 x 2 repeated measures ANOVA's, one with participants as the replication factor (F1) and one with items as the replication factor (F2). For both analyses there were three within (-participants or -items) variables: Lexical Identity (identical, non-identical), Prime (SV, VS and neutral) and Target (SV and VS).

Table 4.1 Mean reaction times and standard deviations in milliseconds on target picture descriptions as a function of prime condition and identity in Experiment 1.

			SV target		VS target	
			mean rt	SD	mean rt	SD
Prime condition	Identical	SV	762	120	781	138
		VS	767	126	744	126
	non-identical	SV	841	135	852	122
		VS	818	101	856	123
	Neutral		842	122	846	111

Table 4.1 displays the mean reaction times for all conditions. It shows that lexically identical primes produce target latencies that are on average 78 ms faster than non-identical primes. Indeed, the analysis revealed a significant main effect of Lexical Identity (F1 (1, 23) = 24.068, MSE = 8107.6, $p < 0.01$; F2 (1, 10) = 82.06, MSE = 1074.6, $p < 0.001$). A significant main effect was also found for Prime (F1 (2, 22) = 8.788, MSE = 4873.3, $p < 0.005$; F2 (2, 9) = 7.675, MSE = 3341.6, $p < 0.05$). However, this effect was completely due to the neutral condition; when this was removed from the analysis, the effect

disappeared (F1 (1, 23) = 2.09, MSE = 3572.5, p = .162; F2 (1, 10) = 1.002, MSE = 2945.8, p .340). The analysis did not exhibit a main effect of Target (all Fs < 1). None of the first order interactions were significant either: Lexical Identity (all p's > 0.05)), including the crucial interaction of Prime and Target (all F's < 1), except for the interaction of Lexical Identity and Prime (F1 (2, 22) = 11.538, MSE = 2937.8, p < 0.001; F2 (2, 9) = 37.023, MSE = 944.6, p < 0.001), which also disappeared when the neutral condition was removed from the design (all Fs < 1). Finally, the second order interaction of Lexical Identity, Prime and Target also did not obtain (F1 (2, 22) = 2.61, MSE = 3553.6, p = .095; F2 (2, 9) = 1.046, MSE = 5576.9, p= .391).

Discussion

The experiment shows no effect of speed-up of the compatible prime-target pairs in comparison to the incompatible pairs, as would be predicted by the effort reduction theory. On the contrary, the pattern of reaction times is rather mixed: although in the identical prime condition the reaction times of target picture descriptions of the incompatible pairs are indeed somewhat slower (by 42 ms) than of the compatible pairs, in the non-identical prime condition the incompatible pairs are actually a little faster than the compatible pairs (by 27 ms). These effects are by no means significant, though.

There are several possible explanations for the lack of effect: first, the paradigm at hand may not be accurate enough to register reaction time differences given the different conditions. Second, participants may not have processed the prime sentence sufficiently in order for their target production to be affected by the word order of the prime. Reading of the prime was instructed to take place silently, and it is difficult for the experimenter to monitor whether prime sentences are thoroughly parsed, or read at all. For both explanations the significant reaction time difference between the identical prime-target pairs and the non-identical pairs (irrespective of the compatibility of the word order of prime and target) offers insight. The fact that identical conditions produce significantly shorter reaction times for the picture descriptions than non-identical conditions proves that the paradigm is at least sensitive to some of the temporal aspects of sentence processing. With respect to the second possibility: since the identical pairs have reaction times that are on average 78 ms faster

than the non-identical pairs, some (at least lexical) processing of the prime sentence must have taken place. The question remains of course whether also the word order of the prime sentence was fully parsed and processed. This last question will be addressed in the next experiment.

EXPERIMENT 2

Experiment 2 was designed with the aim of forcing participants to process the prime sentence more thoroughly. The previous experiment displayed no effect of syntactic priming, but it is possible that this lack of effect originates in poor processing of the prime sentence. Two changes were made to promote processing of the prime. Since in the previous experiment there was no explicit task associated with the prime sentence, apart from reading to oneself, the prime sentences may have been ignored altogether. Therefore, in Experiment 2, participants were instructed to read the prime sentence aloud. Furthermore, even when having read the prime, the time between the prime and the target may have been too short for the prime sentence to be fully processed in order to affect syntactic processing. Thus, in order to let the prime sentence sink in, the pause between prime sentence offset and target (lead-in) onset was increased from 1000 to 3000 ms.

Method

Participants

Participants were 24 native speakers of Dutch, students at Leiden University, who were paid for their participation in course credit or euros.

Materials, design and procedure

The materials, design and procedure were the same as in Experiment 1, with two exceptions: participants were instructed to read the prime sentences aloud and the time between prime offset and target onset was increased from 1000 ms to 3000 ms.

Results

The data were analysed using the same approach as in Experiment 2. Excluded trials that exceeded the 300-8000 ms range totalled 0.5% of all data points. An additional 5.3% were trials on which the reaction time deviated more than two standard deviations from the cell mean which were replaced with the corresponding cut-off value. As before, two 2 x 3 x 2 repeated measures ANOVA's were run, one with participants as the replication factor (F1) and one with items as the replication factor (F2), both with three within participants/items variables, Lexical Identity (identical, non-identical), Prime (SV, VS and neutral) and Target (SV and VS).

Table 4.2 Mean reaction times and standard deviations in milliseconds on target picture descriptions as a function of prime condition and identity in Experiment 2.

			SV target		VS target	
			mean rt	SD	mean rt	SD
Prime condition	identical	SV	738	154	705	120
		VS	717	118	744	154
	non-identical	SV	830	179	837	110
		VS	807	124	838	117
	neutral		807	99	829	98

The mean reaction times per condition are displayed in Table 4.2 below. As in Experiment 2, the main effect of Lexical Identity was significant by participants ($F1 (1, 23) = 40.61$, $MSE = 8177$ $p < 0.001$) and by items ($F2 (1, 10) = 62.14$, $MSE = 2476$, $p < 0.001$), as was the main effect of Prime ($F1 (2, 22) = 7.09$, $MSE = 5955$, $p = 0.004$; $F2 (2, 9) = 11$, $MSE = 3734$, $p = 0.04$). However as in Experiment 2, this effect originated completely from the neutral primes and disappeared when these were removed from the analysis: (both F's < 1). The main effect of Target was not significant ($F1 (1, 23) = 1.96$, $MSE = 5567$, $p = 0.175$; $F2 < 1$), nor were the first order interactions of Target with Prime ($F1 (2, 22) = 2.13$, $MSE = 4724$, $p= 0.143$, $F2 < 1$), and Lexical Identity with Target ($F1 < 1$; $F2 (1, 10) = 4.32$, $MSE = 791$, $p = 0.064$). The significant interaction of Lexical Identity with Prime ($F1 (2, 22) = 19.57$, $MSE = 4796$, $p < 0.001$; $F2 (2, 9) = 28.81$, $MSE = 2229$, $p < 0.001$) once more disappeared upon removal of the neutral prime condition (both F's < 1). Finally, the second order interaction of Lexical Identity with Target and Prime was not significant ($F1 < 1$; $F2 (2, 9) = 2.41$, $MSE = 920$, $p = 0.145$).

Discussion

The aim of this experiment was to promote processing of the prime sentence so that it exerts more impact on target processing. To obtain this goal, two changes were made to the experimental procedure in respect to Experiment 1. First, participants were instructed to read aloud the prime sentence, second, the interval between prime offset and target (lead-in) onset was expanded from 1000 ms to 3000 ms. However, although the speed-up of target picture description following lexically identical primes in comparison to targets described after lexically non-identical primes was again significant, indicating that the paradigm was sensitive to at least some of the temporal aspects of prime processing, the reaction time results crucially reflect no effect of compatibility of prime and target. A possible explanation for the lack of effect lies in the fact that in the preceding series of experiments the compatible and incompatible conditions were completely balanced over the trials, and may thus have cancelled each other out in terms of priming. Experiment 3 will explore one more approach that may increase the impact of the prime sentence on the reaction times of target picture description.

EXPERIMENT 3

The previous experiments displayed no effect of syntactic priming. Reaction times in conditions with syntactically compatible prime-target pairs were not significantly faster than those in incompatible conditions. However, since we did obtain an effect of lexical identity, with target pictures that had to be described using the same words as the prime sentence being described significantly faster than after having read a lexically dissimilar prime (Experiment 1 and 2), we know that the picture-sentence paradigm is not insensitive to reaction time differences between stimulus conditions per se. Reading aloud the prime sentence (in Experiment 2) did not alter the observed pattern of reaction times, nor did extension of the interval between prime offset and target onset. The lack of effect can be explained by the fact that in Experiments 1 and 2, the compatible and incompatible conditions were completely balanced over the trials, and therefore may have cancelled each

other out as far as priming is concerned. For, if one regards priming as the effect of residual activation on one representation of a syntactic construction, tipping the balance toward itself over the alternative construction, having a completely balanced set of materials with no time to allow activation to decay to (near) base level will cause activation levels for both alternatives to accumulate equally over trials, with the result that neither alternative will be favoured over the other and no reaction time benefit can be measured for compatible over incompatible pairs. A way to prevent this is to add several filler prime-target pairs, to prevent balanced cumulative activation.

In view of the implicit learning theory of syntactic priming, the insertion of fillers may however prove less effective. The base-rate measurements of Experiment 1 demonstrated that both alternatives had an equal chance to get selected. Priming, in this view, is supposed to reflect alterations to the relative proportion of the alternatives in the long run, based on frequency information the alternative used most frequently, or most recently has more chance to get selected. Because of the balanced nature of our experiment, it is possible that the proportion of the alternatives has not been affected. Furthermore, the implicit learning theory of priming is based upon the empirical observation of long term priming effects, pertaining even after several additional items have been processed. Inserting only a few fillers may therefore hardly affect the priming effect, or allow the relative proportions to return to normal, on the one hand because the effects are supposed to be long term, and on the other because the relative proportions have probably not changed much, due to the balanced nature of the experiment.

However, although adding fillers is not expected to make a difference according to the implicit learning view, since the residual activation account predicts priming to be promoted by adding filler pairs the current experiment will use filler prime-target pairs to avoid the risk of cumulative activation. Filler pairs are inserted between successive experimental prime-target pairs to allow the activation levels of the primed representations to decrease to (near) base level, before starting a new experimental trial.

Method

Participants

The participants were sixteen students of Leiden University and all were native speakers of Dutch. They were paid in euros or received course credit. Neither of them participated in any of the other experiments reported in this chapter.

Materials, design and procedure

The materials were the same as in the previous experiments, with the exception that lexically identical primes and neutral primes were not included in this experiment. All eleven experimental items occurred once in each of the four conditions of prime (SV and VS) and target (SV and VS) combinations. A total of 128 filler pairs was designed. Filler pairs, like experimental pairs, consisted of sentence-picture combinations, preceded by lead-in words (definite or indefinite articles), resulting in adjective-noun responses. The nouns in the filler trials did not overlap those used in the experimental trials, nor did the filler items contain subject-verb constructions. A typical filler prime would be the sentence: *de groene bal* (a green ball) , a typical filler target picture would depict either a large house or a small house, cued by *het* (the), requiring a description such as: *grote huis* (large house). Between two successive experimental prime-target pairs, two to six filler pairs were inserted.

The procedure differed only with respect to the presentation of the prime sentence which was split into a lead-in word (presented for 2000 ms) and the rest of the prime (presented for 1000 ms, beginning 1000 ms after the lead-in offset). The interval between prime sentence offset and target (lead-in) onset was again set at 1000 ms.

Results and discussion

The data were analysed using the same approach as before. Excluded trials that exceeded the 300-8000 ms range totalled 4.8% of all data points (34 cases). Of these, a total of 19 (2.7%) were produced by a single participant, who was therefore removed from the analysis. An additional 3.6% (23 cases) were trials on which the reaction time deviated more than two standard deviations from the cell mean (per participant and condition) which were replaced with the corresponding cut-off value.

Table 4.3 shows the mean reaction times per condition. The data were analysed with 2 (Prime) x 2 (Target) repeated measures ANOVAs, one with participants as the replication factor (F1) and one with items as the replication factor (F2). As is obvious from Table 4, there is hardly any difference between the conditions. Indeed, the ANOVA revealed no main effects of Prime (F1 (1, 14) = 0.254, MSE = 2438, p = 0.622; F2 (1, 10) = 0.122, MSE = 3661, p = 0.734) nor of Target (F1 (1, 14) = 0.244, MSE = 4194, p < 0.629, F2 (1, 10) = 0.24, MSE = 5202, p < 0.88). Notice that the priming effect predicted by the effort reduction hypothesis should be reflected as a significant interaction between prime and target. However, despite the addition of filler items to overcome activation build-up no such effect between Prime and Target obtained (F1 (1, 14) = 0.713, MSE = 3602, p = 0.413; F2 (1, 10) = 0.776, MSE = 2914, p = 0.399).

Table 4.3 Mean reaction times and standard deviations in milliseconds on target picture descriptions as a function of prime condition in Experiment 3.

		SV target		VS target	
		mean rt	Sd	mean rt	Sd
Prime condition	SV	728	105	750	136
	VS	747	112	743	105

General Discussion

The experiments in this chapter were conducted with the aims of finding a reaction time effect of syntactic priming, and testing the prediction of the effort reduction hypothesis of syntactic priming that the production of a previously processed syntactic structure requires less effort and thus less processing time, resulting in shorter onset latencies, than the production of a syntactic construction that has not been recently processed. To achieve this we employed a new online priming technique in which latencies to cued picture descriptions were recorded after participants had read a prime sentence of the same or of a different word order as that of the intended target description. Experiment 1 demonstrated that the task is sensitive to different prime conditions, as witnessed by shorter reaction times for prime sentences that were lexically identical to the target description as opposed to prime-target pairs that were lexically non-identical. This effect mirrored the effects previously found by Smith and Wheeldon (2001), Corley and Scheepers (2000) and Traxler and

Pickering (2004, 2005), who all of them also only obtained a reaction time effect of syntactic priming when prime and target used identical lexical elements. The predicted effect of word order compatibility between prime and target sentences was not found however: Compatible prime-target pairs that consisted of the same syntactic structure did not produce faster target descriptions than incompatible prime-target pairs. Subsequent experiments addressed two possible sources of the lack of effect: inadequate processing of the prime and cumulative priming effects cancelling out the relative contribution of individual primes.

Experiment 2 was designed to ensure that the prime sentence would be thoroughly processed: instead of reading it silently, participants were instructed to read the prime sentence aloud. The effect of lexical identity was replicated, but again, no syntactic priming effects obtained.

The first two experiments consisted of equal numbers of compatible and incompatible prime-target pairs in randomised order. Furthermore, both word orders were completely balanced over the trials: half of the compatible pairs had SV targets, the other half had VS targets. Although such a design does allow for a clear comparison between the conditions, the drawback is that, in view of the residual activation theory of priming, the activation level of both alternative word orders rises equally and that this may hinder priming: additional activation caused by primes may go unnoticed because of the cumulative activation. To overcome this, in Experiment 3 filler prime-target pairs were inserted between successive experimental pairs, allowing for activation levels to decay to (near-) base level prior to each experimental trial. Despite this, again no reaction time effect of priming obtained. This finding does not rule out the implicit learning theory of priming, which does not predict filler insertion to affect the priming effect.

