

# Effect of lexical cues on the production of active and passive sentences in Broca's and Wernicke's aphasia

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## Abstract

This study compared the sentence production abilities of individuals with Broca's and Wernicke's aphasia in an attempt to explore the extent to which impaired lexical retrieval impedes sentence production. The ability to produce active and passive reversible and non-reversible sentences was examined when varying amounts of lexical information was provided. The results showed that both Wernicke's and Broca's aphasic individuals were impaired in passive sentence production and that these difficulties were not overcome when lexical cues (the relevant nouns and uninflected verb) were provided. However when auxiliary and past tense morphemes were provided along with the verb stem, production of passive sentences improved drastically for both groups. Analysis of error patterns, however, revealed differences between the two groups, suggesting that Broca's aphasic subjects may find passive sentences difficult due to problems with retrieving the relevant grammatical morphemes. Subjects with Wernicke's aphasia may have been unable to automatically access the passive sentence structure.

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## 1. Introduction

Grammatical encoding is considered to be lexically driven in most models of sentence production (Bock, 1995, 1999; Bock & Levelt, 1994). In Levelt's (1999) words, "lexical concepts in the message will activate the corresponding syntactic words ('lemmas') in the mental lexicon. Their selection makes the syntactic frames available that should correspond to the semantic functions and arguments in the message. In grammatical encoding, the speaker uses this lexical-syntactic information to build up the appropriate syntactic pattern, the surface structure." (p. 88). In other words, locating a lemma yields basic information about how a word combines with other words (Bock, 1999). As lemmas become available, syntactic composition occurs by *unification* of syntactic fragments that come with the lemmas (Levelt, 1999).

Per current sentence production models, the production of passive sentences is driven by lexical access in the same manner as production of canonical active sentences. Verbs that appear in different syntactic frames (active, passive, intransitive, etc.) are proposed to have those frames specified in their lexical representations as different lemmas (Levelt, 1989). These representations designate the thematic roles of accompanying arguments for the various frames. Thus the syntactic frame associated with the passive lemma of a transitive verb in the mental lexicon is: verb<sub>passive</sub> [subject<sub>theme</sub> V object<sub>optional agent</sub>] (instead of: verb<sub>active</sub> [subject<sub>agent</sub> V object<sub>theme</sub>] as for active sentences). Correspondingly, the verb morphology (in English) associated with the passive lemma is: [auxiliary V<sub>participle</sub>]. When the passive lemma of a verb is selected, this triggers assignment of grammatical functions and verb morphology that are appropriate to the passive verb. The essence of this proposal is that verb forms such as passives are stored in the mental lexicon, and directly accessed during production (Bock, Loebell, & Morey, 1992). Verb forms are therefore linked to different meaning relations, the choice of any form

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depends on the message to be conveyed (LaPointe & Dell, 1989; Levelt, 1989).

Such lexically driven grammatical encoding has implications for sentence production in aphasia since problems with lexical retrieval occur to a varying extent in almost all aphasic individuals (Kohn & Goodglass, 1985). Failure to activate appropriate lemmas would impair unification of syntactic fragments, and hence sentence formulation. Thus patients with severe lexical impairments should experience difficulty in sentence production. This might be the case for paragrammatism often observed in fluent aphasic individuals, and/or sentence production deficits observed in agrammatic aphasia. Two different but related aphasiological issues could be addressed within the framework of models of normal sentence production: the effect of lexical deficits on production of different syntactic structures and the vulnerability of passives to breakdown in sentence production. These two issues are addressed in the present study.

The relation between lexical and syntactic deficits has been debated. One view is that phrase structure is represented and retrieved in the same manner as lexical items are stored and retrieved (Lapointe, 1985). Bates, Friederici, Wulfeck, and Juarez (1988) proposed a unified lexicalist account according to which both word retrieval and sentence frame retrieval fall under the common domain of item retrieval. This view predicts a strong correlation between lexical retrieval and sentence planning. Bates and Goodman (1997) drew parallels between lexical and grammatical abilities in aphasia and, referring to Wernicke's aphasia, pointed out that "grammatical substitutions (paragrammatisms) are more common in groups that also produce lexical substitutions (paraphasias)" (p. 555). This notion is supported by Bird and Franklin (1999), who, using Saffran, Berndt, and Schwartz's (1989) procedure for analysis of narrative speech, noted improvements in the proportion of well-formed sentences over a period of two years in two of their aphasic patients. These subjects also showed comparable improvements in noun naming scores, leading the authors to conclude that "... word-finding difficulties affect well-formedness and syntactic complexity..." (p. 204). Patients with anomia also have been reported to produce morphological errors and fewer grammatical utterances compared to control groups (Zaroff, Wulfeck, Bates, & Reilly, 1997). In other words, this view suggests that patients with lexical retrieval deficits are also likely to evince phrase and sentential retrieval deficits since the same retrieval mechanisms are involved in both.

Another view of the relationship between lexical and syntactic processes is that of causality. Here lexical retrieval is a necessary precursor to syntactic planning since sentences are composed of lexical items, and there can be no sentence if lexical items are not retrieved.

Difficulties with verb retrieval have commonly been linked to sentence production deficits because verb lemmas are assumed to hold much of the information that determines construction of a structural frame (Berndt, 1991; Bock & Levelt, 1994; Saffran, Schwartz, & Marin, 1980). Berndt, Haendiges, Mitchum, and Sandson (1997a) found verb retrieval to be strongly correlated with measures of sentence structure such as the proportion of words in sentences, mean sentence length, and elaboration of sentences with content words.

However, others have found little correspondence between lexical and syntactic abilities. Butterworth and Howard (1987) found no correlation between the occurrence of paragrammatisms and neologisms, leading them to conclude that paragrammatisms were not due to a lexical selection deficit. In order to investigate the extent to which problems in lexical access could account for grammatical deficits in fluent aphasia, Edwards and Bastiaanse (1998) compared the distribution of clausal structures with the types and tokens of nouns and verbs in narrative speech samples. They found no consistent relationship between lexical richness and the proportion of complete clauses in the narratives, leading to the conclusion that fluent aphasic patients can suffer from grammatical deficits in addition to their frank lexical deficits (see also Edwards, 1998).

Dissociations between impairments of verb retrieval and sentence production have also been reported in aphasic patients, further complicating the picture. For example, Berndt et al. (1997a, 1997b) failed to find a correlation between the presence of agrammatic speech and a verb retrieval deficit. Further, Jensen (2000) described a patient with a severe impairment of verb retrieval, who could produce canonical sentences, often leaving a slot for the verb that he was unable to retrieve. Jensen's case report suggests that sentence formulation may not be exclusively driven by successful lexical retrieval. Syntactic mechanisms are independent to some degree and can drive sentence planning in the absence of lexical mechanisms (in this case, verb lemmas). Language production experiments with normal individuals have also indicated that sentence "production is not fully lexically based, but rather the structure choices that speakers make when influenced by availability result from the interplay between lexical activation and syntactic production" (Ferreira & Dell, 2001, p. 327).

Or alternatively, Jensen's (2000) data may be explained if we assume that canonical sentence structure is over-learned by adult speakers of a language. In this case, canonical sentences may be produced without verbs because formulation of simple active sentences is largely automated in the mental grammatical encoder, and involves filling slots in a general *schema*. In fact canonical word order is largely preserved in individuals with aphasia, including those with agrammatic aphasia (Bates et al., 1988). If active sentences are produced by

accessing an over-learned and automatized *schema*, one should not find any correlation between production of active sentences and lexical deficits. Non-canonical sentences such as passives, are free of this confound of so-called automatic schema-based processing, and may be better suited for investigating the relationship between lexical and grammatical abilities.

Conclusions regarding the relationship between lexical and syntactic abilities are further complicated by methodological issues. Research investigating lexical–syntactic interactions has typically compared word retrieval in isolation with sentence production in spontaneous speech. However, there is no consistent relation between successful word retrieval in isolation and word retrieval in the context of sentence formulation in aphasic patients (Kohn & Cragolino, 1995). Thus studies where word retrieval in isolation is compared with spontaneous speech may not have measured the same lexical retrieval phenomenon (e.g., Bird & Franklin, 1999). Further, in narrative speech, it is possible that patients produce only those words that they can incorporate in sentence planning. Word count measures, such as type-token ratio, therefore may not be a true reflection of lexical abilities of aphasic individuals. Spontaneous speech data also do not give a complete picture of syntactic capacities because patients can avoid the use of sentence structures that are problematic, thereby avoiding syntactic errors (Heeschen, 1985; Kolk & vanGrunsven, 1985). Further, spontaneous speech analyses also do not indicate the relevance and appropriateness of the sentence produced when compared to the intended sentence.

Though it is an undisputed fact that lexical retrieval and sentence formulation are compromised to varying extents in most aphasic individuals, it is preliminary to attribute aphasic patients' difficulties with sentence encoding to impaired lexical access, without systematically investigating the effect of impaired lexical access on sentence production. This study examined the relation between lexical and syntactic abilities in aphasia. The methodological limitations of earlier studies that examined lexical–syntactic relations can be eschewed by examining sentence planning and retrieval of the same lexical items. This can be done by testing confrontation naming and picture description of the same stimuli. Further, lexical items can be provided as cues to aid sentence formulation. Examining the facilitative effect of providing lexical cues would answer some questions regarding the impact of lexical deficits on sentence production in aphasia. The assumption underlying this method is that only access/retrieval of lexical items is impaired in aphasia, while actual lexical representations in the mental lexicon are preserved. Providing lexical cues to aid picture description would activate these intact representations in the mental lexicon and facilitate their retrieval for sentence production.

The second question addressed in this study is difficulty with passive sentence production in aphasia. Several potential factors could impede passive sentence production. As mentioned earlier, lemmas of passive verbs are assumed to be separate lexical entries in the mental lexicon. Difficulties in retrieving passive verb lemmas could occur independent of active verb lemma retrieval, impeding passive sentence production, but not active sentence production. Passive sentences are also less frequent in discourse (Dick & Elman, 1999) and passive lemmas may therefore have higher activation thresholds compared to active verb lemmas (Menn et al., 1998). Lower frequency of passive sentences also implies that the mental grammar is unlikely to store an over-learned automatized schema for passive sentences. In languages such as English, passives have a non-canonical word order, and non-canonicity by itself could place additional stress on weakened sentence formulation resources. Compared to actives, passive sentences also typically contain more grammatical morphemes. Any deficit with grammatical morpheme retrieval would constrain passive sentence production more than it would constrain active sentence production. The contribution of these factors to passive sentence production deficits in aphasia is poorly understood and needs to be investigated.

