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Patterns of Comprehension and Production of Nouns and Verbs in Agrammatism: Implications for Lexical Organization

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This study examined the relationship between verb retrieval and verb-argument-structure properties in seven agrammatic aphasic patients using tasks requiring access to the verb's lexicon for both comprehension- and productionlike processes. Results showed intact comprehension of both nouns and verbs and noun naming, but impaired naming of verbs. Subjects also demonstrated near-normal performance on a grammaticality judgment task involving verb-argument-structure violations but were impaired in categorizing verbs by type (based on number of obligatory arguments). In both naming and categorization conditions, a hierarchy of verb difficulty emerged. Subjects were more accurate in naming/categorizing one-place verbs than two-place verbs and more accurate in naming/categorizing two-place verbs than three-place verbs. The pattern of selective impairment in lexical access/retrieval supports the hypothesis that one dimension of normal lexical organization is by form class. The results also suggest that no necessary relationship exists between production difficulties and comprehension of nouns/verbs in agrammatism. Further, the performance pattern noted supports the claim that verb-argument-structure properties, an important component of the verb lexicon, influence verb production at the single-word and at the sentence level. Subjects' performance on different tasks suggests that the locus of breakdown in the verb-retrieval processes for productionlike tasks may be in accessing information at the lemma level of representation as per Bock's model (1995) of sentence production.

Key Words: verb production in aphasia; verb categorization in aphasia; verb argument structure in aphasia; agrammatism; lexical organization in aphasia.

Comprehension and production of nouns and verbs have been studied in several neurological populations including aphasic patients. Researchers investigating production of nouns and verbs in aphasic patients have reported

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dissociations between these word classes (Berndt, Mitchum, Haendiges, & Sandson, 1997; Miceli, Silveri, Nocentini, & Caramazza, 1988; Miceli, Silveri, Villa, & Caramazza, 1984; Zingeser & Berndt, 1990). Agrammatic aphasic patients show more difficulty naming verbs than nouns, while anomic aphasic subjects show the opposite pattern, suggesting that selective impairment in lexical representation and/or the lexical retrieval process can occur along the form class category. Miceli et al.'s (1988) Italian-speaking agrammatic aphasic subjects also showed such dissociations in comprehension, but this finding has not held up across studies (Berndt et al., 1997); most studies have shown a selective deficit in verb production, with comprehension remaining relatively unimpaired.

Similar patterns also have been reported in studies examining sentence processing and production with a focus on verb-argument structure. Data from sentence comprehension studies indicate that agrammatic aphasic subjects show intact linguistic representation of and on-line access to the lexicon of the verb (Shapiro, Gordon, Hack, & Killackey, 1993; Shapiro & Levine, 1990). In Shapiro et al.'s reaction-time studies, Broca's aphasic patients, but not fluent aphasic patients, accessed all possible argument structures of verbs in the immediate temporal vicinity of the verb during on-line sentence processing. In production, however, aphasic patients with agrammatic deficits do not appear to have the corresponding facility in accessing the verb's lexicon. Thompson, Lange, Schneider, and Shapiro (1997) reported that their agrammatic aphasic subjects demonstrated verb retrieval difficulty in verb naming and in sentence production. In addition, they noted that verb retrieval difficulty increased as the number of arguments associated with the verb increased, suggesting that agrammatic aphasic patients may have disruptions either in the lexical-syntactic representation or in access routines to the lexicon of the verb during production tasks. The question of the relationship between verb retrieval difficulty and verb-argument-structure properties as well as the implications of dissociations between access to the verb's lexical-syntactic representation during sentence processing and sentence production have not been completely researched.

The locus of verb retrieval difficulty with regard to models of lexical representation and processing also has not been fully investigated. Representation of and access to the verb's lexicon in these patients have been discussed mostly in the context of deprived verb production in spontaneous speech (Saffran, Schwartz, & Marin, 1980; Thompson et al., 1997) and impaired comprehension of complex sentences (Grodzinsky, 1986, 1995). A more thorough investigation of access to the verb's lexicon in agrammatic aphasic subjects from a lexical processing point of view may provide information necessary to fully understand agrammatic deficits.

This study was designed to examine the relationship between verb retrieval and verb-argument-structure properties in agrammatic aphasic patients based on a current model of lexical access (specifically, Bock, 1995 adapted from Bock & Levelt, 1994). Bock and Levelt's model separates the

lexical accessing process into two subprocesses. First, a lexical item which matches the meaning and communicative perspective of the speaker is selected. With the selection of the lexical item called a lemma (which is unspecified for phonological form), grammatical information that is associated with the lemma becomes available. In the next stage, the phonological form of the selected lemma (called a lexeme) is activated through lexical retrieval. Although issues regarding the discreteness of processing at each level are still controversial among theorists (e.g., Dell, 1986; Dell & O'Seaghdha, 1991; Levelt et al., 1991a, 1991b), these models in general suggest that verb retrieval failure can occur in one of two stages of lexical access or in both during a single-word retrieval task. First, verb retrieval can fail at the level of lemma selection which will in turn affect the availability of information concerning the syntactic properties of the verb such as its subcategorization frame. Second, verb retrieval can fail at the level of lexeme retrieval. Failure of verb retrieval at this level may produce utterances with NPs representing argument structure in the absence of the target verb.

Production models in general do not discuss whether comprehension data can constrain hypotheses concerning production impairments. Although Garrett (1980) and Bock (1995) consider the possibility that the lexical inventory may be shared in comprehension and production, their models do not address whether any components of the lexical process are also shared. Similar to Bock and Garrett, Berndt and colleagues (1997) consider it plausible that lemma-level representations are shared for comprehension and production. However, as they admit, disruption at the lemma-level representation may impair the two modalities to an unequal extent. As Bock (1995) has pointed out, differences in the goals and the starting points of the two mechanisms implicate differences in the processing routine of lexical access. In the present study it is assumed that both comprehension and production mechanisms draw information from a common lexical storage because of economy of resource management and general lack of data which proves it to be otherwise.

The purpose of the present study was to investigate the relationship between verb retrieval and verb-argument-structure properties in agrammatic aphasic patients using tasks requiring access to the verb's lexicon in both comprehension- and productionlike processes. Verbs were classified based on the number of arguments represented in the lexical-syntactic entry of the verb. First, the dissociation pattern in the comprehension and production of nouns and verbs in agrammatic aphasic patients was examined. Access to the verb's lexicon also was tested using a verb comprehension task (spoken word–picture matching) and a grammaticality judgment task involving manipulation of verb-argument-structure properties via violation of strict subcategorization. It was assumed that subjects access information in the verb's lexicon during the early stage of sentence processing based on normal (Boland, Tanenhaus, & Garnsey, 1990; Holmes, 1987; Trueswell, Tanenhaus, & Kello, 1993) and aphasic data (Shapiro et al., 1993; Shapiro & Levine, 1990). Finally, subjects' verb naming and verb categorization were analyzed to fur-

ther investigate the relationship between verb retrieval failure and argument-structure properties associated with certain verb types. The locus of breakdown in the processes of verb retrieval based on the model of lexical access outlined by Bock (1995) was investigated using the data from grammaticality judgment, verb naming, and verb categorization tasks.