There are however still other possible reasons why the three experiments in this chapter did not succeed in measuring a significant reaction time effect of syntactic priming. One possibility is that the mechanism responsible for syntactic priming does not produce reaction time effects at all. Of the two leading explanations for the priming effect, only the residual activation hypothesis predicts a speed-up of primed sentences in comparison to unprimed sentences. As we have seen at the beginning of the chapter, the implicit learning

account does not automatically predict such reaction time facilitation. Indeed, the mechanisms underlying the learning effect that causes the preference ratio between two alternatives to shift, may easily lead to a more balanced preference ratio, and therefore produce longer reaction times. This is the case if the alternatives should become equally preferred, and competition between the two therefore takes a long time to produce a winner. There are also circumstances in which no reaction time effects at all are predicted. For instance, when one alternative is much preferred over the other, and priming (learning) only causes this alternative to become even stronger, no changes in reaction times are expected. Alternatively, very small changes in preferences may go unnoticed, and thus also not produce a reaction time shift. Of course, these possible explanations for the non-effect are not mutually exclusive.
Another possibility is that the experimental task at hand does not sufficiently tap into syntactic processes, at any rate not in such a way that can be measured. This may be due to the fact that target word order selection was not left free to the participants but imposed by lead-in words. Therefore, in the next chapter, we turn to a reaction time priming study with a syntactic construction where word order is free, i.e. not controlled by earlier words in the sentence.

Before leaving the present experiments, I should point out that, in pilot studies, we have experimented with lead-ins that were presented simultaneously with the target picture, and with a range of shorter delays between the two (100ms, 200ms, 400ms), compared to the current 1000 ms delay. However, none of these manipulations produced any more pronounced differences between the conditions than the current delay. In fact, the shortest delays (0 and 100 ms, and to a point also 200 ms) produced reaction times that were overall very much longer than those reported above, averaging around 1200 ms. It is therefore unlikely that the effects of priming were somehow lost in the interval between the lead-in word and the target picture. Yet it is still possible of course that our experimental set-up is not sensitive enough to measure the reaction time benefits (if any) taking place. The relative difference in reaction time between compatible and incompatible pairs may be so small that, especially if the effect arises with the lead-in, no measurable effects can be registered at a later point in time.

Chapter 5
Reaction time priming in sentence completion

Introduction

In the previous chapter we have seen that the picture description task did not produce reaction time priming effects. A possible explanation for this lack of measurable speed-up in the compatible conditions is the fact that in the picture-sentence experiments we used lead-in words to cue the target sentence. Obligatory word order may bypass the mechanisms that underlie priming. As described in chapter 3, the effort reduction hypothesis assumes that priming is the result of residual activation on the cognitive representations that contributes to the final decision of which alternative will eventually win. Assuming that this mechanism also applies to activation build-up on alternative word orders, the provision of a fixed word order by means of a lead-in word may pre-empt the need to assign a left-to-right order to the words retrieved in response to the pictures. This line of reasoning may also apply to the implicit learning theory of priming, where priming is supposed to result from the shift in preference between two alternatives. In the experiments of Chapter 4, the obligatory target word order, cued by the lead-in may have overruled the predilection of one alternative over the other. Free target word order may help overcome this problem.

The lead-in words in the picture-sentence experiments of the previous chapter were used to ascertain adequate numbers of compatible and incompatible prime-target pairs to validate comparison. Any priming task in which word order production is free should at least produce sufficient measurements of both compatible and incompatible prime-target pairs. Furthermore, the task in question should allow these word order variations to occur without changes at

the semantic level, to avoid a possible confound with conceptual priming. The conceptual structure should remain the same, irrespective of linearization. Hartsuiker and Westenberg (2000) report a response tendency priming experiment that satisfies these constraints. The experiment capitalizes on variations in the order of auxiliary verb and past participle in Dutch subordinate clauses.

Dutch allows free placement of auxiliary verb and past participle at the end of a clause, rendering both (1) and (2) legitimate (and synonymous) word orders (e.g. Haeseryn, Romijn, Geerts, de Rooij & van den Toorn, 1997; Boyton & Brandnetel, 1807).

(*veranderd* is the past participle, *was* the auxiliary verb):

(1) 's Morgens bemerkte Gregor dat hij in een insect veranderd was.
In the morning noticed Gregor that he into an insect changed was.
'In the morning Gregor noticed that he had changed into an insect.'

(2) 's Morgens bemerkte Gregor dat hij in een insect was veranderd.
In the morning noticed Gregor that he into an insect was changed.
'In the morning Gregor noticed that he had changed into an insect.'

Hartsuiker and Westenberg (2000) used sentences like these to find evidence for the hypothesis that positional information is determined separate from hierarchical (functional) information in syntactic processing. In order to do this, they investigated whether the word order of auxiliary verb and past participle in subordinate clauses could be primed in such as way that the likelihood of producing a target sentence in either word order increases after having previously completed a prime sentence in that exact word order. They reasoned that these word order variations allowed for testing of the linearization hypothesis without the possible confound of conceptual priming. Since the auxiliary verb is a function word without meaning, the alternative word orders do not differ in the relations between concepts. Hence, priming effects involving a meaningless word cannot be conceptual in nature, and therefore must originate in something else, like the word order used. For our purpose, the variations in word order have an additional benefit. Since target structures do not differ in anything other than word order, lexical priming effects are also

ruled out, because both alternatives of the target word order contain exactly the same lexical elements.

Hartsuiker and Westenberg tested both the spoken and written modality. They presented participants with sentence fragments to complete like (3), below, which served as primes. Three prime conditions elicited participle (3a), auxiliary (3b) or noun phrase completions (3c) respectively, the latter serving as base rate measurement of the unprimed preference for auxiliary-final and participle-final continuations. The primes were followed by a target fragment, such as (4a) that could be completed with either a participle-auxiliary combination (4b), or with an auxiliary-participle combination (4c).

(3a) Ik kon er niet door omdat de weg was ...
I couldn't pass through because the road was…
'I couldn't pass through because the road was…'

(3b) Ik kon er niet door omdat de weg geblokkeerd...
I couldn't pass through because the road blocked…
'I couldn't pass through because the road … blocked'

(3c) Ik kon er niet door want het wrak stond over...
I couldn't pass through because the wreck stood across...
'I couldn't pass through because the wreck stood across...'

(4a) De skiër lag in het ziekenhuis omdat hij zijn been…
The skier lay in the hospital because he his leg...
'The skier lay in hospital because he … his leg'

(4b) De skiër lag in het ziekenhuis omdat hij zijn been gebroken had.
The skier lay in the hospital because he his leg broken had
'The skier lay in hospital because he had broken his leg'

(4c) De skiër lag in het ziekenhuis omdat hij zijn been had gebroken
The skier lay in the hospital because he his leg had broken
'The skier lay in hospital because he had broken his leg'

The results showed reliable priming effects: participle-final responses occurred most frequently in the condition with participle-final primes (54%, compared to 35% auxiliary final and 11% other completions), auxiliary-final responses occurred most frequently in the auxiliary-final condition (46%, compared to 39% participle-final completions and 15% other completions). The written and spoken conditions yielded a similar pattern.

In this chapter, we apply this sentence completion paradigm in order to study reaction time priming of the word-order of auxiliary verb and past participle in Dutch subordinate clauses. We compare trials in which target completions are compatible to the prime with those trials in which primed target completions are incompatible. Following the effort reduction hypothesis, we expect to find shorter reaction times on target response in the compatible prime-target pairs than in the incompatible pairs. However, as described in the previous chapters, although the residual activation theory of priming does predict a reaction time speed-up, the implicit learning account does not necessarily predict facilitation in terms of reaction times. The opposite effect in which the primed target response is slower than an unprimed response may also occur, if priming causes preferences for the two alternatives to approach one another. In that case the two alternatives may take more competition time to produce a winner than when priming causes one alternative to be more strongly preferred than the other. Whether this is the case depends on the preference for each alternative prior to priming. If each alternative is produced about 50% of the time, it is expected that priming will lead to one of them to become more preferred and reaction times to be faster for primed targets in comparison to unprimed targets.

EXPERIMENT 1

This experiment serves to replicate the response tendency word order priming effect of Hartsuiker and Westenberg (2000), obtained in their spoken sentence completion condition. In Dutch, word order of the auxiliary verb and the past participle in subordinate clauses is prone to regional differences in preference (Haeseryn, 1990, in Hartsuiker & Westenberg, 2000)). Hartsuiker et al. conducted their experiments in a region close to the German border and it is possible that base rate preferences in their sample reflect the German prescriptive participle-auxiliary order, or are in any other way not representative

of the word order preferences of the population in the western part of the Netherlands where our experiments were conducted. Before we proceed to measuring reaction times, we will first check if word order priming in terms of preferences can be obtained at all in our population and establish the base rates for each word order.

Method

Participants

Twenty-eight members of the Leiden University community were paid to participate. All participants were Dutch native speakers and had normal or corrected-to-normal eyesight. No one participated in more than one experiment reported in this chapter.

Materials and design

We used the same set of materials as Hartsuiker et al., consisting of 24 prime-target pairs and 192 fillers (See Appendix D for a complete list), totalling 240 items per list. Target fragments consisted of a main clause and a subordinate clause that required an auxiliary verb and past participle combination for completion. Since in Dutch a participle can be combined with either *hebben* (to have) or *zijn* (to be) as auxiliaries, half of the target fragments were designed to elicit *hebben* and half to elicit *zijn*. Three prime conditions were constructed, all consisting of a main clause followed by a subordinate clause. Auxiliary-final primes ended on a past participle, triggering an auxiliary verb, like (3a). Participle-final primes, such as (3b) ended on an auxiliary verb, triggering a past participle completion. Prime fragments of the baseline condition triggered a noun phrase completion (3c). The auxiliary used in or triggered by prime and target fragments always differed, and prime and target were prosodically and semantically dissimilar. None of the 192 filler fragments contained combinations of auxiliary and non-finite verbs. Fillers included transitives, locatives, datives and *wh*-questions.

Three different lists were constructed, with the three conditions of each prime-target pair distributed over the lists according to a Greek-Latin square. Six to ten fillers separated the experimental pairs. Each list started with six practice trials, followed by twelve prime-target pairs that served to establish a pre-

experimental baseline for both word orders, using the NP-primes. Prime-target combinations differed across lists, and so did the twelve experimental pairs serving as baseline.

Procedure

Participants were tested individually with the experimenter present. Unlike in the Hartsuiker & Westenberg (2000) experiments, our sentence fragments were presented one by one on a computer screen, for 3000 ms each. Participants were instructed to complete the fragments to grammatically correct sentences, as quickly and fluently as possible. Completions were recorded and later transcribed and scored for analysis.

Results

Responses were scored according to three categories: 'participle-final', auxiliary-final' and 'other'. Participle-final completions were fragments which were completed with a participle, in case of a prime, or with an auxiliary followed by a participle, in case of a target. Responses were scored as auxiliary-final if the reverse order was produced. If the completion was ungrammatical of if additional material was inserted, the response was scored as 'other'.

Table 5.1 distribution of completion responses in target sentences as function of prime condition (raw number of responses) in Experiment 1.

		Target completion					
		Auxiliary-final		Participle-final		Other	
		N	%	N	%	N	%
Prime completion	NP- prime	152	45.2	163	48.5	21	6.3
	Auxiliary-final	86	51.2	73	43.4	9	5.4
	Participle-final	64	38.1	94	56.0	10	5.9

There were 672 responses, of which 298 (44.9%) auxiliary-final, 329 (49.1%) participle-final, and 40 'other' completions (6%). Table 1 lists the response frequencies in each condition. The NP prime completion condition, measuring the baseline preference for either completion shows that there is no a priori preference for either word order (45.2% auxiliary-final completions vs. 48.5% participle-final completions, $t(27) = -0.324$, $p > .5$). The experimental conditions

display priming effects for the two word order variants: auxiliary-final completions occur most frequently in the condition with auxiliary-final primes, and participle-final completions occur most frequently following participle final primes. The data were analysed with two 2 X 2 repeated measures ANOVAs, with prime completion (auxiliary-final, participle-final) and target completion (auxiliary-final, participle-final) as within subject and item factors. No main effects of prime, nor of target were revealed (all F's <1). The interaction between prime and target completion was significant however, within subjects ($F1 (1, 27) = 4.21$, $MSE = 3.92$, $p = 0.05$), and within items ($F2 (1, 23) = 4.05$, $MSE= 4.76$, $p= 0.056$).

Discussion

Experiment 1 replicates the word order priming effect obtained by Hartsuiker and Westenberg (2000). The word order of auxiliary verb and past participle combinations in Dutch subordinate clauses is affected by the word order of similar sentences produced earlier. In particular, we found that following a prime fragment eliciting auxiliary-final completions, there were more target completions of that word order than after primes that elicited the alternative, participle-final word order, and vice versa. The experiment demonstrates that word order priming from production to production in terms of response tendencies is possible in our population. The experiment also shows that when left free to decide upon a word order, both alternatives are equally likely to be produced, the base rates are not significantly different from each other. As argued above, within the implicit learning theory of priming, equal base rates of the alternatives are more likely than unequal base rates to lead to a reaction time speed-up when primed, provided the priming effect is substantial enough. In the following two experiments we will therefore assume that the reaction time effect we are looking for is in fact, as also predicted by the effort reduction hypothesis, a reaction time speed up.

EXPERIMENT 2

In the remainder of this chapter I will investigate the possibility of using Hartsuiker and Westenberg's (2000) sentence completion paradigm from

Experiment 1 to measure reaction time effects of word order priming. In addition to just comparing response frequencies of compatible prime-target pairs with incompatible pairs, I will compare their target voice onset times as well. If the effort reduction hypothesis of syntactic priming also applies to word order priming, target completions in the compatible pairs are expected to have shorter onset times than target completions in the incompatible pairs. However, in addition to the reaction time measurement there are some other modifications to the original experiment.

First, contrary to the Hartsuiker and Westenberg (2000) experiment which was a production to production priming experiment, the current experiment uses perception to production priming, just to make sure that the processes priming taps into are not only specific to one modality, but extend to both modalities.

Second, in order to measure reaction times on the target completions, the stimulus materials which were used in Experiment 1 need to be revised. Reaction times are registered by means of a voice key and measure the time elapsed from presentation of the to-be completed sentence on the computer screen until voice onset. It is desirable that this time reflects a minimum of processing other than linearization. The Hartsuiker et al. materials from Experiment 1 were semantically constructed to maximize certain continuations; hence they featured long sentences that provided a lot of conceptual information. Information about possible continuations of the subordinate clause was provided by the main sentence. However, regardless of this, not only word order selection, but also word selection was left free. It is therefore reasonable to assume that with these materials, the time required to produce a sentence completion given a certain fragment reflects not only the linearization process, but also, for instance, both conceptualization and lexicalization. To allow for more precise reaction time measurement, to avoid conceptualization and lexicalization, and to promote fluency, a new set of simpler sentences was constructed, following the same principles as the materials in Experiment 1. More specifically, the main sentence that leads to the to-be-completed subordinate clause in both the prime and the target is replaced by a generic main clause introducing a subordinate complement clause: *I hear that…* or *and that…* respectively, followed by a subject. Additionally, the sentences were presented in parts to ensure that voice key measurement from presentation on screen until voice onset was only minimally made up of reading time per se.

