Clinical Aphasiology, Vol. 23, 1995, pp. 121–140

Analysis of Verbs and Verb-Argument Structure: A Method for Quantification of Aphasic Language Production

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One of the primary deficits seen in individuals with aphasia—particularly those with agrammatic aphasia—is difficulty producing well-formed sentences. Co-occurring with nonfluent aphasia, agrammatism has traditionally been characterized by production of simple, poorly realized sentence structures and frequent omission of bound and freestanding grammatical morphemes (Goodglass, 1968, 1976). Although much research has been focused on agrammatism in an attempt to find a coherent explanation for the deficit patterns seen, lawful patterns of sentence production breakdown have yet to be determined (Berndt, 1991; Saffran et al., 1980; Schwartz, & Marin, 1980; Schwartz, 1987). In fact, dissociations between and among the symptoms that typically co-occur in so-labeled agrammatic individuals have been noted, leading to the notion that the various symptom patterns seen in agrammatism may not result from a single underlying deficit. For example, patients have been described who have apparent structural impairments, but who do not omit or misuse grammatical markers (Berndt, 1987; Parisi, 1987; Saffran et al., 1980; Tissot, Mounin, & Lhermitte, 1973); conversely, patients have been reported who omit grammatical morphemes, but who produce sentences of relatively normal length and syntactic complexity (Kolk, Van Grunsven, & Keyser, 1985; Miceli, Mazzucchi, Menn, & Goodglass, 1983).

In light of these and other reported dissociations of the "symptoms" that characterize agrammatism, careful analysis of sentence production patterns seen in these patients has become increasingly important. As pointed out by Saffran, Berndt, and Schwartz (1989), a systematic method for quantifying the structural and morphological deficits that have been described is needed not only to derive more precise descriptions of aphasic sentence production deficits, but also to lead to a better understanding of these deficits. Without such a system, it is difficult to characterize and compare deficit patterns across patients. Furthermore, careful analysis of sentence production patterns is important for the development of appropriate treatment programs for syntactic or grammatical deficits and to capture changes in sentence production that may occur with recovery or following treatment.

Most methods advanced for analysis of language production patterns have been developed for examination of language development in children (e.g., *Developmental Sentence Analysis*, Lee, 1974; *Linguistic Analysis of Speech Samples*, Engler, Hannah, & Longhurst, 1973; *Language Assessment, Remediation, and Screening Procedure* [LARSP], Crystal, Fletcher, & Garman, 1976; Crystal, 1979, 1982, 1984). Some of these methods have been extended for use with aphasic individuals (e.g., Kearns & Simmons, 1983). For example, Kearns and Simmons (1983) and others have used the LARSP, which provides a method for profiling word, phrase, and clause productions based on structuralist grammar (Quirk, Greenbaum, Leech, & Svartvik, 1972), for analyzing aphasic language samples. However, variables considered important in aphasic language production are not considered in this or in other developmental systems, and mechanisms for extracting and comparing production profiles along the lines considered important in agrammatism are not available with these methods.

The most extensive method for coding aspects of sentence structure in aphasic language samples is that developed by Saffran et al. (1989). Their elaborate system was developed with appreciation for agrammatic speech production patterns. With this method, narrative discourse samples are segmented into propositional utterances, coded, and quantified with regard to morphological and sentence structural characteristics. The system tallies major lexical categories, functional categories, grammatical morpheme complexity, and other aspects of production that are important in agrammatism. The major limitation inherent in this system concerns its resolution of sentence structure. The numbers of subject noun phrases (SNP), verb phrases (VP), and words (open class and pronouns) produced within these phrase structures are simply tallied. The mean SNP length and VP length are then calculated and summed to yield a general index of sentence elaboration. Although this method provides information concerning the number of sentence constituents contained within utterances and their length, it neither provides data concerned with phrasal and clausal information contained within phrases (especially within the VP) nor appreciates the relation between verbs and sentence structure; that is, the lexical semantic representation of verbs (i.e., verb-argument structure) is not considered, and the notion that argument structure represents a complex of information critical to the syntactic behavior of a lexical item is ignored.

Byng and Black (1989) posed a method for analyzing verb-argument structure. However, this system also relies largely on tallying the number of phrase structures occurring in utterances without concern for the full range of argument structure arrangements that a particular verb may take.

Review of Lexical and Syntactic Properties of Verbs

Each verb in the English language carries lexical information that directly influences sentence structure. For example, the verbs *hit*, *give*, and *sleep* each has unique *subcategorization frames*—that is, they can and sometimes must be followed by certain sentence constituents (e.g., noun phrases). Grammatical intuitions indicate that the verb *hit* allows a direct object noun phrase (NP) to follow it; the verb *give*, if followed by a direct object NP, also requires a prepositional phrase (PP); and the verb *sleep* does not require a direct object NP. This phrasal (and clausal) information is known formally as strict subcategorization.

