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Author
Gahl, Susanne

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by

Susanne Gahl

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Committee in charge:

Professor Charles J. Fillmore, Chair
Professor Jerome Feldman
Professor Sharon Inkelas
Professor Nina F. Dronkers

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TABLE OF CONTENTS

"Think of the strange associations that unexpectedly occur when you are falling asleep; your thoughts are confused and you can readily become disturbed by things that appear trifling during the day. [...] [T]he dominant characteristics of objects [...] cease to predominate, but are"leveled off" with secondary, less essential attributes. It then becomes terribly difficult to select the right attribute (hence, also, the right word) from the entire range of alternatives that now seem equally probable."

A. R. Luria, *The Man with a Shattered World*

Chapter 1: Introduction

1.1 Comprehension failure and comprehension impairments

The most surprising fact about language comprehension may be its high rate of success: We consider it the normal, expected outcome if a listener or reader successfully arrives at the intended and correct interpretation of a sentence. Yet, often a listener may fail to comprehend all or parts of a structure. Sentences may get misunderstood or not understood at all: Structures may get parsed incorrectly, or the listener may abandon the attempt to fit all the pieces of the puzzle into a single, coherent picture. "The horse raced past the barn fell" (Bever 1970), or "I couldn't fail to disagree with you less!" (Cowart 1996:47) are examples of sentences that induce comprehension breakdown in most listeners. As these examples show, comprehension breakdown can affect listeners who do not have any pathological comprehension impairments.

This study investigates sentence comprehension in aphasic individuals. The term "aphasia" refers to a family of language disorders that can arise due to injury to the brain. Language impairments in aphasia can range from mild word finding difficulties to severe disruptions both in speech production and in comprehension. Aphasic comprehension impairments can lead to comprehension failure in seemingly very simple sentences that do not normally induce comprehension breakdown in nonaphasic listeners. For example, aphasic patients may have severe difficulties understanding simple active and passive sentences such as the ones given in (1) and (2) below.

(1) The surgeon remembered the patient.

(2) The patient was remembered by the surgeon.

Sentence (1) is taken from a recent study of sentence comprehension in aphasia (Saffran et al. 1998). Aphasic comprehension difficulties with sentences of this type have been the focus of numerous studies. Aphasic patients may be unable to say, upon hearing sentences like (1) and (2), whether the sentences mean that it was the surgeon who remembered the patient, or whether the patient remembered the surgeon. Now consider examples (3) and (4) below. In sentence (3), the verb *remember* is used intransitively, i.e. it does not have a direct object (as in example 1) nor is it used in the passive voice (as in example 2). In sentence (4), taken from a study of nonaphasic sentence comprehension (Trueswell et al. 1993), the verb is used with a clausal complement.

(3) The surgeon finally remembered.

(4) The chef remembered that the recipe would require using fresh basil.

When a verb can be used in more than one type of syntactic frame, for example transitively or intransitively or with a clausal complement, we can ask which of these frames occurs most frequently. Information about the relative frequency of different uses of verbs has been shown to influence normal sentence comprehension. For example, Trueswell et al. (1993) argue that sentences in which a verb is found in its most frequent syntactic frame are processed faster than sentences involving syntactic frames that are less frequent for a given verb.

One of the premises of this study is that the mechanisms leading to aphasic comprehension breakdown with simple sentences need not be qualitatively different from the mechanisms of normal comprehension. It is the goal of this study to relate sources of abnormalities in aphasic comprehension to factors that are also present in nonaphasic comprehension.

Specifically, this study focusses on the role of frequency information of the kind just described in aphasic sentence comprehension. Returning to examples (1-3) above, which are repeated as (5-7) below, this study asks the question whether part of the difficulty aphasic patients experience with such sentences can be related to the relative frequency with which a given verb is used transitively or intransitively.

(5) The surgeon remembered the patient.

(6) The patient was remembered by the surgeon.

(7) The surgeon finally remembered.

The remaining sections of this chapter will describe research on nonaphasic sentence comprehension that motivate the current study, as well as some of the predicted effects of frequency information on aphasic sentence comprehension and the sentence types to be tested.

1.2 Sentence comprehension and frequency

A naïvely-designed automaton simulating the process of human sentence interpretation might treat each piece of the puzzle as equally important and analyze every bit of information with equal degrees of accuracy. Human sentence interpretation does not procede in this way. Instead, some types of information are taken into account more readily and more reliably than others. Moreover, human parsing is guided, not just by information already encountered in a given sentence, but also by expectations about information yet to be encountered, and about the final interpretation of a given structure.[1]

A factor that may cause some linguistic structures to be processed more easily than others is frequency of occurrence. The influence of frequency on language comprehension has long been recognized: More frequent elements are processed more easily and rapidly than less frequent ones.

Psycholinguistic research has turned up ample evidence that frequency of occurrence affects processing at many levels of linguistic structure. Thus, high-frequency words are recognized and read aloud faster than low-frequency ones (e.g. Morton 1969, Rayner & Duffy 1986, Dell 1990, Warrington & Shallice 1984). In addition, speech pauses are more likely to occur before low-frequency words, suggesting that low-frequency words may be more taxing on the speech production system than low-frequency ones (Levelt 1983).

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[1] Of course, we could construct a different kind of automaton that would proceed in exactly the same fallible yet efficient way as a human. In fact, researchers attempting to model human parsing are engaged in constructing just such automata.

Studies of ambiguity resolution have identified frequency effects at several other levels of linguistic structure besides the level of single word frequency. In temporarily ambiguous sentences, i.e. structures that initially permit more than one interpretation, the parse that conforms to the most frequent reading of an ambiguous element is often the one that is most readily adopted. As a result, structures whose correct interpretation relies on a less frequent reading tend to induce longer processing times and may result in parsing failure. Such effects have been documented, for example, for the relative frequency of different senses of a semantically ambiguous word (e.g. Rayner & Duffy 1986, Tabossi et al. 1987). The same type of effect has also been documented for syntactically ambiguous words. For example, the frequencies of *brush* as a noun and as a verb, or the frequency with which the word *that* represents a determiner or a complementizer affect processing times of sentences containing these words (Juliano & Tanenhaus 1994, MacDonald 1993, Tabor et al. 1997). The relative frequency with which a given lexical form represents the past tense or the past participle of a verb (Trueswell 1996) likewise affects reading times for temporarily ambiguous sentences. In all of these cases, more frequent forms are associated with shorter processing times than less frequent ones when listeners or readers process an ambiguous structure.

The observations just mentioned concern what we might call “structural frequencies”, i.e. the frequency of occurrence of a linguistic structure, be it a word, a sense, or a phrase-level construction.

An analogous set of findings concerns cooccurrence frequencies, or “contingent frequencies”, i.e. information on a word’s most frequent interpretation given a particular context. For example, MacDonald 1993 compares reading times for temporarily ambiguous sentences such as *The warehouse fires many workers each spring* and *The corporation fires many workers each spring*. The first of these sentences is read more slowly than the second one. According to MacDonald 1993, this is because the noun *warehouse* functions as a modifier more frequently than the noun *corporation*. As a result, there is a tendency to misparse the sequence *the warehouse fires* as a noun phrase initially, instead of a noun phrase followed by a verb. More generally, MacDonald 1993 interprets these findings to indicate that the relative frequency of a noun being used as a modifier and as head of a noun phrase affects the speed with which the noun will be processed in these structures.

Structural and contingent frequencies interact when sentences are processed. Lalami 1997 investigated comprehension of passive vs. active sentences. Passives generally occur much less frequently than actives. However, some verbs occur in the passive more frequently than others. Lalami 1997 shows that contingent frequency (the frequency with which a particular verb is used in the passive voice compared to the active), as well as structural frequency (active vs. passive) affect speed of processing.

1.3 Argument structure frequency

A type of frequency information that has been the focus of many recent studies of sentence comprehension are argument structure frequencies, which give rise to argument structure preferences, or lexical biases. Many predicates can occur in more than one syntactic environment. Returning to our earlier example, the verb *remember* can take a direct object, as in *The professor remembered the student*, or a finite clause, as in *The professor remembered the student was coming at four o'clock*, or an infinitival complement, as in *The professor remembered to turn in the grades*. When a lexical predicate occurs in one complementation structure more frequently than in another complementation structure, the predicate is said to have a lexical bias towards the first structure.[2]

Evidence from normal language processing suggests that argument structure preferences affect sentence processing: A number of studies have focussed on the effects of argument structure preferences on the processing of temporarily ambiguous structures. Three types of ambiguities in particular have been the focus of these studies: (1) prepositional phrase attachment, (2) the active transitive vs. complement clause ambiguities, and (3) reduced relative clauses.

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[2] Terms that refer to the syntactic and or semantic combinatorial properties of predicates include "valence", "argument structure" and "subcategorization frames". The term "valence" is used to describe the set of elements that a predicate can combine with. For example, the verb *sneeze* has one valence element. The term "subcategorization frame" refers to the syntactic environment of a predicate, not including the predicate's subject. For example, the relevant subcategorization frame for the verb *leave* in the sentence *Harry left* is the frame [_]. More narrowly, the term "subcategorization frame" is used to refer to information about the syntactic categories of the non-subject arguments (as opposed to adjuncts) of a predicate. The term "argument structure", by contrast, is often used to refer to semantic as well as syntactic information about all of the arguments of a predicate, including the argument that is instantiated as the subject. For example, the argument structure of the verb *leave* includes a "Theme"

Prepositional phrase attachment plays a role in parsing sentences like *We saw the man with the binoculars*, in which the prepositional phrase can either be an argument of the verb, or a modifier in the direct object noun phrase. A number of studies have shown that the verb's preference for an [_NP] or an [_NP PP] frame influences how the prepositional phrase is interpreted. Here again, sentences and sentence fragments that realize a verb's preferred subcategorization frame are read faster than sentences or fragments that realize dispreferred subcategorization structures (Taraban & McClelland 1988, Trueswell et al. 1993, Spivey- Knowlton & Sedivy 1995).

Argument structure preferences also affect the processing of an immediately postverbal noun phrase in sentence fragments like *The woman claimed the luggage*.... The noun phrase the luggage can either be the direct object of the verb *claim*, or it can be the subject of a clausal complement, as in *The woman claimed the luggage was hers.* Reading times for the postverbal noun phrase are influenced in part by the verb's preference for an [_NP] or a [_S]. Argument structure preferences for direct objects and complement clauses influence sentence processing, as evidenced in subjects' performance on a variety of tasks, such as self-paced reading tasks, sentence continuation tasks, and eye-tracking studies (Ferreira & Henderson 1990, Boland 1993, Trueswell 1993, Garnsey et al. 1997, Jennings et al. 1997).

Frequency effects have also been invoked in explanations of the well-known "garden-path" effects in sentences with reduced relative clauses such *as The train left at midnight crashed* or *The horse raced past the barn fell* (Bever 1970). The temporary ambiguity of

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argument that is instantiated as a subject in the sentence *Harry left*. I will be using the term "argument strings like *The train left...* arises in part because the verb *leave* can be transitive or intransitive. As suggested by Burgess (Burgess 1991) and again in Trueswell et al. 1994, and MacDonald et al. 1994, the difficulty of parsing this type of sentence may be due to the fact that the transitive use of the verb *leave* occurs far less frequently than the intransitive reading. As a result, the parser is biased towards the intransitive reading, which accounts for the long reading times and frequent parsing failure observed with these sentences. More specifically, MacDonald, Pearlmutter & Seidenberg 1994 showed that the frequency with which a verb is used transitively vs. intransitively, the frequency with which a verb form represents a simple past or a past participle, and the frequency with which a verb, when transitive, appears in the passive voice all influence how sentences with main verb/reduced relative clause ambiguities are processed.[3]

All of these examples show that, in nonaphasic comprehenders, lexical biases exert an effect on sentence processing. Of course, outside of 'garden path' sentences with reduced relative clauses, argument structure preferences do not ordinarily lead to comprehension breakdown in normal listeners. On the contrary, lexical preferences guide parsing and make parsing more efficient: Since, by definition, the most frequent structure is the one that represents the correct parse most often, a parser guided by frequency information will be more efficient than one that considers all possible parses equally.

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structure" to refer to syntactic and semantic information.

[3] Other factors, such as the semantics of the subject noun phrase and the two verbs (the matrix verb and the embedded verb) also affect the comprehension difficulty of these sentences (see Filip et al. 1998).

1.4 Sources of frequency effects

Why do frequency effects arise? Why should it be that the most likely structure is parsed most easily? Models of human comprehension – and other cognitive functions in which frequency of exposure may play a role – have incorporated frequency into models of mental representation in a number of ways. Juliano & Tanenhaus 1993 and MacDonald 1994 argue that effects of argument structure frequency arise because frequency affect the level of activation of syntactic alternatives and thereby influence the choice of interpretation of a structurally ambiguous sentence. For example, reading a word activates a variety of forms and structures to a degree that is in part determined by their frequency of occurrence in the context of that word.

Following MacDonald 1993, Juliano & Tanenhaus 1993, Jennings 1997 and other researchers in lexically-based constraint-satisfaction models of sentence processing, I assume that the lexical entry of a word consists of, among other things, a series of "frames", containing syntactic and semantic information about the word's arguments, one frame for each argument structure which the predicate can appear in. Argument structure preferences arise in this model because the frames have different activation levels, depending on the frequency of occurrence of the different structures for a predicate. If a word in a given sense is used frequently in a particular subcategory structure, the frame for this structure will be highly activated. Frames corresponding to structures which occur less frequently will be less highly activated. Parsing of a sentence will be easier the higher the activation of the syntactic and semantic frame that is invoked.

How might this conception of argument structure apply to lexical representations and sentence processing in aphasia? Is there reason to believe that levels of prior activation would vary depending on frequency of previous exposure in aphasic speakers/comprehenders? The next chapter will summarize some of the available evidence regarding frequency effects in aphasia. For the moment, it will only be noted that effects of word frequency have long been documented in aphasia. This being the case, it is reasonable to hypothesize that other exposure-based effects may be present in aphasia as they are in normal comprehension, and that lexical biases play a role in aphasic comprehension. In fact, as the next chapter will show, there is reason to believe that frequency effects may affect aphasic comprehension to an abnormally strong degree. To anticipate the arguments to be made in the next chapter, aphasic processing may be greatly hindered in structures that represent statistically unlikely patterns, due to pathological limitations on processing resources.

As an example, consider the sentences in examples (6) and (7) below that were tested in a very influential study by Caplan et al. (1980).

(6) The lion hit the tiger and the bear.
(7) The lion hit the tiger to the bear.

Caplan et al. found that aphasic patients had more difficulty understanding sentences like (7) in which the verb *hit* occurs in an [_NP PP] frame than sentences like (6) in which the verb occurs in a simple transitive ([_NP]) frame. Caplan et al.'s explanation for this is that a structure of the [_NP PP] type is more difficult than a simple transitive structure. Given the evidence presented above on the role of argument structure frequency information in comprehension, an alternative explanation suggests itself. The greater difficulty with sentences like (7) could be related to the fact that *hit* occurs in [_NP] structures far more often than in [_NP PP] structures. Corpus evidence is consistent with this approach: According to the argument structure probabilities collected by the COMLEX project (Grishman et al. 1994), of the first 100 occurrences of *hit* in the Brown corpus, only 8 involve an [_NP PP] frame, compared to 76 occurrences of *hit* in an [_NP] frame (Meyers et al. 1995). Perhaps, then, the greater difficulty patients had with sentences like (7) has to do with argument structure preferences of verbs like *hit*, rather than the [_NP PP] structure *per se*.

For reasons to be discussed in the next section, it cannot be assumed that argument structure frequencies affect aphasic and nonaphasic comprehension in the same way. In fact, there is reason to believe that some aphasic comprehension deficits arise precisely because lexical information, including information on argument structure frequencies is not exploited normally in aphasic comprehension.

1.5 The role of rapid lexical access in sentence comprehension

As argued in the preceding section, there is reason to believe that aphasic comprehension should be sensitive to lexical biases. As it stands, however, this conclusion ignores an important set of research findings that form the second source of motivation for the present investigation. These are findings suggesting that lexical information may not enter into aphasic sentence comprehension in the same way as in normal sentence comprehension. Indeed, certain types of aphasic sentence comprehension impairments may arise precisely as the result of a failure to utilize lexical information efficiently.

Before a parser can make use of information on argument structure or argument structure preferences, information associated with a predicate first has to be accessed. Research in normal comprehension over the past two decades has shown that lexical information is activated throughout the course of sentence processing (as opposed to at a later, 'post-syntactic' stage in the comprehension process). Detailed lexical information is normally made available very rapidly, as evidenced by rapid priming effects (cf. e.g. Tyler 1989), and is used rapidly during sentence comprehension (e.g. see Boland et al. 1995 for an overview, Clifton et al. 1984, Ford et al 1982, MacDonald 1993, Tyler 1989).

In many aphasic patients, lexical processing is severely disrupted, both with respect to the nature of the information that is accessed, and with respect to the speed with which information is accessed and subsequently decays. It is an open question to what extent disruptions in lexical access are characteristic of specific clinical categories of aphasia. The next chapter will review evidence on abnormalities in lexical access in different aphasia types, especially Broca's and Wernicke's aphasia. There is currently no consensus on the nature of lexical access in these two aphasia types. It is likely that abnormalities in lexical access exist in all aphasic disorders. The nature of these abnormalities may vary in different aphasia types and perhaps in different individuals. For example, the obvious comprehension difficulties in Wernicke's aphasics have been interpreted as a deficit in activating specific lexical semantic information. There is also strong evidence from lexical priming studies of inconsistent lexical access in Broca's aphasics. The overall conclusion from these studies, simplifying somewhat, is that the time course of lexical activation in Wernicke's aphasics may be similar to normals. What is abnormal in these patients is exactly what information is accessed. In Broca's aphasics, by contrast, lexical access may be slower than normal, though qualitatively, the information that is retrieved may be normal.

Information on argument structure preferences is associated with individual lexical entries. Disruptions in lexical access may therefore affect access to verb argument structure information. In aphasia types that are characterized by disruptions in rapid access of lexical information, therefore, there is reason to believe that effects of lexical biases should be abnormally weak.

1.6 Predicted effects of lexical biases on aphasic comprehension

How would effects of lexical biases, be they abnormally strong or abnormally weak, manifest themselves in aphasic sentence comprehension? As in normals, when lexical biases are taken into account, we would expect comprehension to be slowed down and prone to failure in structures that do not conform to lexical biases. When lexical biases are not taken into account, on the other hand, we would expect preferred and dispreferred structures to be processed with equal speed and accuracy.

The remainder of this chapter describes an experiment designed to test these predictions.

1.7 The sentence types to be examined

The question to be explored in the present study is whether ease of sentence comprehension in aphasic comprehenders can be a function of argument structure preferences effects. If the reasoning in the preceding sections is correct, then the ease with which, for example, transitive sentences are processed should depend, among other things, on the frequency with which the main verb is transitive. In other words, it is the match - or mismatch - between the sentence type and the lexical bias of the main verb in the sentence that in part determines how easily the sentence will be processed .