Based on findings from previous studies, it was predicted that agrammatic aphasic subjects would show a dissociation between noun and verb naming ability with decreased verb naming and near-normal noun naming, but would not show the dissociable pattern in comprehension of nouns and verbs. Based on Thompson et al.'s (1997) findings, it was expected that subjects would demonstrate a hierarchy of verb difficulty in verb naming (i.e., that verbs with more arguments associated with them would be more difficult to retrieve than verbs with fewer arguments) and in categorizing verbs by type because both verb production and verb categorization require access to verbs and their lexical-syntactic entries from a production point of view. Based on the results of previous grammaticality judgment studies (Gardner, Denes, & Zurif, 1975; Linebarger, Schwartz, & Saffran, 1983), it was predicted that subjects would perform the grammaticality judgment test with a high rate of success, indicating intact lexical-syntactic representation of and access to verb entry in the early stage of sentence processing.

METHOD

Subjects

Seven agrammatic aphasic subjects (six male and one female; mean age = 50.7 years) participated in the study. Subjects were recruited from the subject pool of the Northwestern University Aphasia and Neurolinguistic Research Laboratory and from the Rehabilitation Institute of Chicago. All subjects were right-handed, with the exception of one male subject. All subjects had a minimum of high school education (M = 16.3 years) and were at least 36 months postonset (M = 78.6 months). Review of medical records and subject/spouse reports indicated that none had a history of drug or alcohol abuse, hospitalization for psychiatric disorder, developmental speech/language disorders, or prior neurological disease. All subjects had suffered a single, left-hemisphere, thromboembolic stroke in and/or around Broca's area and adjacent white matter per neurological report obtained from the hospitals where they were initially treated. All subjects demonstrated good visual acuity and hearing acuity. Five subjects passed a pure-tone audiometric screening at 500, 1000, and 2000 Hz at 40 dB HL ANSI:1969 in at least one ear. Two subjects were not screened for hearing acuity but informally demonstrated good hearing acuity. All subjects were native speakers of English.

Language testing. The diagnosis of aphasia was based on administration of the *Western Aphasia Battery* (WAB; Kertesz, 1982) as well as narrative discourse analysis. Aphasia quotients (AQs) derived from the WAB ranged from 64.5 to 77.8. Auditory comprehension, while mildly impaired, was superior to verbal expressive ability. Fluency scores were 4.0 for six subjects and 5.0 for one subject. All subjects demonstrated at least a score of 7.0 on the naming subtest of the WAB and ability to read aloud and comprehend single words. Scores on the WAB of individual subjects are reported in Table 1.

Narrative analysis. Lexical and morphosyntactic patterns of narrative discourse were also analyzed to identify symptoms of agrammatism in the subjects' spontaneous speech. A speech sample from each subject was obtained by asking him or her to tell the story of ''Cinderella.''

TABLE 1
Western Aphasia Battery Scores

Subtests	MD	CH	PR	JOC	TE	BW	BH
Aphasia Quotient	77.2	77.8	68.3	75	75.6	64.5	73
Fluency	4	5	4	4	4	4	4
Auditory Comprehension	9.6/10	7.9	8.8	9.6	8.7	9.9	8.4
Repetition	7.2/10	8.4	6.0	7.7	8.8	4.2	8.9
Naming	8.8/10	8.6	7.4	8.2	8.3	7.2	7.2

The speech sample was tape-recorded, transcribed, and analyzed by the examiner, using a method developed by Thompson et al. (1995). Sentences were coded for grammaticality. Words were coded by class to obtain the ratio of open vs closed class words and the ratio of nouns vs verbs. The proportion of verbs produced with correct arguments also was obtained. An independent coder coded 30% of the transcribed language samples, and intercoder point-to-point reliability was calculated for each variable (e.g., sentence grammaticality and word class). Overall agreement ranged from 97.5 to 100% with an overall mean of 99.2%.

Results of this analysis (see Table 2) indicated production patterns consistent with a diagnosis of agrammatic aphasia (Saffran, Berndt, & Schwartz, 1989); the proportion of grammatical sentences ranged from .0 to .36 with a mean of .19. Most sentences were grammatically simple with no embeddings. Open:closed class ratios indicated that subjects produced more open class as compared to closed class words (open:closed class ratios ranged from 1.14 to 13.33 with a mean of 4.11). Within the open class, subjects produced more nouns than verbs (noun:verb ratio ranged from 1.02 to 11.33 with a mean of 3.10). Proportion of verbs produced with correct arguments ranged from .33 to .67 with a mean of .50, indicating that subjects succeeded in producing correct argument structures only 50% of the time when they were able to retrieve the verb in the utterance. Often correct argument structures were produced in imperative sentences in which the external argument was legally omitted and, thus, simpler in its argument structure requirement. The proportion of imperative constructions ranged from .0 to .50 in the sentences in which the main verb was produced.

TABLE 2
Means and Standard Deviations of Selected Lexical and Morphosyntactic Variables from Narrative Samples for Aphasic and Normal, Non-Brain-Damaged Subjects[a]

Language variable	Aphasic subjects: Narratives mean (*SD*)	Normal subjects: Narratives mean (*SD*)
Total words produced	170.286 (79.554)	323.71 (113.57)
Total utterances	39.286 (11.368)	23.60 (7.092)
MLU	4.753 (1.833)	14.472 (2.203)
Proportion of grammatical sentences	0.192 (0.125)	0.898 (0.080)
Proportion open class words	0.649 (0.122)	0.47 (0.02)
Proportion closed class words	0.270 (0.156)	0.53 (0.02)
Open:closed class ratio	4.113 (4.304)	0.91 (0.08)
Noun:verb ratio	3.100 (3.773)	1.21 (0.25)
Proportion of verbs produced with correct arguments	0.501 (0.134)	>0.95

[a] Normal data from Thompson et al. (1995).

Materials

For naming and comprehension tasks, 62 nouns and 62 verbs were selected based on their written frequency (Francis & Kucera, 1982). Selected verbs did not have a listing of noun usage greater than 25% of their frequency when used as a verb and vice versa. For each verb target, one noun was selected to roughly match the verb's cumulative frequency. Mean frequency of occurrence was 135 per million for verbs (range = 1–1264) and 120 for nouns (range = 1–717). Members of each pair were also matched for number of syllables. Words ranged from one to two syllables, except one verb which was composed of three syllables. A complete listing of single-word targets, with frequencies, is found in Appendix A.