Passive sentence production in Wernicke's and Broca's aphasia has often been contrasted in efforts to support a broad double dissociation of semantic and syntactic impairments. Perhaps the most commonly cited evidence of spared syntax in the speech of patients with Wernicke's aphasia is the study of von Stockert and Bader (1976). They tested German Broca's and Wernicke's aphasic subjects using a sentence anagram task in which noun and verb phrases were provided. The experiment was designed such that an equal number of sentences were sensible and grammatical, had reversed normal relationships between subject and object (e.g., *The rabbit shot the hunter*), and employed nonsense words in the place of nouns and verbs. Broca's aphasic subjects tended to arrange the sentences such that the first noun phrase made a semantically sensible agent even if this resulted in a grammatically incorrect sentence. This was taken as evidence of spared semantics and impaired syntax in Broca's aphasia. Patients with Wernicke's aphasia demonstrated 'preserved syntactic abilities' by arranging the sentences in grammatically correct form for all sentence types, although the sentences were often semantically implausible and their thematic roles were reversed.

However, the above pattern may have been due to differences in lexical abilities. Goodglass and Menn (1985) and Martin and Blossom-Stach (1986) pointed out that Wernicke's aphasics have poorer lexical comprehension, and may have relied on morphological cues to formulate sentences. Broca's aphasic subjects may

have given more importance to the meaning of the sentences and may have neglected morphological cues since they have better lexical comprehension. Further, von Stockert and Bader's (1976) findings were not replicated by Edwards, Bastiaanse, and Maxim (2001), who observed similar accuracy rates for active and passive sentence arrangement in both Broca's and Wernicke's aphasic individuals using a similar sentence anagram task. Several researchers have reported grammatical errors in the spontaneous speech fluent aphasic individuals, including those with Wernicke's aphasia (Bates, Friederici, & Wulfeck, 1987; Butterworth & Howard, 1987; Edwards, Bastiaanse, & Kiss, 1994).

Since comparable error rates have been found for Broca's and Wernicke's aphasia (Bates et al., 1988; Edwards et al., 2001; MacWhinney & Osman-Sagi, 1991; Miceli, Silveri, Romani, & Caramazza, 1989; Slobin, 1991; Tzeng, Chen, & Hung, 1991), the notion of a syntax-semantics double dissociation in aphasia has recently been questioned. Some researchers suspect that differences between the morphosyntactic abilities of patients with Broca's and Wernicke's aphasia have been unrealistically magnified. However, nothing precludes two patient groups with unrelated underlying deficits from manifesting similar error rates. Only a qualitative analysis of the pattern of errors will suggest if the similar error rates in Broca's and Wernicke's aphasia are due to the same underlying syntactic deficit.

Role reversals are one type of error frequently reported in experiments designed to elicit passive sentences. Role reversals are sentences that have the opposite agent–theme relation when compared to target sentences. For example, the sentence *The apple is eating the boy* is a role reversal of the target *The apple is eaten by the boy*. Both Wernicke's and Broca's aphasic subjects have been reported to produce role reversal errors (Edwards et al., 2001; Saffran et al., 1980; von Stockert & Bader, 1976). Role reversals, especially for passive targets, could occur in aphasic speech due to one of three reasons: (1) lexico-semantic deficits impairing assignment of grammatical functions, due to which the role of agent is inappropriately assigned to the under-goer of the action, (2) inability to produce grammatical morphemes that mark passive voice, or (3) a default tendency to produce active sentences because they are the most frequent form in English. Thus role reversals could be a manifestation of different underlying deficits. One might hypothesize that role reversals reflect lexico-semantic deficits in Wernicke's aphasia, and grammatical morpheme deficits in Broca's aphasia.

To summarize, the study reported here was conducted to primarily address two issues. First, the relation between lexical retrieval and sentence formulation in aphasia needs to be ascertained. For this purpose, naming and sentence production of the same lexical items was tested. The effect of providing lexical cues to

aid sentence was also examined. Using a picture description task, transitive sentences were elicited under three different conditions: *uncued*, *uninflected cues*, and *passive verb cues*. *Uninflected cues* included the verb and both nouns involved in the action. The verb was provided in its uninflected base form. In addition to both nouns, *passive verb cues* included verb morphology that conveyed passive voice (an auxiliary and inflected verb, e.g., *was pushed*). *Passive verb cues* were meant to facilitate access to passive verb lemmas. *Uninflected verb cues*, on the other hand, could potentially activate both active and passive verb lemmas since verb stems were provided. Sentence production across these three conditions was compared to determine the effect of successful lexical access.

It was predicted that naming scores of Wernicke's aphasic patients would be poorer than those of Broca's aphasic patients. Based on the premise that lexical retrieval interacts with sentence planning and lexical deficits are more pervasive in Wernicke's aphasia, it was hypothesized that providing lexical cues would significantly improve sentence production only for subjects with Wernicke's aphasia. Further, if syntactic errors in the speech of Wernicke's aphasic individuals are the result of impaired lexical retrieval, *uninflected lexical cues* would improve production of active and passive sentences to a comparable extent. If active sentences are produced by accessing an over-learned automatic schema, providing lexical cues would fail to improve active sentence production.

The second issue addressed is the controversy over whether syntactic and semantic deficits are dissociable in Broca's and Wernicke's aphasia. Production of active and passive, reversible and non-reversible sentences was tested to address this question. Passive sentence production was of special interest because passives are syntactically complex and research on Wernicke's aphasics' ability to produce passives has yielded conflicting results. Given a lexical–semantic deficit, it was hypothesized that active and passive sentence production would be equally impaired in Wernicke's aphasia. On the other hand, given Broca's aphasics' well-documented syntactic deficit, passive sentence production would be more impaired than active sentence production for this group. The contrast between reversible and non-reversible sentence production was also crucial. Due to their lexico-semantic deficit, it was hypothesized that Wernicke's aphasic individuals' would produce semantically anomalous role reversals such as *The apple is eating the boy* when required to produce passive sentences such as *The apple is eaten by the boy*. Broca's aphasic subjects are unlikely to produce such anomalous sentences.

In the present study, sentence production errors were classified into five categories (*grammatical morpheme errors*, *role reversals*, *preposition errors*, *unrelated sentences*, and *non-sentences*) in an attempt to tease apart

any qualitative differences between Broca's and Wernicke's aphasic individuals that may have been overlooked during the simple error rate analyses of earlier studies. Analysis of role reversals was crucial: if role-reversals are produced due to impaired semantics, subjects would produce semantically anomalous sentences. However, if role reversals resulted from difficulty with the passive voice morphology only, it was predicted that subjects would avoid role-reversed sentences by producing either unrelated or non-sentence responses, and a high proportion of grammatical morpheme errors. Finally, role-reversed active sentences for passive targets could result from a mere tendency to produce active sentences because they are the most frequent sentence form. In this case, subjects with intact semantic and morphological abilities would produce accurate passive sentences in non-reversible contexts. In Ferreira's (1994) words, "perhaps speakers always attempt an active sentence first, and then change it to a passive if it seems somewhat odd" (p. 732).

## 2. Method

### 2.1. Subjects

Fourteen aphasic subjects, seven each with the diagnosis of Wernicke's and Broca's aphasia, were recruited

for the study. The subjects were all right-handed native monolingual speakers of English and had at least a high school education. Their aphasia resulted from a single episode, left-hemisphere, cerebrovascular accident. They were all at least six months post-onset (except one patient with Wernicke's aphasia who was 4 months post-onset at the time of testing). Their ages ranged between 44 and 76 years (mean age = 62.28,  $SD = 8.27$ ). Subject demographics are given in Table 1. Subject-selection criteria included normal auditory acuity (passed pure-tone audiometric screening at 500, 1000, and 2000 Hz at 40 dBHL, ANSI, 1969) or aided audition, normal or corrected vision, absence of complicating medical conditions including psychiatric disturbances, alcohol/drug abuse and pre-morbid speech and language disorders. Subjects with any history of language intervention that focused on the production of passive sentences were excluded.

### 2.2. Language testing

The diagnosis of Broca's or Wernicke's aphasia was based on subjects' language profile on the *Western Aphasia Battery* (WAB; Kertesz, 1982) (see Table 2). As per the WAB criteria, all subjects with Wernicke's aphasia had fluency scores between 5 and 10, comprehension scores below 6.9 (except W2 and W6), and repetition scores between 0 and 7.9. Earlier WAB

Table 1  
Demographic data of aphasic subjects

Subject	Age	Sex	Handedness	Education	Occupation (years)	Date of stroke	Vision/Hearing	CT scan
B1	56	M	R	16	Teacher	9/26/89	Vision corrected	Left mca region
B2	54	M	R	18	Business man	1/31/99	Normal	Left fronto-parietal in mca region
B3	44	M	R	12	Leasing consultant	8/11/98	Vision corrected	Left mca region
B4	65	M	R	16	Legal liason	12/1/93	Normal	Left mca region
B5	62	M	L	20	Chemist	7/26/97	Normal	Left temporal and small regions of frontal and parietal (mca region)
B6	55	F	R	13	Credit manager	7/7/95	Vision corrected	NIA
B7	64	M	R	16	Accounts manager	2/8/95	Vision corrected	Large left hemisphere frontal and temporal lesion
W1	69	M	R	17	Engineer	1/17/97	Normal	Left Wernicke's area, arcuate fasciculus, temporo-parietal
W2	66	M	R	12	Interplant coordinator	4/23/98	Normal	Left temporo-parietal
W3	65	M	R	20	Physician	2/7/97	Vision corrected	Left parieto-occipital
W4	64	F	R	15	Secretary	3/24/98	Normal	NIA
W5	76	M	R	18	Chemist	12/17/99	Normal	NIA
W6	73	M	R	12	Teacher	Dec-98	Vision + Hearing correction	NIA
W7	59	F	R	12	House wife	10/26/96	Vision corrected	? Sub-arachnoid haemorrhage

B#, Broca's aphasia; W#, Wernicke's aphasia; and NIA, no information available.