Aphasic sentence comprehension impairments surface with structures that are far less complex than sentences with reduced relative clauses that induce nonaphasic comprehension breakdown. For example, many patients encounter serious difficulties with simple active and passive transitive sentences (see for example Caramazza & Zurif 1976, Heilman & Scholes 1976, Caplan et al. 1980, and Berndt et al. 1996). These sentence types - simple active and passive sentences - have been by far the most common types of sentences to be examined in studies of aphasic sentence comprehension. The examples in (8) and (9) taken from Caplan et al. (1980) are typical examples of the sentence types that have served as stimuli in numerous studies of aphasic sentence comprehension:

(8) The zebra hit the lion.

(9) The lion was hit by the zebra.

The reason why the contrast between active and passive sentences holds so much interest has to do with the order of major constituents in these sentences: the distinguished argument (i.e. the argument that is instantiated as the subject in the active, and that may be expressed in a prepositional phrase in the passive) precedes the main verb in the active and follows the verb in the passive. Many studies have found that aphasics have particular difficulty understanding sentences when the order of major constituents does not correspond to an Agent-Action-Undergoer sequence (e.g. Goodglass 1968, Caramazza & Zurif 1976, Heilman & Scholes 1976, Lesser 1974, Parisi & Pizzamiglio 1970, Shewan & Canter 1971, Taylor & Fox 1974, Grodzinsky 1986, and many others).

Examining active and passive sentences, Caramazza & Zurif (1976) focussed on a distinction between "reversible" and "irreversible" transitive sentences. The sentence "The boy ate the apple" is "irreversible" in the sense that there is only one plausible linking of semantic roles to the two noun phrases. By contrast, sentences like *The zebra hit the lion* or *The lion was hit by the zebra* are "reversible": either noun phrase could plausibly represent the Agent and Undergoer of the verb *hit*. While the aphasic subjects in Caramazza & Zurif's study had no particular difficulty understanding who ate whom in an "irreversible" scenario like *The apple was eaten by the boy*, their comprehension of "reversible" passives like *The cat was chased by the dog* was significantly impaired.

The observation that passive sentences elicit poorer performance in English-speaking aphasics than active sentences is not limited to "reversible" sentences, however.[4] More

[4] The reason why the subjects in Caramazza & Zurif 1976 and many similar studies performed well on "irreversible" sentences has to do with the fact that these studies used a sentence-picture matching task. For a reversible sentence such as *The dog chased the cat*, the subjects had to pick out the correct picture from an array that included a picture of a dog chasing a cat, as well as a picture of a cat chasing a dog. For an irreversible sentence such as *The boy ate the apple*, the only incorrect choices were based on lexical foils, e.g. a picture of a girl eating an apple. The pictures to choose from did not include a picture of an apple eating a boy (whatever such a picture would look like). Other studies have shown that

generally, sentences in which order of major constituents does not correspond to an agent- action-undergoer sequence often tend to present greater difficulty for aphasic subjects.

Many other sentence types besides passives in English allow or require an undergoer argument to precede the main verb. One such class would be simple active sentences with intransitive verbs, such as *Butter melts easily.* In the intransitive sentence *Butter melts easily*, the undergoer argument precedes the main verb, just as it does in the passive *The butter got melted.* Although countless studies have examined aphasic comprehension of active vs. passive sentences, surprisingly few have included intransitive verbs and sentences. If it is indeed the case that the order of major constituents is what makes passive sentences so difficult for aphasic patients, then the same would have to be true for intransitive sentences. If passives are interpreted purely on the basis of major constituent order, then intransitives and passives should often receive the same interpretation. Given that intransitives would seem to provide a perfect opportunity to tease apart the effects of major constituent order and passive voice, it is surprising how few studies have included intransitive sentences.

Consider the three sentences in 10(a-c):

(10) a. The cook melted the butter

b. The butter got melted by the cook

c. The butter melted (in the pot).

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comprehension of "irreversible" passives is also impaired: Schwartz et al. 1987, Ansell and Flowers 1982.

As these examples show, the verb *melt* can be transitive or intransitive. In the first sentence, the first noun phrase represents an Agent argument. In the other two sentences, the first noun phrase represents an Undergoer argument. In light of the discussion of lexical biases, we can ask if the degree of difficulty of the three sentences depends on the frequency with which the verb *melt* is transitive rather than intransitive.

The verb *melt* is used intransitively far more often than transitively (cf. Gahl 1998). Based on this fact, the transitive sentences with *melt* should be harder to process for normal listeners than transitive sentences with verbs that have a transitive lexical bias, such as *open*. Conversely, intransitive sentences with *melt* should be slightly easier than intransitive sentences with *open*. Table 1 below summarizes these claims and completes the paradigm of sentence types:

Table 1: Transitive and intransitive sentences containing verbs with transitive and intransitive lexical bias

	melt - intransitive bias	**open - transitive bias**
conforming to verb bias	The butter melted.	My neighbor opened the door. The door was opened by my neighbor.
not conforming to verb bias	The cook melted the butter. The butter was melted by the cook.	The door opened.

The sentences in table 1 are the sentence types that will be the focus of the present study. The comparisons that are of interest in the present context are those between sentences in the first row, i.e. sentences that match the verb's bias, and sentences in the second row, i.e. sentences that do not conform to the verb's bias.

1.8 Motivation of the experimental task used

The generalization that reversible passive sentences are harder than actives for many aphasic patients is primarily based on findings derived from sentence-picture matching tasks. In patients with good single-word comprehension, responses to irreversible sentences in sentence-picture matching tasks tend to appear normal. The reason for this is that responses may not be based on a full analysis of the sentence, but instead on the interpretation of the content words in the sentence and on the patient's knowledge of the real world. To detect syntactic comprehension impairments with irreversible sentences, one would have to determine whether subjects were able to distinguish between a sentence like *The boy ate the apple* and its "reversed" counterpart, *#The apple ate the boy*. Implausible sentences are not easily depictable, however, at least not without the risk of distracting the subjects with the absurd quality of the scenes to be depicted. Hence, it is not possible to ascertain subjects' parsing abilities on irreversible sentences with a sentence-picture matching task.

The experimental task to be used in the present study is a plausibility judgment task. In a plausibility judgment task, subjects are asked to decide whether a sentence they heard or read describes a plausible scenario or not. One advantage of this task is that it allows irreversible sentences such as *The neighbor opened the door* to be tested. In plausibility judgment tasks, a subject who is only taking into account lexical and real-world knowledge would be led to accept all irreversible sentences as plausible, whether they are in fact plausible or not. A further advantage of this task is that it makes it possible to test patients with limited or no speech output.

1.9 Conclusion - The structure of the thesis

The present study is an investigation of the role of lexical biases in aphasic sentence comprehension. Specifically, this study examines the influence of verb transitivity bias on the comprehension of transitive and intransitive sentences.

The preceding sections contained very brief summaries of previous research. A more detailed review is given in chapter 2. Chapters 3 comprises the empirical portion of this thesis. The concluding chapter summarizes the data, arguments, and conclusions presentend in each of the preceding chapters. It reviews some of the implications of this research and suggests directions for future work.

Chapter 2

2.1 Introduction: Overview and outline of this chapter

Argument structure frequencies affect nonaphasic sentence comprehension, as the preceding chapter showed. Effects of argument structure frequency are one of several different types of frequency effects that have been documented in normal language processing. There is abundant evidence showing that frequent linguistic structures are processed faster than less frequent ones in normal comprehension.

The goal of the current study is to explore effects of argument structure frequencies on aphasic sentence comprehension. Few available studies provide any direct evidence on this point. There is, however, ample evidence showing that other types of frequency effects do exist in aphasic processing. Such evidence provides strong motivation for investigating the role of argument structure frequency information in aphasic processing: To the extent that other types of frequency effects exist in aphasia, one would expect to also find effects of argument structure frequency, all other things being equal.

An additional set of facts motivate an investigation of the extent to which aphasic comprehenders appear to be sensitive to argument structure frequency information: Effects of argument structure frequency arise in nonaphasic comprehension in part because information associated with individual lexical items is accessed very rapidly and with a high degree of accuracy during comprehension. Aphasic language processing, on the other hand, is subject to disruptions in lexical processing which may affect the quality of the information that is retrieved, as well as the speed with which it is retrieved. The extent to which disruptions in lexical access might be responsible for aphasic comprehension breakdown at the sentence level is a focus of current debates in aphasia research. Exploring the extent to which aphasic and nonaphasic listeners are sensitive to verb argument structure frequency is of immediate relevance to these debates.

A number of researchers have argued that an additional source of aphasic comprehension difficulties, besides abnormalities in lexical processing, are pathological limitations on processing resources. Operating under such limitations, patients may still be able to interpret simple structures, while failing to process more complex structures. Resource limitations may also prevent the system from utilizing lexical information when complex structures are being processed. Since resource limitations may be more or less apparent, depending on the type of linguistic structure to be processed, sentence type (for instance, active vs. passive voice) can be expected to interact with the degree to which argument structure frequency affects sentence comprehension.

This chapter discusses the implications of previous research for the expected effects of verb bias on patients with different aphasia types. The structure of the chapter is as follows: Section 2.2 discusses effects of word frequency in aphasia, which suggest that verb biases should also have an effect on aphasic comprehension. Sections 2.3-5 introduce a caveat to this suggestion, in the form of evidence for disruptions in processing of lexical information in aphasic disorders. Such disruptions may affect different aphasia types differently (section 2.4), and may interfere with argument structure preference effects (section 2.5). Section 2.6 discusses a recent study that reported no effect of verb argument structure frequencies on fluent aphasic patients. Sections 2.7 and 2.8 discuss the evidence for resource limitations in aphasic comprehenders and expected interactions between sentence type and conformity to verb bias.

2.2 Frequency effects in aphasia

Despite the large number of recent studies investigating frequency effects in normal sentence comprehension, there are only relatively few comparable studies in aphasic comprehension. It is surprising that this should be so, since single-word frequency has long been known to affect aphasic language. High word frequency is often associated with faster and more accurate lexical access, both in comprehension and in production. This effect has been reported for patients in a range of clinical aphasia types. For example, Silver & Halpern (1993), in a study of 30 aphasics, including 10 Broca's, 10 Wernicke's, and 10 anomic aphasics, report that less frequent words were more difficult for all patient groups on four different tasks that were tested: oral and written picture naming, auditory comprehension, and reading comprehension. Similarly, Gerratt & Jones (1987) report that their group of six fluent and six nonfluent patients all performed similarly to nonaphasic controls in that high-frequency words elicited faster reaction times task than low-frequency ones in a lexical decision. Ellis et al. (1983) and Kay & Ellis (1987) present single case studies of a patient with Wernicke's aphasia, and a patient with anomic aphasia, respectively. In both patients, single word production tended to be better for high-frequency words than for low-frequency ones, both in spontaneous speech and in reading aloud.

Luzzatti et al. (1999) report the case of an Italian-speaking patient with Broca's aphasia who performed faster on high-frequency morphologically complex forms than low-frequency ones on variety of tasks requiring lexical retrieval, including lexical decision on spoken and written stimuli, repetition, and reading aloud. Luzzatti et al. conclude from this that high-frequency morphologically complex forms are stored as complex units, i.e. as whole word forms, whereas low-frequency ones have to be parsed into their component morphemes when they are encountered. Since parallel observations also exist for nonaphasic listeners, and since the word-frequency effects in aphasia are widely attested, it is to be expected that many patients should exhibit the same pattern.

Several studies have reported reverse frequency effects in aphasic patients. For example, examining a mixed group of eight aphasic subjects, Breedin et al. (1998) found that, for some subjects, verb retrieval was better for low frequency, semantically highly specific verbs compared to high frequency, semantically 'light' ones. Similarly, Marshall et al. (1998) report the case of a patient who showed markedly better comprehension on low-frequency nouns such as *ottoman* compared to higher-frequency ones such as *chair*. Marshall et al. attribute this effect to the greater semantic richness of *ottoman* compared to *chair*. More generally, for a given set of words, frequency can sometimes be inversely correlated with semantic complexity: very general, semantically 'light' words may be more frequent than semantically more specific words that hold many semantic clues and may therefore make it easier for the speaker to retrieve at least some of the relevant information.

Going beyond the level of single word comprehension and production and looking at morphemes and words in context, a small number of researchers have pointed out possible connections between frequency and ease of processing in aphasic speech.

A connection between fluency and frequency was recognized as early as Goodglass et al. (1969) in a study of aphasic speakers' use of inflectional morphemes, and was pointed out again in Goodglass & Menn (1985). Both of these studies try to explain the fact that the speech of fluent aphasics tends to contain more inflectional morphemes than that of nonfluent aphasics. In this context, Goodglass & Menn (1985) point out that

> "[g]rammatical morphemes as a group tend to be overwhelmingly predictable from context and hence likely to be carried along as highly sequential probability 'completions' in the speech of fluent aphasics, notably in those who are anomic and paragrammatic." (Goodglass & Menn 1985:25).

Menn et al. (1998), in a study of both English-speaking and Japanese-speaking aphasics, extend this proposal to verb valence preferences. Menn et al. report that, in producing narratives, aphasic speakers tend to mention the same semantic elements in a story as nonaphasic speakers. Furthermore, the relative order of a verb and its noun phrase arguments within a clause tends to conform to the pattern of the verb's most frequent syntactic and semantic frame[1]. One reasonable interpretation of this finding, Menn et al. conclude, is that when a verb is activated, its most frequent frame will have a lower activation threshold, facilitating production of a clause instantiating that frame.

It is unfortunate that these types of context-sensitive frequency effects (high sequential probability and relative frequency of verb subcategorization frames) have not been taken up in many discussions of aphasic comprehension.

The only study to date to focus on the effects of verb valence preferences on aphasic processing is that of Russo et al. (1998). For reasons to be reviewed in the next section,

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[1] Menn et al. use the notion of valence frame to include information on the semantic roles of a verb's arguments as well as their syntactic realization.

Russo et al.'s hypothesis was that, unlike nonaphasic controls, fluent aphasics would not show increased reaction times for the non-preferred frames compared to the preferred frames. We will return to a more detailed discussion of this study in section 2.4 below.

2.3 Effects of abnormalities in lexical access

The role of lexical factors in normal sentence comprehension has been the focus of much research in recent years (see e.g. Boland 1996 for an overview; for an early collection of studies exploring the effects of lexical access on sentence comprehension cf. Marslen-Wilson & Tyler 1980).

Early research in aphasic language comprehension typically focussed either on lexical deficits or on syntactic deficits. Indeed, the realization that sentence comprehension could be impaired in the face of good comprehension of words in isolation (Caramazza & Zurif 1976) constituted a major milestone in aphasiology. Taking this finding as their starting point, subsequent studies purposely focussed on structural factors, rather than on any lexical influences on aphasic sentence comprehension. Studies that sought to trace structural (therefore, by assumption, non-lexical) factors in sentence comprehension deficits include Bradley & Zurif (1980), Schwartz, Saffran & Marin (1980), Saffran, Schwartz & Marin (1980), Caplan, Baker & Dehaut (1985), Caplan & Futter (1986), Grodzinsky (1986), Caplan (1987), Druks & Marshall (1995), Caplan & Hildebrandt (1998), and many others. These studies turned up interesting and at times contradictory findings in aphasic comprehension on a variety of syntactic structures. The specific findings of these studies are not immediately relevant for the present discussion. Taken together, however, these studies show that structural factors alone are insufficient for predicting which sentences or sentence types present special difficulties for aphasic comprehenders and hence add to the motivation for investigating lexical factors in aphasic sentence comprehension.

A number of more recent approaches have sought to relate aphasic comprehension deficits to abnormalities in accessing or utilizing lexical information, for example Friederici & Kilborn 1989, Shapiro & Levine 1990, Haarmann & Kolk 1991, 1994, Hagoort 1993, 1997, Swaab et al. 1995, 1997, Friederici & Kilborn 1989, 1994, Swinney et al. 1989, and Blumstein et al.1998). For these researchers, the suspected direction of the cause-and-effect relation between the failure to process sentence-level structures and the failure to process words in sentences has come to be reversed: While earlier studies assumed that any breakdown in producing or comprehending words in sentences was due to a breakdown of syntactic operations, these more recent models hold that a failure to process lexical information can result in impairments at the sentence level. More specifically, many of these researchers have sought to relate the breakdown at the sentence level to abnormalities in the time-course of activation and coordination of lexical and other types of linguistic information. Studies that have focussed on abnormalities in the level or the time-course of activation of lexical information in aphasic subjects include Milberg et al. (1987), Milberg et al. (1995), Chenery et al. (1990), Prather et al. (1991), (1992), Ostrin & Tyler (1993), Hagoort (1993), Swaab et al. (1997). Such abnormalities have been reported for patients with different types of aphasia, including both Broca's and Wernicke's aphasia.

Given that many aphasic patients appear to have problems accessing or utilizing lexical information, effects of subcategorization preferences on aphasic sentence comprehension could be abnormally weak compared to normals: If argument structure information guides normal sentence comprehension, then breakdowns in sentence processing could arise as the result of a failure to exploit lexical information. Put another way, parsing preferences for more frequent forms increase parsing efficiency. When frequency information is not taken into account, parsing may become much less efficient.

2.4 Effects of aphasia type

Abnormalities in the processing of lexical information have been reported for both Broca's and Wernicke's aphasics (Hagoort 1993, Swaab et al. 1997). However, there is considerable disagreement about this issue.

A number of studies report that the time course of lexical activation is abnormal in Broca's, but not Wernicke's aphasics. Milberg et al. (1988) argued, based on data from a primed lexical decision task, that lexical access in non-fluent aphasics was greatly slowed, though accurate. As a result, automatic lexical processing is impaired in these patients, as evidenced in priming studies and other on-line methodologies. By contrast, controlled lexical access, as evidenced in off-line tasks that leave the subject enough time to make a conscious effort to understand the meaning of a word or to apply a deliberate response strategy, may not be impaired in Broca's aphasics, although it is impaired in Wernicke's aphasics.

This difference between aphasia types – impaired automatic access in Broca's, but not Wernicke's aphasics – has been reported in a number of studies of lexical priming. Milberg et al. (1995) argue for example that Broca's rely on heuristic strategies more than Wernicke's aphasics or nonaphasic controls. In fluent aphasics, Milberg et al. (1988) found frequent lexical errors, which Milberg et al. attribute to a "fairly nonspecific lexical access system". Blumstein et al. (1991) report abnormal patterns of syntactic priming (facilitory and inhibitory effects of syntactic phrases) in Wernicke's aphasic patients.

