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Sensitivity to Inflectional Morphology in Aphasia: A Real-Time Processing Perspective

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The present study investigates Broca's aphasics' sensitivity to morphological information in an on-line task. German is used as the test language because it is highly inflected. Results from two word monitoring experiments show first that Broca's patients like normal controls are sensitive to the presence of a contextually incorrect inflection. Contrary to normals, they are, however, not sensitive to the absence of an obligatory inflection even when its presence is syntactically highly constrained. Second, they reveal that Broca's aphasics are only sensitive to the presence of an incorrect inflection when it functions as a marker of lexical category (noun vs. verb) and not when it functions as a diacritical marker (second person singular vs. third person singular). The results are taken as evidence for the claim that Broca's aphasics are impaired in the ability to process the full syntactic information encoded in closed class elements in a fast, automatic, and obligatory way.

During recent years the concept of agrammatism has undergone a series of successive changes. Originally formulated to explain a particular disorder in language production (e.g., Isserlin, 1922; Pick, 1913), the concept was broadened in the seventies and designated to describe a central deficit

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that underlies language production and language comprehension (e.g., Caramazza & Zurif, 1976; Heilman & Scholes, 1976; Parisi & Pizzamiglio, 1970). Some researchers assumed that the deficit involved the entire central syntactic component (Brendt & Caramazza, 1980), while others proposed that only subparts of the syntactic processing component may be affected (Bradley, Garrett, & Zurif, 1980). The latter, in particular, hypothesized that agrammatic language performance is due to the subjects' inability to use a specialized fast and automatic access device for grammatical morphemes—a device which usually guarantees normal language processing allowing early structuring of the language input. This hypothesis was challenged on empirical grounds provided by lexical decision studies showing no such specialized processing for normal subjects in the first place (Gordon & Caramazza, 1982; Kolk & Bloomert, 1985; Segui, Mehler, Frauenfelder, & Morton, 1982).

One aspect of the hypothesis, however, was taken up by Friederici (1985), who argued that the empirical grounds were not sufficient to reject the hypothesis entirely. She proposed that a specifically fast and automatic access to syntactic information may be at work only when sentences but not when isolated words are processed and that it is this ability to access syntactic information in a fast and automatic manner which may be lost in agrammatics. Most studies that had focused on this question had all used a lexical decision paradigm in which content words and free standing grammatical morphemes were presented in isolation and not in sentential context, i.e., a condition in which the grammatical morphemes subserve their actual syntactic function. In a study which examined agrammatics' ability to process free standing grammatical morphemes in sentential context, it was shown that these subjects are able to recognize both content words and function words, but that in contrast to normals they are particularly slow in recognizing function words (Friederici, 1985). It was hypothesized that the inability to access the syntactic information given by grammatical morphemes in a fast and automatic way leaves the agrammatic subjects with an access device which is too slow to keep pace with the incoming information. The slow access to the syntactic information causes a mismatch in the availability of the syntactic and the lexical–semantic information—a mismatch which results in agrammatic comprehension (Friederici, 1988).

The view that agrammatism may be characterized by a computational deficit has also been made on the basis of experiments using other paradigms (Friederici & Kilborn, 1989; Haarmann & Kolk, 1990; Hagoort, 1989, 1990; Linebarger, Schwartz, & Saffran, 1983); Lukatela, Crain, & Shankweiler, 1988; Shankweiler, Crain, Gorrell, & Tuller, 1989; Wulfeck, 1987). Linebarger, Schwartz, and Saffran (1983) have shown in an off-line grammaticality judgment task that agrammatic subjects were able to judge a sentence's grammaticality when under no time constraints. These

results called into question any theory of agrammatism that hypothesized the loss of syntactic knowledge. Zurif and Grodzinsky (1983) tried to deal with the incompatibilities of the different approaches and results by arguing that a sentence judgment task may not test normal language appropriately because it does not require on-line processes. Shankweiler, Crain, Correll, and Tuller (1989), thereupon, investigated the agrammatics' ability to judge a sentence's grammaticality on-line. They found that these subjects are able to do so, although with longer reaction times and lower accuracy than control subjects. From these results they concluded that the agrammatics' particular problem lies in the domain of processing. It may be interesting to note that their findings demonstrate that although the agrammatics' ability to detect incorrect word substitutions was markedly reduced, incorrect substitutions were more easily recognized for those grammatical elements that carried lexical–semantic information (e.g., prepositions and particles) than for those that carried mainly syntactic information (e.g., determiners and auxiliaries). This seems to support a view that agrammatic subjects have particular problems in processing the syntactic information carried by grammatical morphemes on-line.