Table 2  
Western aphasia battery scores of patients

Subject	Fluency	Comprehension	Repetition	Naming	Aphasia quotient	Diagnosis
B1	4	8.1	7.4	5.6	69.9	Broca's aphasia
B2	4	7.85	8	6.7	65.1	Broca's aphasia
B3	4	7.6	5.8	4.9	64.7	Broca's aphasia
B4	4	9.35	6.7	7.8	73.1	Broca's aphasia
B5	4	6.9	6	5	59	Broca's aphasia
B6	4	7.2	5.9	5.1	58.8	Broca's aphasia
B7	5	8.35	6.9	6.9	54.5	Broca's aphasia
W1	6	6	2.8	2	55	Wernicke's aphasia
W2	7	7	5	2.3	60	Wernicke's aphasia
W3	6	6	6.4	3.7	62.2	Wernicke's aphasia
W4	6	6	4	3.8	56.8	Wernicke's aphasia
W5	6	6	7.2	2.3	59.8	Wernicke's aphasia
W6	7	7	6.9	5	74	Wernicke's aphasia
W7	5	5	3.2	6.7	58.2	Wernicke's aphasia

comprehension subtest scores of W2 and W6 were within the range for Wernicke's aphasia (5.4 and 6.0, respectively). However, at the time of the present experiment, their comprehension performance had improved to 7 (Table 2). For Broca's aphasic subjects, the comprehension score was between 4 and 10, and repetition was between 0 and 7.9. In addition, Broca's aphasic subjects had to score a minimum of 4 on the fluency rating of WAB (halting telegraphic speech, occasional use of verbs or prepositional phrases). Aphasia quotients (AQ) of the WAB ranged from 54.5 to 74 across groups. The mean AQ of the Broca's aphasic group was 68.02 ( $SD = 7.47$ ) and that of the Wernicke's aphasic group was 60.85 ( $SD = 6.24$ ). There was no significant difference in the severity between the Broca's and Wernicke's aphasic groups ( $p(6) = .1337$ ) as measured by the AQ. To avoid a confounding effect of patients' severity on their overall sentence production abilities (Menn & Opler, 1990), the aphasia quotient of each subject was treated as a covariate in all statistical analyses.

Narrative speech samples of the "Cinderella" story were obtained for each subject. The samples were then transcribed and analyzed using the method of narrative analysis developed by Thompson et al. (1995). Broca's aphasic subjects produced an average of 33.6 words/min

( $SD = 11.5$ ). All subjects with Broca's aphasia had halting, effortful speech, and an agrammatic profile as revealed by their narrative speech. This included a short MLU, high open class:closed class ratio, and a high noun:verb ratio (see Table 3). Wernicke's aphasic subjects, on the other hand, produced speech smoothly and effortlessly, and often produced long and incoherent utterances. Wernicke's aphasic subjects spoke at a mean rate of 120.54 words/min ( $SD = 19.1$ ). The proportion of grammatical sentences was reduced when compared to normal subjects. Wernicke's aphasic subjects also had a low noun:verb ratio. The ability to read was tested. All subjects, with the exception of B3, were able to read single words and simple sentences.

### 2.3. Stimuli

Black and white line drawings on 8" × 5" cards were developed. These drawings depicted actions involving two elements, and could be described using transitive verbs. Unambiguous nouns and two-place verbs were selected. In pictures used to elicit reversible sentences, both nouns were alike in animacy (both people/animals). The two nouns varied in animacy (an animate agent and an inanimate theme/patient) for stimuli designed to elicit non-reversible sentences. Pictures were randomly as-

Table 3  
Narrative summaries of the Cinderella sample

	Broca's aphasia	Agrammatic aphasia <sup>a</sup>	Wernicke's aphasia	Normal control <sup>a</sup>
Total words	114.5 (66.27)	114.86 (50.61)	195.4 (83.29)	323.71 (113.57)
Words/min	33.6 (11.5)	—	120.54 (19.1)	—
MLU	4.33 (1.25)	4.5 (1.57)	5.6 (1.1)	14.47 (2.203)
% grammatical sentences	0.32 (0.2)	0.154 (0.129)	0.51 (0.26)	0.898 (0.08)
% simple sentences	0.87 (0.16)	0.804 (0.183)	0.75 (0.1)	0.425 (0.169)
% complex sentences	0.13 (0.16)	0.196 (0.183)	0.25 (0.1)	0.575 (0.169)
Noun-verb ratio	2.58 (1.67)	1.52 (0.70)	0.62 (0.14)	1.21 (0.25)
Open-closed class ratio	1.69 (0.6)	2.23 (1.19)	0.77 (0.37)	0.91 (0.08)

<sup>a</sup>Thompson et al. (1995): based on a corpus of five agrammatic aphasic and five normal subjects narrating the Cinderella story.

signed to the active and passive conditions. To elicit a passive sentence, an arrow pointing towards the theme of the action was used. Similarly, to elicit an active sentence, an arrow pointing towards the agent of the action was used. There were no significant differences ( $p > .05$ ) between the frequencies of nouns and verbs in the active and passive stimuli.

Ten neurologically intact individuals with no history of speech, language, hearing, or cognitive problems, (age range: 50–65 years, Mean age = 56.6 years,  $SD = 5.3$ ) were asked to describe the pictures. Only pictures that elicited the target syntactic structure 100% of the time were chosen as stimuli for the study. In the final set of pictures, an equal number were randomly assigned as active or passive sentences. This resulted in 30 stimuli for reversible sentences (15 active and 15 passive), and 20 stimuli for non-reversible sentences (10 active and 10 passive). The stimuli are listed in Appendix A. Three sets of these drawings were made. The *uncued set* contained line drawings without any written cues. In the second set of stimuli, the corresponding nouns and uninflected verb were printed in 18-size font (*uninflected cues set*). In the third set of stimuli, the corresponding nouns and verb phrase were printed. This included the auxiliary and inflected verb for passive sentences and an inflected verb for active sentences. All passive verb cues were provided in past tense with the auxiliary *was* (*was pushed*, *was kicked*, *was called*, etc.). Since data elicited from passive verb cues were the focus of this study, this set was called the *passive verb cues set*. A total of 20 stimuli (10 reversible and 10 non-reversible) were developed with *passive verb cues*. Examples are given in Figs. 1–3.

#### 2.4. Procedure

Testing was completed in four sessions of approximately 1 h each. The *uncued* stimuli were presented in the first and third sessions, and the *uninflected cues* and *passive verb cues* stimuli were presented in the second

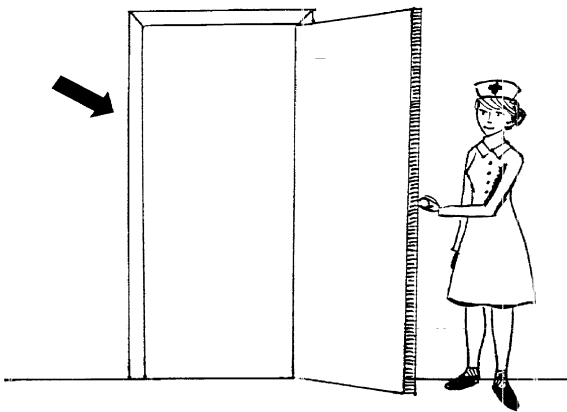


Fig. 1. Stimulus used to elicit an uncued passive non-reversible sentence (for example, *The door is opened by the nurse*).

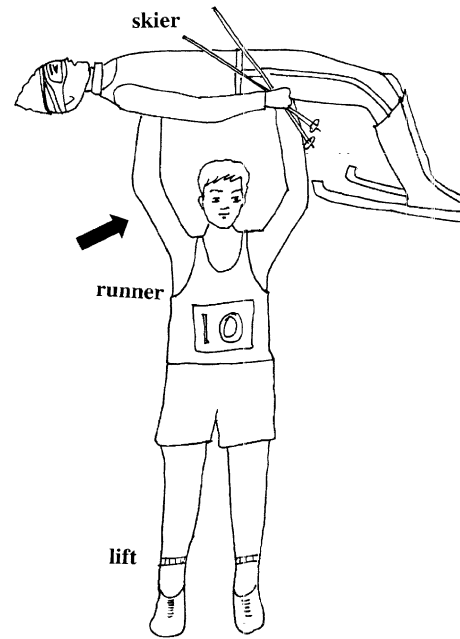


Fig. 2. Stimulus used to elicit a reversible active sentence using uninflected cues (for example, *The runner lifted the skier*).

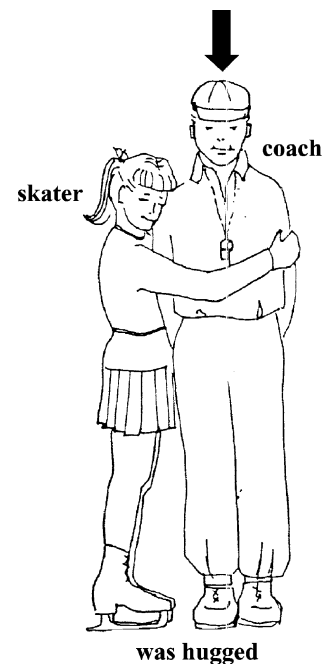


Fig. 3. Stimulus used to elicit a reversible passive sentence using passive verb cues (for example, *The coach was hugged by the skater*).

and fourth sessions. At the beginning of each session, subjects were given three practice sets before presenting the experimental stimuli. Each practice set consisted of two cards with the same picture. Each card was designed to elicit either an active or a passive sentence. For each practice item, written sentences were presented to provide a model of the sentence structure and to highlight

the differences between active and passive sentences. Practice items for the cued conditions contained printed words just as for the experimental stimuli.

Subjects were instructed to produce a single sentence describing the action in the picture and to begin the sentence with the item to which the arrow pointed. Test items were presented in random order that was the same for all subjects. In the *uncued* condition, the patient was asked the question “What is he/she doing?” to elicit active sentences. When the target was a passive sentence, the probe question was “What is happening to her/him?” In both the *cued* conditions, lexical cues were provided by pointing to the items and naming them. For example, *This is the skier and this is the runner and the action here is lift*. Since these items were also printed on the pictures, subjects were given time to read and repeat the items if they wanted to do so. The target sentence was then elicited by asking the subject “What is happening to X?” for passive sentences and “What is X doing?” for active sentences. Attention was directed toward the subject/first noun of target sentences by two devices: naming the subject first and posing the question with focus on the subject. Several studies have shown that the questioned entity tends to be assigned the subject role in the answer (Bates & Devescovi, 1989; Bock, 1977). A maximum response time of one minute was allowed. Subjects were not given feedback about the accuracy of their responses. All sessions were tape-recorded for later transcription.

All subjects were given a naming and recognition test. The *naming test* was given in the first session after the *uncued* stimuli were presented. It included a confrontation-naming task in which all the nouns and verbs in the stimuli were probed. This was done to ascertain that any improvement in sentence formulation seen in both the *cued* conditions resulted from providing lexical items that could not be retrieved and named in the *uncued* condition. The *recognition test* was given at the end of the second session after the cued stimuli were presented. It included a picture-pointing task where the recognition of all the nouns and verbs in the stimuli were tested. The nouns/verbs were printed on the stimuli that were used to test recognition in order to make the demands of the recognition task identical to the demands of the *cued* sets. Subjects were instructed to point to the item that was named. Four options were provided. Recognition was tested to ascertain that subjects succeeded in accessing the appropriate lexical items in the *cued* conditions when the names were provided by the examiner.