These findings, and the corresponding characterizations of lexical impairments in different aphasia types, are by no means universally accepted. Hagoort (1997), for example, report no abnormalities in automatic lexical access in Broca's aphasics, as evidenced in semantic priming.[2] Tyler et al. (1995) find no evidence for slowed or otherwise abnormal access to lexical information in a mixed group of four aphasic patients, characterized as two non-fluent aphasics, one anomic, and one fluent aphasic.

Several studies find that Wernicke's aphasics have disturbances in accessing or utilizing lexical information, whereas Broca's aphasics' performance is qualitatively similar to, though perhaps slower than, that of nonaphasic controls. Blumstein et al. (1983) investigate aphasic comprehension of sentences containing reflexives, comparing the factors affecting Wernicke's, Broca's and conduction aphasics' interpretation of reflexive pronouns. Blumstein et al.(1983) report that Wernicke's aphasics are less able

[2] Results from recent on-line studies suggest that rather than lexical access, the integration of lexical information into the preceding word or sentence context might be impaired in these patients (e.g. Hagoort 1990, 1993, Hagoort et al. 1996, Swaab et al. 1995, Tyler & Ostrin 1994, Tyler et al. 1995). More specifically, Hagoort (1993) has suggested that comprehension problems in Broca's and Wernicke's aphasics result from a temporal mismatch between lexical access and lexical integration, caused by a delay in the integration of lexical information with the context representation.

to consider lexical semantic cues in determining antecedents of reflexive pronouns, compared to Broca's and conduction aphasics and nonaphasic controls.

Kegl (1995) argues that Broca's aphasics (or at least a class of Broca's aphasics that she identifies as "agrammatic"), in contrast to Wernicke's and anomic aphasics, have intact lexical representations, and impairments in sentence processing that are due to processing of lexical information. Evidence for this claim comes from the fact that, according to Kegl (1995), Broca's show an impairment affecting one lexically defined class (unaccusative verbs). Wernicke's aphasics, because syntax is "intact" and lexical access is disrupted, are hypothesized to show no specific impairment that would affect a specific class of lexical items. Wernicke's aphasics, according to Kegl (1995) are "presumed to be incapable of adequately accessing the lexicon" and, as a consequence, are expected to show "either a random syntactic patterning or a more stereotypic sentence frame that instantiates some default case" (Kegl 1995: 192). This last hypothesis, that Wernicke's aphasics may rely on a "more stereotypic sentence frame that instantiates some default case" is intriguing, although Kegl does not say whether frequency of usage might play any role in determining what the default case is.

Finally, it is also possible that there is a trade-off relationship between lexical access and processing of syntactic structures. Such a trade-off effect could lead to apparent disruptions in lexical processing in all aphasia types, as well as in normals. Comprehension of lexical and syntactic information may share attentional or other resources. Odell & McNeil (1998), for example, argue that comprehension of lexical semantics and syntax share an attention resource. Odell & McNeil (1998) used a dual task, in which subjects simultaneiously reponded to a word- picture matching task and a sentence-picture matching task. Odell & McNeil (1998) tested nine aphasic subjects (of unspecified clinical types) and found that accuracy on the word-picture matching task decreased as attention was directed towards the sentence-picture matching task.

2.5 Effects of disruptions in accessing information connected with verbs

Many aphasic patients appear to have more difficulty producing verbs than nouns (cf. Miceli, Silveri, Villa & Caramazza 1984, Zingeser & Berndt 1988, Zingeser & Berndt 1990). Greater difficulty with verbs compared to nouns has sometimes been argued to be characteristic of agrammatism in Broca's aphasia (e.g. Myerson & Goodglass 1972, Saffran et al. 1980), but has also been found in patients with Wernicke's aphasia (Williams & Canter 1987, Berndt et al. 1997, Breedin et al. 1998), indeed in all aphasia types, possibly excepting certain anomic aphasics.

Anomic aphasics are sometimes characterized as the only group of aphasic patients that appears to have greater difficulty using nouns than verbs (e.g. Zingeser & Berndt 1990). This general observation does not hold true for all patients who carry a diagnosis of anomic aphasia. For instance, Breedin and Martin (1996) report impairments in verb comprehension (comprehension of verb argument structure) in two anomic patients, as well as two Broca's. It has to be kept in mind that the diagnosis of anomic aphasia is applied to an extremely heterogeneous group of patients. Unlike Broca's and Wernicke's aphasics, who as a group are consistently nonfluent and fluent, respectively, anomic patients fall along very different points of the fluency spectrum.[3] Of Breedin & Martin's anomic aphasics, one was 'borderline Broca's', the other one was fluent. The catch-all nature of this diagnostic category is in part responsible for the great diversity of behavioral patterns observed in this group.

Verbs may be particularly difficult to access for many aphasic patients, then. At the same time, lexical information associated with verbs is crucial in sentence comprehension. If verb argument structure is not processed normally, then widespread disruption in sentence comprehension should be expected. Unavailability of verb argument structure and related information should interfere, not just with comprehension of the verb itself, but also with the interpretation of its arguments. Because of this, some researchers have focussed on studying retrieval of lexical information associated with verbs.

An early study that relates 'agrammatic' sentence comprehension patterns to deficits in verb retrieval and comprehension is McCarthy & Warrington (1985)'s case report on a patient with progressive aphasia. More recently, and more immediately relevant to the current study, Berndt et al. (1997) reported that greater difficulty with verbs than with nouns was significantly correlated with the failure to comprehend semantically reversible sentences.

Some studies report impairments at the sentence-level affecting semantically-definable classes of verbs, e.g. Breedin and Martin (1986), Breedin et al. (1998), Breedin and Saffran (in press). Specifically, the verb classes investigated in these studies were

[3] The diagnostic category of fluency refers to the patient's average number of words per utterance. Although fluency is thus a gradient notion in principle, patients tend to cluster in nonfluent and fluent

definable based on verb argument structure. Category-specific impairments of naming or comprehension of nouns are not uncommon (see for example Goodglass et al. 1986, Hart et al. 1985, Hart and Gordon 1988, Warrington and Shallice 1984, Warrington and McCarthy 1987). Given the existence of category-specific deficits affecting nouns, it is not surprising that analogous effects should exist for verbs.

A small but growing number of studies have examined the influence of verb argument structure information in aphasic sentence processing. In particular, the effect that has become known as the 'argument structure complexity effect' has been the focus of a series of studies that have attempted to relate lexical and syntactic factors in aphasic sentence processing.

The argument structure complexity effect (Shapiro, Zurif & Grimshaw 1987) is an effect of the number of different subcategorization frames a verb can appear in. The effect consists in slowed processing whenever a verb is encountered that has an especially high number of different subcategorization possibilities.[4]

Shapiro & Levine (1990) and Shapiro et al. (1993) investigate the argument structure frequency effect in aphasic sentence processing. Both studies report that Broca's aphasics do exhibit the argument structure complexity effect, whereas fluent aphasics (including four Wernicke's, one conduction, and one fluent anomic aphasic) do not. In a lexical decision task, Broca's aphasics, just like normal controls, perform less accurately and more slowly when confronted with verbs that can occur in several different subcatego-

regions of the spectrum.

[4] Schmauder (1991) and Schmauder et al. (1991) argue that the findings reported in Shapiro & Levine (1990) are inconclusive, because of failure to replicate the argument structure complexity effect with normal subjects. Schmauder (1991)a and b reports that the argument structure complexity effect may not

rization frames. Fluent aphasics, by contrast, do not show the argument structure complexity effect, and hence do not appear to be sensitive to this aspect of verb argument structure.

2.6 A related study: Russo et al. (1998)

Shapiro et al.'s findings were the starting point for Russo et al. (1998)'s study.In this study, fluent aphasics were predicted to show no effect of verb bias, unlike nonaphasic controls. The basis for this prediction was that the fluent aphasics in Shapiro et al.'s studies did not show the normal effect of argument structure complexity. The reason why fluent aphasics do not show this effect, Russo et al. reason, may be that these patients do not have intact (access to) lexical representations of verb argument structure. This section will discuss Russo et al's study in detail, since its assumptions and predictions are highly relevant to the current study.

Russo et al. used the methodology and the stimuli that are used with normal subjects in Clifton et al. (1984) and Shapiro et al. (1993). These studies examine the influence of conformity to verb bias in a cross-modal lexical decision task. Subjects listen to transitive and intransitive sentences like the following (examples from Russo et al. 1998:538):

(1) The ageing pianist taught his * solo with great dignity.

(2) The ageing pianist taught with his * entire family.

While the sentence is being presented auditorily, a visual probe appears briefly on a screen, at the point marked with the asterisk in examples (1) and (2) above. Subjects have to decide whether the probe, which consists of a string of letters, is an English word or

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generalize to other experimental paradigms besides the cross-modal lexical decision task used by Shapiro and co-workers.

not. In one half of the test sentences, the verbs are used in their preferred form (transitive or intransitive). In the other half of the test sentences, the verb occurs in its non-preferred form. Estimates of subcategorization preferences were based on data from Connine et al. (1984)'s norming study.

Using this methodology, Clifton et al. (1984) and Shapiro et al. (1993) find that reaction times in the lexical decision task increase for nonaphasic subjects when the verbs are encountered in their non-preferred syntactic environment, indicating that normal listeners are sensitive to argument structure preferences.[5]

Russo et al. (1998) apply this methodology to aphasic subjects. Russo et al. test five fluent aphasics and five nonaphasic controls. Their hypothesis is that fluent aphasics would <u>not</u> show increased reaction times for the non-preferred structures compared to the preferred structures. Russo et al.'s findings confirm this prediction, in that the five aphasic subjects as a group do not show the effect, whereas the nonaphasic controls do.

There are individual differences among the subjects in Russo et al. (1998). Of the five fluent aphasics tested in the study, one was a Wernicke's aphasic. Interestingly, the Wernicke's aphasic did show increased reaction times on the trials involving dispreferred argument structures. Hence it is possible that the absence of an effect only applies to the heterogeneous group of fluent aphasics included in the study, not to fluent aphasics in general, and not to Wernicke's aphasics in particular.

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[5] Following Clifton et al. and Shapiro et al. (1993), I am using the term "argument structure", rather than subcategorization.

Russo et al. predict that fluent aphasics should not show effects of argument structure preference, since, by their interpretation of Shapiro et al.'s observations, fluent aphasics do not access information on verb argument structure. Hence, according to Russo et al., fluent aphasics also do not access information on verb argument structure preferences.

There is another possible interpretation of Shapiro's findings, however. Shapiro's findings are also consistent with the assumption that fluent aphasics only activate one argument structure, perhaps the most frequent one. This would explain why these patients do not show the argument structure complexity effect, since at most one argument structure is activated, regardless of how many other frames a verb can occur in. At the same time, if fluent aphasics activate only the most frequent subcategorization frame, then they should show effects of sentence conformity to verb bias.

The fact that Russo et al. report a contrast between their aphasic subjects and nonaphasic controls may be due to problems with the cross-modal lexical decision task. Fluent aphasics perform abnormally on such tasks. The difference in performance between the aphasic subjects and the nonaphasic controls may therefore be due to other factors besides availability of lexical information on argument structure preferences in particular.

Given the wealth of evidence, however varied and controversial, for inconsistent rapid processing of lexical information in aphasic patients, Russo's hypothesis may well be right for some patients. Some aphasic listeners may indeed show abnormally weak tendencies to take argument structure preferences into account, compared to nonaphasic listeners. However, it is not clear, based on the available evidence, that fluent aphasics in particular should not have access to information on verb argument structure. Indeed, most of the available evidence would seem to point in the opposite direction: nonfluent aphasics may access this lexical information too slowly to benefit from it.

Leaving aside for a moment the issue of disruptions in lexical access, we can ask the question what effects verb argument structure preferences could have on aphasic comprehension. In the next section, I will argue that there is reason to believe that the magnitude of these effects should be increased in aphasic comprehension, with potentially disastrous effects.

2.7 Effects of resource limitations and sentence complexity

Why is it that argument structure preferences have an effect on processing times in nonaphasic listeners? In Russo et al.'s words it is because, when encountering a dispreferred structure, "the processor will be 'surprised' and processing load will increase" (Russo et al. 1998: 538). In aphasic comprehenders, this increase in processing load, as we shall see in this section, affects a system that may already be under severe stress from reduced processing capacity.

A number of recent analyses have suggested that aphasic comprehenders resemble normal listeners under adverse processing conditions. Several different types of evidence lend support to these analyses.

The first type of evidence that aphasic impairments may reflect resource limitations is task demands affect the degree of apparent impairment. For example, Ni et al. (1998) report that nonfluent aphasics' production of past tense verb forms improves when task demands were kept simple: the subjects are able to produce the correct verb forms when memory load is lessened. Similar findings are reported for Dutch in Hofstede and Kolk (1994). Friederici and Frazier (1992) report that Broca's aphasics' performance in a sentence-picture matching task is significantly worse when task demands are increased (by presenting the picture set for sentence-picture matching only after the sentences have been presented auditorily). Interestingly, Friederici and Frazier report that Wernicke's aphasics do not seem to be affected by the change in task demands.

A second type of support for likening aphasic impairments to effects of adverse processing conditions in nonaphasic speakers comes from the gradient and highly variable nature of aphasic deficits. Kolk and van Grunsven (1985) emphasize the high amount of variability, both between patients, and between sentences, found in so-called agrammatic subjects. This variability, together with variability linked to variations in the experimental tasks, leads them to propose a theory of agrammatism, Adaptation Theory, that characterizes agrammatic symptoms as the result of adaptive strategies that the patients adopt.

Perhaps the strongest evidence for accounts of aphasia as reflecting resource limitations comes from studies reporting that nonaphasic speakers under adverse processing conditions show "symptoms" that are qualitatively the same as those of aphasic patients. These studies include Miyake et al (1994, 1995), and Dick et al. (1998). Miyake et al. (1994), for example, argue that reductions in working memory capacity for language lead to a slowing down of computational processes when processing demands are high. This makes it harder for aphasic patients to complete all the necessary processing steps in the course of sentence comprehension. In support of this claim, Miyake et al. (1994) report two experiments in which the computational demands on nonaphasic adults were increased by increasing the rate of presentation in a rapid serial visual presentation (RSVP) task. The RSVP task involves presenting words for brief intervals on a computer monitor, one at a time. Miyake et al. tested nonaphasic adults on sentence types that had previously been tested in studies with aphasic patients, such as Caplan et al. (1985). At normal presentation rates, nonaphasic adults made few or no errors on the test sentences. When the presentation rate was increased, the nonaphasic subjects showed the same patterns of comprehension failure as the aphasic patients described in Caplan et al. (1985).

Miyake et al (1995) and Carpenter et al. (1994) note an additional fact that is of great importance to the current investigation. These studies report that the effects of sentence complexity on sentence comprehension are greatest in subjects with relatively low working memory capacity, as measured by reading span tasks, and are magnified (in a super-additive fashion) for complex sentence types. For example, while low-span readers may perform only slightly worse than high-span readers on simple active transitive sentences, their performance worsens dramatically on certain kinds of relative clauses.

Based on this, we predict the effect of nonconformity to verb bias to be more pronounced the more complex the sentence - for those patients that are taking verb bias into account. If aphasic sentence comprehension deficits are reflecting resource limitations, then the effects of lexical biases could be catastrophic whenever a dispreferred structure is encountered: Processing rarer structures will be more costly; hence taking scarce resources away from the processor. This comes at the expense of processing other types of information. As a result, processing may break down precisely as a result of accessing lexical information.

2.8 Expected effects of verb bias on transitive and intransitive sentences

Verb argument structure preference should emerge more clearly in complex sentence types than in simple ones. While it is not clear exactly what makes one sentence type more complex than the next one, this section reviews evidence showing that aphasic comprehenders tend to have far more difficulty processing passive sentences compared to active sentences. That being the case, we may infer that passive sentences are harder to process and that a contrast between active and passive sentences may elicit a different magnitude of the effect of verb argument structure preferences.

There are numerous studies that report aphasic comprehenders performing worse on reversible passive sentences than on reversible actives, for example Caramazza & Zurif (1976), Caplan, Baker & Dehaut (1985), Caplan (1987), Caplan (1992), Bradley & Zurif (1980), Caplan & Futter (1986), Caplan & Hildebrandt (1998), Druks & Marshall (1995), Schwartz, Saffran & Marin (1980), and Saffran, Schwartz & Marin (1980). In fact, this pattern of comprehension - relatively good performance on actives, poor performance on passives, in the face of good single word comprehension- has come to define 'agrammatic' comprehension for some researchers. The extent to which passives in particular are especially vulnerable in 'agrammatic' comprehension appears to have been exaggerated. For example, Badecker et al. (1991) and Druks & Marshall (1995) report patients whose comprehension of reversible active sentences was as poor as or poorer than comprehension of reversible passives.

Indeed, Berndt et al. (1996), in a metanalysis of published cases and group studies of 'agrammatic comprehension' using sentence-picture matching tasks, report that the generalization just outlined only holds true for about a third of the patients reported on in the literature. Two other patterns of perfomance that are equally prevalent are (a) above-chance performance on reversible actives and passives, and (b) below-chance performance on both sentence types.

The finding that is most relevant to the present discussion is that, when there is a difference in performance on the two sentence types, passives almost invariably elicit poorer performance. This finding appears to hold for patients with different types of aphasia, including Broca's, Wernicke's, conduction, and anomic aphasics.[6] Studies that tested other aphasia types found that this pattern of miscomprehension was not limited to Broca's aphasics, but held for other aphasia types as well (e.g. Menn & Goodglass (1985) for Wernicke's aphasia, Caplan et al. (1985) for an unselected group of 37 aphasics, Caplan et al. (1996) for an unselected group of 46 aphasic patients, Naeser et al. (1987) for a group of 60 aphasic patients representing all types of aphasia recognized as clinical categories in the BDAE). Greater difficulty with passives compared to actives is not tied to a specific aphasia type, and is unlikely to be due to a single, localizable neuroanatomic cause. The strongest predictor for the degree of difficulty patients experience with passive (and other) sentences is overall severity of aphasic impairments, rather than

[6] The finding of 'agrammatic' comprehension, i.e. interpretation based on lexical content words, not syntactic structure, was initially not held to be restricted to Broca's aphasics and was also not restricted to comprehension of passive vs. active voice. Caramazza & Zurif (1976) showed that 'agrammatic' and conduction aphasics chose syntactic, but not lexical foils as frequently as target pictures for center-embedded relative clauses. In spite of this fact, 'agrammatism' is primarily associated with Broca's aphasia (e.g. Grodzinsky). The so-called 'agrammatic' comprehension pattern has been observed in

clinical aphasia type. This finding is the basis for capacity-based theories of aphasic sentence comprehension such as Haarmann et al. (1997).[7]

Aphasics' difficulties with passives compared to actives have been taken by some authors as evidence for a loss of syntactic abilities (e.g. with Caramazza & Zurif 1976, Caplan & Futter 1986, Berndt & Caramazza 1980, Grodzinsky 1986), or, in analyses based on GB frameworks, a loss of syntactic representations, esp. of functional categories (Ouhalla 1990, 1992). Others have interpreted the comprehension deficits as the result of patholog-ical limitations on processing resources (e.g. Miyake et al. 1994, 1995).[8] Overall severity appears to be the main predictor of difficulty with passives, as with other sentence types. On the basis of this, several researchers have argued that all aphasic patients share a common deficit. Hagoort (1993), for example, estimates that overall severity accounts for 60-81% of the variance in performance on comprehension experiments.