Part of this subcategorization information is predictable from the meaning of lexical entries and real-world intuitions about language use. It is known, for example, that the object of the verb *hit* is affected by the hitting, and that the object of the verb *give* involves something that must be given to someone and that the action of giving something to someone entails a *path* along which the object metaphorically travels. This type of lexical semantic information (Jackendoff, 1990) encompasses the notions of *theta roles* (i.e., thematic roles: agent, theme, goal, source, etc.) and *argument structure* (a set of elements referring to the lexical representation of grammatical information about a predicate). For the present purpose, we use the term *argument structure* to describe the semantic/thematic information about a predicate. Consider the following sentences:

1. [Zack]$_{AGENT}$ hit [the ball]$_{THEME}$.
2. [Zack]$_{AGENT}$ gave [the ball]$_{THEME}$ [to Joelle]$_{GOAL}$.
3. [Zack]$_{AGENT}$ slept.

The verb *hit* in Sentence 1 requires two logical arguments or participants. One of these arguments is assigned the role of Agent (considered an *external argument*); the other argument is assigned the role of Theme (an *internal argument*—an argument that receives its theta role directly from the verb). The verb *give* requires three arguments, the final argument having the role of Goal. The verb *sleep* requires only one argument, the external Agent.

These lexical properties also are reflected in the syntax. Consider the following sentences:

4. Zack hit the ball.
5. Zack hit Dillon.
6. * Zack hit.
7. * Zack hit the ball Dillon.

Again, the verb *hit* requires only one direct object NP, which is assigned its thematic role by the verb. This is reflected in sentences (4) and (5). But sentences (6) and (7) are unacceptable because no object NP (or Goal) is contained in *Zack hit,* and because two NPs follow *hit* in *Zack hit the ball Dillon.* Because of the *Projection Principle,* which states that lexical properties are observed at *all levels of syntax,* these last two sentences are ungrammatical. The projection principle requires that the lexical properties of *hit* be syntactically represented in sentences; that is, the lexical representations of grammatical information must be present. The verb *theta-marks* its arguments; it assigns its thematic roles onto the argument positions in the sentence, and these argument positions must be represented in the syntax. In this way, lexical information and the projection principle determine to a large extent the syntactic structure of a sentence.

We feel that these lexical and syntactic properties and the ways in which they are violated in agrammatic production may be important for understanding sentence production deficits in aphasia. We have shown in previous work that these properties impact significantly on treatment of sentence production deficits (Shapiro & Thompson, 1994; Thompson & Shapiro, 1994; Thompson, Shapiro, & Roberts, 1993). Therefore, we feel that any system used for analyzing aspects of sentence production also should consider these lexical properties.

Arguments and Adjuncts

Related to the notion that verbs project their lexical properties onto syntax is the distinction between an argument of the verb and an adjunct. An argument of the verb is entailed by the verb's meaning or conceptual structure; it is idiosyncratic to the verb and is thus represented with the verb's phonological form in the lexical entry. The argument position is assigned a thematic role by the verb or its VP. An adjunct, however, is not selected by the verb; it can appear with any verb in the language and thus does not need to be specified as part of the verb's lexical entry. Subsequently, the adjunct is not theta-marked by the verb. Consider the prepositional phrases in the following sentences:

8. Dean sent the car *to the garage.*
9. Dean fixed the car *in the garage.*

The verb *send* allows three arguments: Agent is assigned to the subject NP *Dean,* Theme is assigned to the direct object NP *the car,* and Goal is assigned to the indirect object NP *the garage* that forms part of the prepositional phrase. Something must be "sent to someone or somewhere," and thus the Goal is implied—and supplied—directly by the verb. In the second sentence, the prepositional phrase—*in the garage*—is considered a locative adjunct; its meaning is not inherent in the verb's representation. Although something must be "fixed somewhere," this information cannot be inferred from the verb, but instead is supplied by additional material in the sentence—the adjunct prepositional phrase. Thus, an adjunct is always optional, whereas an argument can be either obligatory (e.g., "Rodney gave the ball to Susan," where "Rodney gave the ball" is ungrammatical if the third argument is omitted) or optional (e.g., "Sandra sent the letter," where the third argument is implied even if it is omitted). Finally, an adjunct can be ambiguous, whereas an argument rarely is. For example, *in the garage* is structurally ambiguous; it can modify either the direct object NP *the car* (as in "It was the car in the garage—and not the car outside the garage—that Dean fixed") or the VP *fixed the car* (as in "It was in the garage—and not in the driveway—that Dean fixed the car"). There are no interpretive or attachment ambiguities involving the prepositional phrase *to the garage* in the first sentence. The PP is the goal of where the car was sent.