### 2.5. Scoring

All responses including self-corrections and other comments made by the subject were transcribed and segmented into utterances. Utterances were segmented mainly on the basis of prosodic information (presence of

a pause and declining intonation). Grammatical cues such as the end of a sentence or an abandoned phrase were also used. When subjects produced more than one utterance or self-corrected, a single *best utterance* was selected. Specific criteria were used to choose the best utterance. An utterance beginning with the target word, that attempted to describe the action, was the closest match to the target, and contained the highest number of correctly produced elements, including lexical items, grammatical elements, and thematic roles was chosen as best utterance (Caplan & Hanna, 1998). In cases where the target was a passive sentence, and one had to choose between an utterance that had the correct thematic roles, but was in the active voice instead of passive, and another utterance that was a partially correct passive, the latter was chosen as the best utterance because it was grammatically closest to the target.

Best utterances then were scored for accuracy. A correct sentence was defined as one which was produced with the target voice (active or passive), appropriately described the action in the picture, and had no errors of grammatical morphology (with the exception of determiner omissions). Determiner omissions were disregarded for analysis because determiners do not convey any crucial information about whether the sentence is in active or passive voice. Responses containing minor phonemic errors were accepted (e.g., *baid* for *maid*). Word substitutions (i.e., verbal paraphasias) were accepted if they were semantically and structurally appropriate (e.g. *The mailman is smooching the woman* was scored as correct when the target sentence was *The mailman is kissing the maid*). Omissions or substitutions of verb auxiliaries and verb inflections were scored as incorrect. The total number of correct active and passive sentences was noted for each subject.

Errors were analyzed to determine the nature of deviations. The error categories included *grammatical morpheme errors*, *preposition errors*, *role reversals*, *unrelated sentences*, and *non-sentences*. *Grammatical morpheme errors* included omissions, substitutions, or inappropriate insertion of auxiliaries (*\*The mailman kissing the girl*) and/or verb inflections (*\*The mailman kiss the girl*). Omissions, substitutions, and additions of prepositions were coded as *preposition errors* (*\*The mailman kiss of the girl*). *Role reversals* errors were utterances that assigned the agent function to the patient of the action and vice versa (*The apple is eating the boy*). *Non-sentences* included single words or a string of words that did not contain any evidence of phrase structure (*boy... boy...*). *Unrelated utterances* were those that did not describe the target action (*The mailman is standing for the target The mailman is kissing the maid*).

Often, sentences had to be reconstructed in order to determine grammatical morpheme errors. For this the most conservative approach was adopted which gave the lowest error score for that utterance. Thus, an utterance

such as *\*The boy push the girl* was reconstructed as *The boy pushed the girl* rather than *The boy is pushing the girl*. This is because the former reconstruction entails only one error, omission of the verb inflection. On the other hand, the latter reconstruction would be considered as two errors—omission of the auxiliary and verb inflection. Responses to passive stimuli were reconstructed as the corresponding passive sentence. Therefore a response such as *The bartender is punching the boxer* was compared with its target *The bartender is punched by the boxer*, and scored as substitution of verb inflection (*grammatical morpheme error*) and omission of the preposition (*preposition error*). In addition, it was counted as a *role reversal*.

For *grammatical morpheme* and *preposition errors*, the proportion of errors was calculated by dividing the number of errors by the number of obligatory contexts for that morpheme. Proportion of *role reversals*, *non-sentences*, and *unrelated sentences* was calculated by dividing the number of occurrences of each error with the total number of *best utterances*.

2.6. Reliability

There were a total of 56 sessions (14 subjects × 4 sessions each). Six of these sessions (10%) were observed by a trained reliability scorer. The reliability scorer kept count of the accuracy with which the experimenter followed the test protocol. This protocol reliability was 100%. The same observer also scored on a 5-point scale, the extent to which she thought subjects comprehended the requirements of the task. On this scale, 4 meant that the subject understood all the instructions and 0 meant that the subject did not understand any of the instructions. The mean comprehension given by the reliability scorer was 3.8 (SD = 0.2).

A total of 84 samples were collected (14 subjects × 3 cue conditions [uncued, uninflected cues, and passive verb cues] × 2 sentence types [reversible and non-reversible]). An independent trained judge scored 25% (21) of randomly selected samples. Point-to-point agreement between the primary experimenter and the reliability scorer was calculated for choice of *best utterance*, for the accuracy score given to each utterance, and for the classification of errors. Point-to-point agreement was 92% for choice of *best utterance*, 92% for accuracy scoring, and 100% for error categorization. Disagreements between the scorers were resolved by discussing the criteria and arriving at a consensus.

Intra-judge reliability was also obtained for the primary experimenter on transcription and scoring of all the samples. All samples were transcribed and scored for the second time by the primary experimenter three months after the first transcription and scoring. Point-to-point intrajudge transcription reliability was 97% and scoring reliability was 100%. Discrepancies between the

first and second transcriptions were resolved by consulting with the reliability scorer.

3. Results

The mean accuracy scores of active and passive uncued and cued sentences for Broca’s and Wernicke’s aphasia are given Figs. 4–7. Separate three-way repeated measures analyses of covariance (2 patient groups × 2 sentence types (active and passive) × 2 cue conditions (*uncued* and *uninflected cues*)) were completed for reversible and non-reversible sentences. The AQ of the Western Aphasia Battery (Kertesz, 1982) was the covariate factor. Analyses revealed a main effect of sentence complexity ( $F(1, 40) = 148.47, p = .0001$  for reversible sentences;  $F(1, 40) = 205.15, p = .0001$  for non-reversible sentences). There were no significant effects of patient group for reversible sentences ( $F(1, 1) = 1.02, p = .33$ ). However there was a significant group difference for non-reversible sentences ( $F(1, 1) = 7.12, p < .05$ ). Post hoc tests revealed a significant difference between Broca’s and Wernicke’s aphasia only for non-reversible passive sentences ( $t(5) = 2.57$ ,

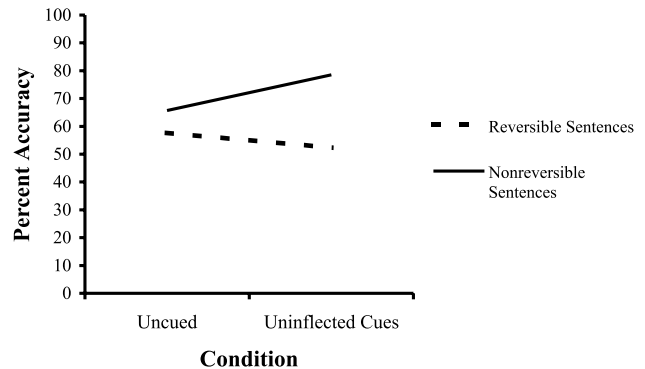


Fig. 4. Accuracy of active sentence production in Broca’s aphasia in both cue conditions (N = 7).

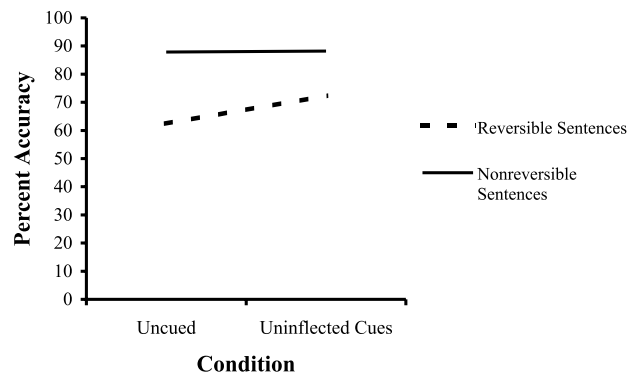


Fig. 5. Accuracy of active sentence production in Wernicke’s aphasia in both cue conditions (N = 7).

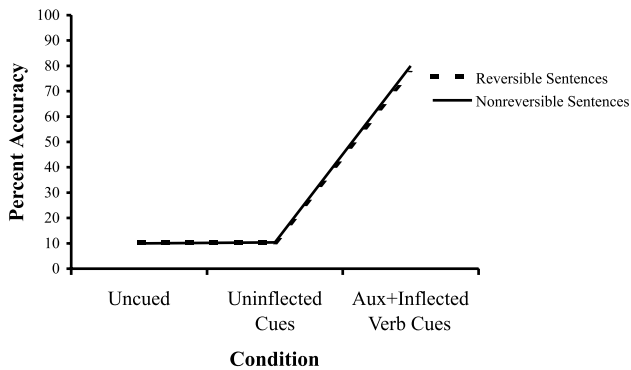


Fig. 6. Accuracy of passive sentence production in Broca's aphasia for all three cue conditions ( $N = 7$ ).

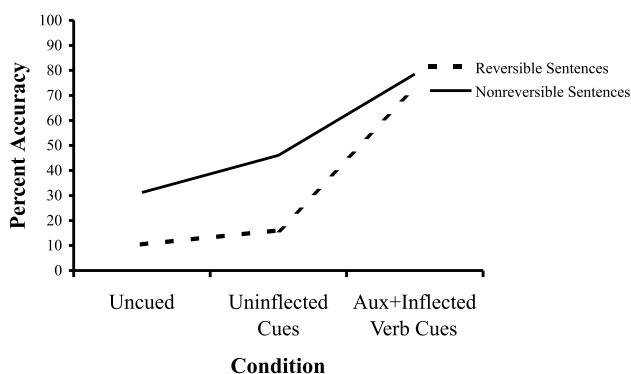


Fig. 7. Accuracy of passive sentence production in Wernicke's aphasia for all three cue conditions ( $N = 7$ ).

$p < .05$ ) indicating better performance of Wernicke's patients. Providing *uninflected cues* failed to improve accuracy in either subject group for both reversible and non-reversible sentences ( $F(1, 1) = 0.39$ ,  $p = .53$  for reversible sentences;  $F(1, 1) = 1.39$ ,  $p = .1$  for non-reversible sentences). None of the interactions were significant.

