Brain and Language **73,** 393–420 (2000)
doi:10.1006/brln.2000.2312, available online at http://www.idealibrary.com on IDEAL®

Verb Retrieval in Brain-Damaged Subjects: 2. Analysis of Errors

David Kemmerer and Daniel Tranel

Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience, University of Iowa College of Medicine

Verb retrieval for action naming was assessed in 53 brain-damaged subjects by administering a standardized test with 100 items. In a companion paper (Kemmerer & Tranel, 2000), it was shown that impaired and unimpaired subjects did not differ as groups in their sensitivity to a variety of stimulus, lexical, and conceptual factors relevant to the test. For this reason, the main goal of the present study was to determine whether the two groups of subjects manifested theoretically interesting differences in the kinds of errors that they made. All of the subjects' errors were classified according to an error coding system that contains 27 distinct types of errors belonging to five broad categories—verbs, phrases, nouns, adpositional words, and ''other'' responses. Errors involving the production of verbs that are semantically related to the target were especially prevalent for the unimpaired group, which is similar to the performance of normal control subjects. By contrast, the impaired group had a significantly smaller proportion of errors in the verb category and a significantly larger proportion of errors in each of the nonverb categories. This relationship between error rate and error type is consistent with previous research on both object and action naming errors, and it suggests that subjects with only mild damage to putative lexical systems retain an appreciation of most of the semantic, phonological, and grammatical category features of words, whereas subjects with more severe damage retain a much smaller set of features. At the level of individual subjects, a wide range of ''predominant error types'' were found, especially among the impaired subjects, which may reflect either different action naming strategies or perhaps different patterns of preservation and impairment of various lexical components. Overall, this study provides a novel addition to the existing literature on the analysis of naming errors made by brain-damaged subjects. Not only does the study advance our knowledge of the relatively underinvestigated topic of action

For their assistance at various stages in this project, we thank Laura Crossett, Alice Davison, Julie Fiez, Mike Hansen, Ashok Jansari, Denise Krutzfeldt, Ken Manzel, Rosemary Plapp, Ellen Steffensmeier, and Robert Woolson. This work was supported by Program Project Grant NINDS NS19632.

Address reprint requests to Daniel Tranel, Department of Neurology, University of Iowa Hospitals and Clinics, Iowa City, IA 52242. Fax: (319) 356-4505.

0093-934X/00 $35.00

naming errors, but it also approaches the analysis from the point of view of a detailed, theoretically motivated, and reliable error coding system.

INTRODUCTION

Within the past few years, an increasing amount of research has been done on verb retrieval impairments in brain-damaged subjects (McCarthy & Warrington, 1985; Williams & Canter, 1987; Kohn et al., 1989; Zingeser & Berndt, 1990; Damasio & Tranel, 1993; Daniele et al., 1994; Kremin, 1994; Breedin & Martin, 1996; Marshall et al., 1996; White-Devine et al., 1996; Berndt et al., 1997a, 1997b; Breedin et al., 1998; Chen & Bates, 1998; Jonkers & Bastiaanse, 1998; Tranel et al., submitted for publication). In a recent study, we investigated the degree to which various stimulus, lexical, and conceptual factors influenced the ability of 53 brain-damaged subjects to name static pictures of actions with the most appropriate verbs (Kemmerer & Tranel, 2000). Group analysis indicated that some factors contributed more than others to the subjects' performance and that the subjects who were impaired on the test exhibited the same pattern of factor sensitivity as the subjects who were unimpaired. A more detailed analysis at the level of individual subjects revealed that all of the factors significantly affected the performance of at least some subjects and that across subjects there were many different patterns of factor associations and dissociations. In this paper, we extend the investigation to include a systematic analysis of the types of naming errors that the subjects made on the test. Because the factors that were considered in the previous study did not distinguish between impaired and unimpaired subjects at the level of group analysis, the primary goal here is to determine whether the two groups of subjects manifest theoretically meaningful differences in the kinds of errors that were most frequently made. Another goal, paralleling the individual subject analysis of the previous study, is to explore the range of variation in error patterns across the subjects.