Sentence Processing Implications

Recent psycholinguistic and neurolinguistic work has shown that virtually all of these theoretical constructs have lexical and sentence processing implications. For example, Shapiro and colleagues (e.g., Shapiro, Brookins, Gordon, & Nagel, 1991; Shapiro, Zurif, & Grimshaw, 1987) have found that a verb's lexical properties directly affect sentence processing; that is, as the verb becomes more complex in terms of the number of different argument structure arrangements possible, the processing load increases in the immediate temporal vicinity of the verb. For example, the verb *fix* allows *only one* two-place argument structure (Agent–Theme, as in "Susan fixed the computer"), whereas the verb *send* allows *both* a two-place structure (Agent–Theme, as in "Susan sent the flowers") and a three-place structure (Agent–Theme–Goal, as in "Susan sent the flowers to her mother"). When embedded in simple NP-V-NP structures, *send*, for example, yields a greater processing load than *fix*. In effect, it appears that all possible argument structures associated with a verb are momentarily and exhaustively activated when the verb is accessed. Shapiro and colleagues also have suggested that, given a verb (e.g., *send*) with multiple argument structure possibilities, a subject's preferences for one of these possibilities might then be used to determine the initial course the parser takes after encountering the verb (Shapiro, Nagel, & Levine, 1993).

Compared with normal subjects, agrammatic Broca's aphasic patients seem to normally activate a verb's multiple argument structure possibilities in the immediate vicinity of the verb and to show the same processing preferences (Shapiro, Gordon, Hack, & Killakey, 1993; Shapiro & Levine, 1990). This result implies that verb properties need to be controlled in language experiments, including treatment research, and considered in analysis of sentence production, because these properties are projected from the lexicon to the syntax and indeed have direct consequences for on-line performance.

Some indication also has been gleaned from recent research that adjuncts are computationally more expensive than arguments of the verb. That is, processing load increases in the immediate temporal vicinity of a preposition heading an adjunct PP (as in, e.g., "The old man sent the toy *in the box*") relative to a preposition heading a PP that contains an argument (as in "The old man sent the toy *to the girl*").

The importance of verbs in sentence production has become increasingly apparent. Clearly, it has been demonstrated that verb production is impoverished in many agrammatic speakers (Gleason et al., 1980; Meyerson & Goodglass, 1972). Additionally, agrammatic speakers are well known to produce primarily simple, incomplete sentences (Bates, Friederici, Wulfeck, & Juarez, 1988; Gleason et al., 1980; Saffran et al., 1980). Given the lexical and syntactic nature of verbs, perhaps the verb impoverishment noted in some agrammatic aphasic individuals results in their asyntactic sentence productions. Indeed, examination of the linguistic, psycholinguistic, and neurolinguistic literature concerned with verbs indicates that verbs influence sentence processing. What remains unknown is the influence of verbs on sentence production.

The present work was undertaken (a) to develop a method for coding verbs and their arguments as well as adjuncts in language samples and (b) to demonstrate both the use and the reliability of this coding system for analyzing discourse samples of aphasic and normal speakers.

METHOD

Subjects

Ten monolingual, English-speaking adults—5 aphasic and 5 normal subjects—matched for age (47–69 years) and educational background, were selected to participate in the study. All subjects presented with a negative history of psychiatric disorders or alcohol abuse and passed a pure-tone audiometric screening at 40 dB HL (ANSI: 1969) in at least one ear. None of the subjects evinced speech and language or neurological disorders other than that related to the aphasia. Aphasic subjects had suffered a single, left hemisphere cerebral vascular accident (CVA) at least 3 years prior to data collection and demonstrated language patterns consistent with nonfluent, Broca's aphasia based on performance on *The Western Aphasia Battery* (WAB) (Kertesz, 1982) and other measures (AQ scores ranged from 60 to 81). *The Porch Index of Communicative Abilities* (PICA) (Porch, 1971) overall percentiles ranged from 54 to 84. General subject characteristics are included in Table 1; aphasia test results are noted in Table 2.

Table 1. Subject Characteristics

Subject	*Age*	*Sex*	*Etiology*	*MPO*	*Education*	*Handedness*	*Hearing*
Aphasic							
1	69	M	LCVA	63	14	R	WNL
2	65	M	LCVA	42	5	R	WNL
3	59	F	LCVA	51	12	R	WNL
4	60	M	LCVA	18	18	R	WNL
5	50	M	LCVA	102	12	R	WNL
Normal							
1	47	F			14	R	WNL
2	52	M			18	L	WNL
3	65	M			13	R	WNL
4	57	M			13	R	WNL
5	68	M			16	R	WNL

Note: MPO = months postonset; M = male; F = female; LCVA = left cerebral vascular accident; R = right; L = left; WNL = within normal limits (pure tone audiometric screening test passed at 40 dB HL [ANSI: 1969] in at least one ear).

Table 2. Aphasia Test Data

Subject	*PICA Overall %ile*	*WAB AQ*	*Aphasia Type*
1	57	62.2	Broca
2	62	64.9	Broca
3	79	80.8	Broca
4	84	74.6	Broca
5	54	59.9	Broca

Note: PICA = *Porch Index of Communicative Abilities* (Porch, 1971); WAB AQ = *Western Aphasia Battery,* Aphasia Quotient (Kertesz, 1983).

An additional 9 non–brain-damaged subjects who were unfamiliar to the experimental subjects served as conversational partners. These participants were all males, ranging in age from 58 to 67.

