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Agrammatic and non-brain-damaged subjects' verb and verb argument structure production

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Abstract

This study examined verb and verb argument structure production in 10 agrammatic aphasic and 10 non-brain-damaged subjects. Production of six types of verbs was examined in two conditions—a confrontation and an elicited condition; and production of verb arguments was examined in a sentence condition in which each target verb was elicited with all possible argument structure arrangements. Results showed statistically significant differences between the aphasic and non-brain-damaged subjects in all conditions, but no significant differences were found between confrontation and elicited labelling conditions for either subject group. The aphasic subjects, however, produced obligatory one-place verbs correctly significantly more often than three-place or complement verbs in the elicited condition and a consistent hierarchy of verb difficulty was found in both the confrontation and elicited conditions. For both subject groups sentence production was influenced by the number of arguments or participant roles and by the type of arguments required by the verb. In addition, the complexity of the verb (i.e. the number of possible argument structure arrangements) influenced sentence production with simple verbs produced correctly with their arguments more often than complex ones. Finally, obligatory arguments were produced correctly more often than optional ones, even when production of the optional arguments was requested. These data indicate that the argument structure properties of verbs are important dimensions of lexical organization that influence both verb retrieval and sentence production in agrammatic aphasic subjects.

Introduction

Selective impairments in accessing lexical categories have been noted in several studies in the aphasia literature. For example, dissociations among semantic categories such as fruits and vegetables, living things and food and inanimate objects have been reported (Basso *et al.* 1988, Hart *et al.* 1985, Warrington and McCarthy 1983, 1987). Recent research also has shown selective impairments in nouns vs. verbs in some aphasic individuals. That is, verb production has been shown to be more problematic than nouns in agrammatic aphasic individuals,

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whereas nouns appear to be more difficult than verbs for some anomic aphasic subjects (Miceli *et al.* 1984, 1988, Saffran *et al.* 1989, Thompson *et al.* 1994, Zingeser and Berndt 1990). Differences between nouns and verbs have also been noted in non-brain-damaged subjects. For example, event-related potential (ERP) studies have shown different brain fields for noun and verb stimuli (Koenig and Lehmann 1996, Teyler *et al.* 1973). Such data suggest that both semantic categories and grammatical class are important dimensions of lexical organization. Further, the observation that naming may be differentially impaired across semantic categories suggests that verb production, too, might be differentially affected. Certain types of verbs may be more difficult than others for some individuals. However, verb deficits in aphasic subjects have not been studied by type.

One important distinction among verbs pertains to their syntactic properties—that is, the number and type of arguments or participant roles required by certain verbs. Verbs, like other classes of words, are acquired and stored in memory based on their phonological form and lexical category. Verbs are also represented in the lexicon based on the sentence environments in which they are allowed to enter. As verbs are learned, it also is learned that they can (and sometimes must) occur with certain phrasal categories (e.g. noun phrases (NPs)). For example the verb *wash* must always be followed by an NP. The verb *put* must always be followed by an NP and by a prepositional phrase (PP). Such phrase structure rules (referred to as strict subcategorization) are related to (but not identical to) argument structure. Argument structure is concerned with the meaning relations between the verb and constituents within a sentence, or the number of participant (thematic) roles described by the verb. Following with our example, the verb *wash* has two participant roles: an Agent or someone doing the washing and a Theme or the thing being washed. The verb *put* has three roles to assign: an Agent or someone doing the putting, a Theme or thing that is put, and a Location or place where the thing is put.

For some verbs all participant roles must be realized in sentence production in order for the sentence to be grammatical; the verb *put*, for example is an obligatory three-place verb because all three of its arguments must be represented when it is used. For other verbs some arguments are optional and do not need to be realized in the syntax, even though they form part of the verb's lexical representation. The verb *eat* for example, is an optional two-place verb; it can be produced with an Agent only as in *John ate*; or it can be produced with both of its arguments as in *John ate the sandwich*. The point here is that the verb's lexical representation includes information about its argument structure and that the grammaticality of sentences, and the syntax, is determined in large part by these arguments and whether or not they are represented in the sentence (Chomsky 1981, 1986). Indeed, the argument structure characteristics of a particular verb is one aspect that defines the category to which it belongs.

Another observation in the aphasia literature is that agrammatic aphasic subjects not only evince difficulty in producing verbs, but also that they do not produce all argument structures required by the verb in their sentence productions (Caplan and Hanna 1996, Thompson *et al.* 1994, 1995). For example, Thompson *et al.* (1994) analysed verb production by type—based on argument structure requirements and the number of participant roles required by the verb—in conversational speech samples obtained from agrammatic and non-brain-damaged subjects. Results showed that the agrammatic subjects produced significantly fewer verbs than

normal subjects. In addition, certain verb types appeared less often than others in the aphasic subjects' corpus. For example, the aphasic subjects showed a preference for producing simple one- and two-place verbs (i.e., verbs with the fewest participant roles) and they rarely produced three-place or complement verbs. When complex verbs (i.e., those with a greater number of possible argument structure configurations) such as optional three-place verbs and complement verbs were produced the aphasic subjects produced them in their simplest argument structure form (e.g. in Agent, Theme form).

The purpose of the present study was to further investigate verb and verb argument production in aphasic subjects. We sought to examine the extent to which our previously derived discourse data accurately depicted the ability of aphasic subjects. Because discourse tasks do not obligate production of verbs or some verb argument structures, we determined that it is necessary to provide opportunities (i.e. in constrained production tasks) for production of various verbs and verb argument structures in order to examine patterns of production in aphasic speakers. Therefore, in this study we examined aphasic and non-brain-damaged subjects' production of six verb types (with verb type based on argument structure characteristics) in order to examine the influence of the argument structure characteristics of verbs on verb retrieval. Verb production was examined and compared in two conditions; a confrontation naming condition in which pictured verbs were presented for subjects to name, and an elicited naming condition in which story-completion cues were provided to facilitate production of target verbs. The elicited condition was included because some verbs (e.g. complement verbs such as *believe*) were determined to be impossible to test using picture stimuli alone. In addition, we examined verb argument production in sentence contexts in order to evaluate the influence of the following: (a) the number of arguments or participants required by the verb; (b) the type of argument required (e.g. Agent/Experiencer, Theme/Patient, Goal/Location); (c) the number of *possible* argument structure arrangements (i.e. verb complexity); and (d) the obligatory vs. optional nature of verb arguments.