In an investigation of the object naming abilities of 32 aphasic subjects, Mitchum et al. (1990) obtained results that are relevant to the first goal of this study. After analyzing the types of errors that the subjects made on the test, they discovered an interaction between error rate and error type indicating that the subjects with the lowest error rates tended to make errors that were semantically or phonologically related to the target, whereas the subjects with the highest error rates tended to make errors that involved either semantically unrelated words or no linguistic response whatsoever. These results are consistent with earlier suggestions that as the severity of naming impairment increases so does the distance in semantic and phonological space between responses and target words (e.g., Shuell & Jenkins, 1961). Mitchum et al.'s findings led us to predict that in the present study, the brain-damaged subjects with normal action naming abilities should produce errors that tend to be closely related to the target verbs, whereas the brain-damaged subjects with action naming deficits should be more likely to produce errors that are either unrelated to the target verb in form and/or meaning or involve the failure to produce any kind of linguistic response.

Only a few studies have focused on the kinds of errors that brain-damaged subjects make when required to retrieve verbs for naming pictures or videos of actions, but these studies are illuminating and constitute a good foundation for the present investigation. Not only do they supplement Mitchum et al.'s (1990) study by providing further information about the kinds of differences we might expect to see between the action naming errors of impaired and normal subjects, but they also offer a window onto the many types of action naming errors that brain-damaged subjects make. The latter point is relevant to the second goal of this study, which is to characterize the diversity of error patterns in individual brain-damaged subjects.

McCarthy and Warrington (1985) reported a single subject who made a wide variety of errors on an action naming test. Among the subject's semantically related errors, there were several instances of verbs that designate an action that is the opposite of the action specified by the target verb—e.g., *pushing* → *pulling; throwing* → *catching.* There were also many errors involving either the conversion of a noun to a verb—e.g., *sitting* → *chairing; closing* → *drawering*—or the production of a bare noun or noun phrase—e.g., *opening* → *the case.* Furthermore, a large proportion of the subject's errors consisted of sentence-like constructions instead of single words. Nearly half of these contained the target verb or a semantically related verb—e.g., *ringing* → *the boy is pushing the doorbell.* The rest had either a ''stranded'' auxiliary verb—e.g., *drinking* → *the woman is a cup of tea*—or a semantically general verb such as *make* or *have*—e.g., *carrying* → *the man is made the coal.*

Kremin (1994) reported another case study of a subject who made 22 errors on a 50-item action naming test. Over half of the subject's errors involved the production of a noun that was semantically related to the target verb, which is similar to the performance of McCarthy and Warrington's (1985) subject. The remaining errors were a mixture of semantically related verbs, phonemic paraphasias, perseverations, and comments.

Several other studies have involved direct comparisons of different kinds of action naming error patterns across aphasic subjects. For instance, Breedin and Martin (1996) described four subjects who all produced a large number of verbs that were semantically related to the target, but who differed in other respects. One subject had ''no response'' for many items; another made a lot of phonological and neologistic errors; and another produced a substantial number of verbs that were semantically unrelated to the target. Similarly, Berndt et al. (1997a) reported five subjects with well-established verb retrieval deficits but with different kinds of error patterns on an action naming test. For three of the subjects, the predominant type of error involved verbs that were semantically related, either associatively or taxonomically, to the target. The fourth subject had a large proportion (over 50%) of ‘‘no response’’ or gestural errors. And the fifth subject tended to produce verbs that were phonologically related to the target. The authors emphasize that one of the most striking features of these subjects (apart from the last one) was their frequent production of nouns instead of verbs—a finding similar to those of McCarthy and Warrington’s (1985) and Kremin’s (1994) case studies. Finally, Breedin et al. (1998) conducted a study in which the nature of semantic errors was investigated more carefully than in most previous studies. They described eight brain-damaged subjects who performed better at retrieving semantically complex and specific verbs than semantically simple and general verbs. They explained this pattern by suggesting that complex verbs are easier to access than simple verbs because rich and densely interconnected semantic structures contain more information that can be activated.[1] On the basis of these findings, the authors predicted that when the subjects are unable to retrieve the target verb, they should tend to substitute a verb that is semantically more complex and specific than the target—e.g., *clean* → *wipe*. The results were as follows: two of the eight subjects substituted complex and simple verbs equally often; two others tended to use only very general verbs (*go* for one subject and *get* for the other), which is similar to McCarthy and Warrington’s (1985) subject; and the remaining four subjects performed in accordance with the predictions, substituting complex verbs significantly more often than simple verbs.