One important distinction among verbs is their lexical-syntactic properties—the number and type of arguments required by certain verbs (Thompson et al., 1997). Therefore, verbs were classified according to the type of verb based on the number of argument(s) associated with the verb (i.e., obligatory one-place, obligatory two-place, obligatory three-place, optional two-place, and optional three-place verbs). Obligatory one-place verbs need only an external argument which is the subject of the sentence. Only unergative (one-place) verbs, which theoretically do not have an internal argument, were used in the present study. Obligatory two-place verbs have one external argument and one internal argument, which is the direct object of the sentence. The number of verbs of each type was not equal due to difficulties selecting picturable verbs which met all criteria.

Black-and-white line drawings were prepared on 5 × 7-in. paper. Normed pictures from Snodgrass and Vanderwart (1980) were used for most nouns. Norms for labeling the pictures were obtained from a group of nine healthy normal subjects, who were tested individually. All normal subjects (six male and three female) were native speakers of English, similar to aphasic subjects in their education (i.e., all had a minimum of high school education; M = 15.7 years) but moderately younger in age (M = 41.8 years). Pictures were randomized within form class blocks, with the nouns presented separately from the verbs. Half the normal subjects named the nouns first and half named the verbs first. For noun targets normal subjects were instructed to ''tell me what this is.'' For verb targets they were instructed to ''tell me what action is shown in the picture.'' If subjects produced an acceptable but nontarget response, they were asked to ''tell me another word for it'' and were allowed two further attempts. Pictures that elicited targets from all nine normal subjects were used in the experiment with aphasic subjects. The same target stimuli were used for both the comprehension and naming tests.

Tasks

For all tasks, practice items were used prior to the test proper to establish that subjects understood the task. No feedback on the accuracy of responses was provided during testing. All responses were scored as correct or incorrect. Self-correction occurring within the given time frame was accepted. A trial ended when the subject indicated his/her selection/production or when the subject admitted his/her inability to provide an answer within the given time frame.

Grammaticality judgment test. The grammaticality judgment test was constructed to investigate agrammatic aphasic subjects' access to verbs and verb arguments during sentence processing. Sixty sentence stimuli were developed using simple canonical sentence structures. Verbs with different numbers of obligatory arguments were used: obligatory one-place (Ob1), obligatory two-place (Ob2), and obligatory three-place (Ob3) verbs. Half of the sentences were grammatical and the remaining half were ungrammatical. Of 30 grammatical sentences, 15 sentences were constructed using the basic argument structure for each type of verb (i.e., Ob1: agent + verb; Ob2: agent + verb + theme; Ob3: agent + verb + theme + goal). The remaining 15 grammatical sentences were constructed using the basic argument structure + an additional adjunct (e.g., Ob1: agent + verb + locative adjunct phrase such as *The dog is barking in the house*). Sixteen ungrammatical sentences were constructed by deleting one or

two obligatory arguments (e.g., Ob3: agent + verb + theme such as **The woman is giving the sandwich*). Fourteen ungrammatical sentences were constructed by adding an additional argument (e.g., Ob1: agent + verb + theme such as **The dog is barking the girl*). Sentence stimuli were constructed by using 20 sentences with obligatory one-place, 25 sentences with obligatory two-place, and 15 sentences with obligatory three-place verbs. Prior to use with aphasic subjects, five healthy normal subjects were tested to select the sentences for the grammaticality judgment test. All normal subjects (one male and four female) were native speakers of English, similar to aphasic subjects in their education (all had a minimum of a high school education; $M = 15.2$ years) but moderately younger in age ($M = 36.8$ years). Sentences that more than one subject failed to judge correctly were excluded from the stimulus set. A complete listing of the sentence stimuli is included in Appendix B.

All sentences were recorded by a native English speaker (standard American dialect) and presented auditorily. Instructions accompanying the task were read by the examiner at the beginning: ''You are going to listen to some sentences. I want you to tell me if each sentence is good or bad.'' After listening to each sentence, the subject was asked to point to one of two cards with the word ''good'' and ''bad'' written on them. Four practice items—two grammatical and two ungrammatical—were presented. Feedback on the subject's response was provided during the practice trials. After completion of practice trials and subjects' demonstration of adequate understanding of the task, the test began. No feedback was provided during the test. When requested by the subject, the recorded sentence was repeated up to two times. All subjects responded within the given response time of 10 s.

Comprehension conditions. Noun and verb comprehension tests involved spoken word-to-picture matching. In the verb comprehension test, two distractors, randomly selected from the set of target verbs, but semantically unrelated to the target stimulus, were used. This was due to difficulty selecting semantically related distractors from the given set of verbs. The array of three pictures was arranged horizontally on the table, with the position of the target item randomized. Verb stimuli in the form of ''to + infinitive'' were presented auditorily by the examiner (e.g., ''Show me *to swim*''). Subjects were asked to indicate comprehension of the spoken word stimulus by choosing the appropriate picture. In the noun comprehension test, a semantically related distractor and an unrelated distractor, which were selected from the set of nouns, were used. The noun comprehension task was similar to the verb comprehension task. Subjects were given 10 s to respond.

Naming conditions. Two naming tests were constructed to evaluate subjects' abilities to orally produce the names of objects and actions. For verb naming, pictures of the verb targets were presented one at a time and subjects were instructed to ''tell me what action that is.'' If the aphasic subject did not appear to understand the instruction, it was rephrased as ''tell me what he/she does.'' No attempt was made to elicit a particular form of the verb. For noun targets, the subjects were instructed to ''tell me what this is.'' Subjects were instructed to produce only one word for the target and given 20 s to respond. If subjects produced an acceptable, but nontarget, response, they were cued to ''tell me another word for it'' and were allowed two more attempts. If subjects produced a sequence of more than one response despite the instruction, the response given following the prompt (''Give me only one word for it'') was used for scoring. Semantically appropriate responses of the target verb type (e.g., production of *hand* instead of *give*) and responses that were approximately synonymous with the target noun (e.g., *stove* for *oven*) were accepted as correct responses.

Categorization conditions. Two categorization tests—a verb categorization and a noun categorization test—were constructed. The verb categorization test was constructed to evaluate subjects' knowledge of the argument structure requirements of certain verb types. Eleven obligatory one-place, 10 obligatory two-place, and 3 obligatory three-place verbs were selected from the 62 verbs used for the naming test. Target verbs were written on 3 × 5-in. cards. Icon(s) representing the obligatory argument(s) were symbolically depicted on icon boards. For instance, the icon board for obligatory one-place verbs included an icon for the agent followed by a line representing the action. The icon board for obligatory two-place verbs contained an icon representing an agent followed by a line representing the action and an

icon representing a theme. The icon board for obligatory three-place verbs contained the icon representing an agent, a theme, and a goal or a location with a line representing the action drawn between the icons for the agent and the theme. The icon boards are found in Appendix C.