Data Collection

The language samples used for analysis were conversations between the aphasic subject and an unfamiliar partner. Together they viewed a short television news segment (*ABC American Agenda),* equated to previous work by Doyle and associates (Doyle, Thompson, Oleyar, Wambaugh, & Jackson, 1994) on a number of interest and complexity parameters. After viewing, they were instructed to discuss it for a total of 6 minutes. All samples were collected in a quiet, distraction-free conversational probe room equipped with a sofa, two chairs, and a TV/VCR unit. A total of 10 samples were audiotaped, transcribed, and entered into a microcomputer for analysis. Samples were segmented into utterances based on syntactic, prosodic, and semantic criteria using conventions adapted from Campbell and Dollaghan (1987) and Saffran et al. (1989). Nonmeaningful words, fillers, automatic nonpropositional utterances, and perseverative responses were excluded from the analysis.

Sample Coding

The center 25 utterances from each sample were coded. Each utterance was coded as a grammatical sentence, an ungrammatical sentence, or a nonsentence. Utterances not containing a matrix verb were considered nonsentences; all others were coded as sentences. Sentences were coded as ungrammatical when necessary phrasal or clausal constituents were absent, when arguments were produced in the wrong syntactic position (i.e., word-order errors), when subject–verb agreement errors occurred, or when other similar errors were noted.

All verbs produced in both grammatical and ungrammatical sentences and their accompanying argument structures then were coded. Verb codes included (a) obligatory one-place, (b) obligatory two-place, (c) obligatory three-place, (d) optional two-place, (e) optional three-place, (f) complement, and (g) copula verbs. Verbs combining with a particle (e.g., wake up) were coded as such together with their primary verb code. Verb codes and definitions are provided in Appendix A. Argument structures, as well as adjuncts found in each utterance, also were coded. These codes and definitions are included in Appendix B. In deriving argument structure codes, the underlying linguistic representation of surface sentences was considered. For example, moved sentence constituents occurring in noncanonical sentences, such as in the passive sentence "The ball was hit by Zack," were coded for arguments assigned prior to their movement. Syntactically legal omissions of arguments also were coded (e.g., truncated passive sentences, such as "The ball was hit," in which the by-phrase is omitted) were coded as containing an obligatory two-place verb (Ob2) accompanied by the internal argument (Theme [Y], *the ball*) with a legally omitted external argument (Agent [X]). Misuse or omission of either verbs and/or argument/adjuncts also were noted in transcript coding. All samples were coded independently by three examiners (two primary coders and one reliability coder). Disagreements between the two primary examiners were discussed and resolved.

Calculations

Several calculations were undertaken. The total words produced and the mean length of utterance (MLU) were computed for each subject group. The proportion of utterances comprised of grammatical sentences, the mean number of verbs produced, and the proportion of utterances containing verbs then were calculated. The frequency of occurrence of each verb type and the proportion of the data accounted for by each verb type then were computed, as was the extent to which each verb type was produced with correct argument structure. The number of arguments and adjuncts produced and the proportion of correctly used arguments and adjuncts also were calculated. *T*-tests were performed to compare the total words produced and the MLU for the aphasic and normal groups. All remaining statistical comparisons were made using the Mann–Whitney U Test.

RESULTS AND DISCUSSION

Reliability

Reliability of transcription and utterance segmentation was performed on all samples. To accomplish this, the original transcripts and corresponding audiorecordings were provided to an independent judge, who was instructed to listen to the sample and note any disagreements with respect to utterance content or segmentation. Disagreements were reviewed by a third rater, and were either resolved by consensus or omitted from the data analysis. In this regard, less than 2% of utterances sampled were omitted due to lack of agreement.

Point-to-point reliability was computed separately for (a) verb codes and (b) argument/adjunct codes on all samples by comparing the data derived from the two primary examiners with that of the third examiner. Interrater agreement ranged from 88% to 95% with a mean of 92% for verb codes and from 80% to 92% with a mean of 86% for argument/adjunct codes.

Corpora Data

Group means and standard deviations for all dependent measures are presented in Table 3. Compared with normal subjects, aphasic subjects produced fewer words and shorter utterances across samples. The total words produced by the aphasic and the normal subjects were 107 and 197 with MLUs of 3.0 and 7.8, respectively. *T*-test comparisons indicated that these values were significantly greater for the normal subjects than for the aphasic subjects ($p < .01$).

The mean number of verbs, the proportion of utterances with verbs, and the proportion of grammatical sentences also were significantly different between groups ($p < .05$), indicating asyntactic sentence production and impoverished verb production in the aphasic samples, as expected. Approximately half (50.5%) of the utterances produced by aphasic subjects contained verbs, compared with 88% of the utterances of normal subjects; 34% of the utterances produced by aphasic subjects were considered to be grammatical sentences, compared with 75% of those of the normal subjects. These data support previously reported findings that nonfluent aphasic subjects produce primarily short, syntactically simple or incomplete sentences with few verbs (Gleason et al., 1980; Meyerson & Goodglass, 1972; Saffran et al., 1980).