This creates sentences like (5) below.

(5)	Prime:	Ik hoor dat...	I hear that…
	Auxiliary final:	het vliegtuig geland is	the airplane has landed
	Participle final	het vliegtuig is geland	
		en dat...	and that…
	Target:	de portomonnee...	the wallet…
	Expected response:	is gestolen	is stolen

To further minimize the number of processes making up the target reaction times, the experimental materials were handed out to the participants to be studied briefly prior to the experiment. On the one hand, reproducing (as opposed to producing) sentence completions reduces conceptualization and lexicalization time, while on the other hand it does not interfere with sentence construction mechanisms (Potter & Lombardi 1990, 1998), thus leaving intact priming effects that tap into positional processing.

As mentioned before, the lack of reaction time effects found in the picture sentence experiments (Chapter 4) may be due to the fact that the word order in the target sentence was obligatory. To be able to compare both mandatory word order and free word order sentence completions within one paradigm, both will be tested. The current experiment focuses on the obligatory word order. The order of auxiliary verb and past participle in the subordinate sentence completions is cued by means of a short dash (__), for auxiliary verb and a long dash (_____), for past participle. This cueing of word-order is a "natural" cue, given the average length of auxiliaries and past participles in Dutch. Free word order of auxiliary verb and past participle in Dutch subordinate clauses will be tested in Experiment 3. If the explanation for the lack of effects found in Chapter 4 lies indeed in the fact that when word order is cued, the need for syntactic priming is reduced, then one expects no effects of compatibility between prime-target completions in the current experiment. If word order of the target completions is left free however, reaction time speed up is expected for compatible prime-target pairs in comparison to incompatible pairs.

Method

Participants

Twenty-four participants were paid in course credits or euros to take part in the experiment. All of the participants in the study were native-Dutch-speaking members of the Leiden University community and had normal or corrected-to-normal vision.

Materials

Twenty sentences were constructed. All sentences started with a generic phrase (*ik hoor dat* (I hear that) for primes and *en dat* (and that) for targets), followed by a subordinate clause, consisting of a subject and an auxiliary verb-past participle construction. Half of the sentences took *zijn* (to be) as auxiliary verb, the other half took *hebben* (to have). Of these, half were plural and half singular (see Appendix E). Each sentence acted four times as prime and four times as target, totalling eighty prime-target pairs in the experimental session. Half of the primes and targets were auxiliary-final, half were participle-final. The pairs were randomly put together, with the provision that primes and targets contained different auxiliary verbs. Past participle constructions in the target sentences were replaced by dashes: a short dash followed by a long dash for participle-final completions and a long dash followed by a short dash for auxiliary-final completions. The pairs were presented randomly, with the restrictions that the same sentence would not occur as prime or target within four consecutive trials, and that the same compatibility between prime and target would not occur in more than three consecutive pairs.

In addition to the experimental block, there were two twenty-trial practice blocks with all sentences acting once as prime and once as target. The purpose of the practice blocks was to familiarize participants with the sentence completion task and to practice the sentence continuations so that during the experimental session, conceptualization time would be minimized. Practice blocks were balanced with respect to word order of auxiliary verb and past participle, so that during the training phase of the experiment neither word order would become primed.

Procedure

All participants were tested individually with the experimenter present. Before

testing, they were given a booklet with instructions about the experiment and the twenty completed sentences to study. Word order of the auxiliary verb and past participle was balanced across sentences and participants, with twelve participants receiving one half of the study materials in auxiliary-final order and the other twelve participants receiving the other half in auxiliary-final order. When participants reported that they had learned the sentence completions the experiment commenced with the two practice blocks, which were repeated if necessary until all sentence completions were correct. Participants were instructed that the exact word order of auxiliary verb and past participle did not matter in the experiment, and to focus on the reconstruction of the sentences studied.

Participants were seated in front of a computer screen and a microphone connected to a voice key. They were instructed to respond only to complete the sentences as fast and clearly as possible. The prime sentence appeared on screen in two fragments, first the generic part *Ik hoor dat*, for 700 ms, then the complete subordinate clause for 1500 ms. Subsequently the generic part of the target sentence (*en dat*…) was presented for 500 ms, followed by a 200 ms pause and the subject of the subordinate clause with the dashes specifying the word order of the sentence completion, until voice onset time. Two trials were separated by a 1000 ms break. All responses were written down for analysis by the experimenter.

Design

The dependent variable in this experiment was the reaction time on the target completion. The independent variable was the combination of prime and target word order, yielding four within-subjects conditions: two compatible: prime auxiliary-final with target auxiliary-final and prime participle-final with target participle-final, and two incompatible: prime auxiliary-final with target participle-final and prime participle-final with target auxiliary-final.

Results

All 1920 target responses were classified as ‘auxiliary-final’, ‘participle-final’ or ‘other’, with ‘other’ completions comprising other words than specified in the instruction booklet, other word orders than specified by the dashes,

omissions or something else entirely. First, all 144 other responses (7.5%) were removed from the data set. Next, all extreme data points were removed. Extreme data points were defined as reaction times shorter than 300 ms and longer than 2400 ms, thus excluding 1.5% (26) of all data points. Finally all data points that deviated more than two times the standard deviation from the mean per participant per condition were replaced by their cut-off points. This resulted in the modification of 4.6% (82) data points, evenly distributed across conditions and subjects.

Table 5.2 shows the mean latencies (averaged across participants and items after filtering) per condition. Latencies for conditions with a participle-final target were on average 24 ms faster than conditions with an auxiliary-final target. A 2 X 2 analysis of variance with prime completion (participle-final and auxiliary-final) and target completion (participle-final and auxiliary-final) as within-subject factors yielded a significant main effect for target completion ($F(1, 23) = 6.09$, $MSE = 2197.92$, $p < 0.05$). However, no significant effects were found for prime completion ($F(1, 23) = 0.88$, $MSE = 1841.97$, $p = 0.358$), nor for the interaction between prime and target completion ($F(1, 23) = 0.158$, $MSE = 1459.23$, $p = 0.695$).

Table 5.2 Mean target voice onset time in milliseconds in Experiment 2 (standard deviations in brackets).

		Target completion	
		Auxiliary-final	Participle-final
Prime completion	Auxiliary-final	904 (115)	877 (107)
	Participle-final	909 (105)	889 (115)

Discussion

The results show that participle-final target completions are significantly faster than auxiliary-final target completions. Although unexpected, the effect can be explained by lexical retrieval mechanisms. Reaction time measurement stops at voice onset of the first word of the target completion. In an auxiliary-final target completion, the first word that must be produced is the past participle. The processes involved herein are: recalling the memorized sentence continuation, retrieval of the verb in question (among numerous competitors), and

determining the past participle inflected form of the verb. In contrast, in a participle-final completion, the first word that must be produced is an auxiliary verb. Auxiliaries have much fewer competitors, thus the retrieval time for the word is probably shorter, leading to shorter voice onset times. In addition to this, auxiliaries are produced much more frequently than individual past participles, which can also explain the faster reaction times.
The key result of the current experiment, however, is that no reaction time effect of prime-target compatibility was found. If the effort reduction hypothesis for syntactic priming also applies to linearization, target completions in compatible prime-target pairs are expected to have faster onsets than target completions in incompatible prime-target pairs, because they re-use the prime structure, instead of calculating it anew. Possibly, the fact that in this experiment word order of the target completions was given already satisfied the need for effort reduction and thus prevented priming to occur. However, there is an alternative explanation. Since prime and target word orders were pre-specified, auxiliary-final and participle-final completions occurred equally often in the experiment. The balanced nature of the stimuli may have prevented priming to occur. The absence of fillers that did not contain auxiliary verb-past participle constructions may have contributed to this balancing effect.

If one assumes priming to affect activation levels of alternative word order possibilities, the balanced nature of the stimuli may have caused the priming effects to be cancelled out, because both alternatives received equal amounts of activation. The insertion of several filler items in the interval between two experimental prime-target pairs may allow activation levels of the experimental word orders to decay to (near) base rate before the start of a new priming trial. However, as was already discussed in Chapter 4, no such benefits of inserting fillers are to be expected in view of the implicit learning theory, first because the pre-existing fifty-fifty proportion of the alternatives (as measured in Experiment 1) will not be affected by a balanced set of stimuli and second because the effects are supposed to be long term. In sum, the residual activation theory of priming predicts priming to be promoted by the insertion of fillers, whereas the implicit learning theory predicts that the insertion of fillers will not affect priming at all.

In Experiment 3, word order of the target completions will be left free and between experimental pairs, some filler pairs will be inserted in order to test the predictions above.

EXPERIMENT 3

This experiment aims to measure reaction time priming effects of the word order of auxiliary verb and past participle constructions in Dutch subordinate clauses, when target word order is left free.

As in Experiment 1, both primes and targets consisted of to be completed sentence fragments. The prime sentence fragments were constrained so as to trigger only one possible word order continuation. The target fragments that were presented immediately after the primes could be completed with the same word order as that of the prime, or with the alternative word order.

In the previous experiment, the number of compatible and incompatible trials was balanced: each participant received compatible prime-target pairs in half of the trials and incompatible pairs in the other half. The order in which the compatible and incompatible trials were presented was random, but with the restriction that the same compatibility between prime and target would not occur in more than three consecutive trials. This equilibrium served to ensure that no prime-target combination would become favoured over the other. However, following the same line of reasoning as in Chapter 4 (Experiment 3), since no filler trials separated successive prime-target pairs, it is possible that in the course of the entire experiment the activation build-up that is supposed to be responsible for priming effects in both directions accumulated to near ceiling level, such that additional priming effects would go unnoticed. In order to avoid this, several filler items were included between successive prime-target pairs. Insertion of fillers between prime-target pairs allows the activation on the recently used representation to return to (near) base rate prior to the next experimental trial. If residual activation is the underlying principle to priming, the additional fillers should promote priming. If however, as explained above, priming is the result of implicit learning processed, it will probably not be affected by the addition of fillers.

Method

Participants

The participants were 35 students of Leiden University and all were native speakers of Dutch. They were paid or received course credit to participate. All had normal or corrected to normal eye-sight.

Materials

Fifteen new experimental sentences were constructed based on the materials of Experiment 2. All sentences started with a generic main clause followed by a subordinate clause, consisting of a subject and an auxiliary verb-past participle construction, like (6) below. In order not to have the experimental sentences stand out by using a single generic main clause for all experimental items, five new sentence beginnings were constructed. Each generic sentence start was shared by three sentences, to avoid that the beginning of a sentences would already give away the completion. As in Experiment 2, half of the sentences took *zijn* (to be) as auxiliary verb, the other half took *hebben* (to have). Of these, half were plural and half singular. Each sentence acted twice as prime (once auxiliary-final, once participle-final) and twice as target, totalling thirty experimental prime-target pairs. The pairs were randomly put together, with the provision that primes and targets contained different auxiliary verbs and different generic sentence beginnings.

(6) Het artikel vermeldde dat de patiënt heeft geleden / geleden heeft
The article mentioned that the patient has suffered / suffered has.
'The article mentioned that the patient has suffered.'

In addition to the experimental sentences, 114 filler items were constructed. Filler sentences were sentences with predictable endings so that they could also be used as prime or target fragments and consisted of idiomatic expressions, proverbs and sentences about well-known facts. These fillers were presented to 20 respondents as to-be-completed sentence fragments in a paper and pencil pilot experiment. Fillers were included in the experiment only if at least 15 respondents completed the sentence exactly as intended by the experimenter. This resulted in the exclusion of 15 sentences; leaving 90 fillers to be used in the experiment, like (7) (see Appendix F for a complete list).

(7) Giraffen hebben een hele lange... (nek)
Giraffes have a very long … (neck)

Three different lists were constructed. Each list contained 60 experimental items (30 prime-target pairs) and 240 filler items (120 'prime'-'target' pairs). The fillers that triggered one-word completions were used as 'prime' sentences, fillers that triggered two-word completions were used as 'target' sentences. Experimental pairs were separated by at least two filler pairs.
To familiarize participants with the sentence completion task and to practice the sentence completions, a practice block was created. It comprised 70 trials (35 prime-target pairs) and was balanced with respect to word order of auxiliary verb and past participle. The block contained all experimental sentences, twice as prime (once auxiliary-final and once participle-final) and twice as target and ten filler sentences.

Procedure
Participants were tested individually in the presence of the experimenter. Before testing, a booklet was handed out, which included the instructions to the experiment and the list of fifteen experimental sentences to study. Word order of the auxiliary verb and past participle was balanced across sentences and participants, with twelve participants receiving one half of the study materials in auxiliary-final order and the other twelve participants receiving the other half in auxiliary-final order. When participants reported that they had learned the sentences, the experiment commenced with the practice block which was repeated until all sentence completions were correct.

During the experiment, participants were seated in front of a computer screen and a microphone connected to a voice key. Participants were randomly assigned to one of the three experimental lists. They were instructed to respond only to complete the sentences as fast and clearly as possible. The prime sentence appeared on screen in two fragments, first the generic part for 1000 ms, then the subordinate clause fragment for 1000 ms or until voice onset time. Subsequently, the generic part of the target sentence was presented for 1000 ms, followed by the subject of the subordinate clause, at which time reaction time measurement started and ran until voice onset. All responses were written down for analysis by the experimenter.

Results

Responses were divided into three categories: 'auxiliary-final', 'participle-final' and 'other', using the same procedure as in Experiment 1. All target reaction times shorter than 220 or longer than 8000 ms were removed from the dataset, resulting in the exclusion of 11 (1%) of the 1050 prime-target pairs. Subsequently, all data points that deviated more than two times the standard deviation from the mean per participant per condition were replaced by their cut-off points. This resulted in the modification of 46 data points (4.4%) evenly distributed across conditions and subjects.

Table 5.3 shows that on the whole, participle-final target completions are more frequent than auxiliary-final completions, but that auxiliary-final completions still occur more frequently after auxiliary-final primes than after participle-final primes, and that participle-final completions occur more frequently after participle-final primes than after auxiliary-final primes. There are on average 7.5% more compatible prime-target pairs than incompatible pairs. A 2 X 2 analysis of variance with prime completion (auxiliary-final, participle-final) and target completion (auxiliary-final, participle-final) as within-participant factors revealed that the interaction effect was indeed significant, by participants (F1 (1, 34) = 20.23, MSE=2.148, $p < 0.001$) and by items (F2 (1, 14) = 6.39, $p < 0.05$). There was no main effect of prime (F1<1, F2 <1). The main effect of target was marginally significant by participants (F1 (1, 34) = 3.12, $p = 0.086$), and significant by items (F2 (1, 14) = 50.19, $p < 0.001$).