Prior to use with the aphasic subjects, five normal subjects were asked to categorize verbs by type by matching each verb to one of the icons. The normal subjects were the same group of individuals who participated in developing the stimuli for the grammaticality judgment task. Verbs incorrectly categorized by more than one normal subject were excluded from the stimulus set. A written script containing instructions for the task and examples was prepared to standardize test administration, based on the responses from the normal subjects. At the beginning of the test administration the examiner read the script. If a subject did not understand the instructions, they were repeated. The instructions contained important rules for subjects to remember and provided two examples using a verb for each verb type. The examples used verbs which were not included in the test. After it was established that the subject understood the task, the cards on which target verbs were written were presented one at a time. The order of presentation was randomized. The subject was asked to orally read the target verb. For one subject with a mild reading difficulty, the examiner read the target verb. The subject was then instructed to ''put the verb on the icon board which has all the necessary items (person/thing) that go with the verb.'' Subjects were given 20 s to respond. The final placement of the card on one of the icon boards, either as a single spontaneous response or through self-correction, was scored. If the subject did not respond within 20 s, the subject was asked to take his/her best guess.

The noun-categorization test utilized 24 items from three familiar object categories—seven items from the food category, eight items from the clothing category, and nine items from the animal category. All but one item were taken from nouns used in the noun comprehension and naming tasks. An iconic picture representing each category was developed. Cards on which target nouns were written were presented one at a time. The subject was asked to orally read the target noun and to put the card on the icon depicting its category. Three practice trials were given, using an item from each experimental category. A complete listing of categorized targets is found in Appendix D.

Procedures

Testing on all experimental tasks was completed in three to four sessions. Testing sessions were held at least a week apart, with no more than 10 weeks elapsing for administration of the entire test battery for any individual. The order of presentation of target items within a task was randomized and held the same for all subjects. Since both comprehension and production tests employed the same targets, task blocking was designed to ensure that no stimulus was elicited more than once in a single session by using split-halves (odd vs even numbered items) of the noun or verb list. The order of presentation of the tasks was counterbalanced (between the noun and verb classes; between the odd- and even-numbered items; and between the naming and comprehension tasks), but the categorization task and the grammaticality judgment task were always the last to be administered.

Reliability Measure

An independent observer scored subject responses on-line as correct vs incorrect for 40% of experimental sessions, based on the criteria presented above. Point-to-point agreement between the primary examiner's and the independent observer's scores ranged from 97 to 100% with overall agreement of 99.8%.

Data Analysis

Percentage correct grammaticality judgment was computed for each subject. Percentage correct comprehension, naming, and categorization of each form class for each subject was

calculated. In addition, percentage correct naming and categorization of each verb type was computed. Differences between conditions and between verb types were analyzed using a series of repeated-measure analyses of variance (ANOVA) calculations. Post hoc pairwise comparisons of mean differences were completed using a test of effects for multiple comparisons. An alpha level of $p < .05$ was set for all statistical tests.

RESULTS

Percentage correct performance of subjects on all experimental tasks is shown in Table 3. Analysis of these data using a one-way repeated-measure analysis of variance indicated statistically significant differences between mean performance across the seven experimental tasks. Verb naming and verb categorization was poorer than performance on the other tasks.

Performance on Grammaticality Judgment

Most agrammatic aphasic subjects showed good performance on the grammaticality judgment task. Mean percentage correct performance was 93.6% with performance ranging from 83.3 to 98.3%. Only one subject performed below 90% accuracy (83.3%). Analysis of errors did not show any consistent pattern.

Performance Pattern by Modality and Form Class

Mean percentage correct performance of noun comprehension, verb comprehension, noun production, and verb production was compared using a repeated-measures analysis of variance with two within-subject factors (modality and form class). Results showed a significant main effect for modality [$F(1, 6) = 72.42$], a significant main effect for form class [$F(1, 6) = 56.92$], and a significant interaction effect for modality $\times$ form class [$F(1, 6) = 33.59$]. The subjects' performance patterns indicated that their overall performance level was better for comprehension than for production and higher for nouns than for verbs. While performance on comprehension tasks was similar for nouns and verbs, performance on production tasks was better for nouns than for verbs.

TABLE 3
Subjects' Performance on Experimental Tests (Shown as Percentage Correct)

Tasks	MD	CH	PR	JOC	TE	BW	BH	Mean (*SD*)
Grammaticality Judgment	96.7	90	83.3	98.3	90	98.3	98.3	93.6 (5.89)
Noun Comprehension	98.4	100	100	100	100	100	100	99.8 (0.60)
Verb Comprehension	98.4	98.4	96.8	98.4	98.4	98.4	93.5	97.5 (1.85)
Noun Naming	98.4	96.8	83.9	93.5	91.9	98.4	85.5	92.6 (5.95)
Verb Naming	80.6	72.6	66.1	80.6	72.6	59.7	66.1	71.2 (7.80)
Noun Categorization	100	100	100	95.8	100	100	100	99.4 (1.59)
Verb Categorization	87.5	87.5	37.5	50	66.7	75	58.3	66.1 (18.86)

TABLE 4
Verb Naming by Verb Type (Shown as Percentage Correct)

Subject	Ob1	Ob2	Ob3	Op2	Op3
MD	12/14 = 85.7	14/18 = 77.8	1/3 = 33.3	11/12 = 91.7	12/15 = 80
CH	13/14 = 92.9	11/18 = 61.1	2/3 = 66.7	9/12 = 75	10/15 = 66.7
PR	11/14 = 78.6	11/18 = 61.1	2/3 = 66.7	9/12 = 75	8/15 = 53.3
JOC	13/14 = 92.9	13/18 = 72.2	2/3 = 66.7	11/12 = 91.7	11/15 = 73.3
TE	10/14 = 71.4	12/18 = 66.7	1/3 = 33.3	10/12 = 83.3	12/15 = 80
BW	10/14 = 71.4	11/18 = 61.1	0/3 = 0	8/12 = 66.7	8/15 = 53.3
BH	9/14 = 64.3	15/18 = 83.3	1/3 = 33.3	8/12 = 66.7	8/15 = 53.3
Mean (*SD*)	79.6 (11.26)	69.043 (8.99)	42.86 (25.22)	78.59 (10.60)	65.7 (12.44)

Verb Naming by Verb Type

Mean percentage correct production of verbs by type in the naming condition is shown in Table 4 and Fig. 1. Results indicated that there was a significant difference in the mean percentage correct production between each verb type [$F(4, 24) = 9.41$]. Post hoc analysis showed significant differences between obligatory one-place and both obligatory three-place and optional three-place verbs, with one-place verbs produced correctly more often than the other verb types. Also differences between optional two-place and both obligatory three-place and optional three-place verbs were significant, with optional two-place verbs produced correctly more often than the other verb types. The difference between obligatory two-place and obligatory three-place verbs also was significant, with obligatory two-place verbs produced

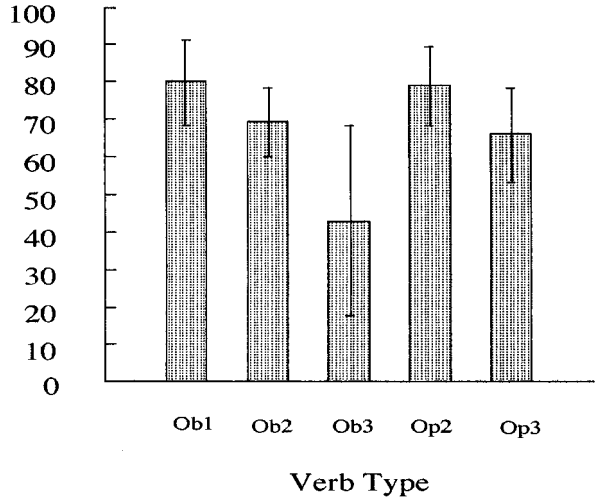


FIG. 1. Percentage correct production of verbs by type in the confrontation-naming condition for 7 agrammatic aphasic subjects. Ob1, obligatory one-place verb; Ob2, obligatory two-place verb; Ob3, obligatory three-place verb; Op2, optional two-place verb; Op3, optional three-place verb. Error bar = Standard Deviation (*SD*).