In other words, both reversible and non-reversible passive sentences were produced significantly less accurately than active sentences, and this pattern was seen for both Broca's and Wernicke's aphasia. There were no between-group differences in accuracy except in the case of non-reversible passives, where Wernicke's aphasic subjects were more accurate. The mean score of Broca's aphasic subjects was slightly lower than that of Wernicke's aphasics for active sentences (Mean = 63.55%,  $SD = 11.38$  for Broca's aphasia versus Mean = 70.63,  $SD = 13.45$  for Wernicke's aphasia). This pattern is consistent with earlier reports that Broca's aphasic subjects are impaired in their ability to construct sentences, even simple active sentences. Providing *uninflected cues* failed to improve the accuracy of either active or passive sentences for either patient group.

A separate three-way analysis of covariance compared passive sentences produced by Broca's and Wer-

nicke's aphasics in three different cue (*uncued*, *uninflected cues*, and *passive verb cues*) and two reversibility conditions. There was no significant group difference [ $F(1, 1) = 1.19$ ,  $p = .29$ ]. There were significant main effects of the type of cue ( $F(1, 2) = 102.23$ ,  $p = .0001$ ) and reversibility ( $F(1, 1) = 12.12$ ,  $p = .0009$ ). Post hoc tests revealed significant improvement with *passive verb cues* compared to other conditions ( $t(5) = 8.61$ ,  $p < .0001$ ), and non-reversible sentences were significantly more accurate than reversible sentences only for Wernicke's aphasia ( $t(5) = 8.13$ ,  $p < .0001$ ). In other words, *passive verb cues* improved passive sentence production for both subject groups.

An interesting and important observation was that Wernicke's aphasic subjects produced passives with a variety of verb tenses, although the experimenter consistently provided past tense morphological cues (e.g., *was pushed*). That is, in 29 out of 105 instances, (i.e., 27.6% of the time) their passives did not contain the exact grammatical morphemes that were supplied by the experimenter although the passive voice was correctly produced. This observation demonstrates adequate access to grammatical morphemes in Wernicke's aphasia. A few illustrative examples are given below.

W2: The king is being shot by the cowboy (verb cue provided : *was shot*).

W5: He is getting shoved by the soldier (verb cue provided : *was shoved*).

### 3.1. Error analyses

The proportion of errors in each error category for active and passive sentences are given in Tables 4 and 5, respectively. The actual number of occurrences are also given in parentheses since proportions do not indicate the magnitude of the pattern. Broca's aphasic subjects produced significantly more *errors of grammatical morphology* compared to Wernicke's aphasic subjects both when cues were not provided ( $t(6) = 2.57$ ,  $p < .05$ ) and when cues were provided ( $t(6) = 2.76$ ,  $p < .05$ ). This pattern was seen for both active and passive sentences.

For active sentence targets, Wernicke's patients produced a significantly higher proportion ( $t(6) = 3.16$ ,  $p < .01$ ) of *preposition errors* when compared to Broca's aphasic subjects. However, this was because Broca's aphasic subjects hardly attempted any utterances with prepositions for active sentence targets. Wernicke's aphasic subjects' errors involved addition of prepositions in inappropriate contexts and substitutions of prepositions. This is shown in the examples below:

W2: He is (is is kill eh is is slacking lacking) lissing with her (Target: The mailman is kissing the maid).

W1: He is looking to the space guy (Target: The scientist is watching (or looking at) the astronaut).

There was no significant between group difference in the proportion of preposition errors in the context of

Table 4  
Proportion of error types for active sentences

			Grammatical morpheme errors	Preposition errors	Role-reversals	Unrelated sentences	Non-sentences
Broca's aphasia	Reversible sentences	Uncued	0.26 (40/154)	0.3 (2/6)	0	0.02 (2/105)	0.14 (14/105)
		Uninflected cues	0.32 (48/150)	0	0	0.01 (1/105)	0.02 (2/105)
	Non-reversible sentences	Uncued	0.14 (15/110)	0	0	0.01 (1/70)	0.02 (2/70)
		Uninflected cues	0.12 (13/111)	0	0	0	0
Wernicke's aphasia	Reversible sentences	Uncued	0.02 (5/195)	0.4 (8/17)	0	0.17 (18/105)	0.1 (11/105)
		Uninflected cues	0.11 (22/195)	0.61 (8/13)	0.04 (4/105)	0	0.01 (1/105)
	Non-reversible sentences	Uncued	0.02 (3/136)	0.08 (1/12)	0	0	0.01 (1/70)
		Uninflected cues	0.03 (3/108)	0	0	0	0

The number of errors and the number of obligatory contexts are given in parentheses.

Table 5  
Proportion of error types for passive sentences

			Grammatical morpheme errors	Preposition errors	Role-reversals	Unrelated sentences	Non-sentences
Broca's aphasia	Reversible sentences	Uncued	0.5 (86/174)	0.85 (45/53)	0.47 (40/105)	0.15 (15/105)	0.2 (21/105)
		Uninflected cues	0.6 (118/196)	0.78 (69/89)	0.7 (73/105)	0.01 (1/105)	0.06 (6/105)
		Passive verb cues	0.08 (12/140)	0.18 (13/68)	0.04 (3/70)	0.01 (1/70)	0.01 (1/70)
	Non-reversible sentences	Uncued	0.4 (41/97)	0.63 (24/38)	0.28 (20/70)	0.01 (1/70)	0.16 (11/70)
		Uninflected cues	0.54 (67/125)	0.42 (20/49)	0.45 (31/70)	0.01 (1/70)	0.03 (2/70)
		Passive verb cues	0.03 (5/140)	0.1 (7/70)	0	0	0
Wernicke's aphasia	Reversible sentences	Uncued	0.3 (49/168)	0.73 (35/52)	0.39 (39/105)	0.34 (36/105)	0.1 (11/105)
		Uninflected cues	0.37 (82/219)	0.74 (66/89)	0.52 (55/105)	0.05 (5/105)	0
		Passive verb cues	0.06 (8/135)	0.2 (13/64)	0.04 (3/70)	0.02 (2/70)	0
	Non-reversible sentences	Uncued	0.1 (13/132)	0.22 (8/35)	0.08 (6/70)	0.14 (10/70)	0.01 (1/70)
		Uninflected cues	0.25 (37/147)	0.34 (20/58)	0.21 (15/70)	0	0.01 (1/70)
		Passive verb cues	0.07 (10/134)	0.03 (2/65)	0	0.03 (2/65)	0

The number of errors and the number of obligatory contexts are given in parentheses.

passive sentences ( $t(5) = 0.95$ ,  $p = .2$ ). Broca's aphasic subjects made efforts to produce passive sentences by producing prepositions, though they were less successful in retrieving the appropriate grammatical morphemes. Examples are given below:

B4: The bag carrying by the doctor (Target: The bag is carried by the doctor).

B7: Sailor is pushing by the soldier (Target: The sailor is shoved by the soldier).

Passive targets elicited large numbers of *role reversals* in both Broca's and Wernicke's aphasic indi-

viduals. The proportion of *role reversals* did not differ significantly between the two groups for reversible sentences ( $t(6) = 0.907$ ,  $p = .19$ ). For non-reversible targets, Wernicke's aphasic subjects showed a tendency to produce fewer *role reversals*, although this trend failed to reach significance ( $t(6) = 1.28$ ,  $p = .07$ ). This finding corresponds with the higher accuracy of non-reversible passives in Wernicke's aphasia. A further pattern was noted: Broca's aphasic patients produced a total of 170 *role reversals* for the 350 passive stimuli, of which 107 *role reversals* had either auxiliary

Table 6  
 Naming and Recognition scores for Broca's and Wernicke's aphasia (Mean and SD, maximum score is 100)

	Naming		Recognition	
	Nouns	Verbs	Nouns	Verbs
Broca's	75.4 (16.2)	66.9 (19.9)	100 (0)	100 (0)
Wernicke's	61.5 (8.2)	63.6 (14.6)	99.63 (.7)	100 (0)

or verb inflection errors or both. This is in contrast with patients with Wernicke's aphasia, who produced only 22 (out of 116) *role reversals* with auxiliary and/or verb inflection errors. A two-way analysis of variance revealed a significant effect of group (Broca's versus Wernicke's aphasia) [ $F(1, 1) = 6.83, p < .05$ ] and type of role reversal (with and without grammatical morphology errors) [ $F(1, 1) = 15.3, p < .05$ ]. This analysis confirms the hypothesis that a large part of Broca's aphasics' difficulty with passive sentences is a manifestation of their difficulty with grammatical morphology.

It should be noted that although Wernicke's and Broca's aphasic subjects produced *role-reversals* for passives, they were aware of their errors. Some excerpts are given below:

W4: Wife is going to cover the husband. That doesn't sound right. How do you do that? (Target: The wife is covered by the husband).

W2: The wife has a cover of the husband. I don't think it's correct, but in any way. (Target: The wife is covered by the husband).

B7: The (the the) guy is helping the bicyclist... The other way around... The man is ... The man is quaching the priest eh the bicycle. (Target: The cyclist is helped by the hunter).

The overall proportion of *unrelated sentences* was quite low for both groups. Wernicke's aphasic subjects produced significantly more *unrelated responses* in the uncued condition for both reversible and non-reversible targets ( $t(6) = 2.61, p < .05$ ). Providing lexical cues significantly decreased the occurrence of *unrelated responses* in Wernicke's aphasia ( $t(6) = 2.58, p < .05$ ) (see Tables 4 and 5). Wernicke's aphasics' *unrelated sentences* also revealed interesting strategies to circumvent their difficulty with passive sentences. A common strategy was to use conjunctions to combine two simple sentences, the first sentence being unrelated to the action in the picture but beginning with the specified noun, and the second sentence describing the action in active voice.

W2: The king has a crown and he (pointing to the cowboy) shot him (referring to the king) (Target: The king is shot by the cowboy).

W3: Lady is sleeping and the father is doing something (Target: The wife is covered by the husband).

Although Broca's aphasic subjects tended to produce more responses that were labeled as *non-sentences*, this failed to reach significance ( $t(6) = 1.39, p = .11$ ).

To summarize, when compared to Broca's aphasic subjects, Wernicke's aphasic subjects produced fewer *grammatical morpheme errors* in general, and in their *role reversals* in particular. Wernicke's aphasic subjects also produced fewer *role reversals* in the context of non-reversible sentences when compared with Broca's patients. Wernicke's aphasic subjects also produced more *preposition errors* for active sentences, although this was because Broca's aphasic individuals hardly attempted any prepositions while producing actives. The proportion of *unrelated sentences* and *non-sentences* was very low for both groups. Wernicke's aphasic individuals also produced more *unrelated sentences* in the *uncued* condition when compared with the *cued* condition. This pattern was not seen for Broca's aphasia.