In the effort toward specifying the agrammatic deficit and in the hope to shed some light on the general relation among a given knowledge source, a computational failure, and the observable performance, we decided to focus our research on the on-line processing of bound grammatical morphemes which primarily carry syntactic information, that is, verb inflections. Studies investigating agrammatics' ability to process inflectional morphology so far are rare (e.g., Goodglass & Berko, 1960; Lukatela, Crain, & Shankweiler, 1988; Tyler & Cobb, 1987; Tyler, Behrens, Cobb, & Marslen-Wilson, 1990). Using an off-line task Lukatela et al. (1988) showed that agrammatic patients—in their case native speakers of Serbocroatian—were able to process inflectional elements. Two case studies of English speaking agrammatics investigating the agrammatics' ability to process inflectional morphology on-line are not univocal: one case (Tyler & Cobb, 1987) appeared to be sensitive to derivational but not to inflectional morphology, while another agrammatic patient (Tyler et al., 1990) demonstrated an insensitivity to both types of morphology.

In this study we will present results from four agrammatic speakers with vascular etiology together with data from three different control groups, young healthy normals, age-matched normals, and nonagrammatic aphasics, who were tested for their ability to process inflectional morphology on-line in a highly inflected language, namely German.

The study consisted to two experiments which tested different aspects of the syntactic properties of inflectional morphemes. The first experiment examined the subjects' sensitivity to the presence or absence of an inflectional morpheme and thereby the subjects' ability to process this par-

ticular element as a marker of word category, whereas the second experiment investigated the subjects' ability to process the full syntactic information, in this case information about person, number, and tense, given by a particular verb inflection.

EXPERIMENT I

Experiment I tested the subjects' sensitivity to inflectional morphology by presenting inflected verb forms (e.g., TANZTE/danced) and the related uninflected stems (e.g., TANZ/dance) which are identical with the related noun forms (e.g., DER TANZ/the dance) in a syntactically correct context (e.g., ER TANZTE/he dance and EIN TANZ/a dance) and in a syntactically incorrect context (e.g., EIN TANZTE/a danced and ER TANZ/he dance).

Our predictions were the following: If subjects are sensitive to the syntactic constraints, processing times should be shorter for grammatical than for ungrammatical constructions—since processing of ungrammatical constructions places a higher computational load on the processing system than the processing of grammatical constructions. This behavioral pattern is expected for normal subjects. Total insensitivity to inflectional morphology should in turn result in processing times which are unaffected by the grammaticality of a given sentential construction.

Given that agrammatics have been shown (a) to be sensitive to inflectional morphology (Lukatela et al., 1988) another grammatical aspect (e.g., Baum, 1988; Linebarger et al., 1983) in an off-line task, (b) to be sensitive to free standing closed class elements in syntactic priming tasks—although not within the normal time constraints (Friederici & Kilborn, 1989; Kilborn & Friederici, 1989), (c) to have problems in retrieving free standing closed class morphemes within the normal time range during sentence processing (Friederici, 1985), and (d) to show a deficient sensitivity toward information encoded in bound morphemes in an on-line comprehension task (Tyler et al., 1990), we predict that when tested on-line agrammatics will show a sensitivity to the presence or absence of close class elements. They may, however, not be able to retrieve the syntactic information encoded by these elements fast enough to show a normal pattern of sensitivity toward this information. Thus, they may well reveal sensitivity to inflectional morphology as a marker of lexical category during sentence parsing, but they may not be able to access the syntactic features encoded in closed class elements as they hear the sentence—although this information may be available when on-line procedures are not required.

Method

Subjects. Four group of subjects participated in the experiments.

Our experimental group consisted of four agrammatic speaking Broca's aphasics of vascular