Table 5.3 Distribution of responses and mean reaction times in milliseconds on target sentence fragments as a function of prime condition in Experiment 3

		Target completion								
		Auxiliary-final			Participle-final			Other		
		N	%	RT	N	%	RT	N	%	RT
Prime completion	Auxiliary-final	216	41.3	1080	285	54.6	1069	21	4.1	1915
	Participle-final	177	34.2	106	324	62.6	1099	16	2.7	1469

The reaction time results are less straightforward. Overall, the compatible prime-target pairs are slower (by 20 ms) than the incompatible prime-target

pairs. Due to the nature of the experiment, the participants did not produce measurable responses in all cells of the design. Even if a participant did produce responses in all cells, the frequency over cells was not constant. Hence, instead of using a conventional method, we employed a 2 X 3 multilevel approach with restricted maximum likelihood estimation. Prime completion (auxiliary-final, participle-final) and target completion (auxiliary-final, participle-final, other) were within-participants factors.

Instead of analyzing the reaction times directly, their square root transformations, which were approximately normally distributed, were analyzed. A compound symmetry model (Maxwell & Delaney, 1990) was fitted to the data using the MLwiN software-programme (Rasbash et al., 2000), in which the main effects and the interaction effect were modeled by dummy variables. There was no significant main effect of prime ($\chi 2 = 1.01$, df = 1, $p = 0.315$). The main effect of target was significant ($\chi 2 = 10.07$, df = 2, $p < .001$). This was completely due to the difference between the 'other' completions and the other two categories, participle-final ($z = 3.14$, $p < .001$) and auxiliary-final ($z = 3.02$, p. <.002), which did not differ from each other. Crucially, no significant interactions of prime completion and target completion were found.

Discussion

In this experiment, we observed a significant effect of word order priming in terms of response frequencies: although participle-final completions are on the whole more frequent than auxiliary-final completions, both auxiliary-final and participle-final target completions occur more frequently after their compatible primes than after incompatible primes. This result replicates the findings of Experiment 1 and of Hartsuiker and Westenberg's original experiment (2000), using the same sentence completion paradigm, but a different set of stimulus sentences, with generic sentence beginnings. The robustness of these findings further corroborates the notion of linearization as a separate process that determines the word order of constituents.

In terms of reaction times, despite allowing free target word order and inserting fillers, the expected speed-up of compatible prime-target pairs over incompatible pairs did not obtain. If anything, target completions in compatible

prime-target pairs were somewhat slower than target completions in incompatible pairs. This tendency proved to be not significant, however.

General discussion

According to the effort reduction hypothesis, priming effects are the result of residual activation of the alternative mental representations caused by previous use of that representation. This residual activation means that less additional activation is required to reach threshold. From this, the prediction follows that the time to accumulate sufficient activation is shorter for primed representations than for unprimed representations. The implicit learning account of priming does also predict reaction time speed up with primed targets as opposed to unprimed targets, if at least the prime causes one alternative to become much more likely to be selected than the other: less competition, resulting in shorter response times. If the two alternatives end up being equally likely, competition between the two will take more time to resolve and reaction times will be longer. The experiments in this chapter aimed to test the reaction time effects for word-order priming.

Word order priming in terms of response tendency was first established by Hartsuiker and Westenberg (2001) and denotes the phenomenon that, like syntactic structure, the word order of a prime sentence is likely to be repeated in a subsequent target sentence. The existence of this phenomenon further contributed to the distinction between two levels of grammatical processing: hierarchical (or functional) processing and word-order (or positional) processing, also called linearization. Experiment 1 confirmed the existence of word order priming in our sample and replicated the results of Hartsuiker et al., using word order variations between auxiliary verb and past participle in Dutch subordinate clauses. Experiment 1 also established that the base-rate preference of auxiliary-first and participle-first completions was about fifty-fifty, making it likely that priming of one alternative over the other would in this case also predict a reaction-time speed-up according to the implicit learning account (provided the priming effect is big enough).

Theories about syntactic priming in general do not distinguish between the functional and positional level; priming effects of word ordering are assumed to

have the same characteristics and underlying dynamics as priming effects of hierarchical syntactic structures. If the effort reduction hypothesis above is correct and if the positional and functional level of syntactic processing indeed display the equivalent priming effects, prime-target pairs that contain the same word order of auxiliary verb and past participle should be produced faster than prime-target pairs that contain different word orders. Both free and obligatory target word order were tested. It was expected that free word order would give rise to a speed-up for compatible prime-target pairs in comparison to incompatible pairs.

Experiment 2 used short and long dashes to elicit target word-order: a short dash represented the auxiliary verb, a long dash the past participle. We obtained no reaction time effects. However, we did find that participle-final target completions were somewhat faster than auxiliary-final completions. Possibly, this is a consequence of the fact that auxiliaries are more frequent than individual past participles and that there are fewer auxiliary alternatives to choose from, whereas the number of past participles is much larger.

Experiment 3 tested free target word order completions, using the same paradigm as in Experiment 1, but with simpler sentences. Filler sentences between successive prime-target pairs furthermore ensured that priming did not accumulate over trials, nor be cancelled out due to the balanced nature of the stimuli. The addition of fillers was expected to benefit priming effects according to the residual activation theory, since it would allow residual activation from previous trials to decay to base-rate levels. If priming is the result of implicit learning processes, fillers were not expected to affect the priming process. The response tendency data revealed a clear effect of priming, similar to that found in Experiment 1. Following prime fragments in one word order, there were more target completions in that order than in the alternative order. However, this priming effect was not reflected in the reaction time data.

In sum, the present results corroborate earlier findings concerning the linearization process; we find consistent effects of priming of word order selection. Still, although the linearization of the words in the sentence can be primed, there is no evidence that this priming effect results in a speed-up of compatible prime-target pairs over incompatible pairs. The next chapter will discuss potential explanations for this discrepancy.

Chapter 6
General Discussion and Summary

Introduction

The aim of this thesis was to study the architecture of syntactic processing by investigating some relationships between grammatical encoding and grammatical decoding processes. This question was approached in two separate ways: by looking into the overlap of the mechanisms involving sentence production and comprehension directly by means of the ERA-experiments, and by studying the online dynamics of one specific phenomenon, namely syntactic priming, which focuses on the representations shared by encoding and decoding processes. Below, I will recount the results of both studies, and their implications for the architecture of the language system.

Syntactic priming

On the basis of the assumption that if the processing of a sentence affects the subsequent processing of another, similar sentence, then the cognitive system must be sensitive to that particular dimension, the phenomenon of syntactic priming can shed light on the relationship between grammatical encoding and decoding. If the processing of a prime sentence takes place in one modality, say comprehension, and processing of the target sentence takes place in the other (production) and the prime sentence still affects the target, this provides especially strong evidence for the case that the two modalities overlap. Chapter 3 discussed existing evidence of syntactic priming affecting response tendencies within and between grammatical production and comprehension. In Chapter 4

and 5 we tested whether the response tendency priming effects of linearization reported in the literature and replicated in our own studies are reflected in shorter reaction times for primed targets over unprimed targets. Such a speed-up is expected according to a residual activation view of priming, especially if the effort reduction theory of priming is true. This theory explains priming as a reflection of the fact that by reusing some aspects of language, in this case the syntactic structure and/or word order, the brain can save effort (and time), which can consequently be directed towards other aspects of language processing. Regardless of the function of priming, the residual activation account predicts that after having processed a certain syntactic construction, the mental representation of that structure retains some of its activation, causing it to become reactivated more easily afterwards. This implies that primed target sentences should be produced faster than unprimed targets.

We tested the implication of the effort reduction theory in two series of word order priming experiments: cued picture descriptions and sentence completions. In previous studies that reported a reaction time benefit of syntactic priming (Smith & Wheeldon, 2001;Corley & Scheepers, 2000; Traxler & Pickering, 2004, 2005, Pickering & Traxler, 2005; Ledoux, Traxler & Swaab, 2007; Noppenney & Price, 2004) part or all of the priming effect seemed to have a lexical component; with target sentences that repeated both syntactic structure and content words (usually the verb) exhibiting a greater priming effect than targets that only repeated the prime structure. In order to avoid lexical sources of the priming effect, we chose to use word order variations as our syntactic manipulations. Word order priming was empirically established by Hartsuiker & Westenberg (2000). By varying only word order, alternative target responses differed only in this respect, but contained the same words and structure. However, even though other reaction time priming effects such as identity priming did occur, as did the response tendency priming effects in the sentence completion tasks, no speed-up obtained in any of our experiments. Furthermore, manipulation of participant's freedom to choose the target structure did not affect these null results.

As for the mechanisms underlying priming, although residual activation does seem to play a role in lexical priming processes, our findings suggest that this is not the case in word order priming, at least not exclusively. We propose that further research should therefore focus on discriminating between two

alternative mechanisms that can account for the — at first sight inconsistent — findings that syntactic priming obtains in terms of response preference, but no speed-up. On the one hand these data can be accounted for by a model in which alternative structures are dependent on each other and engage in direct competition in order to determine which alternative wins. Reaction times in such a model depend on the initial preference ratio of one alternative over the other. Balanced alternatives require more time to resolve the competition than a situation in which one alternative is extremely favoured over the other to begin with. Hence, priming may affect the preference ratio between the alternatives, but may not necessarily lead to a speed-up. In view of the current results, for instance, it may be the case that priming did not affect the preference ratio in such a way that the balance between the two word orders was particularly shifted towards one alternative. The direct-competition model fits with the theory that (at least longer-term) syntactic priming effects are the result of implicit learning of frequency information (Bock & Griffin, 2000; Chang, Dell, Bock & Griffin, 2000). Determining how much priming is needed to tip the balance for a given set of alternatives in order to obtain a reaction time speed-up remains an empirical question.

On the other hand, the online dynamics of syntactic priming as obtained in our experiments are compatible with a model in which the grammatical encoding process is divided into two processes, dealing with the computation of hierarchical (also called functional) structures and word order (linearisation). The separation of positional and hierarchical processes is not new (e.g. Garrett, 1975; Bock & Levelt, 1994). In our view, positional computation prepares the word order of a sentence. This can take place in absence of the lexical elements. Hierarchical computation involves word retrieval and unification of their syntactic (subcategorisation) information into a functional structure. However, these processes are usually assumed to occur sequentially, with linearisation processes taking place after (part of) the functional structure of a sentence is computed. On the basis of our data, we propose that these processes take place in parallel, i.e. they start at the same time. This does not mean that they also end at the same time. In fact, preference effects or constraints put upon the word order of a sentence can cause the positional structure to be computed *before* the functional structure or even the words are available. If this is the case, word order is already determined, and functional information can be quickly inserted into the prepared linear structure.

In this model, word order priming affects positional preparation, but not functional computation. For instance, the lead-in word in the picture description experiments from Chapter 4 acted as a constraint upon the word order. Thus, the lead-in *omdat* paves the way for a subject followed by a verb, which are duly inserted as soon as the words become available when the picture is presented. However, measurement of the reaction time does not start until after the onset of the picture on the screen, in other words, after the effects of priming have taken place. Hence, the reaction time as it is is most likely a reflection of lexical activation and integration processes, not of word order computation. Further research is needed to determine whether purely syntactic priming of hierarchical structures, as in the DO-PO priming experiments exhibits the same contradictory pattern as word order priming. The dative structures used in these experiments typically differ not only with respect to functional structure, but also with respect to word order and even (the number of) lexical elements, all of which can affect the priming process and the reaction times measured.

As far as this model is supported by our data, it is in line with current grammatical theories postulating separate functional and positional levels, such as Performance Grammar (Kempen & Harbusch 2002; Kempen & Hoenkamp, 1987) and Head Driven Phrase Structure Grammar Pollard & Sag, 1994). However, it is hard to reconcile with transformational grammars such as the Government and Binding theory (Chomsky, 1981), which do not distinguish hierarchical and positional levels. In addition, our results confirm the current view (e.g. Ferreira & Bock, 2006) that syntactic priming is a multifaceted phenomenon, with no single underlying process causing the multitide of (sometimes contradictory) effects.

Overlap in syntactic encoding and decoding

The standard model of the language system reflects the fact that language processing takes place in two modalities: production and comprehension. In the model, the assembly of syntactic structures is accordingly subserved by two separate cognitive processing resources: for grammatical encoding and grammatical decoding respectively. However, as argued in Chapter 1, there are substantial similarities between the two, both with regard to control structures and to empirical profiles. Control structure similarities concern the fact that both grammatical encoding and decoding are lexically guided processes, work on an

incremental basis, are nearly deterministic and can be characterized as constraint-based. Empirical similarities reported in the literature range from agreement studies to shadowing effects, syntactic priming and monitoring. These commonalities have been proposed to originate from a shared working memory, but although this theory can explain the similarities between grammatical encoding and grammatical decoding in empirical profiles, working memory limitations cannot account for observed similarities in control structures such as lexical guidance and near-determinism.

The ERA-tasks

The experiments in Chapter 2 served the purpose of testing the implication of the standard dual-processor model that grammatical encoding and decoding should in principle be able to work simultaneously and independently. The results of the dual-tasks with which our participants were presented showed otherwise, however: when dealing with a production task and a comprehension task simultaneously, language users are not capable of doing both, but, at least in our experiments, focus primarily on the production task, thereby ignoring ungrammaticalities in the comprehension task. The effect obtained both when the production task in question was to pluralise the input sentence, and when the task was to paraphrase the input sentence. These results suggest that it is not possible to maintain two separate syntactic structures at the same time. Again, superficially, one could assume that these findings are the result of working memory limitations, given that maintaining two sentences simultaneously requires not only keeping active the words and word order, but also the meaning of the sentences. However, even when the input and the output sentence had virtually the same meaning, as was the case in the paraphrasing task, participants' reaction times were only affected by the grammaticality in the to-be-produced output sentence. It seems that the strict dual processor architecture of the standard model does not hold: grammatical encoding and decoding tasks cannot be performed simultaneously.

Another possibility is, however, that the findings observed in chapter 2 are the result of the architecture of the language system itself. In principle, there are four theoretical options, two of which can be ruled out on the grounds of the observed non-parallelism: the strict dual-processor architecture in which grammatical encoding and decoding each have their own processors which perform distinct tasks, and a dual-processor architecture in which the resources

for encoding are separate, but work in the same way, in parallel. Still, our experiments cannot distinguish between the two remaining options: in particular and most extremely it may be the case that grammatical encoding and decoding are two *modi operandi* of the same structure assembly resources, as is the case in a single-processor model. In such a model, syntactic tree assembly takes place irrespective of modality, with the aid of shared representations and a shared working memory, with capacity for maintaining only one syntactic construction at the time. This process uses all sources of information that are available, bottom-up or top-down, in a dynamic way, in a single grammatical coder. On the other hand, a less extreme option is the minimal interpretation that perhaps encoding and decoding are subserved by separate (yet possibly identical) processing resources sharing a common working memory. Having a shared working memory implies that the two processes cannot operate simultaneously, but only alternatingly, since only one encoding or decoding structure at the time can be assembled and stored. Future experiments are needed to discriminate between this non-parallel system with the shared working memory and the shared resources single coder architecture. In addition, replications of the current results by means of measures of cognitive load other than reaction times, such as event-related scalp potentials (ERPs) are desirable. Particularly promising in this respect is the P600: an ERP component which is characterized by a positive deflection in the recorded potential, with an onset at about 500 ms and a duration of several hundred ms. Although the P600 can be interpreted in many ways, one of these is that it is a reflection of demanding syntactic processes. The P600 is sensitive to syntactic incongruences, especially violations of number agreement (Osterhout, McLaughlin, Kim Greenwald & Inoue, 2004), but has also been reported in anaphoric agreement violations containing reflexive pronouns (Molinaro, Kim & Vespignani, 2007). Observing a P600 effect for grammatical difficulties in the output task, but not following ungrammaticalities in the input sentence in a dual task like the ERA-experiments could serve to further establish our claim that grammatical encoding and decoding cannot take place truly simultaneously.