### 3.2. Naming and recognition

Wernicke's aphasic subjects were significantly more impaired in the naming of nouns when compared to the Broca's aphasic subjects ( $t(6) = 2.86, p < .05$ ). There were no significant differences in the naming of verbs ( $t(6) = 0.28, p = .73$ ), or in the recognition scores ( $t(6) = 0.18, p = .97$ ). The recognition scores of both groups were high indicating that subjects were able to successfully recognize lexical items when they were presented by the examiner. The group means are given in Table 6.

Since the accuracy of active and passive sentences differed significantly for both aphasic groups, naming scores of lexical items in stimuli used to elicit active sentences were compared with naming scores of lexical items used to elicit passive sentences. There was no significant difference in the naming scores of lexical items used to elicit active and passive sentences ( $t(74) = 0.63, p = .2$  for Broca's aphasia;  $t(74) = 1.29, p = .1$  for Wernicke's aphasia).

## 4. Discussion

The present study examined the production of reversible and non-reversible active and passive sentences in Broca's and Wernicke's aphasia. In addition, the effect of uninflected and inflected lexical cues on sentence production was analyzed. The data revealed interesting patterns. First, providing *uninflected lexical cues* failed to improve sentence production to any significant

extent. Secondly, subjects with Wernicke's aphasia evinced considerable difficulty in producing passive sentences. Third, Wernicke's aphasic subjects were better at producing non-reversible passives compared to reversible passives. Fourth, contrary to earlier reports, Wernicke's subjects produced few semantically anomalous active voice sentences (such as, *The apple is eating the boy*). Fifth, both aphasic groups evinced considerable success in producing passive sentences with passive verb cues. Finally, error analyses revealed differences and similarities between Broca's and Wernicke's aphasics. The consistent difference was a higher proportion of morphological errors by Broca's aphasic subjects. The similarity was in the proportion of role reversals produced by both groups in response to passive targets. Different possible explanations for these patterns and their implications for sentence production models are discussed in the following sections.

#### 4.1. Role of lexical retrieval in sentence production

Certain lexicalist accounts predict a strong correlation between lexical retrieval deficits and sentence planning deficits since both lexical retrieval and phrase retrieval are assumed to be mediated by common mechanisms. These accounts are not supported by our findings because overall sentence production accuracy did not differ in Wernicke's and Broca's aphasia, although Wernicke's aphasic subjects were significantly more impaired in noun naming. Further, passive sentence production was significantly more impaired than active sentence production, although confrontation naming scores of lexical items in passive sentences did not differ from confrontation naming accuracy of lexical items in active sentences. Other lexicalist theories assume a causal relationship between successful lexical retrieval and successful sentence planning, and are not supported by this latter finding. Both these results concur with the findings of Edwards and Bastiaanse (1998), who failed to find a correlation between lexical measures (such as type and tokens of noun/verb use) and grammatical measures (such as the proportion of embedded clauses used) in fluent aphasia. Butterworth and Howard (1987) also failed to find a correlation between the occurrence of neologisms, a sign of impaired lexical retrieval, and the occurrence of paragrammatism in fluent aphasia.

Providing *uninflected cues* failed to significantly improve accuracy of sentences for either patient group. This finding was unexpected especially for Wernicke's aphasia because Wernicke's aphasic subjects were significantly more impaired than Broca's aphasic individuals in confrontation naming of nouns. The possibility that lexical cues failed to activate the appropriate lexical representation in the mental lexicon is an unlikely explanation because of the high recognition scores of all

subjects. High word recognition scores suggest that subjects were able to map lexical cues provided by the experimenter onto their mental lexicons. Moreover, Blumstein et al. (2000) provided evidence that aphasics are able to map phonological information onto the lexicon. Since *uninflected cues* failed to facilitate sentence production, it suggests that lexical retrieval deficits do not completely disrupt sentence production.

As mentioned earlier, purely lexically based models of sentence formulation propose syntactic formulation to be automatically set in motion as a consequence of retrieval of lemmas (Bock, 1987; Bock & Levelt, 1994; Levelt, 1989, 1999). According to Levelt (1999), selection of lemmas activates associated syntactic fragments (verb phrase, noun phrase, etc.). Syntactic encoding consists of merely unifying these syntactic fragments. Thus the crucial process in these models is lemma selection. Only those lemmas that meet the conceptual requirements of the message are selected. Since active and passive verb lemmas are associated with different semantic relations, one should not be erroneously selected for the other. Thus only passive verb lemmas should be selected when *uninflected verb cues* are provided, although both active and passive verb lemmas could be potentially activated. However, in our experiment, passive sentence production was not facilitated with *uninflected verb cues*. And attempts at passives frequently resulted in role reversals. This suggests that factors other than lexical retrieval could potentially undermine sentence production in aphasia.

One might propose that activation of lexical items triggers certain *sentence frames* (active, passive, etc.), which in turn sets syntactic formulation mechanisms in motion. Failure to access these *sentence frames* might impair sentence production, without a frank syntactic deficit. This might have been the case with *uninflected verb cues* in this study. Failure of *uninflected cues* to improve production of active sentences might be explained if active sentences are produced by automatic and relatively easy access to an over-learned *canonical sentence schema*. Support for this notion comes from Bates et al. (1988), who found the most frequent canonical word order is often preserved in aphasia in several languages. Further, as mentioned earlier, Jensen (2000) described a subject who was aware of canonical sentence structure despite impaired access to verbs. Therefore the availability of the *canonical schema* is independent of the success of lexical retrieval mechanisms. A closer look at both Broca's and Wernicke's aphasic subjects' utterances reveals that they used pronouns on several occasions (such as *He is kissing her* for the target *The mailman is kissing the maid*). This implies that subjects may have first activated their stored active sentence schema, and then filled in noun slots with pronouns when lexical retrieval failed to select the appropriate nouns.

*Uninflected verb cues* might have failed to improve passive sentence production because these cues failed to activate the passive sentence frame in the mental syntactic encoder. Providing *passive verb cues* activated passive lemmas. This, in turn, activated the passive sentence frame in the mental grammar, leading to successful passive sentence production. Along these lines, Ferreira and Dell (2001) proposed a *lexical–syntactic interactionist model* with an interplay between lexical activation and syntactic production mechanisms. In other words, production of an active or a passive sentence does not depend directly on the availability of the agent or undergoer of an action, rather the availability of the agent or undergoer influences syntactic mechanisms that produce active or passive sentences. Thus functional syntactic mechanisms are as much a precursor to sentence production as accessible lexical items are.

Limited processing resources for syntactic computation have often been implicated for sentence production deficits in aphasia (Hartsuiker & Kolk, 1998). If this were the case, providing *uninflected cues* should have had the effect of reducing processing demands by facilitating lexical retrieval and freeing up more resources for syntactic processing. In other words, processing accounts predict improvement in sentence production when cues are provided. Processing accounts fail to account for sentence production deficits seen in our patients since sentence production was not facilitated when *uninflected lexical cues* were provided.

To summarize, we failed to find a direct effect of lexical cues on the success of sentence production, both in Broca's and Wernicke's aphasia, suggesting the relation between lexical and syntactic mechanisms is far more complex than purely lexically driven models imply. Although these findings support the lexical–syntactic interactionist view of Ferreira and Dell (2001), these results must be interpreted with caution due to two factors. First, failure to retrieve nouns was often compensated by the use of pronouns in the *uncued* condition. Since we scored utterances based on the accuracy with which a particular syntactic structure was produced, *uncued* and *uninflected cue* conditions may not have differed in accuracy due to an artifact of our scoring procedure. Secondly, failure of uninflected cues in improving active sentence production accuracy for Wernicke's aphasics could have been due to a ceiling effect in the uncued condition (Fig. 4). These factors may undermine our conclusions about the role of lexical deficits in active sentence production. Fortunately, conclusions about passive sentences are more straightforward and not undermined by these confounds.

#### 4.2. *Passive sentences in aphasia*

Broca's aphasic subjects' difficulty with passive sentences was not unexpected and has been reported often

(Goodglass, Christiansen, & Gallagher, 1993; Kolk & vanGrunsven, 1985; Saffran et al., 1980). The finding of impaired passive sentence production in Wernicke's aphasia, although surprising, was not totally unexpected given earlier reports. For example, Caplan and Hanna (1998) compared the accuracy of passive constructions by Broca's and Wernicke's aphasic subjects and found no significant group differences. Similarly, Menn et al. (1998, one Wernicke's aphasic subject) and Berndt et al. (1997a, 1997b; two subjects) reported that their aphasic groups evinced a greater difficulty with passive sentence production. Single case studies of patients with Wernicke's aphasia have also reported difficulty with passive constructions (Martin & Blossom-Stach, 1986). The present study supports several others in noting syntactic difficulties in the productions of Wernicke's and other fluent aphasics (Edwards, 1998; Edwards & Bastiaanse, 1998; Edwards et al., 1994; Gleason et al., 1980; Goodglass, 1968).

However, Wernicke's aphasia is not the only non-agrammatic non-Broca's aphasia in which syntactic difficulties have been reported. Grammatical difficulties have been noted in patients with anomia (Zaroff et al., 1997) and in a more heterogeneous group of fluent aphasic subjects (Edwards & Bastiaanse, 1998; Murray, Holland, & Beeson, 1998). Given these findings, it seems reasonable to conclude that production of complex sentences is affected in most forms of aphasia. Ignoring syntactic complexity for the moment, this result can be explained by the fact that passive sentences are less common than actives in English (Dick & Elman, 1999; Hopper & Thompson, 1980), especially with transitive verbs of the type tested in the present experiment (Ferreira, 1994). In fact, in a less constrained picture description task, Menn et al. (1998) found that aphasic and normal subjects produced the same proportion of passive sentences. Active sentences, being canonical and frequent, may be better preserved in both aphasic groups tested here. However, it is likely that additional underlying impairments constrain passive sentence production in aphasia.

Error analyses revealed *role-reversals* with active voice morphology to be the most common error type for passive sentence targets in the *uncued* and *uninflected cues* conditions. This raises two possibilities: (1) patients retrieve the incorrect verb lemma, and (2) they fail to retrieve the appropriate grammatical morphology. The first possibility arises from the assumption that more frequent verb lemmas have lower activation thresholds. Activation of verb lemmas guides the correct assignment of nouns to semantic roles. Difficulties in activating the passive forms of a verb have been proposed as a reason of aphasics' difficulty with passives (Berndt, 1991; Heeschen, 1993; Menn et al., 1998). The more frequent active verb lemmas replace the inaccessible passive lemma. Data from the *uncued* and *uninflected cues* con-

ditions suggest this possibility, especially for Wernicke's aphasia. In both conditions, the [+active] verb lemma may have been erroneously selected, giving a *subject = agent* assignment. This, combined with the constraint of beginning the sentence with the undergoer of the action, may have led to role reversal errors. As mentioned previously, Wernicke's aphasic individuals' role reversals had all the morphology for active sentences, further supporting the conclusion that active verb lemmas were incorrectly retrieved.