Method

Subjects

Two groups of subjects (10 aphasic and 10 non-brain-damaged) participated in the study. There were seven males and three females in each subject group. All subjects were right-handed, with the exception of one aphasic gentleman, and all had completed high school. Years of education for the aphasic subjects ranged from 11 to 20 with a mean of 15; the range for the non-brain-damaged subjects was 14–22 with a mean of 16 years. Review of medical records and subject/spouse reports indicated that none of the subjects had a history of psychiatric or developmental speech–language disorders, alcoholism or prior neurological disease. All subjects demonstrated good visual acuity (20/40, corrected or uncorrected) and hearing acuity (all passed a pure-tone audiometic screening at 500, 1000 and 2000 Hz at 40 dB HL ANSI:1969 in at least one year).

Aphasic subjects had all suffered a single, left hemisphere, thromboembolic stroke. Lesions occupying the pars triangularis and opercular parts of the inferior frontal lobe were evident on CT scan for all subjects, with the exception of one

subject who evinced a parietal lobe lesion. Two of the subjects' lesions extended posteriorly into the parietal area. Additional involvement of the insula was noted for eight of the subjects.

Language testing

The diagnosis of aphasia was based on administration of the Western Aphasia Battery (WAB; Kertesz 1982) as well as additional lexical and sentence comprehension testing and narrative discourse analysis. Aphasia quotients (AQs) derived from the WAB ranged from 62·3 to 77·2. Auditory–verbal comprehension, while impaired, was superior to verbal expressive abilities; WAB comprehension subtest scores ranged from 6·75 to 9·1 with greater difficulty noted in comprehension of sequential commands than yes/no questions or auditory word recognition. Fluency scores were 4·0 for all subjects, reflecting production of primarily short phrases and simple sentences. All subjects demonstrated at least a score of 7·0 on the naming subtest of the WAB and the ability to read aloud and comprehend single words.

Comprehension testing

Sentence comprehension was tested using two tests developed for research—one by Saffran *et al.* (1989) (the Philadelphia Comprehension Battery for Aphasia, PCBA) and the other by Thompson and colleagues at Northwestern University (NWU sentences). Both tests are unpublished, and normative data are not available. The PCBA contrasts lexical comprehension and sentence comprehension, comprehension of semantically reversible and non-reversible sentences, and comprehension of canonical and non-canonical sentences. The NWU sentences test examines comprehension of active, passive, subject relative, and object relative sentences (20 exemplars of each). For all subjects, lexical comprehension was superior to sentence comprehension and semantically reversible sentences were more difficult than non-reversible ones. All subjects also demonstrated better comprehension of active than passive sentences. These findings were consistent with patterns of sentence comprehension seen in some agrammatic aphasic individuals (Bendt *et al.* 1996, Caplan *et al.* 1985, Grodzinsky 1986, Saffran *et al.* 1980).

Narrative analysis

Lexical and morphosyntactic patterns of narrative productions were also analysed in our aphasic subjects. Samples were collected by asking subjects to tell the stories of *Cinderella* and *Little Red Riding Hood.* Narratives derived from both stories were combined to comprise a single sample. All samples were segmented into utterances (based on syntactic, prosodic, and semantic criteria) and analysed using a method developed by Thompson *et al.* (1995). Sentences were coded for grammaticality, sentence type, and embeddings. All open-class and closed-class words were coded by class. Additionally, verbs were coded by type and by argument structure, and the complexity of verb morphology was coded to derive a verb morphology index (VMI).

All language samples were transcribed by two independent transcriptionists in order to determine reliability of data entry and utterance segmentation. Overall

Table 1 Aphasic subjects' narrative production data

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	*M*
Total words produced	318	398	361	441	412	386	555	388	314	474	404·7
MLU	7·44	4·94	3·39	6·89	6·80	4·51	5·46	7·66	5·47	3·86	5·64
Proportion grammatical sentences	0·11	0·10	0·20	0·41	0·43	0·18	0·32	0·60	0·37	0·30	0·30
Proportion simple sentences	0·60	0·48	1·00	0·89	0·72	0·82	0·78	0·75	0·85	1·00	0·77
Proportion complex sentences	0·40	0·52	0·00	0·11	0·28	0·18	0·22	0·25	0·15	0·00	0·23
M embeddings per utterance	0·49	0·53	0·00	0·11	0·25	0·14	0·27	0·50	0·19	0·00	0·25
Noun:verb ratio	1·56	1·65	1·81	1·42	1·82	2·07	2·23	1·82	1·55	1·32	1·73
Open:closed-class ratio	1·95	2·29	2·34	1·17	1·86	1·11	1·37	1·09	1·17	1·74	1·61
M verb morphology index	1·94	2·12	1·69	2·94	2·84	1·96	2·46	2·73	2·55	2·62	2·39
Proportion of verbs produced by type											
One- and two place	0·47	0·32	0·78	0·50	0·30	0·58	0·40	0·63	0·48	0·75	0·52
Three-place	0·04	0·10	0·06	0·00	0·03	0·21	0·06	0·04	0·01	0·25	0·08
Complement	0·41	0·49	0·11	0·02	0·28	0·21	0·37	0·14	0·32	0·00	0·24
Copula	0·08	0·09	0·05	0·48	0·39	0·00	0·17	0·19	0·19	0·00	0·16
Proportion of verbs produced correctly											
One- and two-place verbs	0·73	0·60	0·43	0·80	0·75	0·38	0·78	0·77	0·68	0·77	0·67
Three-place verbs	0·50	0·25	0·00	0·50	0·34	0·33	0·21	0·19	0·50	0·17	0·30
Complement	0·48	0·50	0·89	0·73	0·73	0·00	0·34	0·70	1·00	0·00	0·54
Copula	0·60	0·86	0·57	0·86	0·78	0·17	0·57	0·65	0·79	0·00	0·60
Proportion of arguments/adjuncts produced correctly											
Agents	0·70	0·81	0·56	0·81	0·96	0·59	0·96	0·94	0·89	0·62	0·78
Themes	0·89	0·72	0·76	0·94	0·81	0·57	0·70	0·92	0·93	0·17	0·74
Goals	0·50	0·00	1·00	0·00	0·00	0·50	0·50	0·50	1·00	0·00	0·40
Sentential complements	0·58	0·23	0·00	0·00	0·29	0·00	0·62	0·85	0·79	0·00	0·39
Adjuncts	0·46	0·33	0·67	0·78	0·79	1·00	0·40	0·93	0·00	1·00	0·64