Passives also tend to be more difficult than actives for nonaphasic comprehenders under adverse processing conditions. For example, Miyake et al. (1994) report that a group of normal college students make significantly more errors on passive sentences than on actives when presentation rate is increased.

In sum, there is overwhelming evidence that passives tend to present more difficulties for aphasics of all clinical categories, as well as for normals.

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patients who cannot be classified as 'agrammatic' on the basis of their speech output, or who do not carry a clinical diagnosis of Broca's aphasia, the aphasia type thought to be associated with agrammatism.

[7] Taking issue with this claim, Berndt et al. (1997) argue that general limitations of working memory may account for patterns observed in groups of subjects, but fail to account for patterns obtained from individual patients.

[8] The two approaches need not be incompatible, although few studies atttempt to reconcile them. Conceivably, one could argue that the circumstances under which traces become unavailable are exactly those conditions that limit processing resources or create increased processing demands.

Transitivity may be another complexity factor, along with passive voice. A huge number of studies have examined the contrast between active and passive transitive sentences. Far fewer studies have examined the relative difficulty of intransitive and transitive sentences. The relative difficulty of active transitive, passive, and intransitive sentences is therefore difficult to estimate based on the available evidence.

A few studies have focussed on comparing transitive and intransitive verbs in single-word tasks, and a small number of studies have attempted to study the effect of transitivity on the processing of whole sentences. Kolk & Wejts (1996), Gottfried et al. (1997), and Kegl (1995) examine the processing difficulties posed by intransitive verbs, compared to transitive verbs. When presented in isolation, intransitive verbs may be harder than transitive ones Jonkers & Bastiaanse (1996, 1997) report that a group of Dutch-speaking Broca's aphasics tended to have greater difficulty with intransitive verbs than with transitive in an action-naming task and in sentence production in a picture description task. Jonkers & Bastiaanse (1997) further show that sentence production and action naming could be differentially affected by transitivity: All of the patients in the Jonkers & Bastiaanse (1997) study score significantly lower on intransitive than on transitive verbs in action naming. However, while some of their patients also scored lower on intransitives in the sentence production task, others performed better on intransitives than transitives in this task. Given that this finding is derived from single-word tasks, not sentence comprehension tasks, its implications for sentence comprehension are unclear.

On the other hand, Kim and Thompson (1998) found that a group of seven English-speaking aphasics characterized as 'agrammatic' performed significantly worse with transitive than intransitive verbs on a verb naming task and a categorization task (in which patients had to sort verbs by type (one-place, two-place, or three-place).

Gottfried et al.(1997) used a repetition task to probe aphasics' difficulty with intransitives. Gottfried et al. compared alternating and nonalternating verbs (i.e. verbs with and without transitive counterparts). Gottfried et al. found that, for alternating verbs, intransitives were not harder than transitive ones. This finding is particularly valuable because Gottfried et al. tested a variety of semantic types of grammatical subjects, including agentive and nonagentive, animate and inanimate, volitional and nonvolitional. For non-alternating verbs, intransitive verbs were indeed more difficult. The subjects in Gottfried et al.'s study were a group of eleven aphasics, including three Broca's aphasics, one TMA, and eight anomic aphasics.

In sum, intransitive sentences do not pose obvious greater demands on processing compared to active transitive sentences. The current study includes intransitive sentences as a type of control condition: the order of major constituents is partly the same as in passives.

In addition, there is evidence showing that there are other differences between different aphasia types that affect the processing of combinatorial semantic information beyond the word level. This in turn should affect the difficulty patients have with the semantic plausibility judgment task. Piñango & Zurif (1998) investigated two Wernicke's and three Broca's aphasics' ability to understand sentences such as *The girl jumped until da*wn.

Such sentences involve a phenomenon known as 'aspectual coercion': the verb *jump* by itself is normally understood to denote a single action. In *The girl jumped until dawn*, however, it describes a series of repeated actions. This difference in interpretation cannot be ascribed to the verb *jump* alone; it arises as a function of the whole sentence that the word appears in. The relevance of Piñango & Zurif's observation to the current discussion is that Wernicke's aphasics appear to have impairments in processing semantic information that go beyond their obvious problems with processing semantic information at the word level.

2.9 Summary and conclusion

We have seen that there is reason to believe that argument structure preferences could have an effect on aphasic sentence comprehension. We have seen, in addition, that disruptions in lexical processing may make argument structure information, in particular information associated with verbs, unavailable to some aphasic comprehenders. Although all aphasic comprehenders may in principle be sensitive to argument structure preferences, there is also reason to believe that, in comprehension, fluent aphasics may show this sensitivity with greater consistency compared to nonfluent aphasics: (1) there is evidence for slowed lexical access in nonfluent aphasics, (2) fluent aphasics' production of inflected forms may be driven by sequential probabilities.

Effects of verb argument structure preferences may have a catastrophic effect on aphasic listeners, inducing the same kinds of processing difficulties nonaphasic listeners have with the well-known garden-path sentences with reduced relative clauses. The next chapter presents an empirical investigation of these hypotheses.

Chapter 3

Effects of verb transitivity biases on aphasic comprehension of transitive and intransitive sentences.

3.1 Introduction

This chapter describes an experiment examining the effect of verb transitivity biases on the interpretation of transitive and intransitive sentences in aphasic listeners.

The preceding chapters reviewed evidence suggesting that verb biases influence processing load, provided that a listener successfully accesses lexical information. In normal comprehension, sentences not conforming to lexical biases induce increased processing times and higher error rates. As Russo et al. (1998:538) put it: "[T]he processor will be 'surprised' and processing load will increase." This factor may affect aphasic sentence comprehension, but has not been systematically examined. The goal of the present study is to identify effects of verb biases on the accuracy and speed with which active and passive transitive and intransitive sentences are processed.

The preceding chapter further reviewed evidence linking aphasic sentence comprehension deficits to abnormalities in lexical processing. Lexical information may not get integrated into the sentence parse consistently, due to delayed activation or fast decay of lexical information (Hagoort 1993), or due to limited processing resources (Haarmann & Kolk 1991, Haarmann et al. 1997). Given this, we can expect that in some aphasic listeners, lexical biases will abnormally <u>not</u> affect sentence processing. If lexical information generally does not influence sentence processing in aphasic subjects the same way as in nonaphasic controls, then we expect that sentence conformity to verb bias, in particular, will have no effect on processing speed or accuracy. On the other hand, if lexical information is accessed and processed during sentence comprehension, then mismatches between the emerging syntactic structure and the available lexical information will exert an effect on processing speed and accuracy.

Reduced processing resources have been argued to be present in all clinical types of aphasia, correlating with overall severity of impairment, rather than clinical diagnosis (Hartsuiker & Kolk 1985, Haarmann & Kolk 1991). Disruptions in lexical processing, on the other hand, have been shown to take different forms in different clinical aphasia types. The bulk of the available evidence addresses Broca's aphasia and Wernicke's aphasia, with some studies attempting to generalize this contrast to all nonfluent aphasia types compared to all fluent ones.

A number of studies suggest that Broca's aphasics have difficulties in lexical access that may prevent these patients from activating lexical information with normal rapidity during sentence processing (e.g. Milberg et al. 1987). There is also some evidence suggesting that Wernicke's aphasics do not access verb subcategorization information in the same way as normals do (Shapiro et al. 1993, 1995; Russo et al. 1998).

Comparatively little information about lexical access is available on conduction aphasics and anomics. Anomic aphasics form a very heterogeneous group that includes both fluent and nonfluent patients.[1] Not surprisingly, given that the diagnosis of anomic aphasia is

[1] The term "anomia" is used to refer either to a symptom or to an aphasia syndrome. When it refers to a symptom, it means a word-finding difficulty. In this sense, anomia occurs as a component of many different forms of aphasic language disorders, since word-finding difficulties are common in all aphasic disorders. When the term anomia refers to an aphasia syndrome, it denotes a condition in which word-finding difficulties are the predominant symptoms.

shared by such a heterogeneous group of patients, studies of lexical access that included anomics report vastly differing results.

There is some evidence suggesting that word-finding difficulties in anomic aphasia may be qualitatively different from those in all other aphasic disorders. In most aphasia types, word finding difficulties affect verbs more strongly than nouns nouns (cf. Miceli, Silveri, Villa & Caramazza 1984, Zingeser & Berndt 1988, Zingeser & Berndt 1990). In anomic aphasia, however, the word-finding difficulty may affect nouns as strongly or more strongly than verbs (Zingeser & Berndt 1990).

Many observations about lexical access come from group studies that included, but were not limited to, anomic aphasics. Tyler et al. 1995, for example, report on a mixed group of four patients, characterized as two non-fluent aphasics, one anomic, and one fluent aphasic. This study finds no evidence for slowed or otherwise abnormal access to lexical information in these patients.

The group of fluent aphasics studied in Russo et al. (1998) includes two anomic aphasics. Russo et al. argue that these patients do not appear to access information on lexical biases in the same way that nonaphasic controls do.

3.2 Verb biases in a plausibility judgment task

The experiment reported here examined the influence of lexical biases on sentence comprehension. A sentence plausibility judgment task was used for this purpose. Subjects were asked to listen to sentences some of which were semantically anomalous. Subjects were then asked to decide whether the sentences they heard were plausible or implausible. This paradigm has been used frequently in other studies of normal and impaired sentence comprehension (e.g. Obler et al. (1991) and Davis & Ball (1989) testing elderly subjects, and Schwartz et al. (1987), Cupples & Inglis (1993), Kolk & Weijts (1996), Saffran et al. (1998) testing aphasic subjects).

We tested active and passive transitive and intransitive sentences[2]. The manipulation that is of most interest in the present study concerns the match or mismatch between transitivity of the sentence and verb transitivity bias. In one set of conditions, the sentence type (transitive or intransitive) matches the lexical bias of the main verb. In a second set of conditions, the transitivity of the sentence is the opposite of the verb's bias. The conditions in which the sentence type matches the lexical bias of the main verb will be referred to as the "concordant" conditions. The conditions in which the sentence type does not match the lexical bias of the verb will be referred to as the "discordant" conditions. Sentences of the concordant and discordant type are exemplified in (1) and (2) below. The examples all use the verbs *melt*, which is more often intransitive than transitive. As a consequence, the intransitive sentence appears in the concordant condition, and the transitive sentence types (active transitive and passive) appear in the discordant conditions.

[2] To avoid the rather awkward phrase "active and passive transitive", I will be referring to the three sentence types as active, passive, and intransitive. All of the "active" sentences in the design are transitive. All of the passive sentences in the experiment, like all passives in English, are transitive, and all of the intransitive sentences are in the active voice.

(1) Concordant: Sentence conforms to intransitive verb bias

a. *The butter melted in the pot.* (Intransitive)

(2) Discordant: Sentence not conforming to intransitive verb bias:

a. *The cook melted the butter.* Transitive - Active

b. *The butter was melted by the cook.* Transitive – Passive

3.3 Stimuli

Twenty verbs were tested, ten biased towards being transitive, and ten biased towards being intransitive. Verb bias was estimated based on corpus counts from the 100 mi. word British National Corpus, using the corpus query method described in Gahl (1998a,b). The raw frequency counts and estimated probabilities for transitive and intransitive uses of each verb are given in appendix 1. The verbs are listed in table 1 below:

TABLE 1. Verbs used in the plausibility judgment task

Intransitive bias	**Transitive bias**
1. burst	1. boil
2. crumble	2. clog
3. explode	3. crack
4. grow	4. dissolve
5. harden	5. heat
6. melt	6. open
7. merge	7. pour
8. rip	8. tear
9. shrink	9. shut

10. sink	10. soften

Three types of sentence structure were tested: active transitive, passive transitive, and intransitive. Half of the sentences were plausible and half were implausible. Two sets of noun phrases were used with each verb, so that each verb appeared twice in each sentence type. For example, for the verb *dissolve*, the following sentences were used:

Table 2: Stimulus sentences for the verb *dissolve*

	Plausible	**Implausible**
Active transitive	a. The researchers dissolved the crystals.	a. # The crystals dissolved the researchers.
	b. The baker dissolved the sugar.	b. # The sugar dissolved the baker.
Passive	a. The crystals were dissolved by the researchers.	a. # The researchers were dissolved by the crystals.
	b. The sugar was dissolved by the baker.	b. # The baker was dissolved by the sugar.
Intransitive	a. The crystals dissolved in the solution.	a. # The researchers dissolved in the solution.
	b. The sugar dissolved in the milk.	b. # The baker dissolved in the milk.

The complete design is summarized in table 3 below. There are 20 stimuli in each cell. The list of all 240 stimulus sentences can be found in appendix 2.

To keep sentence length approximately equal across all the conditions, the intransitive sentences contain prepositional phrases: *The door opened after a short while. The butter softened in the pot.*

Table 3: Design of the plausibility judgment experiment, with examples of each sentence type

Condition	Verb bias	I.Plausible sentences	II. Implausible sentences
A.Concordant			
Active	transitive	My neighbor opened the door.	# The door opened my neighbor.
Passive	transitive	The door was opened by my neighbor	# My neighbor was opened by the door.
Intransitive	intransitive	The butter melted in the pot.	# The pot melted in the butter.
B. Discordant			
Active	intransitive	The cook melted the butter.	# The butter melted the cook.
Passive	intransitive	The butter was melted by the cook.	# The cook was melted by the butter.
Intransitive	transitive	The door opened after a short while.	# My neighbor opened after a short while.

Notice that all the sentences in the design are of the semantically "irreversible" type (Zurif & Caramazza 1976): Only one linking of noun phrases to grammatical functions yields a plausible interpretation. Reversing the order of the two noun phrases in each sentence makes the plausible sentences implausible and vice versa. Previous authors have argued, based on evidence from sentence-picture matching tasks, that the interpretations so-called "agrammatic" or "asyntactic" comprehenders assign to semantically irreversible sentences are purely based on lexical semantic information. For example, asyntactic comprehenders might treat the two sentences *The butter was melted by the cook* and # *The butter melted the cook* as if the sentences only consisted of the words "*butter ...melt ... cook*". Subjects who proceed in this manner will tend to accept <u>all</u> sentences in the current experiment as plausible, whether the sentences are in fact plausible or not. As a result, asyntactic comprehenders will tend to respond correctly to all sentences in the "plausible" condition, but not the implausible condition.

Even in asyntactic comprehension, lexical bias may still play a role. If verb transitivity bias influences asyntactic sentence processing, we expect reaction times to be influenced by the relative order of the noun phrases and the verb in the sentence. Sentences in which the relative order of major constituents represents the preferred (i.e. most frequent) order should elicit faster reaction times than sentences representing a dispreferred (less frequent) word order. For example, since the verb *melt* has an intransitive bias, the noun phrase expressing its undergoer argument is more often found preceding this verb, rather than following it. Therefore, when syntactic structure is not processed successfully, both intransitive and passive sentences with *melt* as the main verb should elicit faster responses than the same sentence types with a transitive-bias verb such as *open*. In the case of a transitive-bias verb such as *open*, on the other hand, the undergoer argument will most often follow the verb.

Table 4 below summarizes which sentence types represent the preferred and dispreferred order of major constituents for verbs with transitive and intransitive lexical biases.

Table 4: Preferred and dispreferred order of major constituents for verbs with (a) transitive and (b) intransitive lexical bias

	Condition	**I.transitive bias**	**II. intransitive bias**
Preferred	**Active**	My neighbor **opened** the **door**.	# The **butter melted** the cook.
	Passive	# My neighbor was **opened** by the **door**.	The **butter** was **melted** by the cook.
	Intrans.	# My neighbor **opened** after a short while.	The **butter melted** in the pot.
Dispreferred	**Active**	# The **door opened** my neighbor	The cook **melted** the **butter**.
	Passive	The **door** was **opened** by my neighbor	# The cook was **melted** by the **butter**.
	Intrans.	The **door opened** after a short while.	# The pot **melted** in the **butter**.

There are some verbs that are used more often in the passive than in the active voice. Since the undergoer argument precedes the verb in passive sentences, it is in principle possible for a transitive-bias verb to have a tendency to be preceded, rather than followed, by the noun phrase expressing the undergoer argument. Lalami (1997:50) reports that roughly 91% of the sentences in the Penn Treebank database (Marcus et al. 1993) are active, and 9% are passive (23215 tokens for actives and 2275 for passives). Lalami further reports that not some verbs are used in the passive far more frequently than in the active. For example, 78% of the occurrences of *appointed* and 88% of the occurrences of *sentenced* in the Penn Treebank are passive. For these verbs, then, the most frequent order of major constituents is one in which the undergoer precedes, rather than follows, the verb. None of the transitive-bias verbs in the present study were passive-bias, so the generalizations summarized in table 4 above hold for the verbs in the present study.[3]

3.4 Possible outcomes

The focus of the experiment is the contrast between sentences that conformed to the verb bias and those not conforming to the verb's bias. The first prediction to be tested in the experiment is that, in normal comprehension, sentences involving a mismatch between lexical biases and sentence structure will induce longer processing times than sentences in which lexical bias and sentence type agree.

If this prediction is correct for normal comprehension, then this raises the question to what extent this effect can be observed in aphasic comprehension. Aphasic listeners who take into account information on lexical biases in processing the sentences will take longer and make more errors in the discordant conditions compared to the concordant conditions.

Since comprehension in some aphasic subjects may be asyntactic, it is possible that comprehension could be guided by lexical bias without regard to syntactic structure[4]. In

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[3] Of course, there are also some passive sentences in which the undergoer argument follows the verb, for example inverted passives like "Melted were snowmen, snow forts, and frostwork: spring had finally come." I will assume that such sentences occur infrequently and therefore do not significantly affect the present discussion.

[4] For the purposes of the present discussion, I will be using the term 'asyntactic', rather than the more common term 'agrammatic'. The characterization 'agrammatic' is sometimes applied specifically to patients who show a particular pattern of miscomprehension (poor comprehension of passives, with good comprehension of actives). Some authors (e.g. Grodzinsky 1986) assume that 'agrammatism', in this sense, is a symptom specifically associated with Broca's aphasia. By using the term 'asyntactic', I mean to suggest that comprehension can fail to take syntactic structure into account. I do not mean to imply that the resulting patterns of comprehension failure should be specifically associated with any particular aphasia syndrome.

asyntactic comprehension, the match or mismatch between lexical bias and sentence structure would not play a role, since asyntactic processing, by definition, fails to take syntactic structure into account. Lexical bias, but not conformity of sentence structure to lexical bias, may influence asyntactic comprehension.[5]

To summarize: if the match or mismatch between verb transitivity bias and sentence type is taken into account along with sentence structure in processing transitive and intransitive sentences, then we expect longer reaction times, and possibly also more errors, in sentences involving a mismatch between verb bias and sentence structure. If lexical bias, but not sentence type, is taken into account, then we expect shorter reaction times for those sentences that conform to a verb's most frequent order of major constituents. If the match or mismatch between verb transitivity bias and sentence type is not taken into account, then we do not expect any differences between the concordant and the discordant conditions for each sentence type.