Providing *passive verb cues* activated the passive verb lemma in the mental lexicon, leading to a functional assignment of *subject = undergoer*. This facilitated the production of passive sentences with both noun phrases in appropriate semantic roles. Menn (2000) holds a similar view: "... aphasic problems with producing non-canonical structures such as passives derive principally from two sources: difficulty in retrieving the less frequent frames for a given verb, and difficulty in controlling the placement of retrieved noun lemmas in the correct slot at the functional level." (p. 158). Low accessibility of passive lemmas is a tenable explanation for Wernicke's aphasia because this group of subjects produced passive sentences with a variety of grammatical morphemes when passive verb cues were given. This means that morphological information contained in *passive verb cues* was not used to derive the surface structure of passive sentences.

However, faulty verb lemma retrieval alone without a concurrent self-monitoring failure may not be a sufficient explanation for role reversals in Wernicke's aphasia. Speakers attend to their own internal speech (Levelt, 1993), and a failure in self-monitoring means any mismatch between the intended message and encoded sentence is left uncorrected, leading to role reversals. Butterworth and Howard (1987) proposed a similar account for paragrammatisms. Or, Wernicke's aphasics may be unable to map elements of the message and thematic role onto appropriate grammatical functions. That is, Saffran et al.'s (1980) mapping hypothesis originally proposed for agrammatic aphasia, may characterize Wernicke's aphasics' role reversals. Patients with Wernicke's aphasia produced more passive sentences when the two nouns varied in animacy than when they were both animate, suggesting that mapping between thematic and grammatical roles was facilitated by animacy cues. Normal speakers have also been found to produce more passives when the two nouns vary in animacy (Ferreira, 1994).

The second possibility is that subjects are unable to access the appropriate grammatical morphemes or their phonological representation, despite successful access to the passive verb lemma. Broca's aphasic subjects produced a large number of grammatical morpheme errors both in active and passive sentences with no cues and uninflected cues (0.38 (428/1117), compared to 0.17 (227/

1300) for Wernicke's aphasia). Secondly, for patients with Broca's aphasia, accuracy of passives did not vary as a function of animacy, and neither did the number of grammatical morpheme errors (compare 0.55 (204/370) grammatical morpheme errors for reversible passives with 0.49 (108/222) for non-reversible passives). Broca's aphasic subjects produced large numbers of semantically anomalous role-reversed actives for non-reversible passive targets (0.73 (51/70); compare this with 0.3 (21/70) for Wernicke's aphasia). This could mean that Broca's aphasic patients had assigned thematic roles appropriately but could not retrieve the appropriate grammatical morphemes during real-time formulation of passive sentences. Third, our agrammatic Broca's aphasic subjects produced a few prepositions (a total of 15 instances) for non-reversible passive targets showing that although they could not retrieve the auxiliary and passive participle inflection (*-ed*), they could retrieve part of the passive morphology. The fact that prepositions were more accessible than auxiliaries and verb inflections for patients with Broca's aphasia is not surprising, given that prepositions have a higher semantic content when compared to other function words. In fact, Friederici (1981) and Friederici, Schonle, and Garrett (1982) found that Broca's aphasic subjects were better at producing prepositions when compared to other function words such as auxiliaries. Finally, Broca's aphasics' difficulties with grammatical morphology were negligible when morphological cues for passive voice were provided. Unlike patients with Wernicke's aphasia, Broca's aphasic subjects used only those grammatical morphemes provided by the experimenter. They never produced any variations of tense or aspect, as this would require grammatical morphemes other than those provided by the experimenter.

An utterance like *The painter carried the fireman* (B4, Target: *The painter was carried by the fireman*) may very well have been due to failure to access the auxiliary *was* and the preposition *by*, rather than due to substitution by [+active] verb lemma. There are several reports in literature about deficits in grammatical morphology in agrammatic Broca's aphasia (Bates et al., 1988; Hesketh & Bishop, 1996; Saffran et al., 1989). Although Wernicke's aphasic subjects produced role reversals for passive targets, these reversals more frequently contained the required grammatical morphemes. Further, Shapiro, Gordon, Hack, and Killackey (1993) found Broca's aphasic subjects to be sensitive to the thematic properties of verbs. Therefore subjects with Broca's aphasia may be sensitive to thematic requirements of passive verbs, but are unable to access and/or produce the appropriate grammatical morphemes. In contrast, Shapiro et al. found Wernicke's aphasic subjects to be insensitive to the thematic properties of verbs, suggesting a semantic deficit for this group. This may mean that Wernicke's aphasic subjects are impaired in their ability to access passive verb lemmas and/or the thematic

properties of passive verbs. Thus while both groups of aphasia demonstrate difficulties with passive constructions, the underlying source of these difficulties appears to be different.

Further support of the *impaired access to grammatical morphemes* account in Broca's aphasia comes from Hartsuiker and Kolk (1998), who found Broca's aphasic subjects could be primed to produce passive sentences. Though Hartsuiker and Kolk interpreted these data in relation to capacity theories, the priming effect in Broca's aphasia may have been due to the increased availability of grammatical morphemes that mark passive voice. Based on priming of different verb inflections, Marin and Schwartz (1998) presented evidence that priming effects in Broca's aphasia were due to the availability of closed-class elements.

However, further empirical research is necessary to explore and confirm the possibility of difficulties with passive constructions arising due to different underlying sources in aphasia. One way of exploring this would be to test the production of verbs that are most commonly used in the passive (Menn, 2000). Verbs such as *amaze*, *alarm*, *disgust*, and *impress*, called *theme-experiencer verbs*, more frequently occur in passive sentences, especially in the context of non-reversible sentences (Ferreira, 1994). According to the *most accessible verb frame hypothesis* (Berndt, 1991; Heeschen, 1993; Menn et al., 1998), passive constructions with such verbs would be easier to produce for aphasic subjects who are impaired in passive lemma retrieval. Given our conclusions about Wernicke's aphasia, production of passives should be facilitated in the context of theme-experiencer verbs for this group. If aphasic subjects find passive constructions difficult, access to grammatical morphemes or more abstract levels of syntax may be implicated. This latter pattern might be predicted for Broca's aphasic subjects.

To conclude, lexically driven models of sentence production and similar lexicalist hypotheses are unsuccessful in explaining the pattern of sentence production impairments reported here. This is especially so for the production of active sentences, which appears to be driven by a stored and over-learned *sentence frame* or *schema*. This schema can be activated independent of specific lemmas. These results support a lexical-syntactic interactionist model of sentence production. Pure lexical models also fail to account for aphasics' difficulty with other complex structures such as embedded clauses since lexical items in embedded clauses are not necessarily less accessible than lexical items used in simple sentences. It is the sentence frame of complex sentences that is inaccessible. Secondly, production of complex sentences such as passives is impaired in both Wernicke's and Broca's aphasia, although the underlying reasons for this appear to be different. Data from this study suggest that Wernicke's aphasic subjects' difficulty

lies in access to passive verb lemmas combined with a self-monitoring or mapping failure. Difficulty in the retrieval of grammatical morphemes is a likely cause for impaired passives in Broca's aphasia.

## Appendix A. Stimuli

### A.1. Reversible sentences

#### Practice items

1. The boy is pushing the girl/The girl is pushed by the boy.
2. The girl is tickling the boy/The boy is tickled by the girl.
3. The cow is following the elephant/The elephant is followed by the cow.

#### Active sentences

1. The elephant is leading the dog.
2. The scientist is watching the astronaut.
3. The nurse is weighing the man.
4. The minister is greeting the bride.
5. The student is answering the teacher.
6. The judge is scolding the convict.
7. The runner is lifting the skier.
8. The lion is licking the pig.
9. The juggler is pinching the clown.
10. The policeman is trapping the thief.
11. The waitress is stopping the guest.
12. The mailman is kissing the maid.
13. The reporter is interviewing the chef.
14. The doctor is examining the patient.
15. The mother is teaching the son.

#### Passive sentences

1. The guard is stabbed by the thief.
2. The child is blessed by Jesus.
3. The artist is pulled by the dancer.
4. The painter is carried by the fireman.
5. The swimmer is touched by the lifeguard.
6. The coach is hugged by the skater.
7. The wife is covered by the husband.
8. The sailor is shoved by the soldier.
9. The driver is called by the woman.
10. The hunter is helped by the cyclist.
11. The horse is kicked by the cow.
12. The witch is chased by the angel.
13. The bartender is punched by the boxer.
14. The gymnast is filmed by the photographer.
15. The king is shot by the cowboy.

### A.2. Non-reversible sentences

#### Practice items

1. The man is carrying the box/The box is carried by the man.

2. The boy is drying the plate/The plate is dried by the boy.
3. The boy is pulling the wagon/The wagon is pulled by the boy.

#### Active sentences

1. The man is pushing the cart.
2. The girl is weighing the box.
3. The lady is cutting the cake.
4. The man is sharpening the pencil.
5. The woman is eating the noodle.
6. The boy is catching the baseball.
7. The lady is cleaning the window.
8. The woman is baking the cake.
9. The man is wrapping the gift.
10. The waiter is pouring water.

#### Passive sentences

1. The bag was carried by the doctor.
2. The black board was erased by the teacher.
3. The snow was dug by the man.
4. The door was opened by the nurse.
5. The apple was eaten by the boy.
6. The wagon was pulled by the girl.
7. The bottle was dropped by the baby.
8. The table was cleaned by the maid.
9. The tea was spilled by the girl.
10. The floor was cleaned by the maid.