Verb Productions by Type

When we analyzed the data for the types of verbs produced by the two subject groups, we noted statistically significant differences for

Table 3. Group Means and Standard Deviations for All Dependent Measures

	Aphasic Subjects		*Normal Subjects*	
	Mean	*SD*	*Mean*	*SD*
Total words produced	107.0	37.5	197.0	44.12
Mean length of utterance	3.0	1.65	7.8	1.7
Mean number of verbs	14.4	9.0	35.8	5.35
Proportion of utterances with verbs	50.4	26.9	88.0	6.32
Proportion of grammatical sentences	33.6	27.5	75.2	13.4
Proportion of verbs produced by type				
Copula	34.28	19.23	27.93	14.25
Obligatory one-place	18.52	11.59	11.17	1.96
Obligatory two-place	24.28	19.66	37.98	6.73
Obligatory three-place	0.0	0.0	5.02	2.52
Optional two-place	17.14	12.87	7.82	4.61
Optional three-place	0.0	0.0	1.67	2.08
Complement	5.71	4.32	8.3	1.79
Phrasal (verb-particle)	4.28	3.23	16.2	4.25
Proportion of verbs produced by type with correct argument structures				
Copula	66.6	36.51	94.0	5.27
Obligatory one-place	91.7	10.33	100.0	0.0
Obligatory two-place	82.4	21.79	93.0	3.44
Obligatory three-place	—	—	100.0	0.0
Optional two-place	84.6	16.77	100.0	28.92
Optional three-place	—	—	100.0	0.0
Complement	40.0	26.66	95.0	5.59
Phrasal (verb-particle)	66.6	44.72	86.0	11.37
Proportion of correctly produced arguments and adjuncts				
X (agent)	85.42	20.94	98.94	2.37
Y (theme)	93.46	10.84	97.02	4.83
Z (goal)	—	—	80.00	44.2
S' (sentential complement)	26.66	43.46	86.0	21.9
P (predicate structures accompanying copulas)	56.67	36.52	97.5	5.59
J (adjunct)	40.0	54.77	100.0	0.0
Total arguments produced correctly	52.44	10.59	91.88	1.75

obligatory one-place and optional two-place verbs, with the aphasic subjects producing significantly more of these verb types than the normal subjects ($p < .05$). The normal subjects, however, produced significantly more obligatory three-place, complement, and phrasal verbs ($p < .05$). The normal subjects, however, produced significantly more obligatory three-place, complement, and phrasal verbs ($p < .05$). No significant differences were noted in the proportion of copulas or obligatory two-place verbs, as both subject groups produced a large number of these verb types. Significant differences also were not found for optional three-place verbs, as both groups produced them infrequently. Group differences in the proportion of each verb type produced are shown in Figure 1.

Despite differences in the number of each verb type produced, the hierarchies of verb types used by normal and aphasic subjects were strikingly similar, as shown in Figures 2 and 3, respectively. As can be seen, both subject groups used predominately copula, obligatory one-place, and obligatory two-place verbs, with these verb types making up 77% of the corpus for normal subjects and 67% of the corpus for aphasic subjects. Interestingly, optional two- and three-place verbs, obligatory three-place verbs, and complement verbs were produced with less frequency by both subject groups. These findings are somewhat consistent with distinctions in verb complexity borne out using reaction time studies with both normal and aphasic subjects; that is,

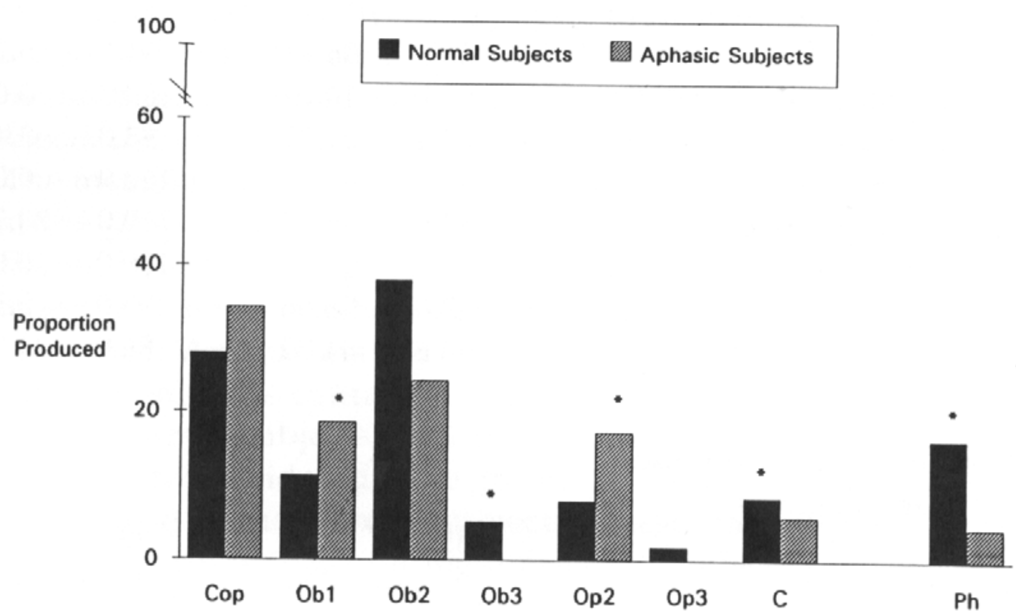

Figure 1. Proportion of verbs produced by verb type in discourse samples of aphasic and normal subjects. Cop = copula; Ob1 = obligatory one-place; Ob2 = obligatory two-place; Ob3 = obligatory three-place; Op2 = optional two-place; Op3 = optional three-place; C = complement; Ph = phrasal.