Table 5 below summarizes the possible outcomes for three different scenarios. The abbreviations "conc." and "disc." stand for "concordant" and "discordant", respectively. The notation "conc. << disc." indicates that concordant sentences are predicted to be processed faster and more accurately than discordant ones. The notation "conc. = disc." indicates that no difference is predicted between the two sentence conditions.

[5] Sentence type is likely to be a relevant factor in patients who exhibit asyntactic comprehension only some of the time, since syntactically complex sentences are more likely to induce asyntactic comprehension than simple sentences. For example, research by Miyake et al. 1994 suggests that so-called agrammatic patients successfully parse active transitive sentences, but resort to asyntactic comprehension strategies when confronted with passive sentences. This point will be taken up again in the discussion in the following chapter.

Table 5: Predictions about relative ease of processing concordant and discordant sentences, taking into account lexical bias or sentence structure or conformity of sentence structure to lexical bias

	Match between lexical bias and sentence structure taken into account	Lexical bias, but not syntactic structure, taken into account	Sentence structure, but not lexical bias, taken into account
Active	conc. << disc.	conc. << disc.	conc. = disc.
Passive	conc. << disc.	disc. << conc.	conc. = disc.
Intransitive	conc. << disc.	conc. << disc.	conc. = disc.

A second focus of this experiment concerns the differences between groups of patients with different types of aphasia. If lexical biases influence sentence processing in the same way for all speakers, we would expect no differences across patient groups in the effects of lexical biases. On the other hand, if different types of aphasics are differentially sensitive to lexical biases, we would expect the response patterns to be different for the different groups. If subcategorization preferences affect speed or accuracy of aphasic comprehension, then this provides evidence that lexical information is accessed during sentence comprehension. On the other hand, if subcategorization preferences do not influence speed or accuracy of sentence comprehension, then this is evidence that lexical information is not exploited normally.

3.5 Subjects

The subjects were sixteen aphasic patients and five nonaphasic controls with no known history of neurological or psychiatric disease. All subjects were recruited through the Aphasia and Related Disorders Center at the Martinez campus of the VA Northern California Health Care System.Of the aphasic subjects, six were Broca's aphasics, four were Wernicke's aphasics, two conduction aphasics, and six anomics. Background information on all these subjects was supplied by the Aphasia Center and is presented in tables 6 and 7. All aphasic subjects had suffered a left-hemisphere cerebro-vascular accident at least one year prior to data collection. Diagnosis of aphasia type was based on performance on the Western Aphasia Battery (WAB; [Kertesz, 1983]), and for some patients also on the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan 1983).

Table 6: Subject information, aphasic subjects

Subject	Age (years)	Years post	Gender	BDAE	WAB	handedness	education (in years)
AK	64	7	male	unclassifi-able	Broca's	right	16
HM	70	11	male	Broca's	Broca's	right	12
LI	54	7	male	n.a.	Broca's	right	12
DM	41	2	male	n.a.	Broca's	ambidex-trous	16
DO	62	1.8	female	n.a.	Broca's	right	13
WR	55	9	male	unclassifi-able	Broca's	right	14
JC	73	4	male	n.a.	Wernicke's	right	12
WG	79	1	male	n.a.	Wernicke's	right	13
JT	74	6	male	n.a.	Wernicke's	left	14
WT	64	1.3	male	n.a.	Wernicke's	right	16+
JCn	50	13 mos.	male	Within normal limits	anomic	right	14
JD	72	12	male	anomic	anomic	right	20
AF	55	5	female	n.a.	anomic	right	11
BK	53	3	male	anomic	anomic	right	16
NP	69	2	male	n.a.	anomic	right	14
FY	75	5	male	n.a.	conduction	right	12
RM	67	1.8	male	n.a.	anomic	right	16
GB			male		conduction	right	

Table 7: Subject information, nonaphasic controls

Subject	age (years)	Gender	education (yrs)	handedness
AA	72	Male	12	right
CA	62	Male	15	right
JB	63	Male	12	right
GJ	74	Male	14	right
Bri	68	Male	12	right

3.6 Procedure

The 240 sentences were tape recorded by a male native speaker of American English at a natural pace and with standard intonation. The recording of each sentence was then digitized. The experiment was presented on a Macintosh Performa, using the PsyScope experimental software (Cohen et al. 1993).

Each sentence was played back once, followed by a variable pause during which the subject indicated his or her response. The order of presentation of the stimuli was random and different for each subject.[6] Subjects listened to the sentences over headphones.

Subjects indicated their decision by pushing one of two buttons on a PsyScope button box.

Before starting, the subjects were read the following instructions:

> You will hear a tape recording of some sentences. Some of the sentences won't make any sense. After you hear each sentence, you are to decide if the sentence is a good sentence or a sentence that

[6] The sentence were presented in random order to avoid any possible effect of syntactic priming or learning effects. Structural priming (previously heard sentences predisposing subjects to produce a particular sentence structure) has been demonstrated to be effective with nonaphasic subjects (Bock 1986) and nonfluent aphasics (Saffran and Marin 1997, Hartsuiker and Kolk (1998 in press), Marin and Schwartz 1998.

> does not make sense. A sentence that does not make sense is one that describes something that is not likely to happen in real life.
>
> If the sentence you heard made sense, press the green button. If the sentence did not make any sense, press the yellow button.

Five practice trials were provided, with feedback and explanation as needed. The practice trials were repeated until subjects responded accurately on the practice trials. Specific feedback was discontinued for the actual trials.

Mandatory rest breaks occurred once every twenty sentences, but the duration of these breaks varied from subject to subject. Subjects were tested individually in a quiet room at the Aphasia and Related Disorders Center. All subjects completed the testing in a single session of less than one hour, including breaks.

Treatment of the data

The effects of conformity to verb bias on response accuracy and response times were examined in sets of paired t-tests. Separate analyses were performed for each group of subjects.

Since the number of subjects in each group was small, and since the current study is exploratory in nature, it was decided to set the significance level at $p = .10$. Adopting this lax significance level, rather than a more stringent level, increases the chances of a type I error, i.e. of concluding that the effect of sentence conformity to verb bias were significant in cases where differences in mean reaction times or accuracy in the concordant and discordant conditions arose due to chance. One goal of the current study is to point up directions for future research on effects of verb argument structure frequencies on aphasic sentence comprehension. Since the methodology (the plausibility judgment task) has not been previously employed in investigations of effects of verb argument structure frequencies, it was felt that adopting a less stringent significance level was appropriate, so that possible effects of sentence conformity to verb bias could be identified more easily.

The analyses for plausible and implausible sentences were performed separately. The main motivation for this decision was that the implausibility of the implausible stimuli becomes apparent before the last phrase in each sentence is encountered (compare e.g. *The cook was melted* ...vs. *The butter was melted* ...) The plausibility of the plausible sentences, by contrast, can only be ascertained once the last word of the sentence has been encountered.

Trials on which errors occurred were not excluded from the analysis. Many studies of sentence comprehension exclude data from erroneous responses on the grounds that such responses most likely reflect lack of attention or types of comprehension failure that are extraneous to the research question. In the current study, however, erroneous responses may reflect the effects that are the focus of the investigation. In particular, one of the hypotheses to be examined is that certain sentences will tend to induce errors, as well as longer response times. Excluding the response times associated with errors from the analysis would therefore amount to suppressing crucial data points.

An additional reason why excluding data from erroneous responses would not be appropriate in the present study is that high degrees of response accuracy on some conditions will not necessarily be an indication of good comprehension. As discussed in section 2.2 above, asyntactic comprehenders may accept all of the sentences in the design as plausible. As a result, asyntactic comprehenders may not tend to make any errors in the plausible condition.

3.7 Results for nonaphasic controls

For each sentence type, we compared the number of errors and the mean response times in the concordant and discordant conditions.

The number of errors and the number of times subjects responded before the end of the sentence or failed to respond within 5000 milliseconds after the end of the sentence (missing responses) are summarized in table 8.

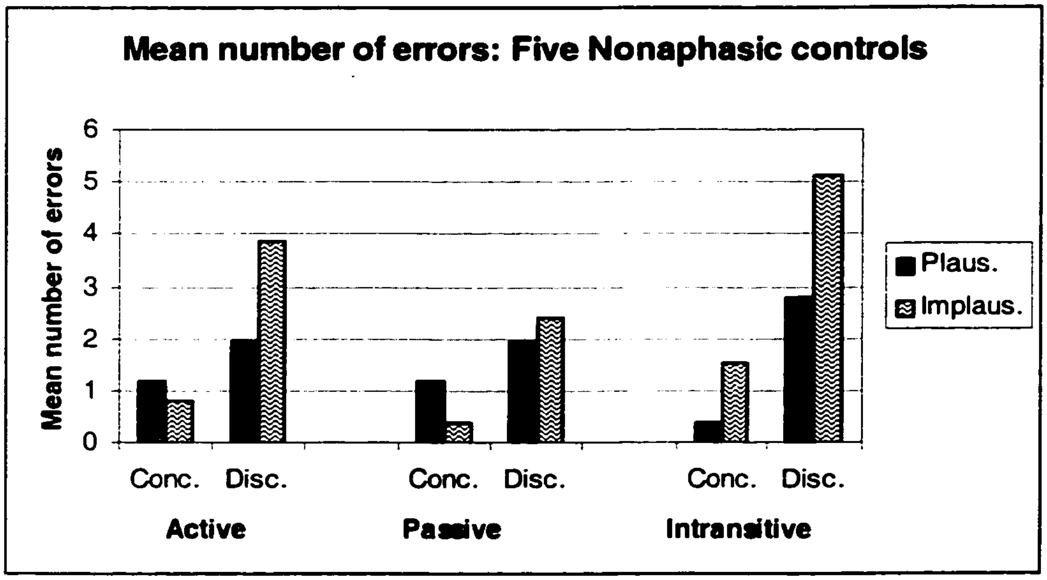
Table 8: Number of errors and missing responses (in parentheses), nonaphasic controls

		Active		**Passive**		**Intransitive**	
		Conc.	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
Ag	Plaus.	2	1	0	3	0	2
	Impl.	2 (1)	1	0 (1)	0	1	3
Al	Plaus.	0	1 (1)	0 (1)	0 (5)	0 (1)	3 (1)
	Impl.	0	1 (1)	0 (4)	0 (3)	1	5
JB	Plaus.	1	1	3	0 (1)‘	1	1
	Impl.	0	3	1	4	0	3
Bri	Plaus.	0	0	0	0	0	1
	Impl.	0	1	0	2	0	0
GJ	Plaus.	0 (3)	1 (5)	0 (1)	1 (2)	0 (2)	0 (1)
	Impl.	0 (1)	2 (3)	0 (2)	0 (5)	1 (2)	1 (2)
Sum	Plaus.	3 (3)	4 (6)	3 (2)	4 (8)	1 (3)	7 (2)
	Impl.	2 (2)	8 (4)	1 (7)	6 (5)	3 (2)	12 (2)

As was to be expected, the nonaphasic controls made very few errors on any of the conditions. As table 8 shows, the total number of errors was greater in each of the discordant conditions compared to the corresponding concordant condition for the plausible, as well as the implausible sentences.

Figure 1 shows the mean number of errors for each sentence type. Paired t-tests were carried out to determine whether the error rates were significantly different in the concordant and the discordant conditions.

Figure 1: Mean number of errors: Nonaphasic controls



In the "plausible" condition, the differences were not significant for the two transitive sentence types (t(4) = -.535, p = .311, NS for the active sentences, t(4) = -.206, p = .423, NS for the passive sentences). For the intransitive sentences, the difference was significant at the level of significance adopted here: t(4) = -2.058, p = .054, though the number of observations was small. In the "implausible" condition, the five nonaphasic controls made significantly more errors in the discordant condition compared to the concordant condition, under the significance level adopted here. For the active sentences, $t(4) = -1.809$, $p = .072$. For the passive sentences, $t(4) = -1.581$, $p = .095$. For the intransitive sentences, $t(4) = -2.25$, $p = .044$. Since the number of errors is small, even for the implausible sentences, it is not possible to draw any firm conclusions from this. A larger sample size will be needed to follow up on this point.

Figure 2 presents the mean reaction times in the 'plausible' conditions for the nonaphasic control subjects. Paired t-tests were carried out for each sentence type, showing that subjects responded significantly faster in the concordant concordant than the discordant condition for the active transitive and intransitive sentence types ($t(4) = 3.630$, $p < .001$ for active sentences, $t(4) = 3.205$, $p = 0.002$ for intransitive sentences). The comparison for the passive sentences did not yield a significant difference ($t(4) = .283$, $p = 0.778$). This was partly due to the fact that two of the subjects (JB and BR) responded faster in the "against bias" condition than in the "with bias" condition.

Table 9: Mean response times for plausible sentences: Nonaphasic controls

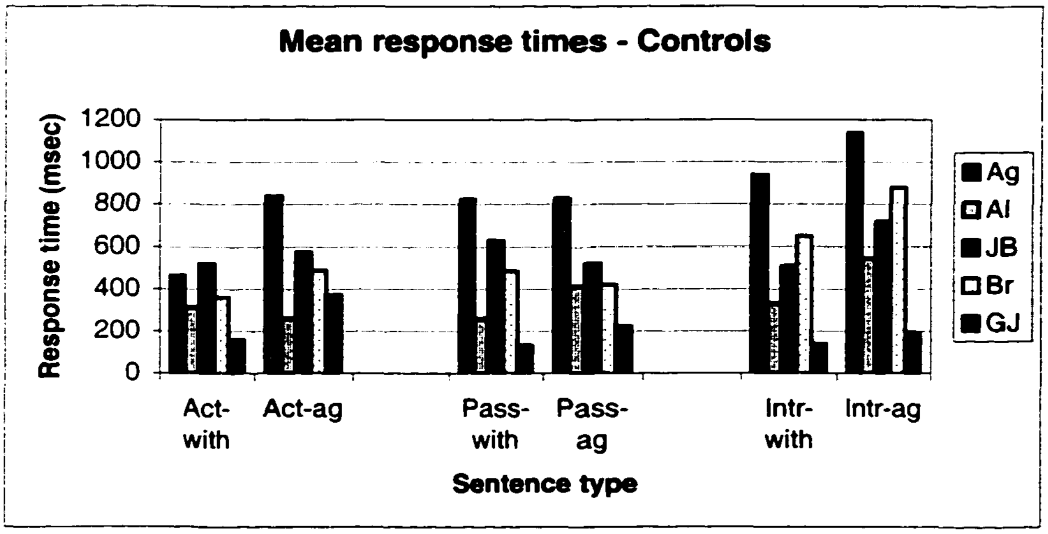
	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
Ag	464.05	838.95	824.85	828.35	938.7	1137.8
Al	314.25	262.053	261.526	414.4	333.211	547.421
JB	521.3	576.4	628.45	521	508.85	717.6
Bri	361.35	489.95	486.3	420.9	648.4	878.55
GJ	159.882	372.6	132.278	224.412	139.778	193.722
Mean	364.166	507.991	466.681	481.812	513.788	695.019

Table 10: Mean response times for implausible sentences: Nonaphasic controls

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
Ag	756.526	666.3	705.316	939	960.1	828.75
Al	426.316	412.474	265.375	514.688	666	555.85
JB	620.85	661.55	670.15	699.9	676.15	744.6
Bri	549.8	651.3	371.35	498.85	801.7	668.05
GJ	168.895	165.938	170.056	196.067	195	216.278
Mean	504.477	511.512	436.449	569.701	659.79	602.706

In the implausible conditions, the comparisons for the active transitive and intransitive sentence type did not yield significant differences. For the active condition, t(4) = .126, p = .900, NS; for the intransitives t(4) = 1.054, p = .293, NS. For the passive sentences, the difference was highly significant: t(4) = 2.950, p = .004, NS.

Figure 2: Mean response times: Controls



These results confirm one of the predictions of this study: For nonaphasic subjects, conformity to verb bias affects reaction times on plausible sentences in the plausibility judgment task. Nonaphasic subjects also tended to make more errors in the discordant condition than the concordant condition, although, given the small number of errors overall, this trend did not reach statistical significance.

The finding that, for passive sentences, there was no significant difference between the mean responses times for the concordant and discordant passive sentences does not confirm the hypothesis that sentences conforming to verb bias should be associated with shorter reaction times in normal comprehension than sentences not conforming to verb bias.

If we consider the individual mean response times, we see that the mean response times for plausible passive sentences for two of the subjects were faster in the discordant condition than the concordant condition. The differences between the concordant and the discordant conditions for these subjects were as great as for the active and intransitive sentence types. Faster response times in the discordant condition compared to the concordant condition are expected if lexical biases, but not sentence structure, are taken into account. It is possible, therefore, that two of the subjects were weighing lexical biases more strongly than sentence structure in processing the passive sentences.

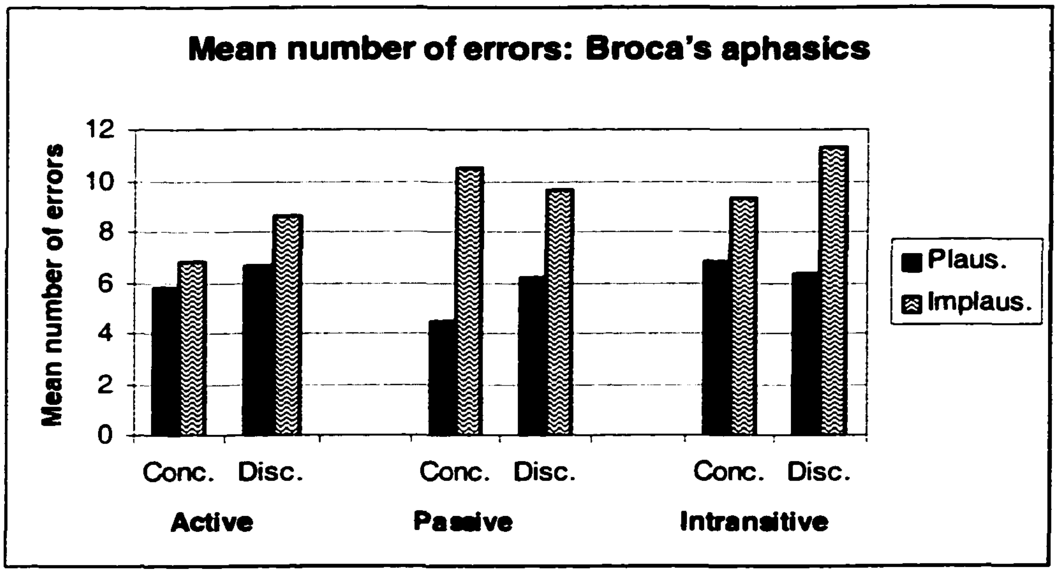
3.8 Results: Broca's aphasics

In the sections to follow, we report the observed effects of conformity to verb bias on aphasic listeners. We will first consider the results of the experiment for the six Broca's aphasics. Table 11 shows the number of errors and missing responses for this group of subjects. The number of times subjects failed to respond within 5000 milliseconds of the end of the sentence is indicated in parentheses. When all responses occurred within 5000 milliseconds of the end of the sentence, no number is given in parentheses.