## References

- ANSI (1969). American National Standards Institute. ANSI Press: Washington DC.
- Bates, E., & Devescovi, A. (1989). Crosslinguistic studies of sentence production. In B. MacWhinney, & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (pp. 225–253). Cambridge: Cambridge University Press.
- Bates, E., Friederici, A., & Wulfeck, B. (1987). Grammatical morphology in aphasia: Evidence from three languages. *Cortex*, 23(4), 545–574.
- Bates, E., Friederici, A. D., Wulfeck, B. B., & Juarez, L. A. (1988). On the preservation of word order in aphasia: Cross-linguistic evidence. *Brain and Language*, 33, 323–364.
- Bates, E., & Goodman, J. (1997). On the inseparability of grammar and the lexicon: Evidence from acquisition, aphasia and real-time processing. *Language and Cognitive Processes*, 12(5/6), 507–586.
- Berndt, R. S. (1991). Sentence processing in aphasia. In M. T. Sarno (Ed.), *Acquired aphasia* (2nd ed., pp. 223–269). San Diego, CA: Academic Press.
- Berndt, R. S., Haendiges, A. N., Mitchum, C. C., & Sandson, J. (1997a). Verb retrieval in aphasia 2. Relationship to sentence processing. *Brain and Language*, 56, 107–137.
- Berndt, R. S., Mitchum, C. C., Haendiges, A. N., & Sandson, J. (1997b). Verb retrieval in aphasia. 1. Characterizing single word impairments. *Brain and Language*, 56(1), 68–106.
- Bird, H., & Franklin, S. (1999). Cinderella revisited: A comparison of fluent and non-fluent aphasic speech. *Aphasiology*, 13(2), 187–206.
- Blumstein, S. E., Milberg, W., Brown, T., Hutchinson, A., Kurowski, K., & Burton, M. W. (2000). The mapping from sound structure to the lexicon in aphasia: Evidence from rhyme and repetition priming. *Brain and Language*, 72, 75–99.
- Bock, K. (1977). The effect of a pragmatic presupposition on syntactic structure in question answering. *Journal of Verbal Learning and Verbal Behavior*, 16, 723–734.
- Bock, K. (1987). An effect of accessibility of word forms on sentence structures. *Journal and Memory and Language*, 26, 119–137.
- Bock, K. (1995). *Sentence production: From mind to mouth, speech, language and communication* (pp. 181–216). New York: Academic Press.
- Bock, K. (1999). Language Production. In R. A. Wilson, & F. Keil (Eds.), *The MIT encyclopedia of cognitive sciences*. Cambridge, MA: MIT Press.
- Bock, K., & Levelt, W. (1994). Language production: Grammatical encoding. In G. M. A (Ed.), *Handbook of psycholinguistics*. San Diego: Academic Press.
- Bock, K., Loebell, H., & Morey, R. (1992). From conceptual roles to structural relations: Bridging the syntactic cleft. *Psychological Review*, 99, 150–170.
- Butterworth, B., & Howard, D. (1987). Paragrammatisms. *Cognition*, 26, 1–37.
- Caplan, D., & Hanna, J. (1998). Sentence production by aphasic patients in a constrained task. *Brain and Language*, 63, 184–218.
- Dick, F., & Elman, J. (1999). *An examination of sentence type frequencies* (Technical Report 9904). San Diego, La Jolla: University of California.
- Edwards, S. (1998). Single words are not enough: Verbs, grammar and fluent aphasia. *International Journal of Language and Communication Disorders*, 33 (Suppl), 190–195.
- Edwards, S., & Bastiaanse, R. (1998). Diversity in the lexical and syntactic abilities of fluent aphasic speakers. *Aphasiology*, 12(2), 99–117.
- Edwards, S., Bastiaanse, R., & Maxim, J. (2001). *Grammatical disorders in Dutch and English Broca's and Wernicke's aphasia*. Paper presented at the 31st annual clinical aphasiology conference, Santa Fe, New Mexico.
- Edwards, S., Bastiaanse, R., & Kiss, K. (1994). Fluent aphasia and grammatical complexity in three languages. *Brain and Language*, 47, 414–416.
- Ferreira, F. (1994). Choice of passive verb is affected by verb type and animacy. *Journal of Memory and Language*, 33, 715–736.
- Ferreira, V. S., & Dell, G. S. (2001). Effect of ambiguity and lexical availability on syntactic and lexical production. *Cognitive Psychology*, 40(4), 296–340.
- Friederici, A. D. (1981). Production and comprehension of prepositions in aphasia. *Neuropsychologia*, 19(2), 191–199.
- Friederici, A. D., Schonle, P. W., & Garrett, M. F. (1982). Syntactically and semantically based computations: Processing of prepositions in agrammatism. *Cortex*, 18(4), 525–534.
- Gleason, J. B., Goodglass, H., Obler, L., Green, E., Hyde, M. R., & Weintraub, S. (1980). Narrative strategies of aphasic and normal-speaking subjects. *Journal of Speech and Hearing Research*, 23(2), 370–382.
- Goodglass, H. (1968). Studies on the grammar of aphasics. In S. Rosenberg, & K. Joplin (Eds.), *Developments in applied psycholinguistics research*. New York: Macmillan.
- Goodglass, H., Christiansen, J. A., & Gallagher, R. (1993). Comparison of morphology and syntax in free narrative and structured tests: Fluent vs. nonfluent aphasics. *Cortex*, 29(3), 377–407.
- Goodglass, H., & Menn, L. (1985). Is agrammatism a unitary phenomenon?. In M. L. Kean (Ed.), *Agrammatism* (pp. 1–26). New York: Academic Press.
- Hartsuiker, R. J., & Kolk, H. H. J. (1998). Syntactic facilitation in agrammatic sentence production. *Brain and Language*, 62(2), 221–254.
- Heeschen, C. (1985). On parallelism between production and comprehension in agrammatism. In M.-L. Kean (Ed.), *Agrammatism*. Orlando, FL: Academic Press.

- Heeschen, C. (1993). Morphosyntactic characteristics of spoken language. In G. Blanken, J. Dittman, H. Grimm, J. C. Marshall, & C.-W. Walleh (Eds.), *Linguistic disorders and pathologies* (pp. 16–34). Berlin: Walter de Gruyter.
- Hesketh, A., & Bishop, D. V. M. (1996). Agrammatism and adaptation theory. *Aphasiology*, 10(1), 49–80.
- Hopper, P. J., & Thompson, S. A. (1980). Transitivity in grammar and discourse. *Language*, 56, 251–299.
- Jensen, L. R. (2000). Canonical Structure without access to verbs. *Aphasiology*, 14(8), 827–850.
- Kertesz, A. (1982). *Western aphasia battery*. New York: Grune Stratton.
- Kohn, S., & Cragolino, A. (1995). *Sentence-based anomia*. Paper presented at the Academy of Aphasia, San Diego, CA.
- Kohn, S. E., & Goodglass, H. (1985). Picture-naming in aphasia. *Brain and Language*, 24(2), 266–283.
- Kolk, H., & vanGrunsven, M. (1985). Agrammatism as a variable phenomenon. *Cognitive Neuropsychology*, 2(4), 347–384.
- Lapointe, S. G. (1985). A theory of verb form use in the speech of agrammatic aphasics. *Brain and Language*, 24(1), 100–155.
- LaPointe, S. G., & Dell, G. S. (1989). A synthesis of some recent work in sentence production. In T. M. K. Carlson GN (Ed.), *Linguistic structure in language processing* (pp. 107–156). Dordrecht: Kluwer Academic Publishers.
- Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. Massachusetts: MIT Press.
- Levelt, W. J. M. (1993). Language use in normal speakers and its disorders. In G. Blanken, J. Dittman, H. Grimm, J. C. Marshall, & C.-W. Walleh (Eds.), *Linguistic disorders and pathologies* (pp. 1–15). Berlin: Walter de Gruyter.
- Levelt, W. (1999). Producing spoken language: A blueprint of the speaker. In C. M. Brown, & P. Hagoort (Eds.), *The neurocognition of language* (pp. 83–122). New York: Oxford University Press.
- MacWhinney, B., & Osman-Sagi, J. (1991). Inflectional marking in Hungarian aphasics. *Brain and Language*, 41, 164–183.
- Marin, J. W., & Schwartz, M. F. (1998). Facilitating sentence planning in nonfluent aphasia. *Brain and Language*, 65, 175–177.
- Martin, R. C., & Blossom-Stach, C. (1986). Evidence of syntactic deficits in a fluent aphasic. *Brain and Language*, 28(2), 196–234.
- Menn, L. (2000). It's time to face a simple question: Why is canonical form simple? *Brain and Language*, 71, 157–159.
- Menn, L., & Obler, L. (Eds.). (1990). *Agrammatic aphasia: A cross-language narrative sourcebook*. Amsterdam: Benjamins.
- Menn, L., Reilly, K. F., Hayashi, M., Kamio, A., Fujita, I., & Sasanuma, S. (1998). The interaction of preserved pragmatics and impaired syntax in Japanese and English aphasic speech. *Brain and Language*, 61(2), 183–225.
- Miceli, G., Silveri, C., Romani, C., & Caramazza, A. (1989). Variation in the pattern of omissions and substitutions of grammatical morphemes in the spontaneous speech of so-called agrammatic patients. *Brain and Language*, 36, 447–492.
- Murray, L. L., Holland, A. L., & Beeson, P. M. (1998). Spoken language of individuals with mild fluent aphasia under focused and divided-attention conditions. *Journal of Speech, Language, & Hearing Research*, 41(1), 213–227.
- Saffran, E. M., Berndt, R. S., & Schwartz, M. F. (1989). The quantitative analysis of agrammatic production: Procedure and data. *Brain and Language*, 37, 440–479.
- Saffran, E. M., Schwartz, M. F., & Marin, O. S. M. (1980). The word order problem in agrammatism II production. *Brain and Language*, 10, 263–280.
- Shapiro, L. P., Gordon, B., Hack, N., & Killackey, J. (1993). Verb-argument structure processing in complex sentences in Broca's and Wernicke's aphasia. *Brain and Language*, 45, 423–447.
- Slobin, D. I. (1991). Aphasia in Turkish: Speech Production in Broca's and Wernicke's patients. *Brain and Language*, 41, 149–164.
- Thompson, C. K., Shapiro, L. P., Tait, M., Jacobs, B., Schneider, S., & Ballard, K. J. (1995). *A system for the linguistic analysis of agrammatic language production*. Paper presented at the Academy of Aphasia, San Diego.
- Tzeng, O. J., Chen, S., & Hung, D. L. (1991). The classifier problem in Chinese aphasia. *Brain and Language*, 41(2), 184–202.
- von Stockert, T. R., & Bader, L. (1976). Some relations of grammar and lexicon in aphasia. *Cortex*, 12, 49–60.
- Zaroff, L., Wulfeck, B., Bates, E., & Reilly, J. (1997). *Morphosyntactic production abilities in Anomic aphasia*. Paper presented at the Academy of Aphasia, Philadelphia.

### Further reading

- Silver, L. S., & Halpern, H. (1992). Word-finding abilities of three types of aphasic subjects. *Journal of Psycholinguistic Research*, 21(5), 317–348.