ERROR CODING SYSTEM

In order to analyze the action naming errors made by the 53 brain-damaged subjects in this study, an error coding system was developed that draws upon several sources of information: previous approaches to the analysis of naming errors (e.g., Mitchum et al., 1990; Berndt et al., 1997a; Goodglass & Wingfield, 1997; Anstell & Harley, 1998; Breedin et al., 1998); theoretical semantic considerations (e.g., Fillmore, 1977, 1982; Cruse, 1986; Pinker, 1989; Jackendoff, 1990; Levin, 1993; Fellbaum, 1998); the criteria for scoring the subjects’ responses as correct or incorrect (see *Procedures*); and careful scrutiny of the subjects’ actual errors. The coding system contains 27 different types of errors that fall into five broad categories depending on such factors as whether they involve verbs or other parts of speech, whether they involve single words or phrases, and whether they involve linguistic responses, gestural responses, or the lack of any kind of response. The broad error categories and the specific error types are listed below; a more detailed description of the coding system, including definitions and examples of each error type, is provided in the Appendix.

[1] See Kemmerer and Tranel (2000) for further discussion of this ‘‘complexity effect.’’

Category 1: Verb errors

1. V-Superordinate
2. V-Subordinate
3. V-Cohyponym
4. V-Opposite
5. V-Associative
6. V-Unrelated
7. V-Inflection
8. V-Phonological

Category 2: Phrasal errors

9. P-Target Verb
10. P-Superordinate
11. P-Subordinate
12. P-Cohyponym
13. P-Opposite
14. P-Associative
15. P-Unrelated
16. P-Phonological
17. P-No Verb

Category 3: Nominal errors

18. N-Actor
19. N-Undergoer
20. N-Instrument
21. N-Associative
22. N-Unrelated

Category 4: Adpositional errors

23. Preposition / particle
24. Adjective / Adverb / Interjection / Direct Speech

Category 5: Other errors

25. Neologism
26. Gesture
27. No Response

Overall, our coding system contains a large number of distinct error types, more so than any other system with which we are familiar. The principal advantage of having a detailed coding system is that it enables us to capture some of the richness of the full range of errors that subjects make. This is important for the present study because our main goals are, first, to determine whether there are significant differences in the kinds of errors made by brain-damaged subjects with and without verb retrieval impairments, and second, to explore the variety of error patterns across individual subjects. Both of these goals, but especially the second one, are better served by a fairly refined error coding system than by one that makes only a few general distinctions.

PREDICTIONS

Based on the previous studies of object and action naming errors reviewed earlier, it is possible to make several predictions about differences that we should expect to find in the prevalence of certain kinds of errors among the subjects with and without verb retrieval impairments in this study. These predictions involve the broad error categories as well as many of the specific error types described above. All of the predictions concern the relative proportion, rather than the absolute number, of different kinds of errors made by each group of subjects.

As is the case for control subjects, the unimpaired group did not make a large number of errors. Nevertheless, for the errors that they did make, we predict that, at the level of broad error categories, there should be a greater proportion of errors in the verb category than in any of the other categories. This is because when normal control subjects give nontarget responses, their errors usually involve the production of an incorrect verb (Fiez & Tranel, 1997). By contrast, the impaired group should have an error profile that is more distributed across the various categories since, after all, these subjects have verb retrieval deficits and hence may frequently make errors that consist of phrasal or nonverb linguistic responses or perhaps the kinds of responses that fall in the category labeled ‘‘other.’’ This implies that two salient differences that should emerge between the groups are as follows: the unimpaired group should have a larger percentage of errors in the verb category than the impaired group, and conversely, the impaired group should have a relatively larger percentage of errors in each of the nonverb categories than the unimpaired group.

At the level of specific error types, the same general pattern should be manifested, only at a more fine-grained scale and with some qualifications. First of all, for each of the error types in the verb category, we would expect the unimpaired group to have a greater proportion of errors than the impaired group, with three exceptions—V-Unrelated, V-Inflection, and V-Phonological—where the prediction is reversed for the following reasons. Based on Mitchum et al.’s (1990) study, it is likely that the impaired group has a greater proportion of V-Unrelated errors than the unimpaired group. In addition, it is reasonable to expect the impaired subjects to have more errors of the V-Inflection type than the unimpaired subjects because verb retrieval deficits are often associated with agrammatism and one of the common features of agrammatism is difficulty with inflections (Miceli et al., 1984, 1988; Menn & Obler, 1990; Menn et al., 1995; Ullman et al., 1997).[2] Previous studies also suggest that the impaired subjects should make more errors of the V-Phonological type than the unimpaired subjects.