There is no doubt that production and comprehension work together in close connection on all levels of language processing. The existing evidence for syntactic overlap as described in the literature reviews of Chapters 1 and 3 is both confirmed and expanded in this thesis. We have found evidence for overlap between the processes underlying grammatical processing (in the ERA-

experiments), and for shared representations used by these processes (in the syntactic priming experiments). Functionally, the connection between the two has been approached in two ways: to describe how the language production system uses the comprehension system to monitor speech plans and output (e.g. Levelt, 1989; Hartsuiker & Kolk, 2001), and very recently it has been argued that comprehension uses the production system to generate predictions about what is coming next (Pickering & Garrod, 2007). Whereas we agree with both approaches as to the functionality of interaction, the results presented in this thesis tentatively suggest that the overlap between grammatical production and comprehension is not so much a question of a master process calling for the assistance of a slave process, as is the case in both of these approaches, but perhaps more a cooperation of equals. What exactly is the nature of these equal processes, whether they reflect a single underlying grammatical coder, or one of the other options described above remains a topic of further investigation.

Appendix A

Chapter 2. Experiment 1: Pluralising task

Experimental sentences

Alle bomen in het park hebben de blaadjes verloren.
Mijn pasjes moeten gisteren bij het omkleden uit mijn zak zijn gevallen.
De boeken die Hermans heeft geschreven zijn bedoeld voor iedereen.
De lezingen over kunst zullen niemand interesseren.
Ik ben pas blij als alle studenten een milieumok gebruiken
Op de eerste schooldag moeten de kinderen hun boeken kaften.
Die muziekstukken voor de piano zijn gecomponeerd door Mozart.
De hoofdrolspelers zijn de tekst vergeten te leren.
Ik zag die eendjes in de sloot naar de kant zwemmen.
De foto's uit de krant vervormen de waarheid.
Die meisjes uit Londen verblijven even in Amsterdam.
De ruimtewezens van Mars hebben het ruimteschip gerepareerd.
De geleverde apparaten bleken defect te zijn.
De dieren in de dierentuin worden bekeken vanachter een hek.
Ik snap niet waarom de kerkklokken ieder kwartier slaan.
De zangers zingen de liederen uit volle borst mee.
De vogeltjes op het terras bedelen bij alle klanten.
Zie je dat mijn tantes op die foto op mij lijken?
De puzzels uit dit boekje hebben me steeds geboeid.
Die TV-programma's van gisteren werden bewonderd door menigeen.
Hoewel de lantaarnpalen vanaf zonsondergang branden is het toch donker.
Die auto's rijden veel te hard voor deze weg.
De bliksems kliefden de eeuwenoude eik doormidden.
De politici in Brussel zijn gebonden aan een partij.
Omdat de stormen de scheepsvaart bedreigen, varen de veerboten niet.
Die broodjes uit de kantine, die ik at, smaken goed.
Ik vraag me af of de kluisjes vele schatten bevatten.
De struik werd op verzoek tegen de schutting gebonden.
De verslaggevers van de radio verslaan de verkiezingen.
Vervelend dat de regenbuien in de herfst altijd overlast veroorzaken.
De aanbiedingen van de supermarkt trekken veel klanten.
Die flatgebouwen verpesten het uitzicht over de weilanden.
De geitjes op de kinderboerderij vertederen iedereen.
De tafels in de etalage zullen al wel verkocht zijn.
De patiënten wachten in de wachtkamer op de dokter.
De verdachten in de rechtszaak vertrekken geen spier.
De kabouters uit het sprookje werken in de mijn.
Die vliegtuigen arriveren met vertraging op Schiphol.
Zie je dat de jassen op de grond gevallen zijn?
De verkopers schreeuwen om de waren aan te prijzen.
Welke fans hebben de posters van die film gestolen?
De havens worden gedempt omdat de grond nodig is.
De kranten van zaterdag hebben over de vliegramp bericht.
De kaarten kwamen veel te laat voor de verjaardag.
De poolhonden komen oorspronkelijk uit Lapland.
De interviews werden uitgesteld toen bleek dat de ster ziek was.
De produkten van die slager zijn gekeurd en bekroond.
De vrienden die ik bij Maartje zag, lijken wel aardig.
Pas op dat de kopjes van oma niet breken.
De uitslagen van het tentamen zijn bekend vanaf morgen.
De klanten worden geholpen door de eigenaar van de winkel.
Het is goed dat die kinderen met mes en vork eten.
Ik hoorde dat de demonstranten in Utrecht niet vervolgd worden.
De skateboarders op de stoep nemen veel risico's.
Ik zie dat de tekeningen op het prikbord hangen.
De drenkelingen werden gered met behulp van een helicopter.

Die nichtjes uit Canada logeren bij ons.
De supporters van de winnaar juichen na de wedstrijd.
Grappig hoor, als de jonkies van de poes samen spelen.
De kledingstukken aan de lijn wapperen in de wind.

Practice items
De jongens uit de straat begroeten de buurman.
Ik zag dat de viltstiften veel gebruikt worden.
De bloem verwelken door die hitte van de zon.
De koe in de wei grazen langs de sloot.
De groenten heeft de gasten heerlijk gesmaakt.
De heuvels bij het meer wordt beklommen door mij.
Moedig dat de reiziger met de rugzak door Europa lift.
De kwal op het strand verpest de wandeling.

Appendix B

Chapter 2. Experiment 2: Paraphrasing task

Experimental items
De groepsleider | zuchtte: | " Ik | vergeet | een boterham | met pindakaas | voor mezelf | te maken".
De rijke vrouw | riep: | "Ik |weiger | vandaag | iets | te drinken | te halen | voor mezelf".
Het jarige meisje | antwoordde: | " Ik | hoop | een heleboel | leuke cadeaus | te krijgen | voor mezelf".
De lottowinnaar | zei: | "Ik | heb besloten | een rode auto | te kopen | voor mezelf".
De man | vertelde: | " Ik | vergeet | een tas met kleren | in te pakken | voor mezelf".
Het verlegen meisje | fluisterde: | " Ik | hoop | tijdens | een pittige discussie | voor mezelf | op te komen"
De timmerman | zei: | " Ik | probeer | een sauna | in elkaar te zetten | voor mezelf".
De zieke vrouw | zuchtte: | "Ik | beloof | deze week | een beetje beter | voor mezelf | te zorgen".
De kok | riep: |" Ik | heb besloten | vanaf nu | alleen nog | voor mezelf | te koken".
De vrijgezel | fluisterde: | "Ik | probeer | zo snel mogelijk | een vrouw | voor mezelf | te vinden".
De egoïstische man | antwoordde: | " Ik | beloof | niet meer | continu | aan mezelf | te denken".
De kunstenaar | vertelde: | "Ik | weiger | onder deze omstandigheden | een portret | te maken | van mezelf".

Fillers correction
De vrouw | ging | naar de supermarkt | en | kocht | een paar appels.
De jongen | denkt | dat | het meisje | hem | leuk vindt.
De zwemleraar | zei, | dat | de kleine jongen | zijn bandje | om moest.
Gisteren | was het | slecht weer, | maar vandaag | schijnt de zon.
Hij | zei: | "Iedereen | is vrolijk, | want | de vakantie | staat | voor de deur."
Mijn tante | vertelde | mij | een verhaal | over haar jeugd.
De lerares | riep: | "Als je | nu niet | stil bent, | moet je | straks | nablijven."
De monteur | repareerde | de auto | binnen | een half uur.
Vanavond | is er | een feestje, | omdat | mijn broer | jarig is.
De bakker | riep | de vrouw | terug | toen zij | haar tas | vergat.
Als we | snel zijn, | halen we | de laatste bus nog.
De supporter | schreeuwde: | "We | worden | kampioen."

Fillers correction (ungrammatical)
De twee meisjes | liep | samen | terug | naar huis.
De vader | vertelde | de jongetje | een verhaaltje | voor het slapen gaan.
De bediende | vertelde, | dat | hij | nog nooit | iets | had gesteeld.
Mijn buurjongen | hebben | een grote kamer | vol speelgoed.
De geslaagde zakenvrouw | verdient | elke week | een kleine fortuin.
Mijn moeder | riep: | "Blijf | met je vingers | van het taart af."
De vuilnisman | gooien | elke vuilniszak | in de wagen.
Om 11 uur | moet hij | afrijden, | maar | hij | denken, | dat hij | zal zakken.
Zijn vliegtuig | vertrekt | vanmiddag | om halve vijf.
De coach | zei, | dat | zijn team | harder trainen | dan elk ander team.

De kleuter | fluisterde: | “Ik | heb | de vaas | met bloemen | laten val.”
De automobilist | weigerde | zijn parkeerplek | af te staat.

Fillers paraphrasing
De barman | zei: | “Ik | moet | werken | tot 2 uur.”
De jongen | antwoordde: | “Ik | wil | gaan zeilen | met de boot | van mijn vader.”
De examenkandidaat | zei: | “Ik | moet leren | voor mijn tentamens.”
Het meisje | antwoordde: | “Ik | wil slapen, | omdat ik | moe ben.”
Het verwende meisje | riep: | “Mijn oom | gaat klagen | over de service | van het restaurant.”
De moeder | zuchtte: | “Ik | probeer | zo min mogelijk | aan mijn geldproblemen | te denken.”
De oudste zus | riep: | “Ik | beloof | mijn broertje | van school | te halen.”
De verwarde man | zei: | “Ik | hoop | mijn portemonnee | terug te vinden.”
De studente | zei: | “Ik | heb besloten | om na dit jaar | een paar maanden | te gaan reizen.”
De therapeut | zuchtte: | “Ik | wist | dat zij | vandaag | niet | wilde komen.”
De verkoopster | zei: | “Ik | wil pauzeren | als het | wat minder | druk is.”
De bejaarde vrouw | fluisterde: | “Ik | probeer | te lopen | zonder | mijn wandelstok.”

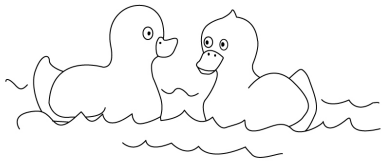
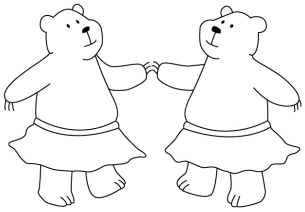
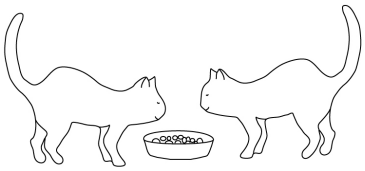
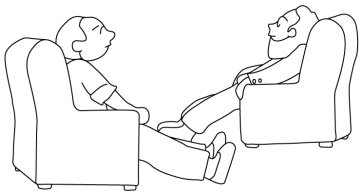
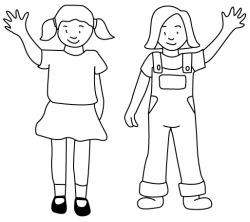
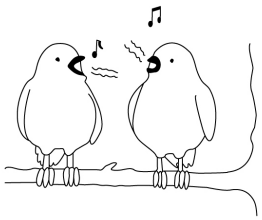
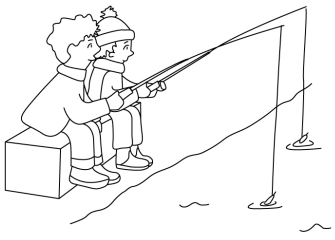
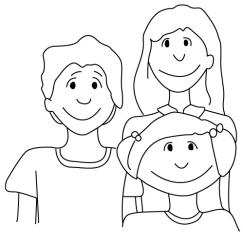
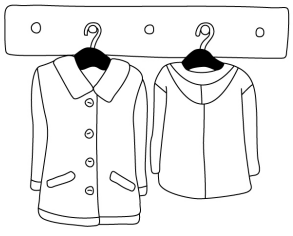
Fillers paraphrasing (ungrammatical)
De puber | riep: | “Ik | probeer | om vier uren | thuis te zijn.”
Het verliefde meisje | fluisterde: | “Ik | hoopt | hem | binnenkort | nog een keer | te zien.”
De jongen | zuchtte: | “Ik | beloof | de hele week | het afwas | te doen.”
De leraar | riep: | “Mijn zus | gaan | tennissen | na de lunch.”
De coach | riep: | “Ik | weigert | een speech | te houden | na de verloren wedstrijd.”
De werkloze acteur | fluisterde: | “Ik | droom | van een huis | aan de strand.”

Practice items correction
Ik | heb | mijn broer | gisteren | uitgezwaaid | op het vliegveld.
Zij | zijn | vorige week | met z’n allen | gaan eet | in Amsterdam.
Volgende week | gaat zij | eindelijk | naar de kapper.
Zijn vriendin | heeft | een hele rijk | vader.
Ik probeer | een lekkere salade | te maken | voor zichzelf.

Practice items paraphrasing
De presentator | zei: | “Ik | wil stoppen | met mijn talkshow.”
Het meisje | antwoordde: | “Ik | ga spelen | in de tuin.”
De koffiejuffrouw | fluisterde: | “Ik | heb besloten | geen feest | te geven | voor zichzelf.”
De zanger | riep: | “Ik | hoop | snel | mijn stem | terug te krijgen.”
De leerling | zuchtte: | “Ik | vergeet | een jas | te pakken | voor mezelf.”