point-to-point agreement on data entry was 97% and agreement on utterance segmentation was 96%. Two independent coders also coded all language samples and inter-coder point-to-point reliability was calculated for each variable (i.e. sentence grammaticality codes, verb codes). Overall agreement ranged from 86% to 92%, with an overall mean of 87·5%.

Results of this analysis (see Table 1) indicated production patterns consistent with a diagnosis of agrammatic aphasia (Saffran *et al.* 1989, Menn and Obler 1989, Goodglass *et al.* 1993); the proportion of grammatical sentences ranged from 0·10 to 0·60, with a mean of 0·30, and most sentence productions were grammatically simple in that they did not contain moved sentence constituents or embeddings. Open/closed class ratios indicated that the subjects produced more open-class as compared to closed-class words (open-class to closed-class ratio ranged from 1·09 to 2·34), and, within the open class, subjects produced more nouns than verbs (noun:verb ratio ranged from 1·32 to 2·23).

Analysis of verb and verb argument structures showed that the subjects produced primarily one- and two-place verbs and production of correct arguments occurred more often for one- and two-place verbs and copulas as compared to three-place and complement verbs. Attempts to produce more complex verbs (i.e. those that take a greater variety of argument structure arrangements) resulted in either selection of the more simple form or in failure.

Materials

A total of 47 verbs were selected for testing from an original set of 72 (12 for each of the six verb types). Verbs ranged from one to three syllables and were matched for frequency of occurrence and familiarity. Mean frequency of occurrence was 236 per 1000 (Francis and Kucera 1982) and familiarity ratings made by 20 age-matched non-brain-damaged adults were all at least 6·5 on a scale of 1 to 7 (1 = not familiar at all; 7 = very familiar). Verb types included the following: obligatory one-place, obligatory two-place, obligatory three-place, optional two-place, optional three-place, and complement verbs (see Appendix A). The final set of 47 verbs was selected by asking five judges (graduate and post-doctoral students in linguistics and speech–language pathology) to categorize the 72 verbs by type. Only verbs on which 100% agreement across the five judges was obtained were retained for use in the study.

For each of the 47 verbs, black-and-white line drawings (5 × 7 inches) were prepared. All were action pictures that included both objects and people. Three of the five judges discussed above were asked to provide a single verb label for each of the 47 pictures; 100% agreement was established for 30 of the pictures, therefore these 30 verbs were included in the confrontation naming condition. For eliciting verbs in sentences, arrows were included on the pictures to denote objects or people that represented obligatory or optional arguments of the verb. The verb label was also included on these sentence-elicitation pictures. Sample stimuli used for confrontation and elicited naming and for sentence production are included in Appendix B.

Story-completion stimuli were also prepared for use in the elicited naming condition and in the sentence production condition (see details for each condition below). Stories used in the elicited naming condition consisted of two simple sentences with the target verb embedded in the first. A sample story completion

item used to elicit the verb *laughs* was: 'The boy laughs at the joke. I want you to tell me what the boy does.' Stories used in the sentence production condition consisted of three simple sentences. Target verbs were not embedded in these sentences. For example, the story completion stimulus for the verb *shaves* in the sentence production condition was: 'The man looks in the mirror. His face is hairy. He finds a razor. What happens next?' The picture and story completion items were pretested with five non-brain-damaged, age-matched subjects in order to determine whether they reliably elicited target verbs and sentences. Four of the five subjects produced 100% of the target verbs and sentences; one subject erred on one verb and two sentences, but produced target responses with prompting.

All subjects were pretested on their ability to comprehend each of the 47 verbs by asking them to point to one of four pictured verbs named by the examiner. All subjects demonstrated good comprehension across verb types (*M* percentage correct comprehension for the aphasic and normal subjects was 91% (SD = 6·96) and 98% (SD = 1·84), respectively). A *t*-test comparing these means indicated no significant difference in comprehension between the aphasic and non-brain-damaged subjects.

Conditions and procedures

Each subject participated in the following three test conditions: (a) a confrontation verb naming condition, (b) an elicited verb naming condition, and (c) a sentence production condition. The complete test was administered to each subject in a single (approximately 2-hour) session. The same examiner tested all subjects. Confrontation naming and elicited naming conditions were administered in random order across subjects; because the verb label was provided in the sentence production condition, this condition was administered at the end of the test session for all subjects. In all conditions two practice items were presented prior to administration of test items.