Table 11: Broca's aphasics: Number of errors and missing responses (in parentheses).

		Active		Passive		Intransitive	
		Conc.	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
WR	Plaus.	3	4 (1)	3	3 (1)	2	5
	Impl.	8	5	10	10	8 (1)	8
AK	Plaus.	8	8	3	9	11	5
	Impl.	5	3	7	6	3	8
DM	Plaus.	2 (1)	2 (1)	2	4	4	4
	Impl.	11	11	13	11	15	11
HM	Plaus.	9	12	10	10 (1)	10	14
	Impl.	4 (1)	13	7	11	10	13
DO	Plaus.	3 (1)	5	4	5 (1)	5	3
	Impl.	3	8	17	11	14	16
LI	Plaus.	10	9 (1)	5	6 (1)	9	7
	Impl.	10	12 (1)	9	9	6	12
Total	Plaus.	35 (2)	40 (3)	27	37 (4)	41	38
	Impl.	41 (1)	52 (1)	63	58	56 (1)	68

Figure 3: Mean number of errors: Broca's aphasics



Paired sample t-tests were performed to compare the error rates for the concordant and discordant sentence types. For the plausible sentences, the comparisons between the concordant and discordant conditions did not yield a significant difference for the active transitive or intransitive sentences ($t(5) = -1.38675$, $p = .112$, NS for the active sentences, $t(5) = .033$, $p = .376$, NS for the intransitive sentences. The difference for the passive sentences was significant at the level of significance adopted here ($t(5) = -1.814$, $p = .065$).

For the implausible condition, the differences were significant for the active transitive and intransitive sentences: $t(5) = -1.714$, $p = .074$ for the active transitive sentences and $t(5) = -1686$, $p = .076$ for the intransitive sentences. The difference for the passive sentences $t(5) = .359$, $p = .367$, NS was not significant.

Like the nonaphasic controls, the group of Broca's aphasics tended to make more errors in the discordant conditions compared to the concordant conditions. This tendency was stronger for the Broca's aphasics than the nonaphasic controls, reaching significance for three of the six conditions (plausible and implausible active, passive and intransitive).

Mean response times for the six Broca's aphasics are shown in tables 12-13 and figure 4. Paired t-tests were performed for each sentence type, comparing for each sentence type the response times for the concordant and the discordant condition.

In the 'plausible' conditions, the comparisons between the response times on the concordant and discordant active, passive, and intransitive sentences did not yield significant differences for any of the sentence types: $t(5) = .207$, $p = 0.836$, NS for active sentences, $t(5) = .544$, $p = 0.587$, NS for the passive sentences, $t(5) = .779$, $p = 0.437$, NS for the intransitive sentences.

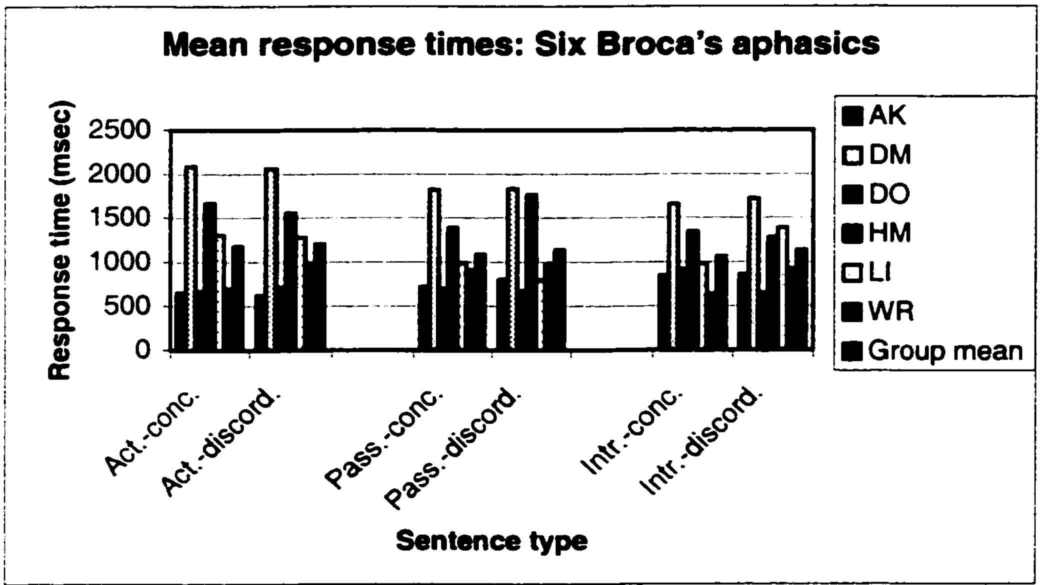
Table 12: Mean response times for plausible sentences: Broca's aphasics

	Active		**Passive**		**Intransitive**	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
AK	652.1	621.55	715.1	798	845.85	856.4
DM	2091.263	2067.632	1826.2	1838.4	1662.4	1724.1
DO	668.474	718.15	699.6	673.263	910.1	646.35
HM	1670.8	1557	1388.85	1769.263	1347.25	1278.45
LI	1305	1279.105	990.3	792.421	985.75	1385.65
WR	698.3	975.842	908.45	973.947	636.8	923.05
Mean	1180.989	1203.213	1088.083	1140.882	1064.692	1135.667

Table 13: Mean response times for implausible sentences: Broca's aphasics

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
AK	717.1	673.5	690.75	726.85	691	705.4
DM	1958.25	2252.4	1976.15	2084.2	2518.6	2335.95
DO	1005.15	836.35	1070.05	681.8	820.6	821.65
HM	1085.211	1524.7	1296.45	1404.65	1243.15	1519.7
LI	1490.5	1991.579	1179.75	1041.95	772.35	1524
WR	1175.1	1060.05	1127.75	961.9	967.1579	1040.25
Mean	1238.552	1389.763	1223.483	1150.225	1168.81	1324.492

Figure 4: Mean response times: Broca's aphasics



In the 'implausible' conditions, none of the comparisons yielded significant differences: For the active sentences, $t(5) = 1.476$, $p = .141$. For the passive sentences, $t(5) = .766$, $p = .444$. For the intransitive sentences, $t(5) = 1.510$, $p = .132$.

To summarize, the Broca's aphasics did not show significant effects of conformity to verb bias on response times, unlike the nonaphasic controls. This same patient group did tend to make more errors in the discordant conditions than in the concordant conditions. It is therefore not the case that the Broca's aphasics were not sensitive to the match between lexical bias and sentence type. The timing, but not the accuracy of the responses in this patient group was abnormal.

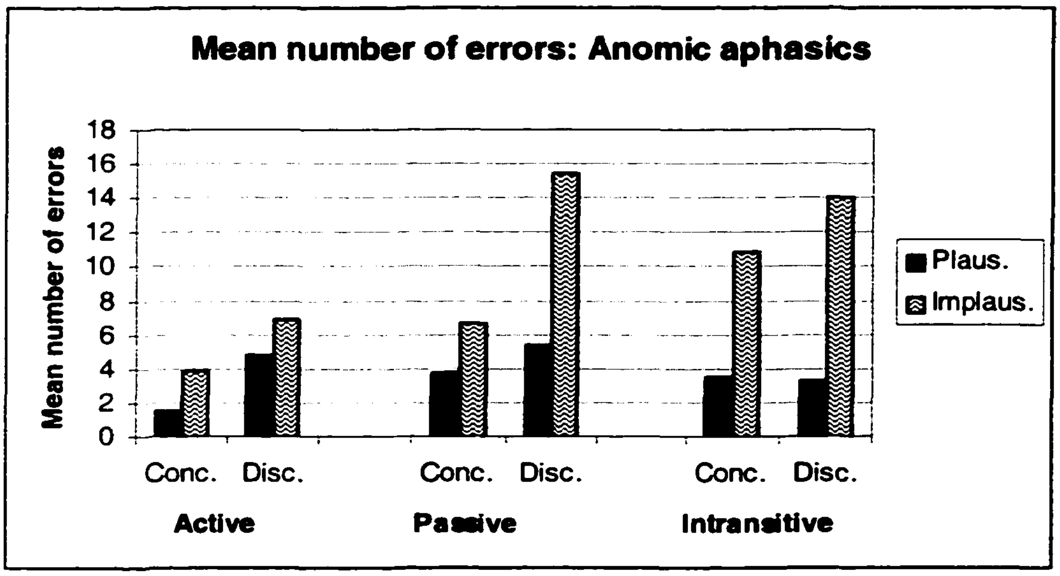
3.9 Anomic aphasics

We now turn to the results for the six anomic aphasics. Table 14 shows the number of errors made by the anomic aphasics.

Table 14: Anomic aphasics: Number of errors and missing responses (out of 20 possible per condition)

		Active		Passive		Intransitive	
		Conc.	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
JD	Plaus.	1	1 (1)	1	3 (3)	0 (1)	1
	Impl.	2	2 (2)	5	8 (1)	7	10 (1)
AF	Plaus.	0	2	3	6	2	2
	Impl.	5	4	11	12	10	12
BK	Plaus.	0	1	1	1	0	0
	Impl.	4	7 (1)	7	9 (1)	9 (1)	12
NP	Plaus.	1	1	1	1	0	0
	Impl.	0	0	0	1 (1)	1	3
RM	Plaus.	2	3	1	0	3	0
	Impl.	3	4	1	10	5	6
Crc	Plaus.	0	5	4	6	4	6
	Impl.	0	5	2	9	5	5
Sum	Plaus.	4	13 (1)	11	17 (3)	9 (1)	9
	Impl.	14	22 (3)	26	49 (3)	37 (1)	48 (1)

Figure 5: Mean number of errors: Anomic aphasics



The comparisons between the concordant and discordant conditions yielded a marginally significant difference for the plausible active sentences: t(5) = -1.472, p = .100. For the passive and intransitive plausible sentences, the differences were significant: for passive sentences, t(5) = -3.162, p = .013, for intransitive sentences, t(5) = 2.169, p = .041.

For the implausible condition, the comparison between the concordant and discordant conditions yielded a significant difference for the active sentences: t(5) = 1.777, p = .068 as well as for the passive sentences (t(5) = 2.521, p = .027). For the intransitive sentences, the difference was not significant: t(5) = .131, p = .451.

To summarize, sentence conformity to verb bias significantly affected the number of errors made by the group of six anomic aphasic patients in all conditions with the exception of the plausible active sentences and the implausible intransitive sentences. By contrast, the effect on error patterns was not significant for the nonaphasic control subjects and marginally significant in some conditions for the Broca's aphasics.

In the case of the nonaphasic controls, the absence of a significant effect is likely to be due in part to the fact that these subjects find the task easy and make few errors. With the exception of subject Crc, the anomic aphasics also tended to make very few errors. It is possible, then, that the absence of a significant effect of conformity to verb bias on error patterns for the plausible active transitive and implausible intransitive sentences is due in part to the fact that the task was relatively easy for this group of subjects, or to a lack of statistical power.

We now turn to the effect of conformity to verb bias on response times in the anomic aphasics.

Tables 15-16 and figure 6 present the mean reaction times for this patient group. The comparisons between the response times on the concordant and discordant sentences did not yield significant differences for the passive sentences. For the active transitive and intransitive sentences, the differences were significant: $t(5) = 1.750$, $p = 0.081$ for active sentences, $t(5) = .063$, $p = 0.950$, NS for the passive sentences, $t(5) = 1.575$, $p = 0.117$ for the intransitive sentences.

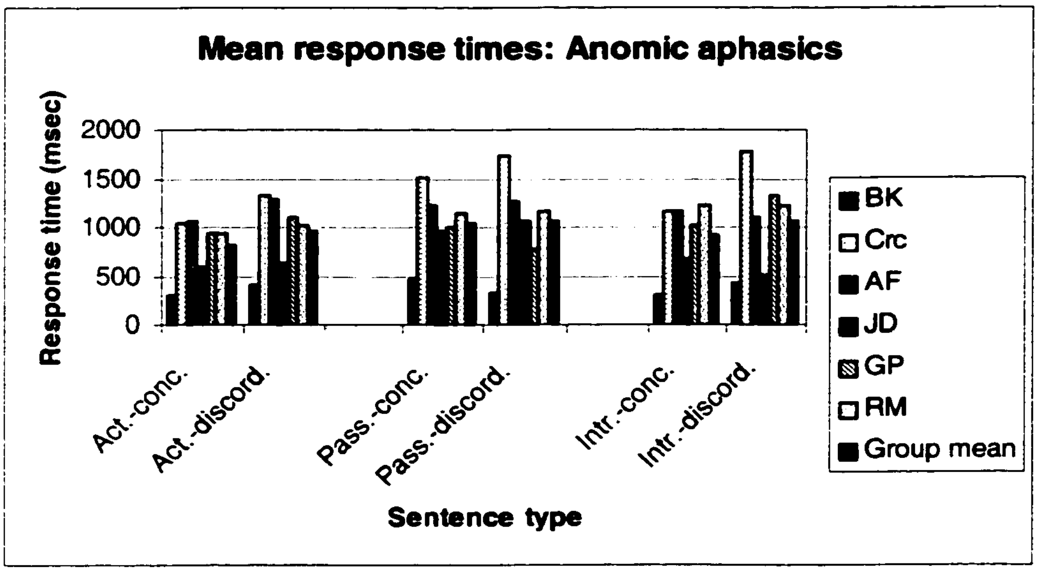
Table 15: Mean response times on plausible sentences: Anomic aphasics

	Active		**Passive**		**Intransitive**	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
BK	310.15	407.3	460.45	332.65	297.45	434.95
JCc	1047.6	1320.1	1508.05	1741.35	1170.55	1765.4
AF	1060.15	1280.7	1217.7	1267.1	1161.8	1095.8
JD	596.65	640.368	968.55	1069.765	663.579	517.5
GP	930.05	1099.7	994.55	767.05	1013	1330.5
RM	938.45	1020	1152.5	1165.2	1217	1232.55
Mean	813.842	961.361	1050.3	1057.186	920.563	1062.783

Table 16: Mean response times on implausible sentences: Anomic aphasics

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
BK	641.7	578.368	608.95	524.55	631.105	592.35
JCc	1142	1150.15	1252.75	1159.45	1409.2	1301.25
AF	1327.5	1348.55	1842.8	1434.65	1618.1	1479.1
JD	737.8	1249.833	993.75	2133.263	1788.55	1264.526
GP	751.65	699.05	784.6	994.368	961.1	1107
RM	954.25	856.65	889.75	1326.3	1220.9	1252.8
Mean	925.817	980.434	1062.1	1262.097	1271.493	1166.171

Figure 6: Mean response times: Anomic aphasics



For the implausible conditions, there was no significant effect for the active sentences (t(4) = .564, p = .574. The difference was significant for the passive sentences (t(4) = 1.758, p = .080. For the intransitive sentences, response times were slightly longer in the discordant condition than the concordant condition, but this difference was not statistically significant: t(4) = .983, p = .327.

To summarize, the group of anomic aphasics, like the Broca's aphasics, showed effects of conformity to verb bias on error patterns. For the anomic aphasics, these effects reached statistical significance in all but two of the conditions. Furthermore, the anomic aphasics, like the nonaphasic controls, and unlike the Broca's aphasics, showed significant effects of conformity to verb bias on reaction times.

3.10 Conduction aphasics

We now turn to the results for the conduction aphasics. Since only two subjects in this group were tested, the results cannot be subjected to the same types of statistical analysis as the other group data. Interestingly, both of the subjects in this group showed a trend towards greater number of errors and longer reaction times in the discordant conditions than the concordant conditions.

Table 17: Conduction aphasics: Number of errors and missing responses (out of 20 possible per condition)

		Active		**Passive**		**Intransitive**	
		Conc.	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
FY	Plaus.	3	4	0	2	2	2
	Impl.	0	2 (1)	2 (1)	6 (1)	2	3
GB	Plaus.	0	0	0	0	0	0
	Impl.	1	0	0 (2)	2	0	1 (1)
Sum	Plaus.	3	4	0	2	2	2
	Impl.	1	2 (1)	2 (3)	8 (1)	2	4 (1)

Since only two patients in this group were tested, the differences in number of errors were not subjected to statistical analysis. Notice that the number of errors the subjects made in each of the discordant conditions is greater than in the corresponding concordant conditions.

Table 17 presents the mean response times for the conduction aphasics. Since only two subjects in this group were tested, the reaction times were also not subjected to statistical analysis. Both subjects do show longer mean response times in the discordant conditions than the concordant conditions for the active transitive and intransitive sentences. In the passive, reaction times are slightly faster in the discordant condition than in the concordant condition for both patients. This finding is intriguing, given that two of the nonaphasic controls also showed faster reaction times in the discordant passive sentences than the corresponding concordant sentences.

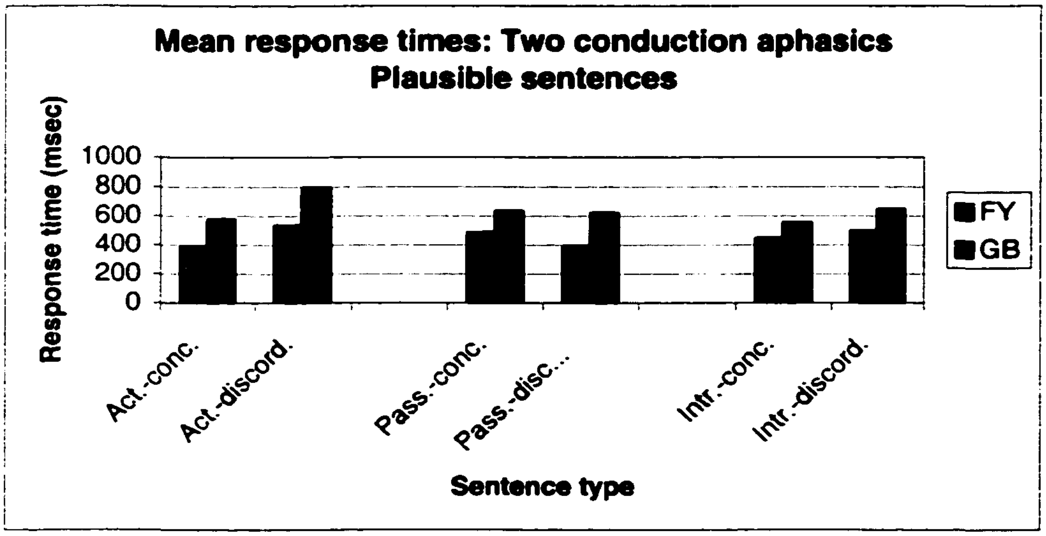
Table 18: Mean response times on plausible sentences, conduction aphasics

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
FY	383.95	532.25	484	385.75	443	489.05
GB	574.15	791.1	630.85	617.05	552.2	634.85
Mean	479.05	661.675	557.425	501.4	497.6	561.95

Table 19: Mean response times on implausible sentences, conduction aphasics

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
FY	487.2	415.737	374.263	444.737	453.15	585.15
GB	669.9	707.4	591.056	759.425	649.35	761.053
Mean	578.55	561.568	482.659	602.081	551.25	673.101

Figure 7: Mean response times: Conduction aphasics



For the implausible sentences, reaction times were longer in the discordant than the concordant condition for the passive and the intransitive sentences, but not for the active sentences.