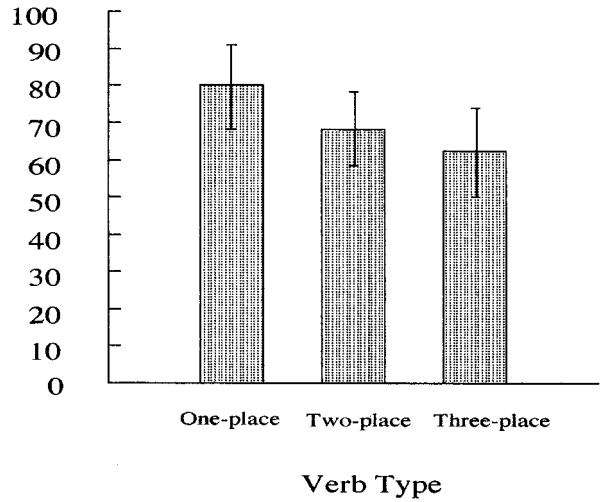


FIG. 2. Percentage correct production of verbs by type in the confrontation naming condition for 7 agrammatic aphasic subjects, with obligatory and optional category collapsed. One-place, obligatory one-place verb; Two-place, obligatory two-place + optional two-place verbs; Three-place, obligatory three-place + optional three-place verbs. Error bar = *SD*.

correctly more often than obligatory three-place verbs. Although some of the differences did not reach statistical significance, means in Table 4 indicate that a hierarchy of verb difficulty clearly exists with obligatory three-place verbs the most difficult to produce, obligatory two-place verbs less difficult, and obligatory one-place verbs the least difficult to produce in the category of obligatory verbs. In the category of optional verbs, optional two-place verbs were less difficult to produce than optional three-place verbs.

When verbs were collapsed across obligatory and optional categories as shown in Fig. 2, the difference in the mean percentage correct production between one-place verbs (Ob1) and three-place verbs (Ob3 + Op3) was statistically significant, but there were no significant differences between other verb types. When verbs were collapsed across the number of arguments to look at all obligatory verbs (Ob1, Ob2, and Ob3) vs all optional verbs (Op2 and Op3), as shown in Table 5, no significant differences were found between obligatory and optional verb production [$F(1, 6) = 0.016$].

Noun and Verb Categorization and Verb Categorization by Verb Type

Mean percentage correct categorization of nouns and verbs was analyzed using a one-way repeated-measures analysis of variance with form class as the within-subject factor. A significant difference was found between the means of noun and verb categorization [$F(1, 6) = 23.17$]. Whereas six of seven subjects performed noun categorization with 100% accuracy, subjects' performance on verb categorization was variable with accuracy ranging from 37.5 to 87.5% ($M = 66.1\%$, $SD = 18.86$).

TABLE 5
Obligatory and Optional Verb Production in Naming
(Shown in Percentage Correct)

Subject	Obligatory verb	Optional verb
MD	27/35 = 77.1	23/27 = 85.2
CH	26/35 = 74.3	19/27 = 70.4
PR	24/35 = 68.6	17/27 = 63
JOC	28/35 = 80	22/27 = 81.5
TE	23/35 = 65.7	22/27 = 81.5
BW	21/35 = 60	16/27 = 59.3
BH	25/35 = 71.4	16/27 = 59.3
Mean (*SD*)	71.014 (6.881)	71.457 (11.246)

Mean percentage correct categorization of verbs by type is shown in Table 6 and Fig. 3. Analysis of the categorization of three types of verbs (Ob1, Ob2, and Ob3) showed a significant effect of verb type [$F(2, 12) = 27.08$]. Post hoc analysis showed significant differences in means of all pairs: differences in means between obligatory one-place and two-place verbs, between one-place and three-place verbs, and between two-place and three-place verbs. A hierarchy of verb difficulty emerged in the verb categorization condition as in the verb naming condition—obligatory three-place verbs were the most difficult to categorize, obligatory two-place verbs were less difficult to categorize than obligatory three-place verbs, and obligatory one-place verbs were categorized correctly more often than other verb types.

DISCUSSION

Findings from this study were consistent with previous studies by Miceli et al. (1988) and Zingeser and Berndt (1990) in that performance of agrammatic aphasic subjects showed a selective deficit in the production of verbs as compared to nouns in the confrontation naming condition. This finding provides further evidence supporting the claim that one dimension of normal lexical

TABLE 6
Verb Categorization by Verb Type (Shown in Percentage Correct)

Subject	Ob1	Ob2	Ob3
MD	10/11 = 90.9	10/10 = 100	1/3 = 33.3
CH	11/11 = 100	9/10 = 90	1/3 = 33.3
PR	5/11 = 45.5	3/10 = 30	1/3 = 33.3
JOC	8/11 = 72.2	4/10 = 40	0/3 = 0
TE	9/11 = 81.8	6/10 = 60	1/3 = 33.3
BW	11/11 = 100	6/10 = 60	1/3 = 33.3
BH	9/11 = 81.8	5/10 = 50	0/3 = 0
Mean (*SD*)	81.743 (18.95)	61.429 (25.45)	23.786 (16.25)

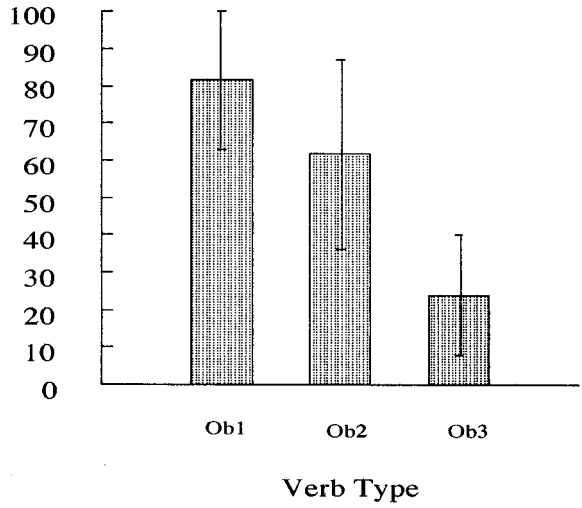


FIG. 3. Percentage correct categorization of verbs by type in the verb categorization condition for 7 agrammatic aphasic subjects. Ob1, obligatory one-place verb; Ob2, obligatory two-place verb; Ob3, obligatory three-place verb. Error bar = *SD*.

organization is by form class. However, the subjects' performance on single-word comprehension tasks did not reveal the pattern described by Miceli et al. The subjects' performance on both noun and verb comprehension was highly accurate with no dissociable pattern associated with the class of target words. These data suggest that no necessary relationship exists between difficulty producing nouns/verbs and difficulty understanding their meaning. Thus, single-word comprehension performance of agrammatic aphasic subjects in the present study does not provide support for the double-dissociation hypothesis maintained by Miceli and colleagues. Berndt et al. (1997) reported comprehension data similar to the results of the present study.