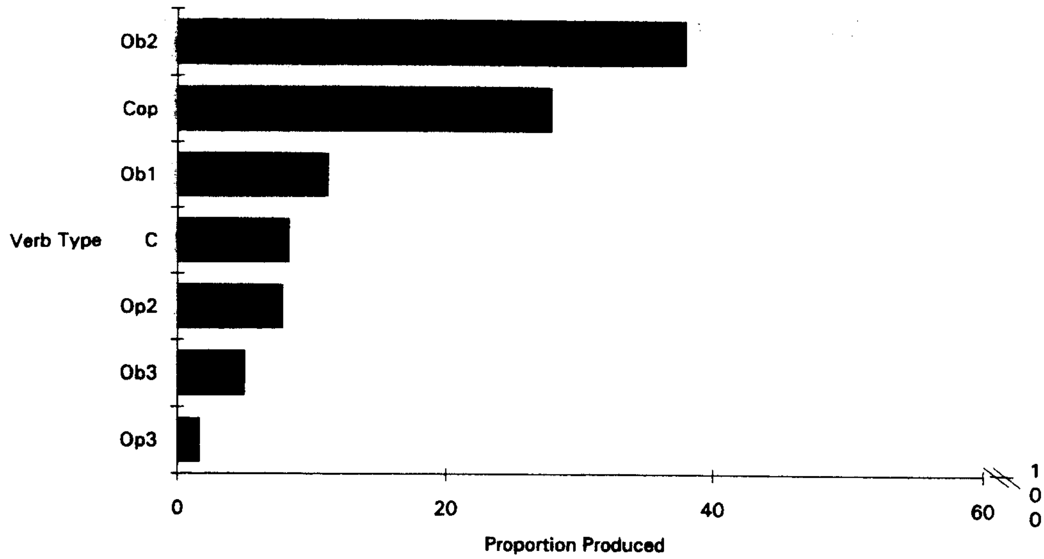

Figure 2. Verbs produced by type in normal subjects' discourse samples arranged in hierarchical order, from those produced proportionately least often to those produced proportionately most often. Op3 = optional three-place; Ob3 = obligatory three-place; Op2 = optional two-place; C = complement; Ob1 = obligatory one-place; Cop = copula; Ob2 = obligatory two-place.

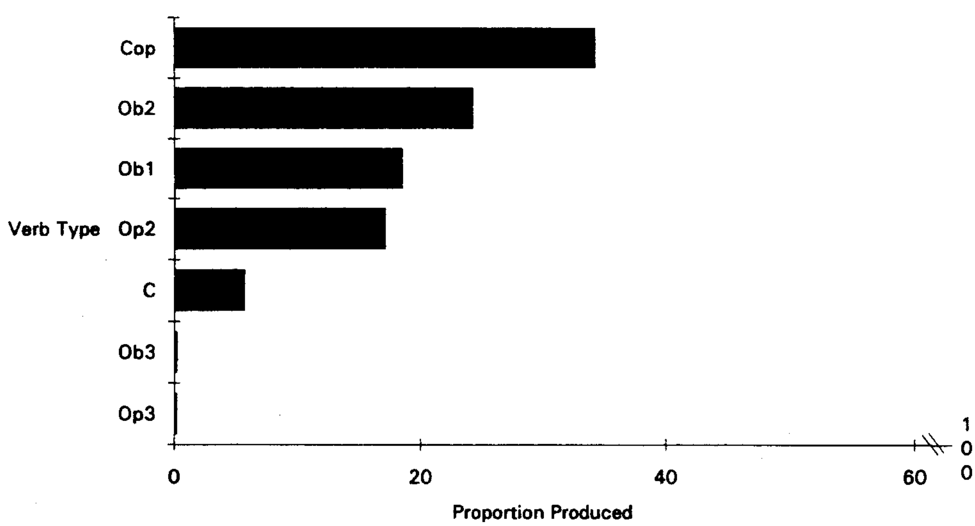

Figure 3. Verbs produced by type in aphasic subjects' discourse samples arranged in hierarchical order, from those produced proportionately least often to those produced proportionately most often. Op3 = optional three-place; Ob3 = obligatory three-place; C = complement; Op2 = optional two-place; Ob1 = obligatory one-place; Ob2 = obligatory two-place; Cop = copula.

verbs that allow fewer possible argument structure arrangements (e.g., obligatory one- and two-place verbs) require less processing time in on-line experiments than do verbs that allow more argument structure arrangements (e.g., optional three-place and complement verbs). Similarly, our production data indicate that both aphasic and normal subjects seem to have a preference for producing primarily simple verbs that require accessing simple argument structure arrangements.