With regard to the specific error types in the various nonverb categories, it is possible to formulate predictions about some of them. Within the phrasal category, we predict that, as with the verb category, the impaired subjects

[2] It is important to note, however, that the English *-ing* verb suffix, which is required for 75 of the 100 items in the Action Naming Test (see *Materials*), is less likely to be disrupted than other inflectional morphemes, such as verb suffixes that have syntactic functions like agreement (Menn et al., 1995). Hence the proposal about the V-Inflection error type should be regarded as more of a suggestion than a strong prediction.

should have a greater proportion of errors of the P-Unrelated and P-Phonological types than the unimpaired subjects. In addition, because the impaired subjects are characterized as having verb retrieval deficits, they should make more errors of the P-No Verb type than the unimpaired subjects. Shifting to the three specific error types in the ‘‘other’’ category—Neologism, Gesture, and No Response—previous studies suggest that the impaired subjects should make significantly more errors than the unimpaired subjects. For the remaining specific error types in the phrasal, nominal, and adpositional categories, we do not have enough information about each particular error type to formulate strong predictions about whether differences between the two subject groups should emerge. However, given that at the level of broad error categories we expect the impaired group to have more errors in each of the nonverb categories than the unimpaired group, we can safely predict that *if* a difference between groups emerges for any of the specific error types, it should be such that the impaired group has a larger proportion of errors than the unimpaired group.

METHODS

Subjects

We studied the same 53 left-hemisphere brain-damaged subjects whose verb retrieval abilities were reported by Kemmerer and Tranel (2000). The criteria for selecting the subjects, as well as their demographic features, are described in that paper.

Materials

The subjects were administered the Action Naming Test that was recently developed and standardized by Fiez and Tranel (1997). In brief, the test consists of 100 color photographs of various actions, each of which is intended to elicit a specific verb or else one of a small set of verbs. The first 75 items are single pictures that show ongoing activities; they are meant to elicit verbs in the imperfective aspect (expressed by the suffix *-ing*). By contrast, the last 25 items are picture pairs that show the initial and final states of causative events; they are meant to elict verbs in the perfective aspect (expressed by either the regular past tense suffix *-ed* or by an irregular past tense form). Further information about the nature of the test items is provided by Kemmerer and Tranel (2000).

Procedures

Details about the manner in which the stimuli were presented to the subjects are described by Kemmerer and Tranel (2000). For present purposes, it is sufficient to note that the subjects were instructed to name each picture or picture pair with a single verb that best characterizes the action. They were told that only verbs should be used and that other kinds of words and phrases should be avoided. They were also told to include the proper inflection on all verbs. Responses that were any of the predetermined target verbs (based on control data; see Fiez & Tranel, 1997) were scored as correct, and all other responses were considered incorrect.

The 53 subjects made a total of 1418 errors, and these were classified according to the coding system described earlier (and in the Appendix). Each error was treated as belonging to only a single error type. Because some of the distinctions between error types in the coding system are rather subtle, there were several occasions when it was difficult to know exactly how to classify an error. A few examples help to illustrate the range of challenges that we confronted. Should *shredded (paper)* → *dissolved* be treated as a V-Associative or a V-Unrelated error? Both the target verb and the response verb specify that, in a very general sense, the undergoer loses its structural integrity; hence the two verbs appear to be associated. On the other hand, they differ in the way in which the process happens: the target verb specifies that the undergoer is transformed into an unbounded number of long, thin, discrete, two-dimensional objects, whereas the response verb specifies that the undergoer gradually disintegrates and diffuses throughout a liquid medium. In this particular case, and in similar cases where the semantic relation between the target and response verbs was very weak or metaphorical, we decided to code the error as V-Unrelated. To take another example, should *winding (toy)* → *twisting* be treated as a V-Superordinate or a V-Cohyponym error? In other words, is winding a particular way of twisting something, or are both activities at roughly the same level of taxonomic specificity? We believe that the former characterization is correct because the verb *twist* appears to have a broader range of applicability than the verb *wind*—e.g., *twist/ *wind the lid of the jar*. Hence we coded the error as V-Superordinate. Finally, should *stirring* → *mixing* be coded as V-Superordinate, V-Subordinate, or V-Cohyponym? One can stir something without causing it to become mixed (e.g., a glass of water), and one can mix something without stirring it (e.g., by shaking it), so neither verb necessarily entails the other, which suggests that neither the V-Superordinate nor the V-Subordinate labels are correct. On the other hand, the V-Cohyponym label does not seem entirely applicable either, since *mix* is a pure change of state verb and *stir* is a pure manner of motion verb (Pinker, 1989; Levin, 1993). Nevertheless, the two verbs are closely related since stirring is a very common way of mixing things (as in the stimulus picture), and for this reason we decided to code the error as V-Cohyponym.