In the confrontation naming condition the examiner presented one of the picture stimuli and instructed the subject to name the pictured action. Thirty of the total 47 verbs were included in this condition. In the elicited naming condition the picture stimuli were presented together with a story-completion stimulus and the subject was required to produce the target verb. In this condition the complete set of 47 pictured verbs was presented for verb naming. One repetition of the story-completion stimulus was allowed for each picture. In both conditions subjects were given a maximum of 30 seconds to respond. Responses were recorded as correct or incorrect. Self-corrections occurring within the 30-second time frame were accepted as correct responses, as were responses containing minor phonemic errors. Semantically appropriate responses of the target verb type were also accepted as correct responses (e.g. production of *gives* instead of *hands*). On infrequent occasions when semantically appropriate, but non-target, verbs were produced, the examiner prompted production of the target verb. For example, some subjects produced *sleeps* instead of *snores*; when this occurred the examiner pointed to the zzz marks on the picture and said 'yes, but he also ____'.

In the sentence production condition a picture stimulus was presented together with the coinciding story-completion stimulus. Subjects were instructed to produce a sentence (a) completing the examiner's story, (b) using the verb provided, and (c) including all people and/or objects marked in the picture with arrows. Each of the

47 target verbs was tested in all of its possible argument structure contexts. Obligatory one-place, obligatory two-place, and obligatory three-place verbs were tested in only one sentence context; optional two-place, optional three-place and complement verbs were tested in two sentence contexts each. Therefore, a total of 69 sentences were elicited in this condition. Once again, one repetition of the instructions and story-completion stimulus was provided, if necessary, for each picture stimulus and responses produced were scored as correct or incorrect. Arguments missing in incorrect sentences were also recorded. Sentences were considered correct when the verb as well as all target arguments were correctly produced. Word substitutions (i.e. verbal paraphasias) were accepted when they were semantically and structurally appropriate (e.g. *The lady eats noodles* was considered a correct response for the target *The woman eats spaghetti*). Subjects were not penalized when either bound or free-standing grammatical morphemes were missing or substituted (e.g. *Lady eat spaghetti* was considered a correct response for the aforementioned sentence).

Reliability

Eight of the total 20 experimental sessions were observed by an independent observer who transcribed subject responses on-line and scored each as correct vs. incorrect based on the criteria presented above. Point-to-point agreement between the primary examiner and the independent observer's scores ranged from 97 % to 100 % with overall agreement at 99·8 %.

Data analysis

Percentage correct production in both naming conditions and in the sentence production condition was calculated for each subject group. In addition, percentage correct production of each verb type was computed for each of the verb naming conditions. For the sentence production conditions, percentage correct production of sentences using each verb type in each of its sentence contexts was calculated. Group means and standard deviations were then computed and arcsine transformations were completed. Differences between groups and conditions were analysed using a series of analyses of variance (ANOVA) calculations. *Post-hoc* pairwise comparisons of mean differences were accomplished using the Tukey test for multiple comparisons. An alpha level of $p < 0{\cdot}05$ was set for all statistical tests.

Results

Percentage correct production of target responses across conditions for the two subject groups is shown in Table 2. Analysis of these data using a 2 (subject group) × 3 (condition) analysis of variance indicated statistically significant differences between the aphasic and non-brain-damaged subjects' productions in all conditions. There was a significant main effect for subject group ($F(1,4) = 103{\cdot}12$) with the non-brain-damaged subjects performing better than the aphasic subjects across all conditions, as expected. A significant interaction effect was also found ($F(2,4) = 3{\cdot}84$) with the non-brain-damaged subjects performing consistently well across all conditions and the aphasic subjects showing better performance in the elicited verb naming condition than in the other two conditions. *Post-hoc* analysis revealed no significant differences between conditions for either subject group.

Table 2. Mean percentage correct production (and standard deviations) of target responses across conditions for aphasic and non-brain-damaged subjects

Condition	Aphasic subjects $\bar{x}$ (SD)	Non-brain-damaged subjects $\bar{x}$ (SD)
Confrontation verb naming	59·70 (16·94)	95·0 (5·42)
Elicited verb naming	76·20 (22·40)	100 (00)
Sentence production	59·15 (18·70)	93·08 (7·56)

Verb production by type in confrontation and elicited conditions

Mean percentage correct production of verbs across types in both the confrontation and elicited conditions for the aphasic and non-brain-damaged subjects is shown in Figure 1. A 2 (subject group) × 5 (verb type) ANOVA performed on the confrontation naming data showed a significant effect for group ($F(1,8) = 84·13$) but not for condition ($F(1,8) = 1·034$). No interaction effects were noted. A 2 (subject group) × 6 (verb type) ANOVA on the elicited naming data also showed a significant effect for group ($F(1,10) = 75·68$) and, in addition, a significant interaction effect was found ($F(1,10) = 2·23$). *Post-hoc* analysis showed no significant differences between verb types for the non-brain-damaged subjects in either condition. However, significant differences were found between obligatory one-place and both three-place and complement verbs for the aphasic subjects in the elicited naming condition, with one-place verbs produced correctly more often than the other verb types. Further, even though statistically significant differences