Wernicke 100%

TABLE 1
INDIVIDUAL PATIENT HISTORY

	Age	Sex	Etiology	Onset	Token test	AAT comprehension	Classification
Broca 1	36	F	CV	12/77	21	104	Broca 100%
Broca 2	37	M	CV	4/86	13	96	Broca 100%
Broca 3	55	M	CV	2/81	10	110	Broca 100%
Broca 4	52	F	CV	5/86	7	116	Broca 100%
Aphasic Control 1	67	F	CV	4/83	8	101	Amnestic 92%
Aphasic Control 2	48	F	CV	12/83	7	116	Amnestic 100%
Aphasic Control 3	74	F	CV	8/78	22	85	Wernicke 80%

etiology, who suffered from a left hemisphere anterior lesion (for details see Table 1). Three left hemisphere patients with posterior lesions served as aphasic controls. Two of these patients showed the clinical picture of amnestic aphasia with paragrammatic output and one that of a mild to moderate Wernicke's aphasia with paragrammatic output. All patients were classified according to the Aachen Aphasia Test (Huber, Poeck, Weniger, & Williams, 1983) and a neurological examination. Twelve age-matched subjects were used as normal controls. These subjects were found through advertisement in the local newspaper and had no known neurological or hearing deficits. In addition a group of young healthy controls were included as a second reference group. All subjects were native speakers of German. Normal subjects were paid for their participation in the experiment.

Procedure. The experiment used a *word monitoring paradigm.* In such a paradigm subjects are asked to monitor for a given word that has previously been specified in an auditorily presented sentence and to indicate its detection by pressing a response key.

In the present experiment the target word appeared on a PC screen before each sentence and the subjects were asked to read the word out loud, to make sure that they were monitoring for the correct target. When the word was read correctly, the trial started with a warning tone and 250 msec later the sentence started. In order to minimize memory problems for the target word, the word remained on the screen in front of the subject throughout the task and disappeared after the subjects' response.

Material. Inflected verb forms and uninflected forms were presented in a sentence context which was either grammatical or ungrammatical. For example, the inflected verb form TANZTE/danced was presented in sentence which provided a correct verb context, e.g., ER TANZTE/he danced, or in a syntactic context that obligatorily required a noun continuation, e.g., EIN TANZTE/a danced. Uninflected forms such as the German verb stem TANZ/dance were also presented in grammatical and ungrammatical sentence contexts. Note that the form TANZ in German has two different grammatical functions: (a) as the base form of a noun TANZ/the dance and (b) as the verb stem of the verb TANZEN/to dance. This uninflected form was presented in a grammatical context that required a noun, e.g., EIN TANZ/a dance, and in an ungrammatical context that required an inflected verb, e.g., ER TANZ/he dance, respectively.

The target word that subjects had to monitor for was the word after the critical item, i.e., the inflected or uninflected form. This word was identical in the four experimental conditions. It was always an *adverb* because in German adverbs make grammatical continuations after a verb as well as after a noun (for examples of the test sentences see the Appendix).

There was a total of 30 critical sentences in each condition with adverb targets. For each condition there were 50 filler items, 10 with adverb targets, 20 with noun targets, and 20 with prototypical closed class elements as targets, e.g., articles, conjunctions, etc. All sentence material, consisting of 320 sentences, was presented in four sessions of 80 sentences each, such that subjects heard each target only once during one session. Different sentence types were mixed quasi randomly such that each sentence condition appeared in each test session equally often.

Results

Separate analyses of variance were calculated for each experimental group. For the two clinical groups individual patient data are also provided.

Control group data. For normal control groups raw data were trimmed by replacement values more than 2.5 standard deviations from the mean by the condition mean. Missing data points and extreme values were

TABLE 2
EXPERIMENT I: MAIN MONITORING REACTION TIMES (msec) AND ERROR RATES (%) PER CONDITION FOR CONTROL GROUPS

	Verb inflected				Noun stem			
	Grammatical		Ungrammatical		Grammatical		Ungrammatical	
	RT	ER	RT	ER	RT	ER	RT	ER
Student controls	305	0.21	416	0.14	354	0.35	390	0.27
Age-matched controls	310	1.53	399	0.83	355	1.81	375	0.56

replaced by the condition mean (young controls 1.3%, age-matched controls 4.72%).

Mean monitoring times and error rates per condition and group are displayed in Table 2 and Fig. 1.

A two-way analysis of variance with the factors Context (grammatical/ungrammatical) × Item Type (Verb inflected/Noun stem) was calculated over subjects and over items. For normal young controls there was a significant main effect of Context (Subject: $F(1, 11) = 259.39$, $p < .001$; Item: $F(1, 29) = 45.48$, $p < .001$) with faster monitoring times for targets following grammatical constructions (329 msec) than ungrammatical constructions (403 msec). The main effect of Item Type was significant in the subject analysis ($F(1, 11) = 15.60$, $p < .01$), but not in the item analysis ($p < .1$). Monitoring times were faster for adverbs following verbs (360 msec) than for adverbs following nouns (372 msec). The interaction was significant in both analyses (Subject: $F(1, 11) = 92.11$, $p < .001$; Item: $F(1, 29) = 12.44$, $p < .01$).