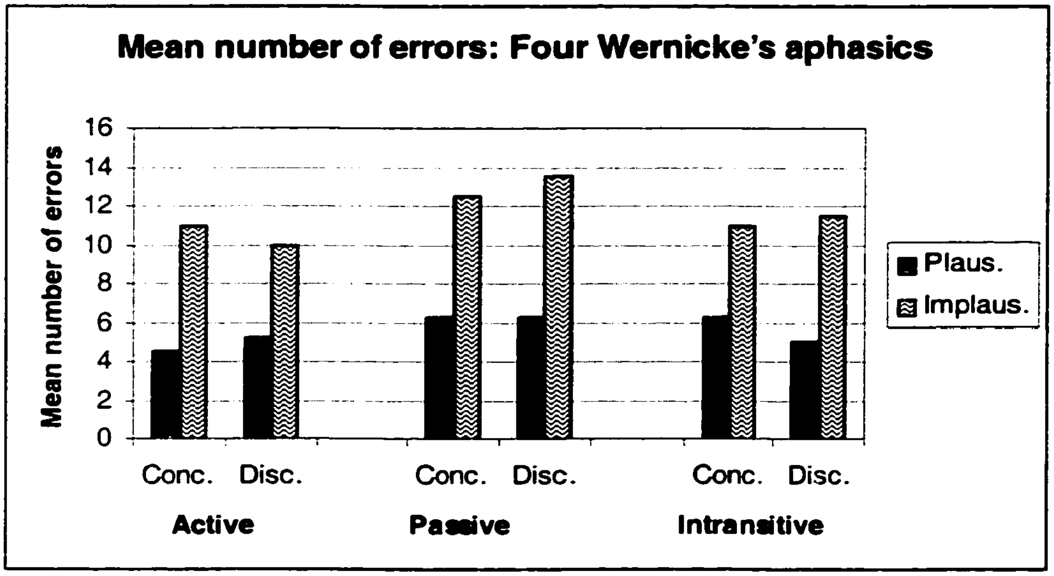
3.11 Wernicke's aphasics

We now turn to the results for the four Wernicke's aphasics. Table 20 below shows the number of errors and missing responses for this patient group.

Table 20: Number of errors in each condition and missing responses (in parentheses): Wernicke's aphasics

		Active		Passive		Intransitive	
		Conc.	Disc.	Conc.	Disc.	Conc.	Disc.
JC	Plaus.	6	6 (1)	9	8 (2)	11 (2)	8 (1)
	Impl.	12	6 (1)	7	12	11	8
WG	Plaus.	7 (2)	9 (2)	8 (1)	8 (1)	10	6 (1)
	Impl.	7	8 (1)	14 (2)	11	10 (1)	11
JT	Plaus.	5 (1)	4	4 (2)	5 (2)	3 (3)	4 (4)
	Impl.	9 (3)	11 (2)	12 (1)	14 (1)	10 (1)	13 (2)
WT	Plaus.	0	2	4	4	1	2 (1)
	Impl.	16	15	17	17	13	14
Sum	Plaus.	18 (3)	21 (3)	25 (3)	25 (5)	25 (5)	20 (7)
	Impl.	44 (3)	40 (4)	50 (3)	44 (1)	44 (2)	46 (2)

Figure 8: Mean number of errors: Wernicke's aphasics.



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The comparisons between the concordant and discordant conditions did not reveal any significant differences for any of the sentence types in either the plausible or implausible conditions. In the "plausible" condition, $t(3) = -1.000$, $p = .196$, for the active sentences, for passive sentences, t(3) = 0.000, p = .500, and for intransitive sentences, t(3) = .951, p = .206. For the implausible condition, the active sentences showed t(3) = .562, p = .307, for the passive sentences t(3) = .594, p = .297, and for the intransitive sentences t(3) = -.397, p = .359.

Figure 8 presents the mean response times for the Wernicke's aphasics. Mean response times for each subject are presented in table 21. The comparisons between the response times on the concordant and discordant active, passive, and intransitive sentences did not yield significant differences for any of the sentence types: t(3) = .141, p = 0.888 for active sentences, t(3) = 1.174, p = 0.242 for the passive sentences, t(3) = .510, p = 0.611 for the intransitive sentences.

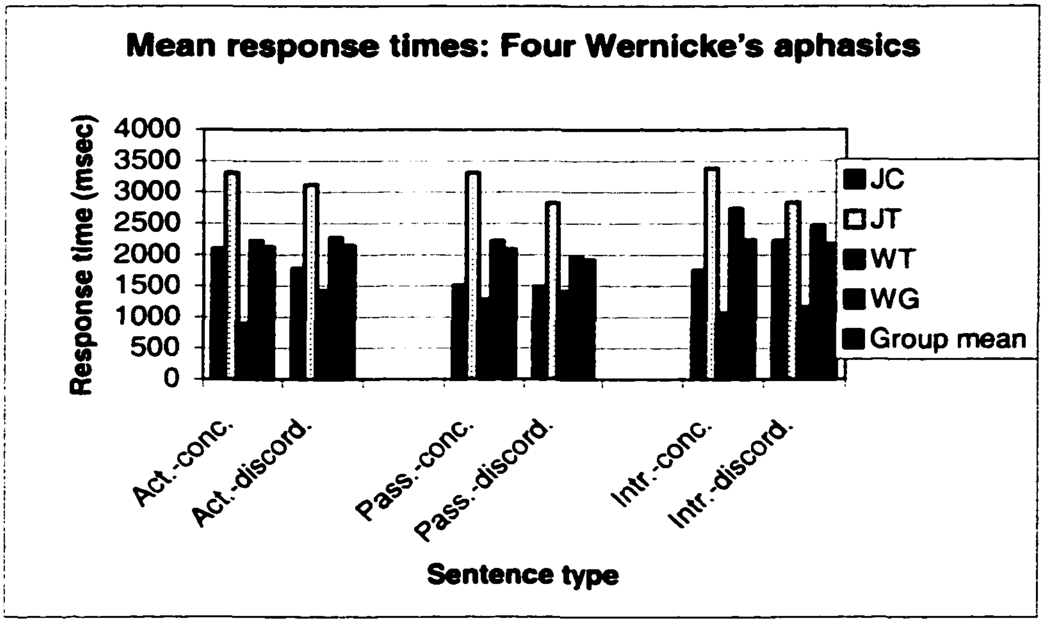
Table 21: Mean response times for plausible sentences: Wernicke's aphasics

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
JC	2086.6	1775.579	1510.1	1484.611	1746.889	2226.789
JT	3305.368	3120.45	3306.389	2826.222	3387.706	2833.063
WT	883.2	1411.65	1277.1	1410.5	1068.9	1149.737
WG	2214.111	2271.944	2218.842	1951.421	2740.75	2458.158
Mean	2122.32	2144.906	2078.108	1918.189	2236.061	2166.937

Table 22: Mean response times for implausible sentences: Wernicke's aphasics

	Active		Passive		Intransitive	
Subject	**Conc.**	**Disc.**	**Conc.**	**Disc.**	**Conc.**	**Disc.**
JC	1801.3	1889.105	1646.5	1867.15	2114.2	2354.95
JT	3546.882	3147.667	3607.316	3018.789	3170.579	3432.444
WT	1214.9	929.65	1872.1	1006.3	1436	1392.6
WG	2468	2271.579	2885.889	2217.85	2744.211	2153.7
Mean	2257.771	2059.5	2502.951	2027.522	2366.247	2333.424

Figure 9: Mean response time: Wernicke's aphasics



For the implausible conditions, the response times were insignificantly shorter in the discordant condition than the concordant condition in the active sentences: t(3) = 1.400, p = .164. For the passive sentences, the reaction times were significantly <u>longer</u> in the concordant condition than the discordant condition: t(3) = 3.366, p = .001. For the intransitive sentences, the response times were not significantly different: t(3) = .224, p = .824.

The Wernicke's aphasics showed an abnormal pattern of effects on response accuracy and speed: There was no effect of conformity to verb bias on response accuracy. The only significant effect of conformity on response times showed a reverse effect of conformity on response time: The Wernicke's aphasics responded faster in the discordant condition than the concordant condition for this sentence type.

To summarize, the four Wernicke's aphasics, unlike the Broca's aphasics or the anomic aphasics, did not show any effect of sentence conformity to verb transitivity bias on response accuracy. Given the high number of errors made by this group of patients, it is possible that the task was so difficult that the subjects resorted to guessing.

3.12 Summary and preliminary discussion

The factor that was manipulated in this experiment was the match between sentence type, a syntactic variable, and verb transitivity bias, a lexical variable. We probed for the effect of sentence conformity to verb bias in nonaphasic controls and in patients diagnosed with Broca's aphasia, anomic aphasia, Wernicke's, and conduction aphasia. We begin by considering the observed effects on the group of nonaphasic controls.

3.13 Nonaphasic controls

The data from the five nonaphasic control subjects indicate that information on the match between sentence structure and verb bias influences processing times in these subjects. Planned comparisons revealed that subjects responded faster to concordant sentences than to discordant ones for plausible active transitive and intransitive sentences. These findings support earlier claims on argument structure preferences, such as those made in Trueswell et al. (1994) and Garnsey et al. (1997), and confirm the validity of the experimental method used in this study.

For the passive sentences, two of the control subjects responded faster in the discordant condition than in the concordant condition. As a result, there was no significant effect of sentence conformity to verb bias in this sentence type. As discussed in section 2.3 above, the order of major constituents in the passive, in which the noun phrase representing the undergoer argument precedes the verb, represents the preferred (i.e. most frequent) order in the case of intransitive-bias verbs. For transitive-bias verbs, the order of major constituents in the passive does not represent the preferred order. The examples in table 23 below illustrate this point:

Table 23: High-probability and low-probability order of major constituents for intransitive-bias and transitive-bias verbs

Verb	***melt***	***open***
Verb bias	Intransitive	Transitive
Most frequent ordering of Undergoer NP and verb:	Undergoer precedes Verb	Undergoer follows verb
Conditions representing most frequent ordering:	Intransitive e.g. *The butter melted* **Passive** **e.g. *The butter was melted by the cook***	Active e.g. *My neighbor opened the door*
Conditions <u>not</u> representing most frequent ordering:	Active e.g. *The cook melted the butter*	Intransitive e.g. *The door opened (after a while)* **Passive** **e.g. *The door was opened (by my neighbor)***

In other words, the discordant passive condition (passives of intransitive-bias verbs) represents the preferred word order, whereas the concordant passive condition (passives of transitive-bias verbs) represents the dispreferred word order. The fact that discordant passive sentences tended to elicit faster reaction times for some of the subjects may therefore be related to a tendency to respond faster when major constituent order conforms to verb bias than when major constituent order conflicts with verb bias.

The nonaphasic controls showed a trend towards making more errors in the discordant condition compared to the concordant condition for each sentence type. This trend did not reach statistical significance for either of the two transitive sentence types (active and passive), and was only significant for the intransitive sentences. The control group made very few errors. All of the subjects in this group reported that they found the task very easy. The absence of a significant effect on response accuracy in these subjects is thus likely to be due to the fact that these subjects made so few errors overall.

The fact that error rates were higher in the discordant conditions than in the concordant conditions is intriguing. Previous research with elderly subject has documented subtle comprehension impairments in healthy subjects. The resulting patterns of miscomprehension have been found to parallel those found in aphasic patients (e.g. Miyake et al. 1995, Davis & Ball 1989). It is possible that the higher error rates in the discordant conditions reflect a parsing failure induced by the mismatch between lexical bias and sentence type, as predicted for the aphasic subjects. Given the small number of subjects, any interpretation of this finding has to remain speculative. A larger sample will be needed to follow up on this question.

3.14 Aphasic subjects: summary of results

We now turn to the observed effects on response accuracy and speed in the aphasic patients. As we saw in the previous chapter, there were significant effects on either accuracy or speed on all of the groups tested, except for the group of four Wernicke's aphasics. Table 24 below summarizes the findings for the plausible sentences for each group of subjects. The notation "Conc. << Disc." stands for "mean response time faster in concordant than discordant condition". Findings in parentheses indicate trends. Effects that reached statistical significance at the .10 level of significance are marked with an asterisk. Effects that were significant at the .05 level of significance are marked with two asterisks.

Table 24: Summary of effects of sentence conformity to verb bias for five groups of subjects

		Active	Passive	Intransitive
Controls	**Effect on response times**	Conc. << Disc.**	No sign. effect	Conc. << Disc.**
	Effect on accuracy	(More errors in discordant condition)	(More errors in discordant condition)	More errors in discordant condition*
Broca's	**Effect on response times**	No sign. effect	No sign. effect	No sign. effect
	Effect on accuracy	(More errors in discordant condition)	More errors in discordant condition*	(More errors in concordant condition)
Anomics	**Effect on response times**	(Conc. << Disc.)	No sign. effect	(Conc. << Disc.)
	Effect on accuracy	More errors in discordant condition*	More errors in discordant condition **	More errors in discordant condition **
Conduction	**Effect on response times**	Conc. << Disc.	No sign. effect	Conc. << Disc.
	Effect on accuracy	More errors in discordant condition	More errors in discordant condition	No sign. effect
Wernicke's	**Effect on response times**	No sign. effect	No sign. effect	No sign. effect

	Effect on accuracy	No sign. effect	No sign. effect	No sign. effect

The results for the anomic aphasics and conduction aphasics indicate a trend for both of these groups to be sensitive to the match between verb bias and sentence structure. The effect on response accuracy was significant in the passive and intransitive sentences for the anomic aphasics.

There was also a tendency for the Broca's aphasics to make more errors in the discordant conditions, despite the fact that there was no significant effect on reaction times for these subjects.

The Wernicke's aphasics did not show any effect, either on reaction times or on accuracy.

However, individual subjects in this group, especially those with relatively low error rates, did tend to show the effect. The absence of an effect for this group could therefore be due to task difficulty. Task difficulty cannot completely account for the absence of an effect, however, since several subjects in the other groups were at or below chance in all conditions and showed the effect nevertheless. It would be premature to conclude that Wernicke's aphasics as a group are not sensitive to verb bias.

Chapter 4

4.1 Introduction

The preceding chapter described the results of an experiment probing the effect of sentence conformity to verb transitivity bias on sentence comprehension. This chapter discusses some of the implications of the results reported in the preceding chapter.

Previous research has shown that verb argument structure preferences influence sentence processing (cf. e.g. MacDonald 1997 for an overview). The most frequent syntactic environment is parsed most readily. Sentences that do not match the preferred parse induce longer processing times in normal subjects than sentences that match argument structure preferences (see e.g. Trueswell et al. 1993). This raises the question whether aphasic comprehension is likewise sensitive to argument structure preferences.

Research in aphasic processing has shown that effects of word frequency are common in aphasia (e.g. Warrington 1975, Warrington & Shallice 1984), which suggests that other types of frequency effects may likewise affect aphasic processing. At the same time, there is abundant evidence for disruptions in processing of lexical information in aphasia. For example, Shapiro et al. (1993) argue that fluent aphasics do not appear to be processing information on verb argument structure normally. Russo et al. (1996), in a study probing the effects of argument structure preferences in a group of five fluent aphasics, report that these patients, unlike normal controls, do not appear to be sensitive to argument structure preferences.

The main question this study set out to answer was whether verb transitivity biases affected aphasic sentence comprehension. We tested response accuracy and response times in a plausibility judgment task. In one set of conditions, the "concordant" conditions, the sentence type (transitive or intransitive) matched the lexical bias of the verb. In a second set of conditions, termed the "discordant" conditions, sentence type and lexical bias did not match.

The results indicate that some aphasic listeners are indeed sensitive to verb biases. This sensitivity was reflected in subjects' response accuracy and response times. As we saw in the preliminary discussion of the results in the previous chapter, the effects manifested themselves differently in different clinical groups. Nonaphasic controls, Broca's aphasics, anomics, and conduction aphasics all tended to make more errors in the discordant conditions, compared to the concordant conditions. For a group of four Wernicke's aphasics, there were no significant differences between the number of errors in the concordant and the discordant conditions. Similarly, response times for nonaphasic controls, anomics and conduction aphasics (though not Broca's aphasics) tended to be longer in the discordant than in the concordant conditions. The group of Wernicke's aphasics again did not show any effect of sentence conformity to verb bias. The remainder of this chapter will discuss some of the implications of these findings.

4.2 Implications for research on aphasic sentence comprehension

4.2.1 Lexical factors in aphasic sentence comprehension

The following statement from Kegl (1995) articulates an assumption that underlies much research in aphasic sentence comprehension:

> "Problems exhibited by agrammatics apply across the board to all constructions of a given argument structure type and do not break down acording to semantic verb classification, further supporting the claim that agrammatism involves a syntactic rather than semantic deficit." (Kegl 1995:153).

In other words, the assumption is that only syntactic information, be it syntactic information associated with lexical representations or syntactic information about sentence structure, can influence agrammatic comprehension difficulties. Kegl emphatically denies that lexical classes defined by any other criteria besides structural ones could have any relevance to patterns in agrammatic sentence production or comprehension. There are a number of studies (e.g. Breedin & Martin 1996 and Breedin et al. 1998) that report aphasic sentence comprehension impairments differentially affecting sentences with different, semantically-definable classes of verbs. Despite this fact, the assumed dichotomy between syntactic and lexical (or structural and semantic) factors reflects widely held beliefs about the nature of agrammatism, and about aphasic sentence comprehension in general. Research in aphasic sentence comprehension has tended to focus exclusively on the role of sentence structure, and has often failed to consider the interaction between lexical and syntactic information.[1]

[1] It is a telling fact, for example, that the Academy of Aphasia conference regularly schedules separate sessions for semantics and word-class phenomena on the one hand and syntax and sentence comprehension on the other.