Verb and Verb-Argument Structure Production

When we considered the data with regard to the proportion of verbs produced with correct argument structure, we noted that the normal subjects produced most verbs in their correct context (i.e., normal subjects produced 95% of all verbs with correct argument structure). The aphasic subjects also produced obligatory one-place and obligatory and optional two-place verbs often with correct argument structure. Significant differences were not seen between the normal and the aphasic subjects in the proportion of these verb types produced correctly ($p < .05$).

These data indicate that the aphasic subjects had little success in accessing argument structure for "complex" verbs (e.g., complement verbs). Additionally, these subjects evinced some difficulty in accessing argument structure for copulas, as they were produced correctly in only 66% of contexts by the aphasic subjects. Given our present concern with the number of possible argument structure arrangements for a given verb, copulas can be considered complex verbs in that they can be produced with several different argument structure arrangements. Therefore, it is not surprising that copulas were produced correctly less frequently than other verbs (e.g., obligatory one-place) for which only one argument structure arrangement is possible. It is of interest to note that both copulas and complement verbs, when produced by the aphasic subjects, were produced correctly *only* in their simplest form—with X,P or X,Y; they were *never* produced correctly with a sentential clause, although attempts to do so were noted.

These findings also are in keeping with expectations based on verb difficulty. Aphasic subjects were unable to consistently access appropriate arguments around simple verbs, and had even less success in retrieving appropriate argument structures for more complex verbs. When they produced more complex verbs, the most simple argument structures for these verbs were accessed. These data suggest that aphasic subjects have greater access to the same argument structures *in production* as do both normal and Broca's aphasic subjects *in on-line sentence processing*. These findings, therefore, explain in part the simple sentence production patterns noted in agrammatic aphasic individuals. Compared with normal subjects, nonfluent aphasic patients do not use the full range of lexical properties available given a particular verb. This restriction, we surmise, is not due to any simple length or "economy of effort" consideration, but is due to a complex mixture of verb and sentence variables that affect the computational complexity of producing sentences. In fact, we postulate that this limitation may explain the short utterance length that is prevalent in agrammatic aphasia.

Argument and Adjunct Production

Finally, we considered the extent to which individual arguments and adjuncts were produced correctly. These data, presented in Figure 4, indicate that the aphasic subjects produced significantly fewer arguments and adjuncts overall than did the normal subjects, although aphasic subjects produced most agents (85%) and themes (93%) correctly, when used. However, significant differences ($p < .05$) between aphasic and normal subjects were noted in the proportion of correctly produced third arguments taking the thematic role of goal, sentential complements, predicate structures accompanying copulas, and adjuncts, indicating that aphasic subjects often err in attempts to produce these arguments. A note regarding adjuncts is important here. As seen in

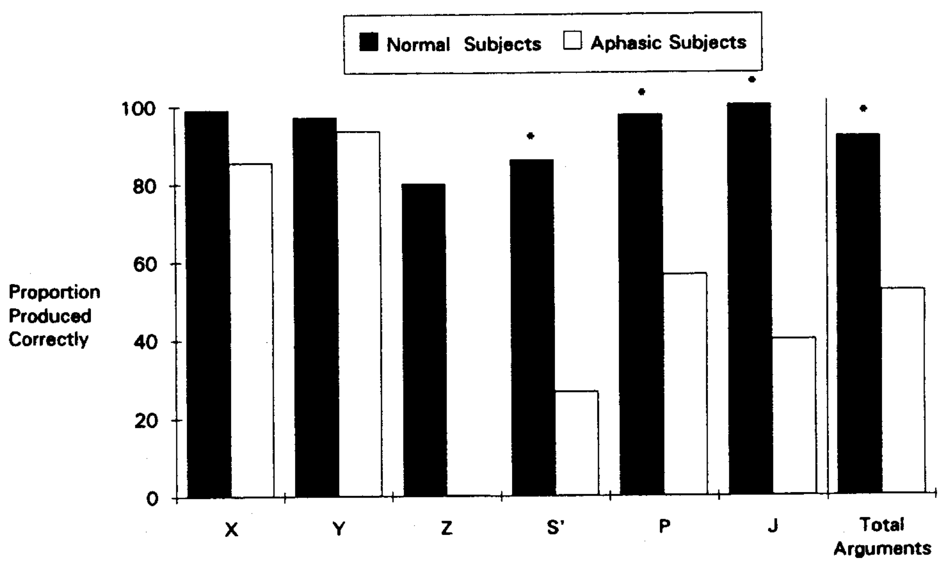

Figure 4. Proportion of correctly produced arguments and adjuncts in discourse samples of aphasic and normal subjects. X = agent; Y = theme; Z = goal; S' = sentential complement; P = predicate structure accompanying copulas; J = adjunct.

on-line sentence processing research with both normal and aphasic individuals, for aphasic subjects, adjuncts appear to be more computationally expensive than verb arguments, perhaps because they fall outside the purview of the verb (Shapiro & Levine, 1990).