For normal age-matched controls there was a significant main effect of Context (Subject: $F(1, 21) = 110.43$, $p < .001$; Item: $F(1, 29) = 31.46$, $p < .001$) with faster monitoring times for the grammatical (332 msec) than for the ungrammatical condition (387 msec). The main effect of Item Type was significant in the subject analysis ($F(1, 21) = 17.90$, $p < .001$), but not in the item analysis ($p < .1$). Monitoring times were slightly faster for adverbs following verbs (354 msec) than for adverbs following nouns (365 msec).

A separate analysis for Item Types for the two control groups revealed a significant grammaticality effect for verb inflected forms ($F(1, 29) = 65.73$, $p < .001$) and for noun stem forms ($F(1, 29) = 4.66$, $p < .05$) in young student controls. For age-matched controls a significant grammaticality effect was present for verb inflected forms ($F(1, 29) = 78.59$, $p < .001$), but not for noun stem forms ($p < .1$).

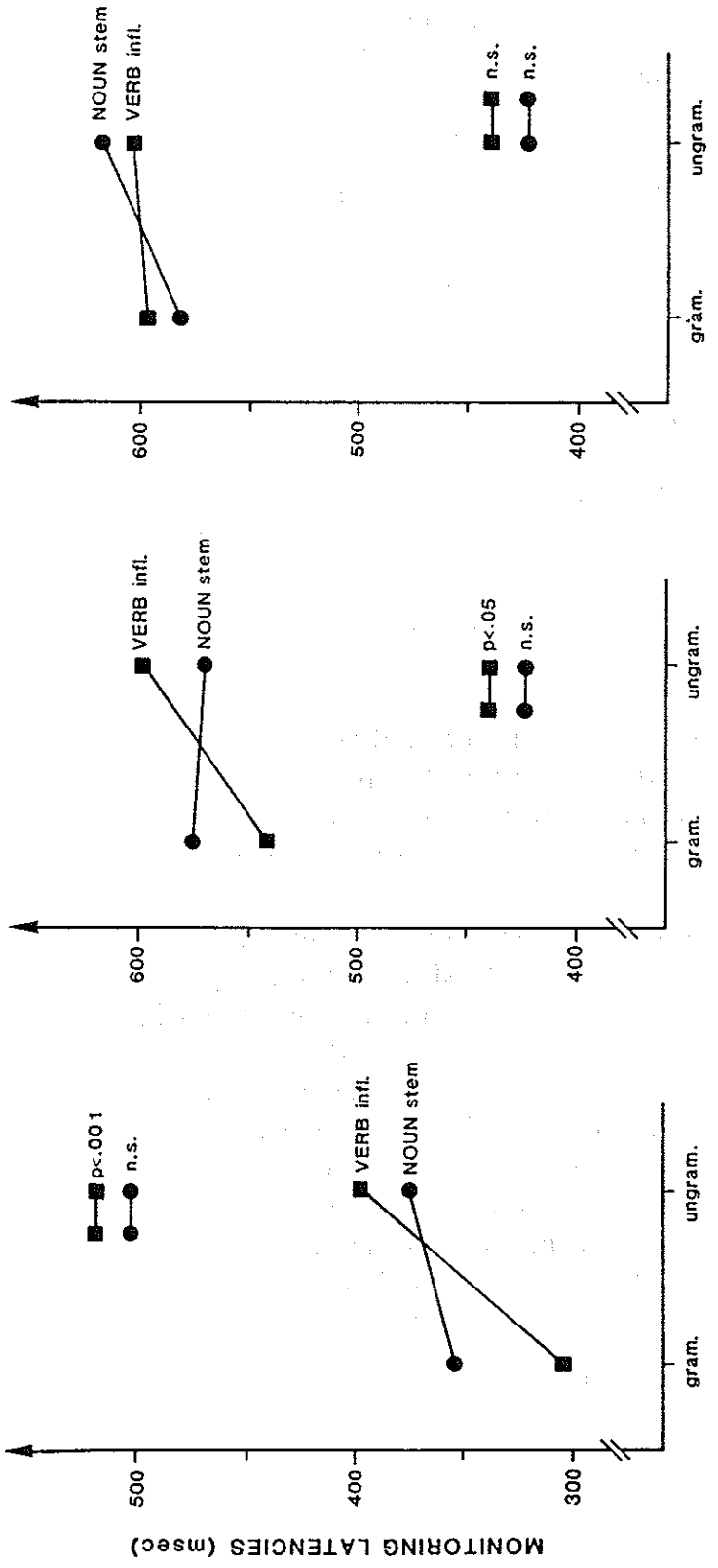

FIG. 1. Mean monitoring latencies for Experiment I. ● NOUN stem gram(matical): ein tanz (a dance). ● NOUN stem ungram(matical): * er tanz (he dance). ■ VERB infl(ected) gram(matical): er tanzte (he danced). ■ VERB infl(ected) ungram(matical): * ein tanzte (a danced).