Analyses of verb effects in the naming condition revealed results generally consistent with those of Thompson et al. (1997) in that verb production was influenced by verb type. Although some of the differences in the means did not reach statistical significance, a clear hierarchy of verb difficulty associated with the number of arguments emerged. Within the category of obligatory verbs, obligatory one-place verbs were produced correctly more often than obligatory two-place verbs, and obligatory two-place verbs were produced correctly more often than obligatory three-place verbs. Within the category of optional verbs, optional two-place verbs were produced correctly more often than optional three-place verbs. When the verbs were collapsed across obligatory and optional categories—one-place, two-place, and three-place verbs—an identical hierarchy of difficulty emerged. This finding provides further evidence to the claim made by Thompson et al. that the number of arguments associated with verbs influences verb production.

Data from the categorization tasks revealed the expected pattern of performance in that noun categorization was intact while verb categorization was impaired. While this finding may have reflected our subjects' impaired retrieval of information from the verb's lexical entry, it also may have reflected unequal difficulties of the tasks. While noun categorization required knowledge of semantic categories, verb categorization required knowledge of both lexical and syntactic information. Information on semantic categories might be easier to retrieve because the normal lexicon is organized by semantic categories and speakers often explicitly operate on semantic categories during normal language processing and production. Categorization based on lexical-syntactic information, however, might be more difficult than semantically based categorization because syntactic knowledge is an implicit type of knowledge that a competent native speaker of the language possesses and utilizes constantly, but rarely operates on at the level of explicitly manipulatable knowledge. In general it took more practice and longer response times for both normal subjects who participated in developing the stimuli and aphasic subjects to perform the verb categorization task than the noun categorization task. However, normal subjects were accurate in categorizing verbs by type once they understood the task instruction. Thus, agrammatic aphasic subjects' poor performance on verb categorization was likely due to their difficulties accessing the verb's lexical-syntactic properties and not due to task difficulties.

The verb categorization task is a productionlike task that does not necessarily involve articulatory processes. The task, however, requires subjects to generate some sort of rudimentary syntactic structure verbally or nonverbally in order to correctly categorize verbs by the number of obligatory arguments associated with the target verb. It was observed during testing that some subjects verbally generated a sentence and computed the number of ''things'' (arguments) that accompanied the verb. Generation of grammatically correct sentences did not always result in correct computation of the number of arguments. However, inability to produce grammatically correct sentences almost always resulted in failure to identify the correct number of arguments associated with the target verb.

The identical hierarchy of verb difficulty emerged in the verb categorization data as was observed in the confrontation naming condition. This finding also supports Thompson et al.'s (1997) sentence production data. The verb effect in categorization was statistically significant in all pairs of means compared: subjects categorized obligatory one-place verbs most accurately, obligatory two-place verbs less accurately, and had the most difficulties categorizing obligatory three-place verbs. Although the effect obtained from the obligatory three-place verbs in both naming and categorization conditions may not be robust due to the small number of obligatory three-place verbs used, the effect of the remaining two types of verbs was robust. Data from the naming and categorization conditions suggest the following concerning the relationship between verb argument structure properties and verb re-

trieval difficulties: Agrammatic aphasic subjects have difficulties retrieving verbs in confrontation naming conditions. As the number of arguments associated with the target verb increases, difficulty in retrieving the verb also increases. Agrammatic aphasic subjects have similar difficulties retrieving argument structure properties of the target verb when the verb is provided. As the number of arguments associated with the target verb increases, difficulties in retrieving arguments increases. Thus, it appears that agrammatic aphasic subjects have difficulty accessing the verb's lexical-syntactic entry in its entirety during productionlike tasks.

In contrast to these findings, agrammatic aphasic subjects in the present study showed near-normal performance on grammaticality judgment.[1] All sentence stimuli in the present study used simple, canonical sentences (sometimes followed by an optional adjunct) and the only type of grammatical violation involved was that of subcategorization. Assuming that verb-specific syntactic information is accessed and used during the early stage of sentence parsing, as suggested by some recent studies, the grammaticality judgment task employed in the present study minimally requires the subjects to access the lexical-syntactic entry of the verb at the lemma level.

Consideration of the subjects' performance patterns across tasks provide information that helps to form hypotheses concerning the locus of breakdown in agrammatic aphasic subjects' verb production deficiency. Considering the performance pattern on naming, categorization, comprehension, and grammaticality judgment, the locus of breakdown appears to be in accessing the lemma level of representation for production. Near-normal performance on the verb comprehension and grammaticality judgment tasks by all subjects indicates intact representation of the verb's lexical-syntactic entry, which is assumed to be shared by both input and output processes. This also implicates intact access to the lemma level of representation for tasks using input modality. Impaired production and the repeatedly- observed emergence of the hierarchy of verb difficulty associated with verb-argument-structure properties appear to implicate disrupted access to the lemma level of representation for output tasks including verb production and categorization. Disrupted access at the lemma level will inevitably affect operations involved in the subsequent stages during sentence production. This was also evident in the analyses of narrative samples. When agrammatic aphasic subjects produced verbs

[1] This finding is not necessarily inconsistent with that of other studies in which agrammatic aphasic patients demonstrated difficulties in judging the grammaticality of sentences. For example, Grodzinsky and Finkel (1998) reported that agrammatic aphasic subjects showed difficulties judging the grammaticality of sentences involving the movement of phrasal categories. Whereas Grodzinsky and Finkel's task involved judging the grammaticality of sentences containing the movement of various linguistic constituents, the task in the present study involved only the violation of argument structure requirements with no movement of phrasal categories. Thus, the conclusion regarding the grammaticality judgment in agrammatic aphasic patients in the present study is limited to one type of violation, that of verb-argument structure requirements.

in their narratives, they produced proper argument structures only half of the time. Thus, these subjects were often able to activate the verb but were able to only partially activate the verb's lexical-syntactic entry at the lemma level in their narratives. This was not due to generally decreased word retrieval skills because all subjects demonstrated at least a score of 7/10 on the naming subtest of the WAB. Moreover, sentences were often produced in imperative constructions in which the external argument (agent) was legally omitted and thus required only internal argument(s) which accompanied the verb. This indicates that subjects were often successful at producing correct argument structures by decreasing the complexity of the argument-structure requirements. Thus, emergence of the hierarchy of verb difficulty, poor realization of argument structures in narrative production, and attempts to simplify argument-structure requirements appear to implicate that retrieval failure occurs at the stage when verb-argument-structure information is available, that is, the lemma level in Bock and Levelt's model.