DISCUSSION

In summary, the findings from this preliminary study indicate that the analysis system we have described may be reliably used to quantify aspects of verbs and their lexical entries in sentence production. This analysis procedure may, therefore, assist in understanding the nature of sentence production deficits in aphasic subjects. In this regard, we have found interesting patterns of verb productions that appear to coincide with findings derived from on-line sentence processing research. Of course, further analysis of normal and aphasic subjects' production using this coding system will attest to the lawfulness of the findings reported here. For example, we presently are analyzing additional conversational samples, as well as narrative discourse samples obtained from both aphasic and normal subjects. Additionally, it would be of interest to test both aphasic and normal subjects' ability to produce verbs of various types in their various argument structure contexts in obligatory sentence production conditions.

This coding system may also be used to derive treatment targets and to develop treatment strategies for individuals who evince sentence production difficulties. Indeed, careful inspection of production patterns needs to be undertaken in aphasic patients prior to implementing treatment. Furthermore, careful analysis of the types of production errors made might lead to development and implementation of the proper treatment. Finally, this analysis system may be used to attest to the efficacy of treatments implemented to ameliorate sentence production deficits in aphasic patients; such treatment should ultimately influence sentence production patterns in discourse conditions. The coding system presented here may assist clinicians in capturing these important changes.

ACKNOWLEDGMENTS

The work reported here was supported by National Institutes on Health (National Institute on Deafness and Other Communication Disorders) Grant DC01948 and by the Department of Veterans Affairs Rehabilitation Research and Development Grant 330-CRA.

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APPENDIX A: VERB CODES

Ob1: Obligatory one-place verbs. Intransitive verbs, requiring an external argument only (Agent); e.g., the verb *work.*
[The men]$_{AGENT\ (X)}$ work.

Ob2: Obligatory two-place verbs. Transitive verbs, requiring two arguments (Agent, Theme); e.g., the verb *fix.*
[Zack]$_{AGENT\ (X)}$ fixed [the radio]$_{THEME\ (Y)}$.

Ob3: Obligatory three-place verbs. Transitive verbs, requiring three arguments (Agent, Theme, Goal); e.g., the verb *give.*
[Joelle]$_{AGENT\ (X)}$ gave [the ball]$_{THEME\ (Y)}$ [to Zack]$_{GOAL\ (Z)}$.

Op2: Optional two-place verbs. Also known as optional transitives, these may take two possible argument structure arrangements, (X) and (X,Y); e.g., the verb *eat.*
[He]$_{AGENT\ (X)}$ ate.
[The woman]$_{AGENT\ (X)}$ ate [the salad]$_{THEME\ (Y)}$.

Op3: Optional three-place verbs. These include both alternating and nonalternating datives, which may take three possible argument structure arrangements, (X,Y), (X,Y,Z), and (X,Z,Y); e.g., the verb *send.*
[John]$_{AGENT\ (X)}$ sent [the paper]$_{THEME\ (Y)}$.
[John]$_{AGENT\ (X)}$ sent [the paper]$_{THEME\ (Y)}$ [to Joan]$_{GOAL\ (Z)}$.
[John]$_{AGENT\ (X)}$ sent [Joan]$_{GOAL\ (Z)}$ [the paper]$_{THEME\ (Y)}$.

C: Complement verbs. These may be produced with two argument structure arrangements, requiring (a) an external argument plus a direct object (X,Y), or (b) an external argument plus a sentential complement, such as a *wh–* clause, *that* clause, or an infinitive clause (X,S'); e.g., the verb *accept.*
[Zack]$_{AGENT\ (X)}$ accepted [the money]$_{THEME\ (Y)}$.
[Zack]$_{AGENT\ (X)}$ accepted [that the money was for research]$_{(S')}$.

Cop: Copula verbs. This verb is a form of *be* serving as the matrix verb in a sentence. It may occur in two possible argument structure arrangements: (a) with an external argument plus a predicate noun phrase, prepositional phrase, or adjective phrase (X,P), or (b) with a sentential complement (X,S'); e.g., the verb *is.*
[John]$_{AGENT\ (X)}$ is [a boy]$_{P}$.
[John]$_{AGENT\ (X)}$ is [who I want]$_{S'}$.

*: Used preceding any verb code, denotes its production without appropriate verb-argument structure as specified above.

APPENDIX B: VERB-ARGUMENT AND ADJUNCT CODES

X: Agent (usually the subject except in sentences in which constituents are moved out of their canonical order as in passive and object relative sentences).

Y: Theme (usually the direct object of the verb except in noncanonical sentences).

Z: Goal (usually the indirect object of the verb).

S': Sentential Complement (may take the form of a *that* clause, *wh*– clause, or infinitive clause).

P: Predicate noun phrase (NP), prepositional phrase (PP), or adjectival phrase (AP) occurring with copulas.

J: Adjunct (usually prepositional phrases that are optional to the verb structure).

*: Used preceding any verb-argument/adjunct code to denote its misuse or absense.