TABLE 3
EXPERIMENT I: MAIN MONITORING REACTION TIMES (msec) AND ERROR RATES (%) PER CONDITION FOR CLINICAL GROUPS

	Verb inflected				Noun stem			
	Grammatical		Ungrammatical		Grammatical		Ungrammatical	
	RT	ER	RT	ER	RT	ER	RT	ER
Broca								
aphasics	592	7.5	675	14.9	628	12.5	621	17.4
Broca 1	768	20	863	36.3	800	20	787	36.3
Broca 2	604	6.7	731	20.0	638	23.3	586	13.3
Broca 3	563	3.3	613	3.3	600	6.7	614	13.3
Broca 4	433	0	493	0	473	0	498	6.7
Aphasic								
controls	598	8.3	604	11.9	583	14.2	618	18.6
Control 1	569	10.0	576	3.3	616	15.0	634	18.3
Control 2	675	10.0	657	20.0	604	15.0	694	20.0
Control 3	550	5.0	578	12.5	529	12.5	528	17.5

Thus the present data show that normal student controls are sensitive both to the incorrect presence and to the incorrect absence of an inflectional morpheme as a marker of lexical category. The incorrect presence of an inflection, however, seems more salient than the incorrect absence of an inflectional morpheme.

Interestingly, this difference between presence and absence of inflectional morphemes in sentential context is even more pronounced in age-matched controls. Whereas the incorrect presence of an inflectional element clearly disrupts their normal parsing, the incorrect absence of an obligatory inflection does not influence processing in any dramatic way. Whether this observation is to be attributed to an active on-line restoration of the incomplete input, or whether the incompleteness is not detected at all, cannot be decided based on the data at hand. This aspect of the present findings will be taken up in Experiment II.

Clinical group data. Mean monitoring times per condition for groups and individual subjects are given in Table 3. Mean monitoring times per group are displayed in Fig. 1. Separate analyses were conducted for each group.

For Broca's aphasics—like for the age-matched controls—there was a significant main effect of Context ($F(1, 3) = 255.05$, $p < .001$). The interaction between Context and Item Type was significant in the Item analysis ($F(1, 29) = 6.03$; $p < .05$), but just failed to reach the 5% level of significance in the subject analysis ($F(1, 3) = 6.83$, $p < .08$).

Separate analyses for each item type revealed a significant grammati-

cality effect for inflected forms ($F(1, 29) = 12.05$; $p < .01$), but not for uninflected forms ($F(1, 29) = 0.09$). Inspection of the individual patient data revealed that all Broca patients demonstrate longer monitoring times for targets following inflected verbs in ungrammatical than in grammatical context (this difference is significant in a χ^2 test for all patients—except Broca 3—at the 5% level of significance).

For aphasic controls there was no significant main effect or interaction in a two-way analyses of variance with the factors Context × Item Type. No aphasic control showed a clear difference in monitoring times for the inflected verb grammatical versus ungrammatical condition. Only control patient 2 showed longer monitoring times in the noun stem ungrammatical than in the grammatical condition.

Discussion

The results suggest that Broca patients like normal age-matched controls are sensitive to inflectional elements as a marker of lexical category. When present, these morphological elements are recognized to mark the verb category. Their absence does not seem to disrupt processing in Broca's aphasics and in age-matched normals. In contrast, the three aphasic control patients show no sensitivity to inflectional morphology as a marker of lexical category. Thus, these three patients with posterior lesions, who were classified as paragrammatic patients (two Wernicke patients and one amnestic patient), show a pattern of performance which suggests a total insensitivity to the grammatical aspects tested here. These data are in line with recent findings revealing grammatical deficits in Wernicke aphasics' comprehension and grammaticality judgments (Huber, Cholewa, Wilbertz, & Friederici, 1990).