Appendix C

Chapter 4. Experiments 1, 2 and 3: Cued picture description task

	eendjes zwemmen		beren dansen
	katten eten		baby's huilen
	kaarsen branden		mannen rusten
	meisjes zwaaien		vogels fluiten
	jongens vissen		kinderen lachen
	jassen hangen		

Appendix D
Chapter 5. Experiment 1

Baseline primes
Herman is trots op zijn opa, omdat die tijdens de oorlog deelnam aan
Het meisje beet in de appel die ze kreeg van
De grond erodeert binnen twee jaar na het kappen van
Klaas baalde van het verlies van
Er is veel ziekteverzuim door het toemenemen van
Diana is erg nerveus voor het maken van
De vogel lag op de grond, hij viel namelijk van
De automobilist moest vanochtend krabben, want de ruiten zaten vol met
Willem is erg blij met het boek dat hij gisteren kocht op de
's Ochtends ben ik pas echt wakker na het drinken van
Toen ik de keuken in liep, rook ik de vette lucht van
De leerlingen bekogelden de boze leraar met

Participle-final primes
De leeuwin rustte uit, nadat ze een prooi had
De kwajongen kreeg een pak slaag, omdat hij jeukpoeder in zijn ouders bed had
Vader vloekte luid nadat hij bij het timmeren op zijn duim had
Johan was blij met de broek die hij in de uitverkoop had
Mijn broer wreef kreunend over de knie die hij had
Dennis stikte bijna, nadat er een graatje in het verkeerde keelgat was

Auxiliary-final primes
De vrouw vroeg haar zoon waarom hij haar geen kaartje gestuurd
We konden er niet door, omdat de weg versperd
Ze is depressief omdat ze door haar ouders verwaarloosd
Iedereen dacht dat Vincent gek was, omdat hij zijn eigen oor afgesneden
De verdachte hield stug vol dat hij het niet had gedaan
Met kerst viert men dan Jezus geboren

Targets
De schaatser stak trots zijn armen in de lucht toen hij zag dat hij het record
De voetballer liep blij naar zijn supporters nadat hij het winnende doelpunt
De supporters waren niet meer welkom in het stadion, nadat ze een aantal stoeltjes
Ik heb geen oordeel over haar, omdat ik haar nog nooit
Ik rammel van de honger omdat ik sinds 7 uur vanmorgen niet meer
De skieer lag in het ziekenhuis omdat hij zijn been
Wat Piet laatst vertelde is het vreemdste verhaal dat ik ooit
De verdachte hield stug vol dat hij het niet
Nu ik die gevel zie, herinner ik mij dat ik hier eerder
Dankzij het sporenonderzoek wist de brandweer dat het vuur door een pyromaan
De student zag tot zijn opluchting op het bankafschrift dat zijn beurs
De onbetrouwbare jongen deed nooit wat er met hem
De begrafenisondernemer zag tot zijn schrik dat zijn auto door de garage felroze was
De condor is zo'n geliefde jachtbuit dat hij inmiddels bijna
De man belde de politie omdat hij portemonnee
De man moest naar de dokter omdat hij door een hond
Het is duidelijk dat je haar met jouw opmerking op een idee
Henk kreeg een aanmaning, omdat hij zijn contributie nog niet
De arrestant ontkende dat hij de brand
Erna werd een beetje misselijk, nadat ze teveel bonbons
Het rapport toont aan dat het aantal verkeersdoden sinds 1992 met drie procent
De makelaar moest het echtpaar teleurstellen omdat het huis al
Het was een hele schok toen men hoorde dat de Titanic
Ik geloof dat we door die oplichter bij de neus

Fillers
De hunebedden in Drenthe trekken jaarlijks vele duizenden
Niet de Dom in Utrecht maar de Martinitoren in Groningen is de hoogste kerktoren
De olijke komiek maakte aan de lopende band grappen over
Remco parkeerder de auto van zijn vader natuurlijk precies
De Nederlander neemt niet langer genoegen met
De advocaat van de van moord verdachte vrouw pleitte in zijn slotbetoog
De bankier presenteerde het jaarverslag aan
De museumdirecteur kocht voor een recordbedrag een beroemd schilderij van
Wij waren iets te laat vanwege
De slager gaf de jongen
Op het moment dat het meisje haar pony aan het roskammen was sloeg het dier
Nu je over tuinieren begint schiet me opeens iets
Het is nu droog dus ga maar snel naar
Regelmatig groenten en fruit eten is volgens de meeste diëten
De driejarige Laura is dol op
Wat denk je van
Ik heb een hekel aan pretparken want ze zijn vaak zo
De rivier overspoelde een dorp met
’s Avonds gaan de luiken
Dichte mosselen moet je niet eten, want die zijn
De jongen sloeg het meisje met
Parijs is wereldberoemd vanwege
Marianne verdwaalde hopeloos na het missen van de laatste
Als ik ooit nog eens rijk word dan verhuis ik onmiddellijk
De dame ontdekte tot haar schrik dat er een vlek zal op haar nieuwe
De fotograaf was bijzonde ingenomen met zijn nieuwe
De vakbondsleider dreigde met
Het ondeugende kind kreeg een pak slaag van
Zie de maan schijnt door de
Sandra is een dromer, ze loopt altijd met haar hoofd in de
Mijn favoriete huisdier is
Als Saskia te lang achter de computer zit krijgt ze altijd
De monteur gaf het gescheurde overall
Het kenmerk van een leuk feest is
Heel dunne mensen hebben meestal iets weg van
De verbaasde tolk zei dat ze wel Japans sprak maar geen
Waar dat nu op slaat is voor mij
Goede isolatie zorgt zowel voor een lage gasrekening als
Er zitten veel vitaminen in
Ricardo kreeg onverwacht bezoek van
De tandartsassistente lachte naar me terwijl de tandarts in mijn kies stond
De baldadige demonstranten gooiden met rotte eieren en tomaten naar
Als een bergbeklimmer eenmaal op de top is gaat hij weer
Welke waanzinnige loopt er nu ’s avonds laat
Als Niels klaar is met zijn werk gaat hij meestal rechtstreeks naar
De dokter van de president werd wereldberoemd vanwege
De ridders bestormden het kasteel met
Jantje lust echt alles behalve spruitjes en
De gevolgen van een verkeersongeluk zijn
Ik erger me verschrikkelijk aan die
De dronken student liep naar de bar en bestelde drie
De Zeeuwse mosselkweker was
De majorette gooide haar baton zo hoog op dat hij midden in het publiek
De bokser deelde een hele harde
De Mobiele Eenheid maakte op gewelddadige wijze een einde aan
De op geld beluste huisjesmelker verhoogde de huur met
De neurotische patiënt vertoonde allerlei interessante
De rebel had voor niets of niemand
Bijenwas is erg geschikt voor het verzorgen van
Brulapen zijn leuke dieren maar het is alleen jammer dat ze zo

De koning van de kolonies ging er prat op dat in zijn rijk de zon
In het pas geopende tuincentrum had men voor alle klanten
De hoogleraar had door al die vergaderingen geen tijd meer voor
De honkballer gooide
Honkbal is een van de weinige sporten waarbij het de bedoeling is dat je de bal uit het veld
Niemand weet dat Roodkapje eigenlijk een enorme hekel had aan
Na een lange verkiezingscampagne koos de bevolking hem
De parkeerwacht gaf de auto een
De penningmeester constateerde dat hij een bedrag van
De analfabeet had grote moeite met het spellen van
De kikker belandde met een grote plons in de
In een raceauto voel ik mij thuis als ene vis in het
Ik vind dat je behoorlijk in de weg
De vlieger viel plotseling naar beneden, waardoor het touw verstrikt raakte in
De advocaat toonde de rechter
Ik wou dat ik een kip had die gouden
Volgende week vertrekt zij voor drie maanden
Ik weet niet waar de schaar is, misschien ligt hij
Waarom zijn de bananen niet recht in plaats van
De juridische faculteit leidt op tot meester in
De appel valt niet ver
Wij konden de zeilen hijsen want er stond genoeg
Sinds ze de weg weet op Internet zit ze dagen achter
Beter een half ei dan
De timmerman schaafde een stukje van de deur af omdat die niet in de sponning
Ik heb het cadeautje geruild bij de winkel omdat ik het al
Als ik ga kamperen dan valt de regen met bakken
Als de Limburgers carnaval vieren dan doen ze dat
Als je veel hoest en keelpijn hebt dan heb je waarschijnlijk
Bij mijn kopje koffie ’s ochtends neem ik altijd
Door al die programma’s over hart- en vaatziekten heb ik helemaal geen zin meer in
De grap die Marleen met haar collega’s uithaalde zorgde voor
Wanneer je een lange wandeling maakt, is het belangrijk dat je
Door het slechte weer viel onze fietsvakantie
De vertrekkende directeur kreeg een fraai schilderij van
Toen ik van de ene bureaucratische instantie naar de andere moest werd ik enorm
Door die reclamestunt krijg je bij aanschaf van een pak wasmiddel
In de garage staat een
De over het paard getilde voetballer kreeg een straftraining wegens het missen
Ik hoorde laatst een te gekke plaat van
De nieuwe bankbiljetten van 100 Euro vind ik eerlijk gezegd
Tijdens de tenniswedstrijd sloeg Yvonne de bal
De relschoppers gaven de schuld
De naaktslak trok een slijmerig spoor over
Otto is een stuk vrolijker sinds hij weer een vriendinnetje
Valt het jou ook op dat Donald Duck nooit een broek
Gelukkig was er een behulpzame wandelaar die ons de weg
De Buurman stond woedend voor de deur omdat de muziek
In de tuin bloeiden duizenden
Bij de uitreiking van de Oscars waren talloze
Wie houdt er niet van
De sollicitante maakte zich bijzonder zenuwachtig voor
De kaping op de Zwarte Zee is nu alweer
De hongerige reiger viste al onze goudvissen uit de
Op zondag maken mijn ouders altijd een wandeling door het
Ieder huis heeft
Omdat ze jarig was kreeg Julia van haar vriend
De douanebeambte zei tegen de reiziger dat hij
De kok bereidde een
Caroline vertelde urenlang met smaak over de verwikkelingen in
Het raadsel loste zich

In steeds meer openbare ruimtes is het tegenwoordig niet meer toegestaan om te
De honden blafte toen ik ze hun eten kwam
Er is tegenwoordig meer behoefte aan verkeersinformatie wegens
Het nemen van de fiets is beter voor
De auto raakte het kind met
De hoogleraar at een bord met friet met
De pinguïns op de zuidpool zwemmen het liefst
Het woord kaas rijmt op
De kapitein voerde het gezag over
Toen de degenslikker tijdens een voorstelling hoestte
Elviera vond de jonge hondjes
De journaliste wekte de woede van het Universiteitsbestuur met haar artikel over
Tijdens haar bezoek aan het dorpje Schoonhoven droeg de koningin een leuk
De verliefde tiener stuurde het meisje van zijn dromen een
Het jonge stel kocht een auto van
De antiquair bestempelde het tafeltje van oma als
De Cubaanse zangers zongen een lied over
Als het dit weekend zulk mooi weer is gaan we met zijn allen een dagje naar
Nadat de auto met grote snelheid uit de bocht vloog sloeg hij drie keer
De taxichauffeur keek even opzij naar zijn passagier en reed dientengevolge
Als er een kermis is dan gaan Hans en Stephanie het liefst in
Bij het ongeluk in de kerncentrale kwam er een radioactieve gaswolk
Het schijnt dat bij oostenwind het ijs veel langzamer
Fransen eten doorgaans graag
De zwerver bedelde bij alle voorbijgangers om
Iedere vier jaar mogen we weer met naar de stembus om onze regering te
Mensen met schizofrenie hebben vaak waandenkbeelden en ze horen ook vaak
Toen Inge na het bezoek aan de kapper in de spiegel keek schrok ze
De tentoonstelling liep storm en dat veroorzaakte een gigantische
De bisschop protesteerde stellig tegen de nieuwste decreten van
Gastvrijheid is voor de meeste volken
Betty houdt wel van een beetje extra tomatenketchup op
Gert spaart al jaren voor een
Omdat de kinderen dit jaar erg braaf waren kregen zij van Sinterklaas
De veehouder fokt
Tijdens de ochtendspits staan veel forensen elke dag weer
Laat ’s avonds nooit
De cultuur van de inca’s ging uiteindelijk ten onder aan
Waarom krijgen andere altijd
Hoewel aaseters nuttige dieren zijn vinden de meeste mensen ze
De door zijn luxe leven verwende erfgenaam kleedde zich altijd
De knorrige conducteur zette de zwartkijker
Fluitenkruid en paardebloemen groeien meestal
Voorspoed is een ander woord voor
Dat beren broodjes smeren is eigenlijk
Na de laatste noten van het concert klonk er
Klein Duimpje verdwaalde zelden omdat hij zijn pad altijd bestrooide met
De kamercommissie rapporteerde de bevindingen in een dik
Tom en Jerry zit net als andere tekenfilms altijd vol met
In de Derde wereld heeft grootschalige mijnbouwvaak nadelige gevolgen voor
Wat is het verschil tussen appels en
Het grootste nadeel van regen is dat
De pas ingezaaide gewassen waren het slachtoffer van
De wielen van het overbelastte vliegtuig scheerden rakelings
De stuurman zag het eiland met
De verkoopster raadde haar af het iets te kleine
Claudia liep naar de warme bakker en bestelde een
Mijn computer vertoont
Tot mijn grote spijt rukken de mieren langzaam op richting
Als het springpaard niet over de hindernis kan dan loopt hij
Ik schrijf mijn afspraken allemaal trouw op mijn

Of ik volgende week tijd heb moet ik eerst opzoeken in mijn
Mijn ome Gerrit loopt al zijn hele leven op
De ouders schrokken zich een ongeluk toen ze de babysit betrapten met
Waarom zijn ambtenaren toch allemaal
Doe die deur eens
In de herfst vallen de bladeren van de bomen
De malafide rederij onderhield een verbinding met
Sporten is niet altijd
De inbrekers gingen er met
Vanwege de zure regen gaan onze bossen langzaam maar zeker
De machinist gaf de conducteur
De louche advocaat toonde
De professor betreurde het ten zeerste dat zijn beste student
De flauwe grap leidde tot

Appendix E

Chapter 5. Experiment 2

Experimental items

Ik hoor dat / en dat...	de brief	is verzonden / verzonden is
Ik hoor dat / en dat...	de portemonnee	is gestolen / gestolen is
Ik hoor dat / en dat...	de fouten	zijn verbeterd / verbeterd zijn
Ik hoor dat / en dat...	de scholen	zijn begonnen / begonnen zijn
Ik hoor dat / en dat...	vreemde dingen	zijn gebeurd / gebeurd zijn
Ik hoor dat / en dat...	de problemen	zijn opgelost / opgelost zijn
Ik hoor dat / en dat...	de patiënt	heeft geleden / geleden heeft
Ik hoor dat / en dat...	de raadsleden	hebben vergaderd / vergaderd hebben
Ik hoor dat / en dat...	de dames	hebben gewinkeld / gewinkeld hebben
Ik hoor dat / en dat...	de bouwbedrijven	hebben gefraudeerd / gefraudeerd hebben
Ik hoor dat / en dat...	de weg	is afgesloten / afgesloten is
Ik hoor dat / en dat...	je voorspelling	is uitgekomen / uitgekomen is
Ik hoor dat / en dat...	het vliegtuig	is geland / geland is
Ik hoor dat / en dat...	de bedriegers	zijn ontmaskerd / ontmaskerd zijn
Ik hoor dat / en dat...	de verdachte	heeft bekend / bekend heeft
Ik hoor dat / en dat...	de zon	heeft geschenen / geschenen heeft
Ik hoor dat / en dat...	het eten	heeft gesmaakt / gesmaakt heeft
Ik hoor dat / en dat...	de minister	heeft gelogen / gelogen heeft
Ik hoor dat / en dat...	de kinderen	hebben gevoetbald / gevoetbald hebben
Ik hoor dat / en dat...	de studenten	hebben gedemonstreerd / gedemonstreerd hebben