It is interesting to note that, in the study just cited, Kegl (1995) explicitly stipulates that "agrammatic aphasics have access to the lexical representation of the verb" (Kegl 1995: 158). Kegl's specific claim is that verbs that have an external argument are "more stable and processible [sic] by agrammatic aphasic subjects" (Kegl 1995: 161). As a consequence, unergative verbs are processed more readily than unaccusative verbs, according to Kegl's analysis. Without considering the specific merits of this claim, we note that Kegl makes crucial use of lexical representations in accounting for patterns in agrammatism. Once it is recognized that aphasic sentence comprehension difficulties may stem from difficulties in integrating lexical and sentence-level information, we have to question the assumption that relevant lexical factors should only concern structural information, not other types of lexical properties, such as semantic information.

The finding presented in the current study that comprehension may be more or less impaired depending not just on the sentence type (e.g. active vs. passive), but also on verb transitivity bias, points up the need to consider the interaction of lexical and syntactic factors in aphasic language processing. Aphasic sentence comprehension ability varies not just with structural factors, but also with lexical factors.

4.2.2 The "word order problem" and lexical bias

Studies that sought to trace structural (therefore, by assumption, non-lexical) factors in sentence comprehension deficits include Bradley & Zurif (1980), Schwartz, Saffran & Marin (1980), Saffran, Schwartz & Marin (1980), Caplan, Baker & Dehaut (1985), Caplan & Futter (1986), Grodzinsky (1986), Caplan (1987), Druks & Marshall (1995), Caplan & Hildebrandt (1998), and many others. These studies formed the basis for what has been called the "word-order problem" (a term used for example in Schwartz et al. 1980, Saffran et al. 1980) in aphasic sentence comprehension. The word order problem is the problem of accounting for the fact that many aphasic patients have difficulty understanding sentences whose interpretation crucially relies on the order of noun phrases with respect to the main verb.

Taken together, studies focussing on structural factors alone show that these factors are not sufficient to explain the patterns of aphasic miscomprehension. Performance on passives, for example, tends to be worse than on actives. However, performance on passives is not invariably bad, and performance on active sentences is often far from normal. Indeed, as Berndt et al. (1997) show, only about a third of the patients tested in studies exhibit the overall tendency of chance-level performance on passives in the face of above-chance performance on actives. The high degree of variability on sentence comprehension tasks raises the question to what extent patients' performance is tied to lexical factors. For example, are <u>all</u> passives equally likely to elicit poor performance, or are there some passive sentences that are easier to understand, due perhaps to properties of the main verb in the sentence?

The present study asked the question of whether the frequency with which the verb is transitive rather than intransitive affected the level of performance on passive, as well as active sentences. We found that some passives are indeed understood far more readily than others.

4.2.3 Importance of sentence plausibility in selecting stimuli

This study also points up the need for experimenters to pay attention to contingent frequencies in constructing stimulus sentences. For example, many studies include stimulus sentences like *The zebra hit the lion*. The noun phrase *The zebra* is extremely unlikely to be followed by the verb *hit*, since zebras are not often said to hit things (and are even less often said to hit lions, in particular). In the current study, implausible sentences systematically elicited longer response times and more errors than plausible sentences. This means that sentences such as *The zebra hit the lion* are likely to be far more difficult to process than more plausible sentences that use the same syntactic structure, such as *The student read the paper*.

A similar point can be made about the need to consider lexical biases in constructing stimuli. When testing aphasic comprehension abilities on sentences involving a particular syntactic frames, it is important to consider that different verbs will be more or less likely to appear in the given structure. For example, studies focussing on patterns of the type NP-Verb-NP-PP, as in *She compared the building to an ant hill*, need to take into account that this structure conforms to the lexical bias of some verbs, but not others. When testing sentences like *The zebra hit the bear to the lion* alongside *The zebra gave the bear to the lion* (examples from Caplan et al. 1985), it needs to be kept in mind that the verb *give* is far more likely to occur in this structure than the verb hit.

4.3 Some limitations

The sentence plausibility judgment task imposes certain limitations on the conclusions that can be drawn from this study. One such limitation lies in the high number of errors some of the subjects made. It is important to note that the high error rates cannot have been due just to the difficulty of the metalinguistic judgment task. Linebarger (1983), as well as numerous studies that have appeared since Linebarger's influential paper, report that even severely impaired patients perform at very high levels on grammaticality judgment tasks.

A possible reason for the high number of errors subjects made in the current study is the fact that simple transitive and intransitive sentences may be far more difficult for aphasic subjects than studies using sentence-picture matching tasks make it appear. The sentence types tested in the present study are far simpler than many sentence types commonly discussed in studies of aphasic sentence comprehension. For example, sentences with object relative clauses, such as *The girl saw the boy that the woman hugged*, are the focus of many studies, e.g. Caplan et al. (1980), Grodzinsky (1986), and numerous more recent studies employing sentence-picture matching tasks or enactment tasks.

In sentence-picture matching tasks, subjects hear or read sentences and are asked to select one from among several pictures, usually in the form of line drawings. These tasks do not permit testing implausible sentences, since implausible scenarios of the kind described by sentences in the current study cannot easily be depicted in a line drawing. Caplan et al. (1980) argues for the use of enactment tasks over sentence-picture matching tasks, on the grounds that the forced-choice nature of the sentence-picture matching task unduly constrain the subjects' range of alternatives. Yet, as we just saw, enactment tasks also constrain the possible responses, or rather, the range of sentence interpretations that can be probed, since many implausible scenarios cannot easily be acted out. Hence, the high number of errors elicited in the present study may reflect the fact that comprehension even of very simple sentence types, such as simple active transitive sentences, may be more seriously impaired in some patients than would be apparent had we used a different experimental paradigm.

A limitation of the current study that far more serious than the high error rate is due to the fact that the plausibility judgment is given after the entire sentence has been heard. At that point, subtle variations in processing speed that occur mid-sentence may have become undetectable. This problem is exacerbated in the implausible sentences, since the implausibility of the implausible sentences becomes apparent before the last word of the sentence. As a result, there is a long interval between the time when the listener may have already determined the plausibility of the sentence and the moment when the judgment is given.

Furthermore, factors that come into play mid-sentence may be in conflict with each other. For example, in sentence like *#The cook melted the butter,* the lexical meanings of the first noun facilitates processing, to the extent that sentences with Agent phrases as subjects are processed more readily than sentences with Undergoer subjects (Bever 1970). However, the fact that *melt* is an intransitive-bias verb should slow the processing of the sentence, since the sentence is transitive. These two effects – facilitation due to Agent-as-first NP and slowing due to mismatch between verb bias and sentence structure – may cancel each other out and may therefore become undetectable by the time the plausibility judgment occurs. As a consequence, the absence of a significant detectable effect of sentence conformity to verb bias on response times in some of the groups does not constitute conclusive evidence that information on lexical bias was not accessible to the subjects in question.

The only way to address these problems would be to use a task that keeps track of processing speed mid-sentence. Not all such tasks lend themselves to research with the particular subjects who participated in the present study. For example, a self-paced reading task would not have been suitable for all of the patients, since some of the patients have great difficulty reading.

This study is a beginning of a project, rather than the end of one. The next logical step along the path this study has outlined will be to test aphasics patients' sensitivity to sentence structure and lexical bias in a task that is time-locked to the comprehension process as sentences unfold. For example, tracking gaze movement while patients are listening to sentences offers an experimental technique that is able to reveal immediate effects of lexical information on sentence interpretation.

4.4 Conclusion and future directions

This study explored the role of a lexical factor – verb transitivity bias – in aphasic sentence comprehension. It is hoped that such techniques can further probe the main premise underlying this study: The same mechanisms underlie nonaphasic and aphasic comprehension. The grammar of aphasic comprehension is that of normal comprehension, working under adverse processing conditions.

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Appendix I: Verbs used in the plausibility judgment task

Tables I and II below (next page) show the corpus counts for the twenty verbs used in the plausibility judgment task. Tokens were classified as transitive, intransitive or "neither" (for verb uses that fall outside of the distinction between transitive and intransitive, e.g. speech act uses of *begin*, etc. For technical reasons, sentences containing more than one occurrence of a given verb were excluded from the tally. Corpus counts are based on the 100 million word British National Corpus. Figures marked with an asterisks were counted manually. Figures not marked with an asterisks were obtained using the following tools, which are described in Gahl (1998a,b):

- CQP (Corpus Query Processor, Christ (1994)), a general corpus query processor for complex queries with any number and combination of annotated information types, including part-of-speech tags, morphosyntactic tags, lemmas and sentence boundaries.

- A set of complex queries, written in the CQP corpus query language, which uses regular expressions over part-of-speech tags, lemmas, morphosyntactic tags, and sentence boundaries. The queries apply in a cascading fashion, sorting the concordance lines for each verb into subcorpora based on the surrounding context.

I: Transitive-bias verbs

Verb		Tokens in BNC	transitive	intransitive
1.	boil	999	365	618
2.	clog	249	180*	35*
3.	crack	1571	718*	631*
4.	dissolve	1445	828*	449*
5.	heat	1385	787	362
6.	open	23498	13902	9078
7.	pour	3682	2538*	930*
8.	shut	5497	2439	1517
9.	soften	915	609*	271*
10.	tear	2862	1610	865

II: Intransitive bias verbs

Verb		Tokens in BNC	transitive	intransitive
1.	burst	2491	252	1690
2.	crumble	556	59	449
3.	explode	1502	116*	1335*
4.	grow	17307	2320	11148
5.	harden	712	181	469
6.	melt	1221	389*	764*
7.	merge	1244	373	820
8.	shrink	792	106	614
9.	sink	3334	717*	2494*
10.	rip	1208	627*	364*

Appendix II: Stimuli for the plausibility judgment task

1. Concordant conditions

1.1 Sentence type: Active. Transitive -bias verbs:

	A. Plausible	B. Implausible
1.	My neighbor opened the door.	The door opened my neighbor
2.	The teacher opened the box.	The box opened the teacher.
3.	The traffic was clogging the streets	The streets were clogging the ttraffic.
4.	The leaves clogged the pipe.	The pipe clogged the leaves.
5.	The waiter poured the wine.	The wine poured the waiter.
6.	The waiter poured the water.	The water poured the waiter.
7.	The reseachers dissolved the crystals.	The crystals dissolved the researchers.
8.	The baker dissolved the sugar.	The sugar dissolved the baker.
9.	The heat softened the butter.	The butter softened the heat.
10.	The heat softened the cheese,	The cheese softened the heat.
11.	The cook boiled the soup.	The soup boiled the cook.
12.	The chef boiled the water.	The water boiled the chef.
13.	The cook heated the soup.	The soup heated the cook.
14.	The nurse heated the milk.	The milk heated the nurse.
15.	The professor shut the door.	The door shut the professor.
16.	The assistant shut the store.	The store shut the assistant.
17.	The children cracked the walnuts.	The walnuts cracked the children.
18.	The baker cracked the eggs.	The eggs cracked the baker.
19.	The teacher tore the paper.	The paper tore the teacher.
20.	The girl tore her sweater.	The sweater tore the girl.

1.2 Sentence type: Passive. Transitive-bias verbs:

	A. Plausible	B. Implausible
1.	The door was opened by my neigh bor.	My neighbor was opened by the door.
2.	The box was opened by the teacher.	The teacher was opened by the box.
3.	The streets was clogged by the traf fic.	The cars were clogged by the traffic.
4.	The pipes were clogged by the leaves.	The leaves were clogged by the pipe.
5.	The wine was poured by the waiter.	The waiter was poured by the wine.
6.	The drinks were poured by the waiter.	The waiter was poured by the drinks.
7.	The crystals were dissolved by the	The researchers were dissolved by the
8.	researchers.	crystals.
9.	The sugar was dissolved by the baker.	The baker was dissolved by the sugar.
10.	The butter was softened by the heat.	The heat was softened by the butter.
11.	The cheese was softened by the heat.	The heat was softened by the cheese.
12.	The soup was boiled by the cook.	The cook was boiled by the soup.
13.	The water was boiled by the chef.	The chef was boiled by the water.
14.	The soup was heated by the cook.	The cook was heated by the soup.
15.	The milk was heated by the nurse.	The nurse was heated by the milk.
16.	The door was shut by the professor.	The professor was shut by the door.
17.	The store was shut by the assistant.	The assistant was shut by the store.
18.	The walnuts were cracked by the children.	The children were cracked by the wal nuts.
19.	The egg was cracked by the baker.	The baker was cracked by the egg.
20.	The paper was torn by the teacher.	The teacher was torn by the paper.
	The sweater got torn by the girl.	The girl got torn by the sweater.

1.3 Sentence type: Intransitive. Intransitive-bias verbs:

	A. Plausible	B. Implausible
1.	The butter melted in the pot.	The pot melted in the butter.
2.	The cheese melted in the sun.	The sun melted in the cheese.
3.	Mushrooms grow in the dark.	The dark grew in the mushrooms.
4.	The flowers grew in clusters.	The clusters grew in the flowers.
5.	The boat sank in the storm.	The storm sank in the boat.
6.	The ship sank in the bay.	The bay sank in the ship.
7.	The bomb exploded in the street	The street exploded in the bomb.
8.	The dynamite exploded in a side street.	The side street exploded in the dynamite.
9.	The clay hardened in the sun.	The sun hardened in the clay.
10.	The concrete hardened in the sun.	The sun hardened in the concrete.
11.	The jeans shrank in the wash.	The wash shrank in the jeans.
12.	The shirt shrank in the wash.	The wash shrank in the shirt.
13.	The companies merged in the spring.	The spring merged in the companies.
14.	The firms merged in the fall.	The fall merged in the firms.
15.	The cake crumbled in my hands.	My hands crumbled in the cake.
16.	The crackers crumbled in the box.	The wrapper crumbled in the cheese.
17.	The balloon burst behind the boy.	The boy burst behind the balloon.
18.	The bubble burst behind the girl.	The girl burst behind the bubble,
19.	The shirt ripped almost at once.	The boy ripped almost at once.
20.	The sweater ripped almost at once.	The girl ripped almost at once.

2. Discordant conditions

2.1 Sentence type: Active. Intransitive-bias verbs:

	A. Plausible	B. Implausible
1.	The cook melted the butter.	The butter melted the cook.
2.	The chef melted the cheese.	The cheese melted the chef.
3.	My neighbor grows mushrooms in the yard.	Mushrooms grow my neighbor in the yard.
4.	His parents grow flowers on their balcony.	Flowers grow his parents on their balcony.
5.	The waves sank the boat.	The boat sank the waves.
6.	The storm sank the ship.	The ship sank the storm.
7.	The guards exploded the bomb.	The bomb exploded the guards.
8.	The crooks exploded the dynamite.	The dynamite exploded the crooks.
9.	The sun hardened the clay.	The clay hardened the sun.
10.	The sun hardened the sand.	The sand hardened the sun.
11.	The photographer shrank the pictures.	The pictures shrank the photographer.
12.	The hot water shrank the shirt.	The shirt shrank the hot water.
13.	The directors merged the companies.	The companies merged the directors.
14.	The directors merged the firms.	The firms merged the directors.
15.	The cook crumbled the cake.	The cake crumbled the cook.
16.	The children crumbled the crackers.	The crackers crumbled the children.
17.	The boy burst the balloon.	The balloon burst the boy.
18.	The girl burst the bubble.	The bubble burst the girl.
19.	The boy ripped his shirt.	The shirt ripped the boy.
20.	The girl ripped her sweater.	The sweater ripped the girl.

2.2 Sentence type: Passive. Intransitive-bias verb:

	A. Plausible	**B. Implausible**
1.	The butter was melted by the cook.	The cook was melted by the butter.
2.	The cheese got melted by the chef.	The chef was melted by the cheese.
3.	The mushrooms were grown by my neighbor.	My neighbor was grown by the mush rooms.
4.	The flowers were grown by my parents.	My parents were grown by the flowers.
5.	The boat was sunk by the wave.	The huge wave was sunk by the boat.
6.	The ship was sunk in the storm.	The wave was sunk by the ship.
7.	The bomb was exploded by the guards.	The guards were exploded by the bomb.
8.	The dynamite was exploded by the crooks.	The crooks were exploded by the dynamite.
9.	The clay was hardened by the sun.	The sun was hardened by the clay.
10.	The sand was hardened by the sun.	The sun was hardened by the sand.
11.	The pictures were shrunk by the pho tographer.	The photographer was shrunk by the pictures.
12.	The shirt was shrunk by the woman.	The woman was shrunk by the shirt.
13.	The companies were merged by the directors.	The directors were merged by the companies.
14.	The firms were merged by the directors.	The directors were merged by the firms.
15.	The cake was crumbled by the cook.	The cook was crumbled by the cake.
16.	The crackers were crumbled by the children.	The children were crumbled by the crackers.
17.	The balloon was burst by the boy.	The boy was burst by the balloon.
18.	The bubble got burst by the girl.	The girl got burst by the bubble.
19.	The shirt got ripped by the boy.	The boy got ripped by the shirt.
20.	The sweater got ripped by the girl.	The girl got ripped by the sweater.

2.3 Sentence type: Intransitive. Transitive-bias verbs:

	A. Plausible	B. Implausible
1.	The door opened after a short while..	My neighbor opened after a short while.
2.	The box opened after a short while.	The teacher opened after a short while.
3.	The streets clogged during rush hour.	The traffic clogged during rush hour.
	The pipe clogged after the rain.	The leaves clogged after the rain.
4.	The wine poured over the table.	The table poured over the wine.
5.	The water poured out of the pitcher.	The pitcher poured out of the water.
6.	The crystals dissolved in the solu tion.	The researchers dissolved in the solu tion.
7.	The sugar dissolved in the milk.	The baker dissolved in the milk.
8.	The butter softened in the heat.	The heat softened in the butter.
9.	The cheese softened in the heat.	The heat softened in the cheese.
10.	The soup boiled in the pot.	The cook boiled in the pot.
11.	The milk boiled in the kettle.	The nurse boiled in the kettle.
	The soup heated in the pot.	The cook heated in the soup.
12.	The water heated in the cup.	The nurse heated in the cup.
13.	The door shut behind the professor.	The professor shut behind the door.
	The store shut at six o'clock.	The assistant shut at six o'clock.
14.	The walnut cracked under our feet.	The feet cracked under the walnuts.
15.	The eggs cracked in the carton.	The baker cracked in the carton.
16.	The paper tore in two pieces.	The pieces tore in the paper.
	The sweater tore along the seams.	The seams tore along the sweater.
17.	The valley flooded after the storms.	The storms flooded after the valley.
18.	The fields flooded after the rain..	The storms flooded after the rain..
19.	The vase dropped on the floor.	The floor dropped on the vase.
20.	The pencil dropped on the floor.	The floor dropped on the pencil.