From the present data it is unclear whether the insensitivity to the absence of inflectional morphology seen in Broca patients and in age-matched normals is due to the same underlying processes or whether different underlying mechanisms are at work. It could be that the same restoring mechanism that fills in the missing element is active in both normals and agrammatic patients or that such a restoring mechanism is only at work in normals and not in agrammatic patients—as these patients may not be able to activate the missing inflectional element including its encoded syntactic information as they hear the sentence.

EXPERIMENT II

Experiment I tested the subjects' sensitivity to inflectional morphology as a marker of lexical category. Their sensitivity toward this aspect of inflectional morphology was investigated by introducing a lexical category violation (noun vs. verb). Apart from marking lexical category, however, inflectional morphology often carries additional syntactic information.

TABLE 4
EXPERIMENT II: MAIN MONITORING REACTION TIMES (msec) AND ERROR RATES (%) PER CONDITION FOR CONTROL AND CLINICAL GROUPS

	Verb inflection			
	Grammatical		Ungrammatical	
	RT	ER	RT	ER
Age-matched controls	317	1.15	352	1.56
Broca aphasics	474	6.3	478	6.9
Broca 1	630	15.0	654	15.0
Broca 2	430	7.5	390	10.0
Broca 3	473	2.5	474	2.5
Broca 4	362	0	396	0
Aphasic controls	559	8.3	564	10.8
Control 1	489	5.0	503	5.0
Control 2	680	20.0	713	20.0
Control 3	507	0	474	7.5

Verb inflections in many languages—like the language tested here—carry information about person, number, tense, etc.

Experiment II was designed to investigate whether Broca's aphasics are able to access this type of syntactic information encoded in an inflectional element on-line as they hear a sentence.

This was done by introducing a grammatical violation which stayed within the lexical category of verb and which is only detectable when the inflection is processed with respect to the aspect of person marking (second person singular vs. third person singular). Sensitivity to this subtle within-category violation would indicate a subject's ability to process the syntactic information given in an inflectional element.

Method

Subjects. Three groups of subjects participated in Experiment II. A group of agrammatic Broca aphasics, a group of aphasics controls aphasics, and a group of age-matched controls. The subjects in these groups were identical to those of Experiment I.

Material. The critical sentence material in Experiment II consisted of 30 grammatical sentences in which a preceding pronoun did not agree with the inflected verb in person, e.g., ER TANZTEST/he danced (second person singular). The grammatical sentences were identical to those of the condition verb inflected of Experiment I and the ungrammatical sentences were constructed by replacing the correct inflection by an incorrect one. The filler items were identical to those of Experiment I.

Procedure. The procedure was identical to Experiment I. Because Experiment II consisted only of a total of 160 sentences, with target words reoccurring twice, two sessions with 80 sentences each were conducted with each subject. Experiment II was conducted 6 weeks after Experiment I.