Appendix F

Chapter 5. Experiment 3

Experimental Items

De verwarde vrouw beweert dat	de portemonnee	is gestolen / gestolen is
De verwarde vrouw beweert dat	er vreemde dingen	zijn gebeurd / gebeurd zijn
De verwarde vrouw beweert dat	de pianist	heeft gespeeld / gespeeld heeft
Het lijkt erop dat	de kwajongens	hebben aangebeld / aangebeld hebben
Het lijkt erop dat	het mailtje	is verzonden / verzonden is
Het lijkt erop dat	de scholen	zijn begonnen / begonnen zijn
Op teletekst stond dat	het vliegtuig	is geland / geland is
Op teletekst stond dat	de files	zijn opgelost / opgelost zijn
Op teletekst stond dat	de minister	heeft gelogen / gelogen heeft

Ik hoop dat	de voorspelling	is uitgekomen / uitgekomen is
Ik hoop dat	de verdachte	heeft bekend / bekend heeft
Ik hoop dat	de hapjes	hebben gesmaakt / gesmaakt hebben
Het artikel vermeldde dat	de fouten	zijn verbeterd / verbeterd zijn
Het artikel vermeldde dat	de patiënt	heeft geleden / geleden heeft
Het artikel vermeldde dat	de dames	hebben gewinkeld/ gewinkeld hebben

Fillers
hoge bomen vangen veel wind
De slager gaf de jongen een plakje worst
Het gaat zo regenen dus ga maar snel naar binnen
“s Avonds gaan de luiken dicht
De kinderen keken voor het slapen gaan naar Sesamstraat
Parijs is beroemd vanwege de Eiffeltoren
Paddestoelen groeien meestal in het bos
De zon ging schuil achter donkere wolken
Waar dat nu op slaat is voor mij een raadsel
Het boek is niet dun, maar dus
De student liep naar de bar en bestelde drie bier
De bokser deelde een hele harde klap uit
Vissen zwemmen in het water
Huisdieren moet je goed verzorgen
Op je verjaardag krijg je van iedereen cadeautjes
Ik vind dat je behoorlijk in de weg staat
Waarom zijn de bananen krom?
Een paraplu beschermt je tegen de regen
Hij was ziek en had hoge koorts
Alle meisjes dromen van de prins op het witte paard
Het team met de meeste doelpunten wint
De band van mijn fiets is lek
Na regen komt zonneschijn
Het schaap had een dikke wollen vacht
Je doet je jas aan of uit
Ga buiten even een luchtje scheppen
Na de zomer komt de herfst
Giraffen hebben een hele lange nek
Weet jij hoe laat het is?
Zij ging naar de kapper om haar haar af te knippen
Jezus is de zoon van God
In Egypte zijn veel piramides
Sneeuwwitje en de zeven dwergen
Wie het laatst lacht, lacht het best
Italianen spreken Italiaans
Eilanden zitten niet aan het vasteland
Op het naambordje staat de verkeerde naam
Met Pasen gaan veel kinderen in de tuin eieren zoeken
In de zomer liggen veel mensen op het strand
Kun jij een handje helpen?
In veel openbare gelegenheden is het verboden om te roken
De meisjes in de discotheek dansen
Fransen drinken graag wijn
De vulkaan barstte uit
Het stadhuis staat in het midden van de stad
‘s Nachts gaan de meeste mensen slapen
De zuster verpleegt de patiënt
Als er ijs op de sloten ligt kun je schaatsen
De demente heer kon het zich niet zo goed meer herinneren
Hij ging naar de copyshop om een boek te kopiëren
Internet is iets van de laatste tijd
Roodkapje ging aan grootmoeder koekjes brengen

Iedereen is vrolijk als de zon schijnt
Zo sluw als een vos
De tevreden poes lag te spinnen
Zoals het klokje thuis tikt, tikt het nergens
De baby kwam ter wereld na een zware bevalling
De bruid zocht een jurk uit voor de bruiloft
Om beter te kunnen zien, droeg zij een bril
Om de tafel staan vier stoelen
Elk huisje heeft zijn kruisje
In de oorlog vielen er veel doden en gewonden
Lege flessen horen in de glasbak
De Efteling trekt jaarlijks vele duizenden bezoekers
Als de kat van huis is dansen de muizen op tafel
De piloot bestuurt het vliegtuig
De brandweer was op weg om de brand te blussen
Het is licht op de gang want de lamp is aan
De spin maakte een groot web
Na een week verwelkten de bloemen
Je hebt poep onder je schoen
De danseres kan zichzelf zien in de spiegel
Haastige spoed is zelden goed
De boer staat vroeg op om de koeien te melken
Waar een wil is is een weg
De harde muziek bezorgde de buren veel overlast
De appel valt niet ver van de boom
Het meisje stiftte haar lippen met haar nieuwe lippenstift
De veerpont bracht de mensennaar de overkant
De buitenlander sprak nog geen woord Nederlands
Een woordenboek is gesorteerd op alfabet
Als het spitsuur is staan veel automobilisten in de file
Hij moet de rommel in zijn kamer eens opruimen
De brandweer kwam voor niets, het was vals alarm
Hij dronk zijn glas fris in een teug leeg
In de stilte kon je een speld horen vallen
Al is de leugen nog zo snel, de waarheid achterhaalt hem wel
Wie een kuil graaft voor een ander, valt er zelf in
Indianen schieten met pijl en boog
De pot verwijt de ketel dat hij zwart ziet

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Samenvatting

Verbanden tussen grammaticaal[7] encoderen en decoderen.

Een experimenteel taalpsychologisch onderzoek.

Hoe kan het dat we, als we iets willen zeggen, zomaar kunnen beginnen met praten, zonder heel erg stil te hoeven staan bij hoe we dat gaan zeggen? De zinsbouwprocessen gaan vanzelf. En degene die ernaar luistert hoeft ook niet heel hard zijn best te doen om te begrijpen wat je zegt: de zinsontleedprocessen verlopen óók automatisch. Het doel van dit proefschrift was het bestuderen van de architectuur van grammaticale verwerking door te kijken naar de relatie tussen de processen die ten grondslag liggen aan zinsbouw en zinsontleding. Deze kwestie is op twee manieren benaderd: ten eerste door direct te kijken naar de overlap tussen de mechanismen die betrokken zijn bij zinsproductie en zinsbegrip (in Hoofdstuk 1 en 2), en ten tweede door middel van onderzoek naar het reactietijdverloop van één verschijnsel in het bijzonder, namelijk syntactische priming en de representaties die hierbij gedeeld worden door syntactisch encoderen (zinsbouw) en decoderen (zinsontleding) (in Hoofdstuk 3-5). Hieronder behandel ik de resultaten van beide onderzoeken en de implicaties daarvan voor de architectuur van het taalverwerkingssysteem.

Syntactische priming

Syntactische priming is het verschijnsel dat het verwerken van een zin met een bepaalde structuur (de primezin) de verwerking van een erop volgende zin (de

[7] In deze samenvatting gebruik ik het woord *grammaticaal* zowel de betekenis van *welgevormd*, als om aan te geven dat iets *betrekking heeft op de grammatica*, hetgeen in het Nederlands ook wel met *grammatisch* kan worden aangeduid. Hierin volg ik dus de Angelsaksische traditie waarop dit proefschrift aansluit. Dit is een bewuste keuze waarmee ik wil aangeven dat taalevolutie, ook in taal over taal, allesbehalve stilstaat.

targetzin) met dezelfde structuur beïnvloedt. Als men ervan uitgaat dat dit alleen maar kan gebeuren als het cognitieve systeem dat verantwoordelijk is voor de verwerking gevoelig is voor deze structuur, kan met name syntactische priming tussen de modaliteiten (dus van begrijpen naar produceren of andersom) ons iets vertellen over hoe de processen die betrokken zijn bij zinsconstructie en zinsbegrip zich tot elkaar verhouden en of deze overlappen.

In Hoofdstuk 3 werd de bestaande literatuur besproken over hoe syntactische priming effect heeft op de voorkeuren van proefpersonen om een bepaalde zinsconstructie te kiezen. Als proefpersonen bijvoorbeeld een zin hebben gelezen zoals: *De pinguïn geeft de pizza aan het meisje*, dan zal een daaropvolgend plaatje van een tijger die een spiegel laat zien aan een oude man vaker worden beschreven als *De tijger toont een spiegel aan de oude man* dan als *De tijger toont de oude man een spiegel*. De zinsconstructie met het prepositionele meewerkend voorwerp is geprimed en wordt eerder geselecteerd en geproduceerd dan de alternatieve zinsconstructie met een nominaal meewerkend voorwerp. Het hoofdstuk behandelt ook de verschillende verklaringen die er gegeven zijn voor dit fenomeen. Eén theorie stelt dat primingeffecten worden veroorzaakt door impliciet leren van de verbanden tussen betekenis en zinsstructuur (Bock & Griffin, 2000; Chang, Dell, Bock & Griffin, 2000). Deze theorie is gebaseerd op de bevinding dat sommige primingeffecten van behoorlijk lange duur zijn, tot aan 40-50 tussenliggende zinnen aan toe, of 20 minuten. Het geregeld tegenkomen van bepaalde combinaties van betekenis en zinsstructuur zou ervoor zorgen dat er lange-termijnverbanden ontstaan in het brein, die ervoor zorgen dat je wanneer je een keuze moet maken uit twee alternatieve structuren die allebei hetzelfde betekenen, je de constructie die je vaker bent tegengekomen eerder zult kiezen dan de constructie die je minder bekend voorkomt. Deze theorie beschouwt priming dan ook als een leereffect dat de onderlinge verhouding tussen twee alternatieven beïnvloedt: hoe waarschijnlijker de keuze voor de een wordt om een bepaalde betekenis uit te drukken des te minder waarschijnlijk wordt het dat de andere wordt gekozen.

Een andere theorie baseert zich op de veronderstelling dat kennis in de hersenen pas gebruikt kan worden als de bijbehorende mentale representatie geactiveerd is boven een bepaalde drempelwaarde. Volgens deze theorie zijn primingeffecten geen leereffect, maar het gevolg van restactivatie die

achterblijft op deze representaties wanneer zij net gebruikt zijn (bv. Smith & Wheeldon, 2001; Pickering & Branigan, 1998; Branigan, Pickering, Liversedge, Stewart & Urbach, 1995). Deze restactivatie maakt het makkelijker voor de recent gebruikte representaties om weer opnieuw te worden geactiveerd. Als dus de representatie van de ene zinsconstructie kortgeleden is geactiveerd (gebruikt), omdat je deze constructie net hebt gehoord, of zelf geproduceerd, is vlak daarna de activatie niet helemaal verdwenen, maar blijft er nog een klein beetje restactivatie achter. Hierdoor is er minder extra activatie nodig om weer de drempel te overschrijden en de structuur nogmaals te gebruiken.

Een voorspelling die vooral volgt uit deze laatste theorie is dat het hergebruiken van bepaalde constructies niet alleen vaker gebeurt, maar ook sneller zou moeten gaan dan het berekenen van een geheel nieuwe zinsstructuur. Dit wordt de *effort reduction* theorie genoemd. Immers, als je geen aandacht of moeite (*effort*) meer hoeft te besteden aan de vorm van een zin, kun je meer energie steken in de inhoud (en de toepasselijkheid gegeven de — sociale of andere — context, en de woordkeus...). Verscheidene onderzoeken hebben al laten zien dat het inderdaad mogelijk is om een tijdswinst te meten (Smith & Wheeldon, 2001; Wheeldon & Smith 2003; Corley & Scheepers, 2002; Traxler & Pickering, 2004; 2005; Pickering & Traxler, 2005; Ledoux, Traxler & Swaab, 2007; Nopenney & Price, 2004). In dergelijk onderzoek wordt gekeken of de targetzinnen in de conditie waarin prime en target dezelfde zinsstructuur hebben (de compatibele conditie) sneller worden geproduceerd dan die in conditie waarin prime en target niet dezelfde structuur hebben (de niet-compatibele conditie). Helaas is het niet altijd helemaal duidelijk of de effecten werkelijk veroorzaakt werden doordat de grammaticale structuren geprimed werden, of doordat er ook andere primingprocessen (bijv. lexicale) een rol speelden. De onduidelijkheid komt voornamelijk doordat er in deze experimenten meer gevarieerd wordt dan alleen de zinsstructuur: de primes en targets in de compatibele condities hebben bijvoorbeeld vaker meer (functie)woorden gemeen dan in de niet-compatibele condities. In hoofdstuk 4 en 5 werd er daarom met behulp van twee reeksen experimenten getest of de *effort reduction* hypothese opgaat voor het primen van woordvolgordes. Als we alleen de woordvolgorde van de zinnen veranderen, maar in alle condities wel zoveel mogelijk dezelfde woorden blijven gebruiken kan een eventueel effect namelijk niet worden veroorzaakt doordat prime en target in bepaalde condities meer woorden gemeen hebben dan in de andere condities.

In de eerste reeks moesten proefpersonen nadat ze een kort zinnetje hadden gelezen plaatjes beschrijven naar aanleiding van een cuewoord. De primezinnetjes konden de volgorde werkwoord–onderwerp (verb–subject, oftewel VS) hebben, zoals *hier zwemmen eendjes* of onderwerp–werkwoord (subject–verb, SV) zoals *terwijl eendjes zwemmen*. De cue-woorden *omdat* en *soms* die de plaatjesbeschrijvingen inleidden lokten ook respectievelijk SV en VS woordvolgordes uit in de trant van *[omdat] baby's huilen* of *[soms] huilen baby's*. Proefpersonen hoefden dus steeds alleen maar de twee woorden van de beschrijving hardop te zeggen. Gemeten werd hoe lang het duurde vanaf het moment dat de plaatjes werden afgebeeld op een computerscherm totdat de proefpersonen begonnen te spreken.

Uit de drie experimenten bleek dat het niet uitmaakte of de prime en de target in dezelfde woordvolgorde stonden, of in een andere: de reactietijden waren altijd ongeveer even lang. Ook maakte het niet uit of we de proefpersonen iets meer de kans gaven om de primezin goed te verwerken door ze meer tijd te geven en ze de prime hardop te laten lezen. Tenslotte bleek het ook niet uit te maken of we tussen alle prime–target paren ook steeds een aantal opvulzinnen aanboden, om ervoor te zorgen dat eventuele cumulatieve primingeffecten weer verdwenen zouden zijn bij elke aanbieding van een prime-targetpaar. Wel werden er steeds effecten gevonden als de prime en de targetzin precies dezelfde woorden bevatten: targetbeschrijvingen waren sneller als de woorden al bekend waren uit de primezin. Dit laatste toont aan dat het experiment op zich wel gevoelig is voor reactietijdeffecten van lexicale priming, maar kennelijk niet voor woordvolgordepriming.