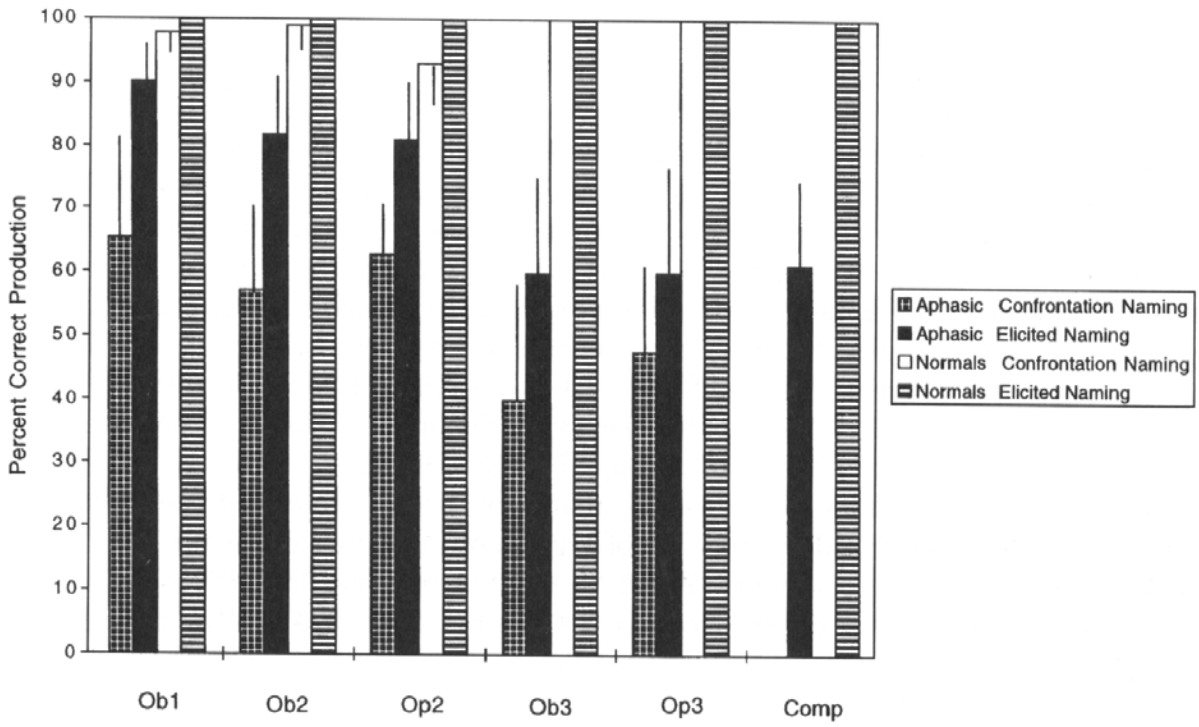

Figure 1. Percentage correct production (and standard deviations as indicated by inserted bars) of verbs by type in confrontation and elicited verb naming conditions for aphasic and non-brain-damaged subjects. Ob1 = obligatory one-place verb; Ob2 = obligatory two-place verb; Op2 = optional two-place verb; Ob3 = obligatory three-place verb; Op3 = optional three-place verb; comp = complement verb.

Table 3. Mean percentage correct production of verbs and verb arguments in sentences across verb types

Verb type	Aphasia subjects $\bar{x}$ (SD)	Non-brain-damaged subjects $\bar{x}$ (SD)
One-place verbs		
Ob1x	90·10 (14·15)	100 (0)
Two-place verbs		
Ob2xy	75·7 (14·72)	98·9 (3·48)
Op2x	91·30 (13·14)	99·3 (2·21)
Op2xy	69·2 (13·18)	88·6 (9·28)
Three-place verbs		
Ob3xyz	40·1 (23·57)	92·9 (10·14)
Op3xy	59·90 (15·87)	98·9 (2·21)
Op3xyz	25·7 (15·88)	82·9 (20·01)
Complement verbs		
Cxy	44·30 (17·24)	90·0 (15·21)
CxS′	27·10 (20·50)	85·8 (13·69)

across verb types were not found in the confrontation naming condition, an identical hierarchy of verb difficulty emerged under the two conditions—three-place and complement verbs were the most difficult to produce, two-place verbs were less difficult than three-place or complement verbs, and one-place verbs were produced correctly more often than the other verb types.

Verb argument structure production in sentences

Percentage correct production of argument structures in sentence contexts across verb types is summarized in Table 3 for both non-brain-damaged and aphasic subjects. We analysed these data in several ways: we examined the influence of (a) the type of argument, (b) the number of arguments, (c) the complexity of verb arguments, and (c) the obligatory vs. optional nature of verb arguments on correct sentence production. When the data were analysed by the type of argument required, we found a consistent hierarchy of difficulty across subject groups. Both groups produced Agent/Experiencers correctly in most sentences, with progressively fewer correct Patient/Themes, Goal/Locations, and Sentential Complements (see Figure 2). Once again, however, the aphasic subjects' performance was poorer than the non-brain-damaged subjects. A 2 (subject group) × 4 (argument type) ANOVA indicated that for both subject groups correct production was influenced by the type of argument in that a significant main effect was noted for both subject group ($F(1,6) = 91{\cdot}85$) and condition ($F(1,6) = 31{\cdot}16$). A significant interaction effect also was found ($F(1,6) = 3{\cdot}749$). *Post-hoc* analysis showed that, for the aphasic subjects, sentences with only an Agent/Experiencer (i.e. Ob1x, Op2x) were produced correctly significantly more often than those requiring a Theme/Patient (i.e. Ob2xy, Op2xy, Op3xy, cxy) or those requiring a Goal/Location (i.e. Op3xyz, Ob3xyz) or sentential complement (cxS′). Further, sentences requiring a Theme/Patient were produced correctly significantly more often than those with a Goal/Location or Sentential complement. A significant difference was not found between sentences requiring a Goal/Location and those