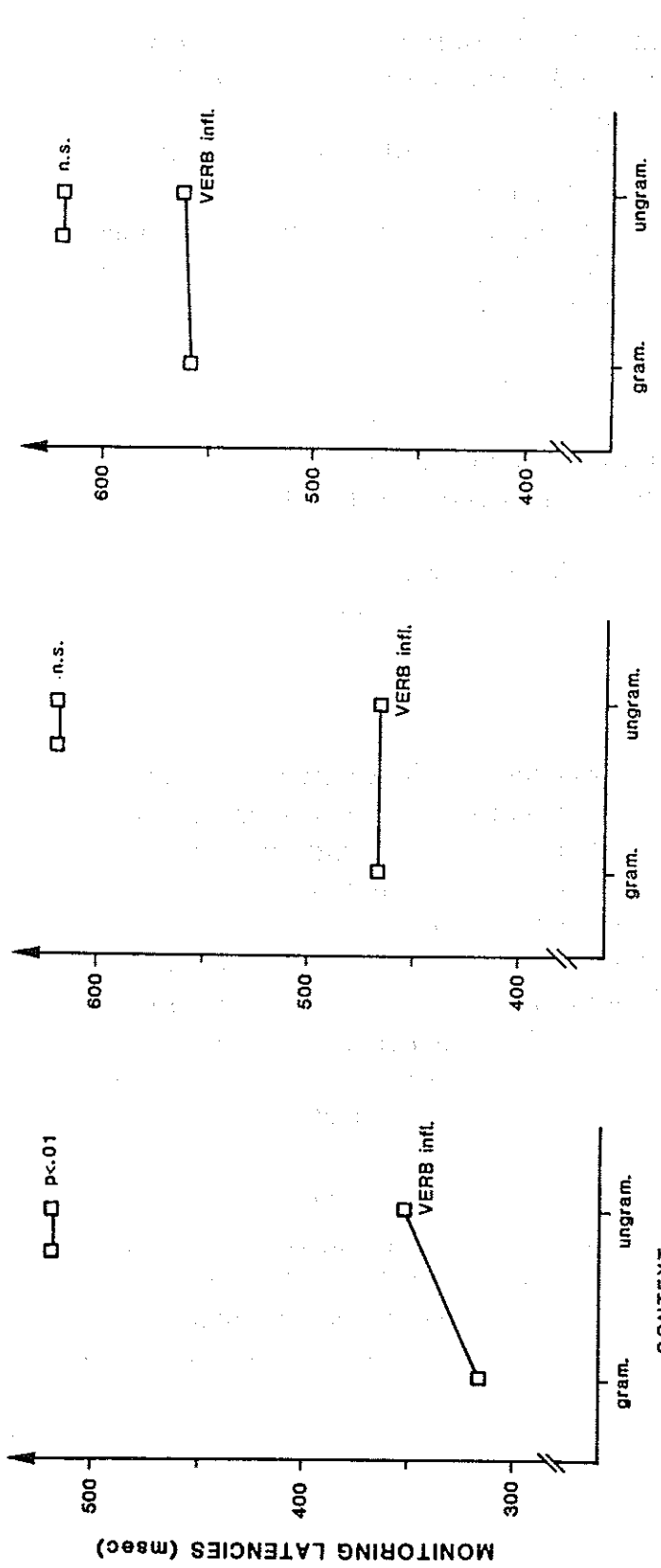

FIG. 2. Mean monitoring latencies for Experiment II. ■ VERB infl(ected) gram(matical): er tanzte (he danced). ■ VERB infl(ected) ungram(matical): * ein tanztest (he danced).

Results

Data treatment was similar to that of Experiment I. Mean and individual monitoring reaction times and error rates are listed in Table 4. Mean monitoring reaction times are displayed in Fig. 2. Separate analyses were calculated for each experimental group. Individual subject data of the two clinical groups are shown in Table 4.

Control group data. Age-matched controls showed a significant grammaticality effect with faster lexical decision times in the grammatical than in the ungrammatical condition (Subject: $F(1, 11) = 56.98$, $p < .001$; Item: $F(1, 39) = 24.10$, $p < .001$).

Clinical group data. Broca's aphasics showed no grammaticality effect (Subject: $p < .9$; Item: $p < .9$). Inspection of individual subject data revealed no clear difference between the grammatical and the ungrammatical condition for either patient (none of the differences is significant as revealed by χ^2 tests).

Aphasic controls similary did not show a grammaticality effect (Subject: $p < .7$; Item: $p < .6$). χ^2 tests for individual subject data reveal no significant differences.

Discussion

In Experiment II normals as expected show a grammaticality effect with faster monitoring times for targets following a correct inflection than for words following an incorrect inflection. This indicates that age-matched normals process the full grammatical information given by the inflection on-line. Broca's aphasics in contrast do not demonstrate a reliable sensitivity to the grammatical information given by the inflectional morpheme in its on-line task. Word monitoring times are not affected by the grammatical status of the preceding inflectional element. It appears that Broca patients like the three posterior aphasics are not able to retrieve the full syntactic information encoded in the verb inflection in this on-line task.

GENERAL DISCUSSION

The combined results from Experiment I and II suggest that the four Broca's aphasics are sensitive to inflectional morphology as a marker of lexical category, but they do not seem to process the syntactic information carried by these elements as they hear the sentence in an obligatory way. It was hypothesized that these patients suffer from a computational deficit which does not allow them to retrieve the syntactic information encoded in closed class elements on-line, i.e., in a fast and automatic way. The observed insensitivity to specific syntactic information encoded in verb inflections may result from this deficit. What seems to be unaffected by this processing deficit is the identification of a closed class element as a grammatical marker—even when tested on-line. This ability would account

aphasia can be characterized as the loss of procedural, i.e., time-dependent, language knowledge, with most of the declarative language knowledge remaining intact. This procedural deficit could be held responsible for the agrammatic behavior seen in production and on-line comprehension compared to the grammatic behavior seen in grammaticality judgment tasks. Wernicke patients' behavior with their inability to perform grammaticality judgments (Huber et al., 1990), their agrammatic behavior in off-line comprehension tasks (e.g., Heeschen, 1980; Friederici & Graetz, 1987), but with parts of their automatic language behavior remaining intact (Milberg & Blumstein, 1981) may be characterized as demonstrating a loss of declarative language knowledge.