Een mogelijke verklaring voor de afwezigheid van een syntactisch priming effect in de plaatje–zin reeks is dat we proefpersonen niet de kans gaven om zelf de woordvolgorde van de targetzin te kiezen. Door met behulp van het cue-woord een woordvolgorde af te dwingen werd wellicht wel het nut van priming (namelijk *effort reduction*: het verminderen van de moeite van het kiezen voor een bepaalde zinsbouw) omzeild. Immers in het Nederlands is het na het woordje *soms* niet mogelijk om de zin anders te vervolgen dan met een onderwerp gevolgd door een werkwoord (eventueel versierd met nog wat bepalingen eromheen, maar de volgorde van onderwerp en werkwoord zal nooit veranderen); hetzelfde geldt voor het cue-woord dat VS uitlokte. Met andere

woorden: proefpersonen hadden niets meer te kiezen. Deze mogelijkheid werd getest in de volgende reeks experimenten.

De primingexperimenten uit hoofdstuk 5 waren gebaseerd op de bevinding van Hartsuiker en Westenberg (2000) dat het mogelijk is om in het Nederlands de volgorde van het hulpwerkwoord en het voltooid deelwoord in bijzinnen te primen. Zij hadden laten zien dat wanneer proefpersonen een zin hardop hebben afgemaakt zoals *'s Morgens bemerkte Gregor dat hij in een insect veranderd* ***was*** (met eerst het voltooid deelwoord en daarna het hulpwerkwoord, waarbij het laatste woord (hier: *was*) werd aangevuld door de proefpersoon), zij vervolgens ook vaker geneigd zijn om een zin als *Ik kon er niet door omdat de weg…* af te maken met *geblokkeerd was* (eerst het voltooid deelwoord, dan het hulpwerkwoord) in plaats van met *was geblokkeerd* (eerst het hulpwerkwoord, dan het voltooid deelwoord). In onze experimenten maakten we gebruik van hetzelfde principe: in de primezinnen vulden proefpersonen steeds maar één woord aan (ofwel voltooid deelwoord, ofwel hulpwerkwoord) en lag de volgorde dus vast, en in de targetzinnen moesten ze beide woorden aanvullen. Allereerst werden de resultaten van Hartsuiker en Westenberg gerepliceerd: ook bij onze proefpersonen werd de volgorde van de prime inderdaad vaker wel dan niet hergebruikt in de target. In de daaropvolgende experimenten werd er gekeken of er ook een versnelling optrad van deze compatibele targets in vergelijking met de niet-compatibele. Gemeten werd hoe lang het duurde vanaf het verschijnen van het laatste woord van de zin tot aan het begin van het antwoord. Om te kijken of priming wellicht beïnvloed zou worden door de antwoordvrijheid die proefpersonen hadden deden we zowel een experiment waarin de proefpersonen helemaal vrij werden gelaten als een experiment waarin de gewenste targetvolgordes met streepjes werden uitgelokt (- — voor hulpwerkwoord + voltooid deelwoord en — - voor voltooid deelwoord + hulpwerkwoord). In beide gevallen werden er wederom geen reactietijdeffecten van woordvolgordepriming gevonden, ook al bleek uit de vrije zinsvoltooiingen dat proefpersonen wel degelijk de woordvolgorde van de primezin overnamen: Er was dus sprake van priming van *responsvoorkeur*, maar niet van *responssnelheid*.

De bestaande theorieën over syntactische priming verklaren deze uitkomsten niet zonder meer. De restactivatietheorie voorspelt een reactietijdeffect van compatibele paren ten opzichte van niet-compatibele paren. De impliciet-

lerentheorie voorspelt niet bij voorbaat een reactietijd-effect, maar sluit het ook niet uit (met name wanneer de alternatieven erg ongelijke waarschijnlijkheden hebben is er kans op een reactietijdeffect).

De uitkomsten passen wel in een model van grammaticaal encoderen dat onderscheid maakt tussen aan de ene kant het proces dat de hiërarchische grammaticale structuur berekent en aan de andere kant het linearisatieproces dat de woordvolgorde bepaalt. De onderverdeling in deze twee deelprocessen is niet nieuw (zie bijvoorbeeld Garrett, (1975) en Bock & Levelt (1994). Kempen & Harbusch (2002); Kempen & Hoenkamp (1987) en Pollard & Sag, (1994) voor grammaticaformalismen die aldus georganiseerd zijn).

Hoe deze processen zich tot elkaar verhouden is niet precies bekend. Over het algemeen wordt verondersteld dat de woordvolgordeberekening plaatsvindt nadat (een deel van) de hiërarchische structuur al is bepaald. Wij stellen voor dat de processen niet na elkaar plaatsvinden, maar tegelijkertijd. De woordvolgorde kan dan al worden voorbereid voordat alle woorden bekend zijn: het patroon wordt alvast klaargezet, het hoeft alleen nog maar te worden ingevuld. Wanneer er echter een sterke voorkeur bestaat voor een bepaalde volgorde, of wanneer de keuze voor een volgorde door andere factoren (zoals cue-woorden) wordt beperkt, dan kan woordvolgordeberekening zelfs al plaatsvinden voorafgaande aan de berekening van de syntactische structuur. Bijvoorbeeld, in de plaatjesbeschrijvingsexperimenten van Hoofdstuk 4 fungeerde het cue-woord als een beperking op de woordvolgorde. *Soms* bereidde de weg voor een zinsvervolg van een werkwoord gevolgd door een onderwerp. Op het moment dat het plaatje gepresenteerd werd (en de reactietijdmeting gestart), waardoor de woorden beschikbaar werden hoefden deze alleen nog maar te worden ingevuld in het geprepareerde patroon. De reactietijdmeting vond dus plaats nadat de effecten van priming al plaats hadden gevonden.

Priming van de ordening van hulpwerkwoord en voltooid deelwoord, zoals in de experimenten van Hoofdstuk 5, veroorzaakt een soortgelijke situatie waarin alle voorbereidingen voor de woordvolgorde al zijn getroffen voordat de woorden zelf bekend zijn. Op het moment dat de woorden beschikbaar komen en de reactietijdmeting wordt gestart, heeft dus alle woordvolgordeberekening al plaatsgevonden. Daarom kan er ook geen verschil gemeten worden tussen de

compatibele en de incompatibele condities: de reactietijden reflecteren niet meer de de processen die betrokken zijn bij het bepalen van de woordvolgorde, maar andere processen, zoals het vinden van de juiste woorden en het integreren ervan in het zinsverband.

Een dergelijk model sluit niet alleen aan op de bestaande psycholinguïstische modellen, maar ook bij grammaticaformalismen die aparte niveaus veronderstellen voor het berekenen van zinsstructuur en woordvolgorde, zoals dat van Kempen & Harbusch 2002 (zie ook Kempen & Hoenkamp, 1987) en *Head Driven Phrase Structure Grammar* (Pollard & Sag, 1994). De gevonden resultaten zijn echter moeilijk te verenigen met transformationele grammatica's zoals de *Government & Binding* theorie (Chomsky, 1981), die dit onderscheid niet maken.

Daarnaast bevestigen de resultaten van de woordvolgorde-primingexperimenten de huidige veronderstelling dat priming een fenomeen is dat uit verschillende facetten bestaat, waarbij de veelheid aan (soms tegenstrijdige) effecten niet door één enkel onderliggend proces te verklaren is (Ferreira & Bock, 2006).

Overlap van grammaticaal encoderen en decoderen

Het standaardmodel van het taalsysteem weerspiegelt het feit dat taalverwerking in twee modaliteiten plaatsvindt: zinsproductie en zinsbegrip. In het twee-processormodel wordt de grammaticale verwerking dan ook door twee aparte cognitieve processoren verzorgd: een voor grammaticaal encoderen (zinsbouw) en een voor grammaticaal decoderen (zinsontleding). In Hoofdstuk 1 werd op een rijtje gezet dat de twee processen in werkelijkheid bijzonder veel op elkaar lijken. Ten eerste hebben ze namelijk allerlei aansturingsprincipes gemeen: beide gebruiken woorden als hun basisinvoer, werken incrementeel, zijn vrijwel deterministisch van aard en gebruiken zogenaamde *constraint-based* principes om de syntactische structuren te berekenen. Ten tweede is er een keur aan empirisch bewijs dat suggereert dat de processen erg veel gemeen hebben, zoals blijkt uit onderzoek naar *shadowing*, syntactische priming, congruentie en *monitoring*. Er is wel voorgesteld dat deze overeenkomsten veroorzaakt worden doordat encoderen en decoderen allebei gebruik maken van een (beperkt) werkgeheugen, maar dat kan weliswaar empirische overeenkomsten verklaren, maar geeft nog geen uitleg over waarom de processen ook wat betreft de onderliggende controleprincipes zo op elkaar lijken.

De ERA-taken

Hoofdstuk 2 onderzoekt op een directe wijze één bepaalde implicatie van het standaardmodel, namelijk dat als er aparte verwerkingseenheden zijn voor grammaticaal encoderen en voor decoderen, deze dan ook tegelijkertijd en onafhankelijk van elkaar hun werk zouden moeten kunnen doen. In twee experimenten werd deze voorspelling getest met behulp van een dubbeltaak waarin proefpersonen een zin stukje voor stukje moesten lezen (dus decoderen) en al doende veranderen (encoderen). De encodeertaak was in Experiment 1: de uitvoerzin in het meervoud zetten; en in Experiment 2: de invoerzin omzetten in indirecte rede. In beide experimenten waren de invoerzinnen echter soms ook ongrammaticaal. Bijvoorbeeld: in het eerste experiment was een van de grammaticale invoerzinnen: *Het meisje uit Londen verbleef in Delft*. Een ongrammaticale zin kon dan zijn: *De meisjes uit Londen verblijft in Delft*, of: *Het meisje uit Londen verblijven in Delft*. In alle gevallen was de gewenste respons: *De meisjes uit Londen verblijven in Delft*. Met reactietijden werd gemeten of proefpersonen de ongrammaticaliteit in de invoerzin opmerkten (het antwoord is nee) en of het ze moeite kostte om de veranderingen door te voeren (het antwoord is ja). De uitkomsten van de experimenten duiden er dus op dat als mensen een taak zoals deze moeten doen – tegelijkertijd encoderen en decoderen – ze eigenlijk alleen maar aandacht besteden aan de zin die ze op dat moment aan het produceren zijn. De verwerkingseenheden voor zinsbouw en zinsontleding lijken dus, in tegenstelling tot wat het twee-processormodel zou voorspellen, niet tegelijkertijd, en ook niet onafhankelijk van elkaar te kunnen opereren. Er kunnen kennelijk niet gelijktijdig twee syntactische structuren actief worden gehouden in ons taalverwerkingssysteem.

Er zijn verschillende verklaringen mogelijk voor deze bevindingen. Ten eerste zou een gedeeld werkgeheugen weer de boosdoener kunnen zijn: tenslotte moet om twee zinnen te onthouden, ook twee keer zoveel informatie in het geheugen vastgehouden worden, niet alleen de structuur, maar ook de woorden en de betekenis. Het bleek echter in onze experimenten dat zelfs wanneer de invoer en de uitvoerzin vrijwel dezelfde woorden en betekenis hadden, de reactietijden toch alleen maar door de productietaak werden bepaald. Het lijkt erop dat het twee-processorenmodel in strikte zin in ieder geval dus niet gehandhaafd kan worden.

Van de andere theoretische mogelijkheden die overblijven, valt de optie met twee aparte maar identiek functionerende processoren direct af, omdat deze ook de mogelijkheid van gelijktijdigheid van gebruik veronderstelt. Een extreme alternatieve verklaring is een model dat maar één enkele processor bevat die zowel encodeer- als decodeertaken op zich neemt, en dus maar één ding tegelijk kan doen. Een minder extreme variant is een model dat nog steeds gebruik maakt van twee gescheiden (mogelijk identieke) processoren, die samen een enkel werkgeheugen delen. Het feit dat dit werkgeheugen beperkt is, en maar één enkele structuur tegelijk kan verwerken of bevatten zou dan de gevonden resultaten verklaren. Toekomstig onderzoek moet uitmaken welke van deze twee modellen geldig is.

Conclusie

Uit beide benaderingen die in dit proefschrift zijn besproken blijkt dat de relatie tussen grammaticaal encoderen en decoderen hecht is. De ERA-experimenten hebben aangetoond dat er aanzienlijke overlap bestaat tussen de processoren: ze kunnen niet tegelijkertijd en onafhankelijk van elkaar werken. De woordvolgordepriming-experimenten hebben nogmaals laten zien dat er sprake is van gedeelde representaties tussen de processen van zinsbouw en zinsbegrip. Bovendien hebben ze licht geworpen op een nieuw aspect van grammaticaal encoderen, namelijk dat het proces van woordvolgordeberekening niet noodzakelijkerwijs volgt op het bepalen van de functionele structuur, maar er soms zelfs aan vooraf kan gaan.

Er zijn verscheidene verklaringen voor het nut van een hechte relatie tussen grammaticaal encoderen en decoderen. Een mogelijke functie is dat het productiesysteem gebruik maakt van het begripssysteem om spraakplannen en spraakuitvoer te controleren (Levelt, 1989; Hartsuiker & Kolk, 2001). Onlangs is ook geopperd dat de twee systemen zo nauw verbonden zijn opdat het productiesysteem alvast voorspellingen zou kunnen doen over wat er aan invoer te verwachten valt en aldus het begrijpen ervan vergemakkelijkt (Pickering & Garrod, 2007). Evenwel, beide benaderingen veronderstellen een “meester”-systeem dat de hulp inroept van een “slaaf”-systeem. De resultaten in dit proefschrift kunnen daarentegen voorzichtig geïnterpreteerd worden als aanwijzingen voor twee systemen (encoder en decoder) die als gelijken met elkaar samenwerken, of zelfs voor één systeem (een grammaticale “coder”). Om deze stelling hard te maken is nochtans verder onderzoek geboden.

Epilogue

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Nomi
Delft, 22 October 2007

Curriculum Vitae

Nomi Olsthoorn werd geboren in Delft, op 28 februari 1974. In 1992 behaalde zij haar gymnasiumdiploma aan het Sint Stanislascollege aldaar, en begon ze met de studie Kunstgeschiedenis en Archeologie aan de Universiteit Leiden, gevolgd door de studie Psychologie in 1993. Zij specialiseerde zich in de Functieleer en Theoretische Psychologie en liep stage bij het Human Communications Research Centre in Edinburgh. In september 1997 studeerde zij *cum laude* af op een onderzoek naar de procesmatige overeenkomsten tussen zinsbouw en zinsbegrip, waarna zij bij de vakgroep Cognitieve Psychologie in Leiden begon met het hier beschreven onderzoek naar grammaticale verwerking en syntactische priming. Als assistant in opleiding gaf zij diverse werkcolleges en begeleidde zij studenten met hun afstudeerprojecten. Daarnaast gaf zij colleges bij de opleiding communicatiewetenschap aan de Universiteit van Amsterdam, en werkte ze als docent bij het Instituut voor Psychologie aan de Erasmus Universiteit Rotterdam. Sinds augustus is zij werkzaam als postdoc onderzoeker bij het Amsterdam Centre for Language and Communication aan de Universiteit van Amsterdam, waar zij onderzoek doet naar cognitieve factoren die een rol spelen bij luistervaardigheid in (tweede) taalverwerking in het NWO-project: *Towards a theory of second-language proficiency: the case of segmenting and comprehending oral language*.