Because we encountered a large number of coding difficulties like those described above, we assessed coding reliability for a randomly selected set of 772 errors. Since Gesture and No Response errors are unambiguous, these were excluded from the set. Two raters, both of whom were trained in linguistic semantic theory and blind to the performance of the test subjects, independently classified the errors according to the coding system. Their classifications were then compared with those of the first author. For 417 (54%) of the errors, there was perfect agreement across all three coders; for 315 (40.1%) of the errors, there was agreement between two of the three coders; and for the remaining 40 (5.2%) errors, there was no agreement at all. To determine the proportion of agreement that could not be attributed to chance, we conducted a generalized kappa analysis which is designed for multiple coders and multiple coding options (Fleiss, 1971; Dunn, 1989). This analysis indicated a high rate of reliability between coders (generalized $\kappa = 0.65$, with a 95% confidence interval of 0.63–0.66). The following strategy was used to assign a particular error type to those errors for which there was not perfect coding agreement: for errors that were classified in the same way by two of the three coders, we adopted the error type that those two coders selected, and for errors that were classified differently by all three coders, we adopted the error type selected by the first author.

Classification of Subjects

The primary goal of this study is to determine whether the brain-damaged subjects identified by Kemmerer and Tranel (2000) as having verb retrieval impairments differ in the kinds of action naming errors they made from those subjects with normal verb retrieval abilities. It is therefore appropriate to review here how the subjects were classified as impaired or unimpaired on the basis of their performance. The impaired group consisted of 19 subjects, each of whom had scores that were 2 or more SDs below the mean percentage correct of the control subjects tested by Fiez and Tranel (1997). This group had a mean Z score of -7.0 ($SD = 4.0$) and a mean percentage correct of 49.7 ($SD = 20.1$). By contrast, the unimpaired group consisted of 34 subjects, each of whom had scores that were within 2 SD of the control subjects. This group had a mean Z score of 0.3 ($SD = 1.3$) and a mean percentage correct of 86.2 ($SD = 6.2$).

RESULTS

Group Analyses

We present the results for the group analyses first and then shift to the results for the individual subjects. Table 1 shows how the errors for the unimpaired and impaired groups were distributed across the five broad error categories. For both groups, the errors were concentrated mainly in the verb category. However, the difference in magnitude between errors in the verb category and errors in the other categories was much greater for the unimpaired subjects than for the impaired subjects; in other words, the slope of the curve extending from the verb category across the other categories declines much more steeply for the unimpaired group than for the impaired group. This is reflected in the differences between the two groups for the various error categories. For each category, unpaired one-tailed t tests were done comparing the mean percentage of errors made by the impaired group with the mean percentage of errors made by the unimpaired group. In order to correct for multiple comparisons across the error categories and for the lack of independence of the error categories (in the sense that individual errors could fall into any category), the α level was set at $p < .01$ (Bonferonni correction). For the verb category, a highly significant difference was found, confirming the prediction that verb errors should be much more prevalent for the unimpaired group than for the impaired group. For the remaining categories, significant differences were also obtained but in the opposite direction, confirming the prediction that nonverb errors of all four kinds should be more common among the impaired subjects than among the unimpaired subjects. These differences were especially large for the nominal and ''other'' categories.

TABLE 1
Proportion of Errors from Each Category for Impaired and Normal Subjects

Error Category	Impaired subjects ($n = 19$)	Normal subjects ($n = 34$)	t-test
1. Verb (error types 1–8)	53.0 (20.5)	81.4 (13.9)	$p = .0001$
2. Phrasal (error types 9–17)	23.6 (16.8)	14.1 14.0)	$p = .01$
3. Nominal (error types 18–22)	9.4 (8.5)	0.8 (2.4)	$p = .001$
4. Adpositional (error types 23–24)	3.7 (2.7)	1.5 (3.3)	$p = .007$
5. Other (error types 25–27)	10.2 (8.5)	2.2 (4.8)	$p = .0001$