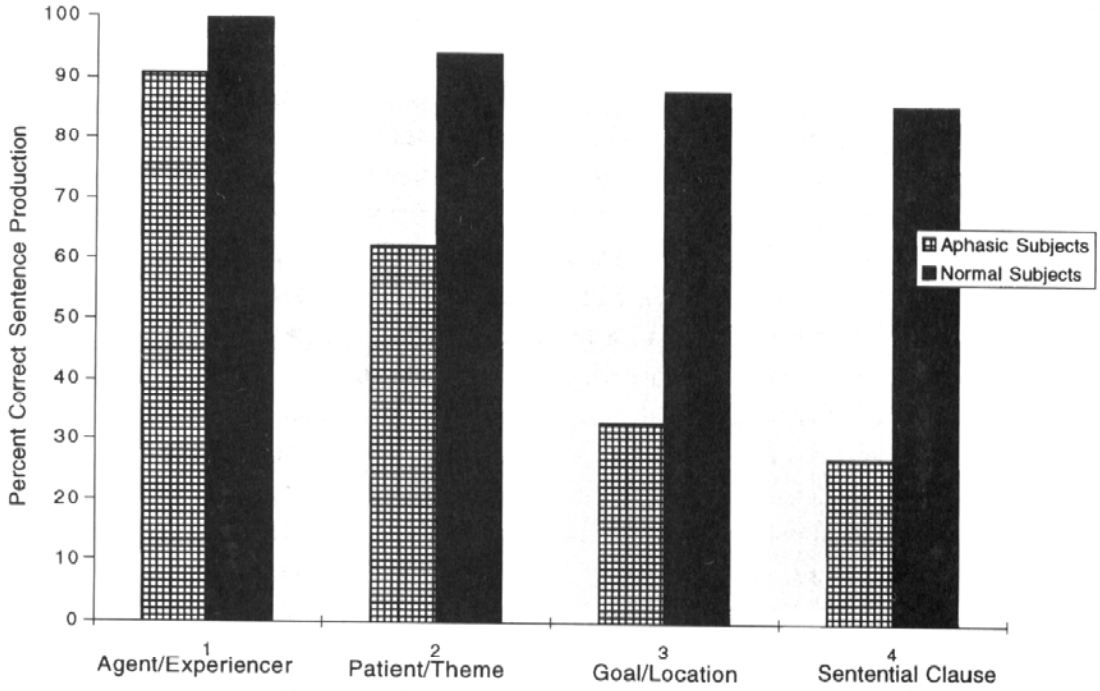

Figure 2. Percentage correct production of sentences by argument structure type—sentences with Agent/Experiencer only (Ob1x, Op2x), Patient/Theme (Ob2xy, Op2xy, Op3xy, Cxy), Goal/Location (Ob3xyz, Op3xyz), and sentential complement (cxS′)—for aphasic and non-brain-damaged subjects.

requiring a sentential complement; both were difficult for the aphasic subjects. For the non-brain-damaged subjects, significant differences were noted between sentences with an Agent/Experiencer and those with a Goal/Location or a sentential complement.

Relatedly, analysis of the data showed that the number of arguments or participant roles required by the verb influenced sentence production for both subject groups, with sentences requiring one, two and three arguments produced increasingly less correctly (see Figure 3). A 2 (subject group) × 3 (number of arguments) ANOVA resulted in significant main effects for both subject group ($F(1,4) = 66{\cdot}2$) and condition ($F(1,4) = 36{\cdot}64$) and a significant interaction effect was also found ($F(1,4) = 5{\cdot}14$). *Post-hoc* analysis indicated that, for the aphasic subjects, a significant difference was noted in production of sentences with one argument (i.e. Ob1x, Op2x) as compared to two (i.e. Ob2xy, Op2xy, Op3xy, cxy, cxS′) or three (i.e. Ob3oxy, Op3xyz), with sentences with one argument produced correctly more often than those with more arguments. Further, a significant difference was found between production of sentences with two arguments as compared to three.

When we analysed the sentence production data in terms of verb complexity we found that the aphasic subjects correctly produced 68·76 % (SD = 18·28) of the sentences with simple verbs—that is, those containing verbs with only one possible argument structure arrangement (i.e. Ob1, Ob2, and Ob3), whereas they correctly produced 47·53 % (SD = 19·1) of the sentences with complex verbs—that is, sentences with verbs that have more than one possible argument structure arrangement (i.e. optional verbs and complement verbs). The non-brain-damaged subjects correctly produced 97·03 % (SD = 4·54) of the sentences with simple verbs as compared to 88·9 % (SD = 10·58) of the sentences with complex verbs. (see figure 4). A 2 (subject group) × 2 (condition; simple vs. complex) ANOVA

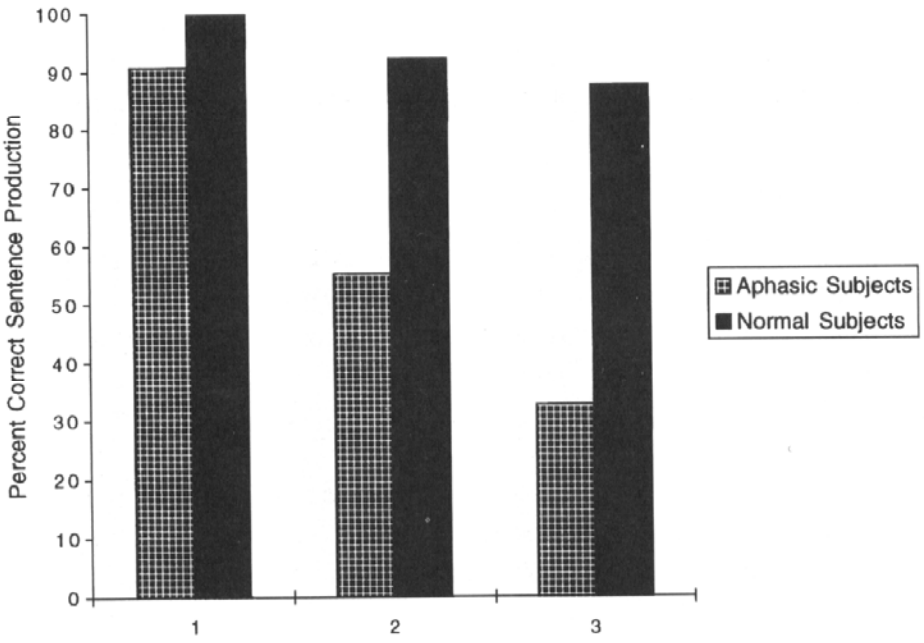

Figure 3. Percentage correct production of sentences with one, two, and three verb arguments or participant roles for aphasic and non-brain-damaged subjects.