Some of the findings in the present study are consistent with results of previous studies. Consistent with the data reported by Linebarger et al. (1983), agrammatic aphasic subjects performed well on the grammaticality judgment task involving the manipulation of argument-structure properties via violation of strict subcategorization, suggesting that agrammatic aphasic subjects access verb-argument-structure properties during the early stage of sentence processing. Access to the verb's lexical-syntactic properties appears to be nonconscious and automatic during the processing of externally generated information (i.e., input tasks). On the contrary, agrammatic aphasic subjects show difficulties accessing the lemma level of representation of verb argument structure properties when conscious recall of the information is required to self-generate a verb label or a rudimentary syntactic structure. When the argument structures associated with the target verb is simple as it is for obligatory one-place verbs, access to the information is more successful. However, increase in the amount of lexical-syntactic information associated with the verb results in more frequent failure in accessing the information.

Any hypothesis concerning the locus of retrieval failure based on the data from the present study, however, should take into account the limitations of the tasks used. For instance, the categorization task was devised to eliminate at least one or two layers of the processes involved in verb production. The task can be performed without producing speech output and thus, poor performance on categorization may implicate disruption in accessing lemma- or both lemma- and lexeme-level information, but is not due to failure at the level of phonological output. However, the nature of the categorization task is still too crude to enable us to pinpoint the level at which subjects were operating in order to perform the task. It is possible to hypothesize that access to lemma-level information is the minimum requirement to perform the categorization task successfully. However, subjects may not operate at the hypothesized level in practice. The observation that some subjects verbally produced a sentence in order to categorize the target verb, on the con-

trary, appears to suggest that the human mind cannot consciously operate at the level of abstraction as hypothesized but requires some sort of verbal/linguistic/heuristic mediation in order to utilize the abstract information accessed in the preceding stages. Thus, subjects may have been performing at the lexeme level or thereafter although intact access to the lemma level information is sufficient to perform the task from the theoretical point of view.

The question concerning the locus of verb-retrieval failure needs to be further investigated and a cautionary approach should be taken in interpreting the data from such studies. As mentioned in the introduction, the present discussion of the lexical-retrieval processes is based on cognitive models of sentence production, which assume two processing stages in lexical access. However, there is no consensus at present regarding the discreteness of processing in each level—whether the staging of the two levels is strictly serial or parallel in the temporal domain and whether processing is interactive between levels or strictly top-down. These issues may not have as much relevance for interpreting data from single-word-retrieval tasks used in the present study as they have for sentence production. However, their implication in the prediction and interpretation of aphasic deficits is significant especially when their performance is examined at the sentence level.

CONCLUSIONS

The findings reported here provide evidence that one dimension of lexical organization is word form information and that agrammatic aphasic subjects have impaired access to the lexical-syntactic entry of verbs as compared to the lexical entry of nouns. Their difficulties accessing the information in the verb's lexical-syntactic entry increases as the number of arguments associated with the target verb increases in productionlike tasks. And, as speculated by some researchers, impaired access to the lexical-syntactic entry of verbs appears to be one important contributor to the sentence production deficit in these patients. The findings in the present study, especially concerning agrammatic aphasic subjects' performance on grammaticality judgment and verb categorization tasks, do not support the explanation that ''degraded representation'' or ''partial activation of information'' in a unified lexicon cause subjects to succeed in comprehension tasks but fail in production tasks. Rather it appears that differences in the starting point, goal, and subsequent processing routines between comprehension and production play a significant role in the different levels of impairment in the two modalities in agrammatic aphasic patients. Although there may be only one lexical storage which is intact and is shared by both comprehension and production, differences in the processing routines between the two modalities can result in the observed pattern: disrupted access to the verb's lexical-syntactic entry in productionlike tasks requiring conscious recall and self-generation of information and intact access in comprehensionlike tasks requiring automatic, nonconscious, implicit processing of externally provided information.

APPENDIX A
Verb–Noun Stimuli

Verb	Frequency	% Noun usage	Noun	Frequency	% Verb usage
Ob1 (n = 14)					
bark*	1	1300	kite	1	0
bleed	18	0	rope	19	5.2
crawl	37	11	belt	36	8.3
cry*	64	54	hat	71	0
jump	58	17	moon	63	1.6
laugh	89	24	box	82	4.9
listen	123	0	finger	106	3.8
pray	30	0	shirt	29	0
run	431	21	foot	361	0.6
sit	314	0	door	348	0
sneeze	3	0	snail	3	0
snore	4	0	vest	4	0
swim	55	1.8	shoe	58	3.4
wink	18	22	axe	19	0
Ob2 (n = 18)					
carry	304	0	table	242	0.4
catch	146	3	bed	139	0.7
dry	72	0	chain	60	0
erase	5	0	carrot	5	0
open	259	4.6	window	172	0
pat	12	16.7	cake	16	12.5
pull	145	9	gun	142	1.4
push	102	7.8	chair	89	0
sharpen	7	0	oven	8	0
shoot	117	0	sun	117	1.7
spill	9	0	stool	8	0
stir	39	0	corn	38	0
wag	4	0	owl	6	0
weigh	33	0	boot	30	13.3
wipe	35	0	pot	33	12.1
wrap	23	8.6	bowl	26	0
wring	3	0	pear	8	0
zip	2	0	goat	8	0
Ob3 (n = 3)					
give	1264	0.15	hand	717	7.3
put	513	0	church	451	0
stick*	50	84	cat	42	0
Op2 (n = 12)					
climb	65	3	nose	65	3
clean	58	1.7	coat	52	11.5
deliver	71	0	jacket	39	7.7
eat	122	0	leg	126	0
juggle	2	0	blouse	2	0
ride	126	17	lips	87	0
sew	18	0	pie	19	0

APPENDIX A—*Continued*

Verb	Frequency	% Noun usage	Noun	Frequency	% Verb usage
shave	23	0	bell	23	0
sing	120	0	ball	123	1.6
sweep	54	15	star	58	6.9
watch	209	15	arm*	217	28.1
whistle	12	25	peanut	11	0
Op3 (n = 15)					
build	249	0.8	horse	203	0
buy	162	0.6	tree	160	0
cut	245	14	heart	199	0
donate	12	0	rabbit	16	0
fry	143	3.4	glass	128	0
hit	126	21	truck	80	3.75
knit	18	11	grapes	10	0
lick	14	0	deer	13	0
pick	143	3.4	dog	147	0.7
pour	48	0	bus	42	0
read	274	0	book	292	2.4
serve	300	0	car	393	0
show	640	17	house	662	8
throw	150	4.6	hair	160	0
write	561	0	eye	524	2.5

Note. Ob1 = obligatory one-place, Ob2 = obligatory two-place, Ob3 = obligatory three-place, Op2 = optional two-place, Op3 = optional three-place verb.