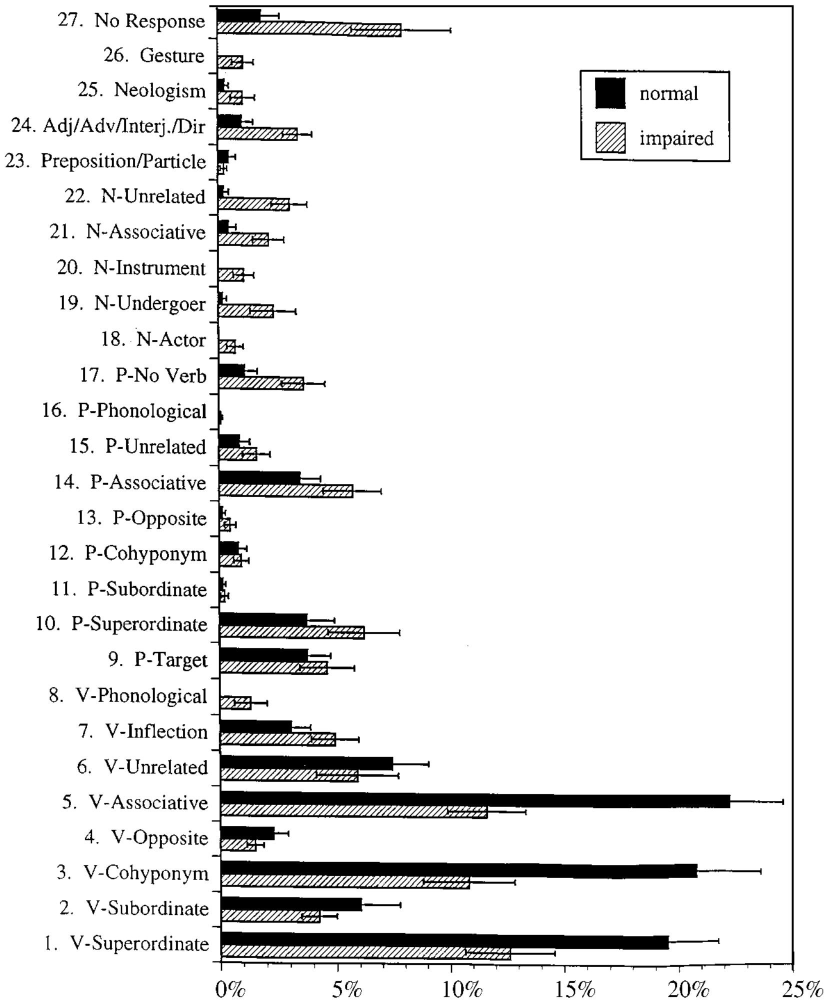

FIG. 1. Proportion of total errors belonging to each error type for the impaired and unimpaired groups.

With regard to the 27 specific error types, Fig. 1 shows the proportion of errors of each type for the unimpaired and impaired groups. To test the predictions that were made for specific error types, unpaired one-tailed *t* tests were carried out. To correct for the fact that comparisons were made for 27 error types that are not independent (in the sense that individual errors could fall into any type), the α level was set at $p < .002$ (Bonferonni correction). We consider this a conservative threshold for significance. Many of the predictions were confirmed. For the first five error types in the verb category, it was predicted that the unimpaired subjects would have a greater proportion of errors than the impaired subjects. We found that the difference between the two groups was significant or marginally significant for two of the five error types—V-Cohyponym ($p < .007$) and V-Associative ($p < .001$)—and it is apparent from Fig. 1 that there was also a substantial, although not statistically significant, difference for the V-Superordinate error type ($p < .05$). For the last three error types in the verb category, we made the opposite prediction, namely that the impaired subjects would have more errors than the unimpaired subjects. A marginally significant difference was obtained for one of these error types—V-Phonological ($p < .005$). Within the phrasal category, it was predicted that impaired subjects would outrank unimpaired subjects for three error types—P-Unrelated, P-Phonological, and P-No Verb. A marginally significant difference was found for the P-No Verb type ($p < .05$%). For the three error types in the ''other'' category—Neologism, Gesture, and No Response—we again predicted that the impaired group would outrank the unimpaired group. This was confirmed for the last two error types—Gesture ($p < .005$) and No Response ($p < .005$)—and there was also a substantial, although not statistically significant, difference for the Neologism error type ($p < .05$).

Although no strong predictions were made about whether differences would emerge between the two subject groups for the remaining specific error types, it was predicted that *if* a difference emerged it would be such that the impaired group had larger proportion of errors than the unimpaired group. Further investigation of the data shown in Fig. 1 revealed that significant or marginally significant differences in the predicted direction did occur for the Adjective/etc. error type ($p = .002$) as well as for all of the nominal error types—N-Actor ($p = .004$), N-Undergoer ($p = .002$), N-Instrument ($p = .0005$), N-Associative ($p = .005$), and N-Unrelated ($p = .0001$). Although no significant differences between the two groups were found for any of the specific phrasal error types (with the exception of the P-No Verb type, noted earlier), it is worth noting that the impaired group had a greater proportion of errors of the P-Superordinate and P-Associative types compared to the unimpaired group (P-Superordinate: impaired, 6.2%, unimpaired, 3.7%; P-Associative: impaired, 5.8%, unimpaired, 3.4%).