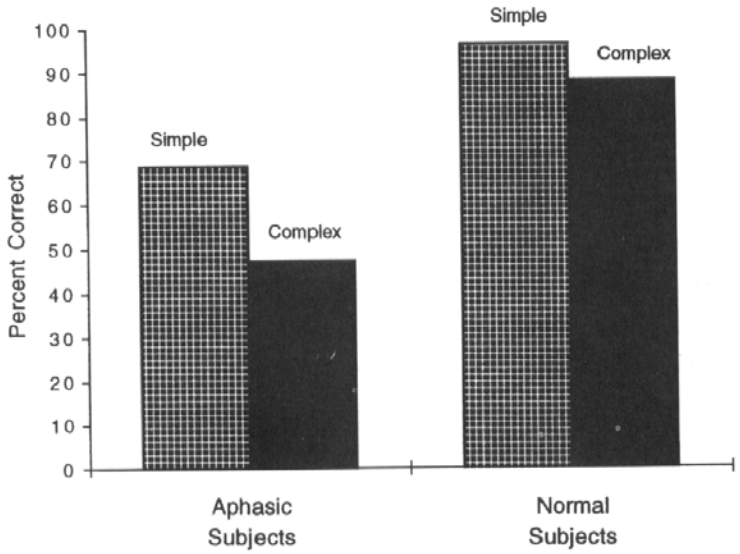

Figure 4. Percentage correct production of sentences with simple (Ob1, Ob2, and Ob3) vs. complex (Op2, Op3, and C) verbs for aphasic and non-brain-damaged subjects.

resulted in significant main effects for both subject group and condition ($F(1,2) = 118{\cdot}53$); however, a significant interaction effect was not found ($F(1,2) = 2{\cdot}79$). Both the non-brain-damaged and the aphasic subjects produced sentences with simple verbs correctly more often than those with complex verbs.

Finally, when we examined verb complexity by comparing only optional and obligatory two- and three-place verbs, we found that both the aphasic subjects and the non-brain-damaged subjects produced sentences containing verbs with obligatory arguments (i.e. Ob2xy and Ob3xyz) better than those with optional arguments (i.e. Op2xy and Op3xyz) (see Table 3). A 2 (subject group) × 4 (verb type) ANOVA showed a significant main effect for subject group ($F(1,2) = 94{\cdot}8$) and for condition ($F(1,2) = 29{\cdot}83$), and a significant interaction effect was found ($F(1,2) = 2{\cdot}78$). *Post-hoc* analysis indicated significant differences between production of sentences with obligatory two-place verbs and those with optional two-

place verbs for both subject groups. Similarly, significant differences were found between production of sentences with obligatory three-place verbs and those with optional three-place verbs for both the aphasic and non-brain-damaged subjects.

Discussion

Findings from this study were consistent with previous findings indicating that verb production is difficult for aphasic individuals with agrammatic deficits. Compared to our non-brain-damaged subjects, our agrammatic subjects evinced difficulty producing verbs in both verb naming conditions, although verb production was less compromised in the elicited naming condition. In addition, the data reported here indicated that verb production is influenced by verb type. For the aphasic subjects, one-place verbs were produced correctly more often than the other verb types, and a consistent hierarchy of verb difficulty emerged in the data. That is, one-place verbs were easier than two-place, three-place or complement verbs; two-place verbs were easier than three-place or complement verbs; and three-place verbs were easier to produce than complement verbs. This finding was consistent with our previous observations of verb production in aphasic narrative and conversational discourse samples. That is, we found a similar hierarchy of verb difficulty in the discourse of agrammatic aphasic subjects (Thompson *et al.* 1994). These findings indicate that verbs with fewer and less complex argument structures appear to be easier for agrammatic aphasic subjects to produce—even when produced as single words.

The differences found in our aphasic subjects' ability to produce verbs of certain types—with verb type defined by its argument structure—indicates that the argument structure properties of verbs influence production. The patterns of verb production seen in our agrammatic aphasic subjects indicate that retrieving verbs that have more and varied argument structures is more difficult for aphasic subjects than retrieving verbs that have less complex argument structure characteristics. Thus, we suggest that verb activation processes, like noun activation processes, involve searches through the lexicon—a lexicon which for a verb includes not only information about its lexical category and phonological form, but also information about its argument structure characteristics. As the number of arguments increase and/or the number of participant roles (thematic roles) of the verb increase, so too does verb activation difficulty.

Our data also indicated that the type of argument structure and number of participant roles required by the verb influence correct sentence production. That is, even when verbs were produced in our sentence production conditions, the ability to correctly produce the argument structures of the verb depended on (a) the type of argument required by the verb in a particular context, and (b) the number of participant roles required by the verb. Specifically Goal/Locations and sentential complements presented difficulty for our aphasic subjects and, regardless of the type of argument required, sentences with verbs with a greater number of participant roles were more difficult than those with fewer. We suggest that these findings reflect, at least in part, agramamtic aphasic subjects' failure to completely activate the argument structure representation of verbs. It also could be argued, however, that the structures that presented difficulty for our subjects required more complex syntax (e.g. Goal/Location, sentential complements) than arguments that presented less difficulty (Agent/Experiencer, Patient/Theme). That is, Goal/

Location arguments are often expressed as prepositional phrases, and sentential complements require an embedded clause. Further, our observation that sentences with more arguments are more difficult than those with fewer could be explained by simple length or 'economy of effort' effects (Goodglass 1976), or even by adaptation—a theory suggesting that adaptive strategies adopted by the aphasic individual underlie the language deficits seen in these individuals (e.g. Kolk and van Grunsven 1985).