*Three-verb (bark, cry, and stick) and one-noun (arm) targets were used in the study, although their percentage of usage for the other form class was >25% because the meaning of the word is different when used as a noun and as a verb.

APPENDIX B

Grammaticality Judgment Task Stimuli

Total number of stimuli: 60 (30 grammatical and 30 ungrammatical sentences)
Sentence stimuli by type:

a. grammatical sentences with basic argument structure (n = 15): 6 Ob1, 6 Ob2, 3 Ob3
b. grammatical sentences with additional adjunct (n = 15): 6 Ob1, 6 Ob2, 3 Ob3
c. ungrammatical sentences with argument deletion (n = 16): 7 Ob2, 9 Ob3
d. ungrammatical sentences with extra argument (n = 14): 8 Ob1, 6 Ob2

Number of stimuli by type of verbs: 20 Ob1, 25 Ob2, and 15 Ob3 verbs

A. Grammatical sentences with basic argument structure
Obligatory one-place verb (Ob1)
1. The dog is barking.
2. The man is laughing.
3. The woman is listening.
4. The girl is sitting.

APPENDIX B—*Continued*

5. The man is snoring.
6. The boy is swimming.

Obligatory two-place verb (Ob2)

7. The man is carrying the box.
8. The boy is catching the ball.
9. The girl is drying the dishes.
10. The girl is pushing the cart.
11. The boy is sharpening the pencil.
12. The woman is weighing the package.

Obligatory three-place verb (Ob3)

13. The woman is giving the money to the girl.
14. The boy is leaning the ladder against the wall.
15. The man is putting the book on the table.

B. Grammatical sentences with an additional adjunct

Obligatory one-place verb (Ob1)

16. The dog is barking in the house.
17. The man is laughing at the woman.
18. The lady is praying in her room.
19. The girl is sitting on the chair.
20. The man is snoring at night.
21. The boy is swimming toward the girl.

Obligatory two-place verb (Ob2)

22. The man is carrying the box to the car.
23. The girl is drying the dishes in the kitchen.
24. The man is erasing the name from the book.
25. The boy is pulling the cart into the house.
26. The boy is pushing the cart in the yard.
27. The girl is spilling the milk on the table.

Obligatory three-place verb (Ob3)

28. The woman is giving the money to the girl in the car.
29. The boy is leaning the ladder against the wall in the morning.
30. The man is putting the book on the table at night.

C. Ungrammatical sentences with deletion of argument(s)

a. Without an additional adjunct

Obligatory two-place verb (−NP)

31. *The boy is carrying.
32. *The girl is spilling.
33. *The boy is pulling.
34. *The boy is sharpening.

Obligatory three-place verb

35. *The woman is giving the sandwich.
36. *The woman is giving to the driver.
37. *The man is putting.
38. *The man is putting the dollar.
39. *The man is putting on the table.
40. *The boy is sticking on the envelope.

b. With an additional adjunct

Obligatory two-place verb

41. *The boy is carrying in the park.
42. *The girl is spilling on the floor.
43. *The boy is pulling to the house.

Obligatory three-place verb

44. *The boy is sticking in the morning.
45. *The man is putting in the afternoon.
46. *The man is putting the book at night.

D. Ungrammatical sentences with an extra argument

Obligatory one-place verb

47. *The dog is barking the girl.
48. *The boy is bleeding the girl.
49. *The man is laughing the woman.
50. *The woman is listening the music.
51. *The lady is praying the cross.
52. *The girl is sitting the chair.
53. *The boy is swimming the girl.
54. *The lady is weeping her baby.

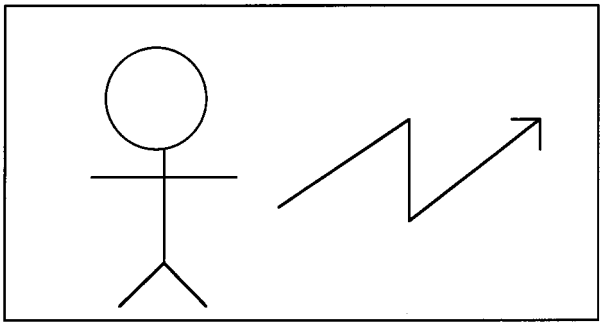
Obligatory two-place verb

55. *The man is carrying the boy a box.
56. *The boy is catching her the ball.
57. *The girl is drying the man the dishes.
58. *The boy is pulling the girl the cart.
59. *The girl is pushing the boy the cart.
60. *The girl is spilling the baby the milk.

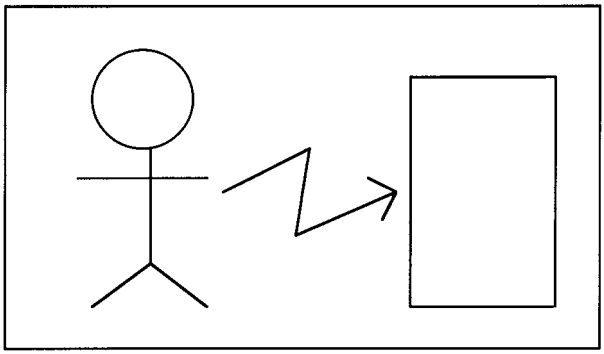
APPENDIX C

Verb Categorization Icon Board

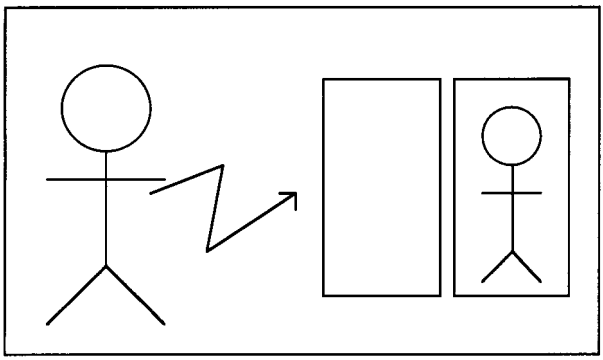
Obligatory one-place verb



Obligatory two-place verb



Obligatory three-place verb



APPENDIX D
Categorization Stimuli

Verb categorization task stimuli	Noun categorization task stimuli
Obligatory one-place verbs (Ob1)	Food
bark	cake
bleed	carrot
laugh	corn
listen	grape
pray	peanut
run	pear
sit	pie
sneeze	sandwich (practice item)
snore	
swim	Clothing
weep	belt
wink (practice item)	blouse
	coat
Obligatory two-place verbs (Ob2)	hat
carry	jacket
catch	shirt
dry	shoe
erase	vest
pull	skirt (practice item)
push	
sharpen	Animal
spill	bird
weigh	cat
wipe	deer
open (practice item)	dog
	goat
Obligatory three-place verbs (Ob3)	horse
give	snail
lean	owl
put	rabbit
stick (practice item)	elephant (practice item)

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