Analyses of Individual Subjects

Tables 2 and 3 show the relative proportion of errors of each broad category and each specific type for the individual impaired subjects and for a subset of the individual unimpaired subjects. For the broad categories, we adopted the strategy proposed by Mitchum et al. (1990) for determining whether a subject has a ''predominant'' error pattern. In particular, for a given subject an error category was considered predominant over the others if it accounted for at least twice the proportion of errors as in any other

TABLE 2
Proportions of Different Categories and Types of Action Naming Errors for Individual Impaired Subjects ($n = 19$)

	Error category type	513MB	615NJ	868RS	983DR	1076GS	1172JP	1247HW	1312BM
1.	Verb	***67.9***	***85.3***	***55.7***	***55.8***	24.3	49.2	***71.7***	***57.1***
2.	Phrasal	3.8	5.9	16.4	25.6	***62.9***	13.8	13.0	39.3
3.	Nominal	11.3	2.9	6.6	2.3	7.1	13.8	0.0	3.6
4.	Adpositional	5.7	2.9	3.3	9.3	1.4	3.1	2.2	0.0
5.	Other	11.3	2.9	18.0	7.0	4.3	20.0	13.0	0.0
1.	V—Superordinate	17.0	***29.4***	11.5	***23.3***	7.1	12.3	10.9	14.3
2.	V—Subordinate	11.3	5.9	1.6	4.7	7.1	6.2	2.2	3.6
3.	V—Cohyponym	5.7	11.8	13.1	16.3	2.9	4.6	4.3	***25.0***
4.	V—Opposite	1.9	2.9	4.9	—	—	—	2.2	—
5.	V—Associative	13.2	***20.6***	11.5	11.6	1.4	7.7	***30.4***	3.6
6.	V—Unrelated	1.9	11.8	3.3	—	1.4	9.2	***21.7***	3.6
7.	V—Inflection	13.2	2.9	6.6	—	2.9	9.2	—	7.1
8.	V—Phonological	3.8	—	3.3	—	1.4	—	—	—
9.	P—Target	—	—	4.9	14.0	8.6	3.1	2.2	7.1
10.	P—Superordinate	1.9	5.9	4.9	4.7	***21.4***	4.6	2.2	17.9
11.	P—Subordinate	—	—	—	—	—	3.1	—	—
12.	P—Cohyponym	—	—	—	—	1.4	—	2.2	—
13.	P—Opposite	—	—	1.6	—	—	—	—	3.6
14.	P—Associative	1.9	—	—	7.0	12.9	3.1	4.3	7.1
15.	P—Unrelated	—	—	—	—	4.3	—	2.2	—
16.	Phonological	—	—	—	—	1.4	—	—	—
17.	P—No Verb	—	—	4.9	—	12.9	—	—	3.6
18.	N—Actor	—	—	—	2.3	—	—	—	—
19.	N—Undergoer	1.9	—	1.6	—	1.4	4.6	—	—
20.	N—Instrument	—	—	—	—	—	4.6	—	—
21.	N—Associative	9.4	2.9	3.3	—	1.4	1.5	—	—
22.	N—Unrelated	—	—	1.6	—	4.3	3.1	—	3.6
23.	Prepositional/Particle	1.9	—	1.6	—	—	—	—	—
24.	Adjective/etc.	3.8	2.9	1.6	9.3	1.4	3.1	2.2	—
25.	Neologism	3.8	—	1.6	—	1.4	—	—	—
26.	Gesture	—	—	1.6	—	—	1.5	—	—
27.	No Response	7.5	2.9	14.8	7.0	2.9	18.5	13.0	—

category. On the other hand, for the specific error types we simply established a cutoff point for any type to qualify as dominant. Since there are 27 distinct error types, an even distribution of errors would amount to 3.7% for each type. Thus, using a cutoff that we consider conservative, we designated that if 20% or more of a given subject's errors belonged to a certain type, that type was treated as dominant for the subject (note, however, that this allows for the possibility of a subject having more than one dominant error type). In Tables 2 and 3, dominant error categories and types are indicated by bold, italic typeface.