However, the conclusion that sentence length or complexity explains the erroneous sentence productions seen in agrammatic aphasia is challenged by our finding that sentences with verbs with optional arguments are produced correctly less often by both non-brain-damaged and aphasic subjects than sentences with obligatory arguments. For example, our subjects produced sentences such as *The girl gives a bone to the dog* correctly more often than sentences such as *The girl mails a letter to her mother*. The verb *give* is an obligatory three-place verb; whereas the verb *mail* is an optional three-place verb. Both verbs have three participant roles in their lexical representation and the syntax required in sentences in which all participants are realized is identical for both. The only difference is that the argument structure for *mail* also includes an Agent/Theme arrangement. Thus, a sentence such as *The girl mails a letter* is grammatical even without the third argument being present in the syntax. Conversely, the verb *give* has only one argument structure arrangement (Agent/Theme/Goal) and, therefore, a sentence such as **The girl gives a bone* is ungrammatical. Our finding—that sentences with obligatory arguments are easier to produce than those with optional arguments—suggests that when verbs are activated for production, so too are its argument structure representations, and that the argument structure of verbs with just one stored configuration—as in obligatory verbs such as *give*—are more readily available than are the argument structure representations of verbs with more than one. When arguments are obligatory, retrieval is uncomplicated; the verb is activated for production and so too are the obligatory arguments that go with it. When arguments are optional, several argument structure options may be retrieved with the verb. Our data suggest that when agrammatic aphasic individuals retrieve optional verbs they incompletely activate all possible argument structure arrangements, even when asked to do so; the simplest arrangement of participant roles is activated and sentences are produced in their simplest form.

Interestingly, our sentence production findings are similar to those derived from sentence processing and sentence comprehension studies. For example, Ahrens and Swinney (1995) showed that, in non-brain-damaged subjects, as the number of participant roles of the verbs in sentences increases, processing load increases. Similarly, Shapiro and colleagues (1991, 1993) showed that the number of possible argument structures—or complexity of the verb—influences sentence processing in both non-brain-damaged and in Broca's aphasic subjects. Greater reaction times were found for complex as compared to simple verbs when subjects were asked to make a lexical decision at the point at which verbs were encountered in sentences. While the relation between comprehension and production is not well understood, the similarities derived from these two lines of investigation involving verbs and verb argument structure are provocative, and suggest that a similar representational base is used for both processes.

Conclusions

The findings reported here provide evidence that agrammatic aphasic subjects have more difficulty producing some types of verbs as compared to others, and that access to verb argument structure is, in part, responsible for the impoverished sentence production seen in these individuals. Compared to normal subjects, non-fluent agrammatic aphasic subjects evince difficulty producing verbs, even in isolation, that have a greater number of participant roles contained within the verbs' lexical representation. In addition, these subjects do not appear to completely activate the full range of lexical properties available, given a particular verb. We suggest that this restriction cannot be fully explained by simple length, 'economy of effort' or adaptation theories; instead, we suggest that it is due to a complex mixture of verb and syntactic variables that influence sentence complexity and production. These data suggest that careful assessment of verb and verb argument structure production is necessary in intervention with aphasic subjects.

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Appendix A: Verbs by type

Obligatory one-place (Ob1).
Verbs that take only an external argument: Agent/Experiencer (x).
Example: The boy *smiles.* (Ob1x)
Test exemplars: sleeps, skates, smiles, runs, listens, skis, snores, laughs, prays.

Obligatory two-place (Ob2).
Verbs that require both two arguments: Agent/Experiencer (x) and Patient/Theme (y).
Example: The boy catches the ball. (Ob2xy)
Test exemplars: hugs, washes, pats, opens, catches, kisses, closes, climbs, measures.

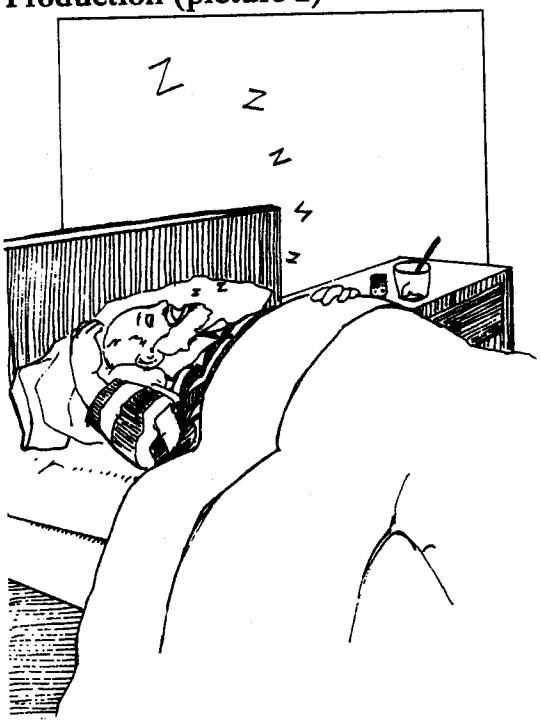
Obligatory three-place (Ob3).
Verbs that require three arguments: Agent/Experiencer (x), Patient/Theme (y) and Goal/Location (z).
Example: The girl gives a bone to the dog. (Ob3xyz)
Test exemplars: leans, puts, feeds, gives, sticks, glues, nails.

Optional two-place (Op2).
Verbs that require one external argument: Agent/Experiencer (x). The second argument (Patient/Theme (y)) is optional.
Example: The woman eats. (Op2x)
The woman eats spaghetti. (Op2xy)
Test exemplars: feeds, studies, eats, sings, juggles, drinks, cleans, shaves.

Optional three-place (Op3).
Verbs that require an Agent/Experiencer (x) and a Patient/Theme (y), but the third argument (Goal/Location (z)) is optional.
Example: The woman throws the stick. (Op3xy)
The woman throws the stick to the dog. (Op3xyz)
Test exemplars: mails, reads, teaches, bakes, throws, writes, pours.

Complement verbs (C)
Verbs that require two arguments: an external argument (Agent/Experiencer (x)) and an internal argument. The internal argument may take the form of Patient/Theme (y), or it may take the form of a sentential complement (S′).
Example: The girl knows the answer. (Cxy)
The girl knows that the cat is in the tree. (CxS′)
Test exemplars: understands, remembers, knows, explains, doubts, says, believes.

Appendix B: Sample Picture Stimuli for Eliciting Verbs in Isolation (picture 1) and for Eliciting Argument Structures in Sentence Production (picture 2)



Picture 1. Stimulus picture for the verb *snores.*

Picture 2. Stimulus picture for the sentence: *The man shaves his moustache.*