The present data support the view that Broca's aphasics have problems in accessing syntactic information encoded in inflectional elements on-line. The finding that they are sensitive to the presence or absence of these elements, however, suggests that they have retained some knowledge about lexical—and may be phrasal—categories which can be used during sentence processing. It is the specific syntactic information encoded in inflectional morphology that cannot be accessed by Broca's aphasics within the temporal constraints underlying normal language production and comprehension.

APPENDIX: EXAMPLES OF TEST SENTENCES

Experiment I

NOUN stem grammatical

Lange hatte sie gehofft, daß er den *TANZ* nur mit ihr tanzen würde.

(She had long hoped that he would save *the DANCE* just for her.)

NOUN stem ungrammatical

* Sie hatte ihn lange Zeit beobachtet, doch er *TANZ* nur mit älteren Damen.

(After watching a long time, she saw that *he DANCE* just with older women.)

Experiment I

VERB inflected grammatical

Sie hatte ihn lange Zeit beobachtet, doch er *TANZTE* nur mit älteren Damen.

(After watching a long time, she saw that *he DANCED* just with older women.)

for the often observed grammatical abilities of Broca's aphasics, as identification of lexical category allows the assignment of phrasal categories which in turn is the basis of grammatical processes (e.g., see also Saddy, 1990). The pattern of performance seems to be specific for agrammatic patients as clinical controls show a different behavioral pattern. The three aphasic controls which were patients with posterior lesions did not demonstrate sensitivity to any of the grammatical aspects assigned by the inflectional morphemes during sentence perception. These patients in contrast to the agrammatics show a clear deficit in grammatical processing. The observation that Wernicke patients, although showing a performance pattern similar to that of normals in some on-line tasks (Friederici, 1985), do show grammatical deficits in off-line sentence comprehension tasks (Bates, Friederici, & Wulfeck, 1987; Friederici & Graetz, 1987; Goodglass & Menn, 1985; Heeschen, 1980) led to a recent experiment in which Huber and co-workers (1990) compared Broca's and Wernicke's aphasics when reading and judging sentences for grammaticality. In this study it was demonstrated that Broca's, but not Wernicke's aphasics were sensitive to grammatical errors when reading a sentence and when judging it. These data support a view which proposes that grammatical knowledge is not intact in Wernicke's aphasics.

Normal age-matched controls are similar to the Broca's aphasics in that the absence of an obligatory inflectional morpheme does not affect sentence processing of the subsequent word dramatically. In discussing the results of Experiment I we proposed that the observed behavioral pattern in the elderly normals might be due to a restoration mechanism which is automatically active whenever auditory input is (minimally) incomplete. The finding that age-matched subjects but not Broca's aphasics are sensitive to the particular syntactic information encoded in inflectional elements during sentence perception suggests that such an automatic restoration mechanism may be at work in age-matched normals, but not in Broca's aphasics.

The present findings seem to provide a further piece of evidence for the view that agrammatic Broca's aphasics' inability to retrieve the full syntactic information encoded in closed class elements in a fast, automatic and obligatory way is impairmented. This is not to say that the syntactic knowledge is not available at all. On the contrary, results from off-line experiments (Lukatela et al., 1988; Shankweiler et al., 1989; Wulfeck, 1987) seem to suggest that the grammatical information encoded in these elements is, in general, available. What patients with a lesion in the Broca's area seem to have lost, however, is the ability to activate this knowledge such that the temporal constraints of normal language processing are met.

Elsewhere (Friederici, 1990) it was claimed that agrammatic Broca's

VERB inflected ungrammatical

* Lange hatte sie gehofft, daβ der den *TANZTE* nur mit ihr tanzen würde.

(She had long hoped that he would save *the DANCED* (second person singular) just for her.)

Experiment II

VERB inflected grammatical

Sie hatte ihn lange Zeit beobachtet, doch er *TANZTE* nur mit älteren Damen.

(After watching a long time, she saw that *he DANCED* just with older women.)

VERB inflected grammatical

* Sie hatte ihn lange Zeit beobachtet, doch er *TANZTEST* nur mit älteren Damen.

(After watching a long time, she saw that *he DANCED* (second person singular) just with older women.)

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