Looking first at Table 2, which shows the error patterns for the impaired subjects, it is clear that the verb category was dominant for the majority of subjects (11 of 19). This is consistent with the group level finding that the majority of the impaired subjects' errors fell into this category (see Table

TABLE 2—*Continued*

1359AS	1566EJ	1599EM	1687RM	1709EH	1726RO	1808VK	1852MV	1962RR	1976RB	1978JB
27.9	***73.3***	44.0	***79.4***	14.3	44.7	***56.8***	23.2	45.5	***79.4***	***51.3***
20.9	13.3	40.0	5.9	24.2	39.5	25.0	48.2	15.6	0.0	35.9
15.1	0.0	8.0	5.9	34.1	2.6	9.1	21.4	19.5	5.9	10.3
7.0	3.3	0.0	5.9	2.2	7.9	2.3	5.4	0.0	5.9	2.6
29.1	10.0	8.0	2.9	25.3	5.3	6.8	1.8	19.5	8.8	0.0
4.7	***23.3***	***20.0***	***23.5***	2.2	7.9	15.9	1.8	3.9	2.9	7.7
2.3	10.0	—	2.9	—	2.6	4.5	1.8	—	5.9	7.7
1.2	***23.3***	8.0	***23.5***	—	13.2	11.4	3.6	3.9	***26.5***	7.7
2.3	—	—	2.9	2.2	2.6	2.3	—	1.3	2.9	—
2.3	13.3	12.0	14.7	2.2	10.5	***20.5***	5.4	15.6	8.8	15.4
1.2	3.3	4.0	2.9	5.5	5.3	—	1.8	3.9	***29.4***	2.6
2.3	—	—	8.8	2.2	2.6	2.3	8.9	11.7	2.9	10.3
11.6	—	—	—	—	—	—	—	5.2	—	—
—	—	—	—	3.3	13.2	13.6	8.9	1.3	—	7.7
—	—	***20.0***	—	3.3	5.3	2.3	8.9	5.2	—	10.3
1.2	—	—	—	—	—	—	—	—	—	—
3.5	—	4.0	2.9	—	—	2.3	1.8	—	—	—
1.2	—	—	—	—	—	—	—	—	—	2.6
3.5	6.7	8.0	—	3.3	10.5	4.5	***21.4***	5.2	—	10.3
1.2	3.3	4.0	—	9.9	—	2.3	3.6	—	—	—
—	—	—	—	—	—	—	—	—	—	—
10.5	3.3	4.0	2.9	4.4	10.5	—	3.6	3.9	—	5.1
—	—	—	—	3.3	—	—	5.4	2.6	—	—
4.7	—	—	2.9	17.6	—	—	—	5.2	—	5.1
1.2	—	—	2.9	6.6	—	—	1.8	1.3	—	2.6
2.3	—	4.0	—	1.1	2.6	—	3.6	9.1	—	—
7.0	—	4.0	—	5.5	—	9.1	10.7	1.3	5.9	2.6
1.2	—	—	—	—	—	—	—	—	—	—
5.8	3.3	—	5.9	2.2	7.9	2.3	5.4	—	5.9	2.6
1.2	—	—	—	1.1	—	2.3	—	9.1	—	—
1.2	3.3	—	—	6.6	5.3	—	—	1.3	—	—
26.7	6.7	8.0	2.9	17.6	—	4.5	1.8	9.1	8.8	—

1). For one subject (1076GS), the phrasal category was dominant. None of the other three categories were dominant for any of the subjects. Finally, 6 subjects did not have a dominant error category at all, instead manifesting either a large proportion of errors in two categories, especially the verb and phrasal categories (1599EM and 1726RO), or a more balanced distribution across three or more categories (1172JP, 1359AS, 1709EH, 1852MV, and 1962RR).

With regard to the specific error types in Table 2, a wide variety of patterns were found. Seven subjects displayed very mixed error profiles with a small to moderate proportion of errors of nearly every type and no dominant error type (513MB, 868RS, 1172JP, 1709EH, 1726RO, 1962RR, and 1978JB). Six other subjects each had a single dominant error type, but every one was different:

TABLE 3

Proportion of Different Categories and Types of Errors for Individual Borderline Subjects with Z Scores between 0 and −2.0 (n = 14)

Error category/type	376MM	414DM	468JG	580LV	725LH	1251UB	1536WV	1560SP	1621LL	1707LS	1713MH	1733RK	1897FW	2170SH
1. Verb	***78.9***	***89.5***	***94.4***	***70.6***	***75.0***	***52.6***	***70.0***	***70.6***	***91.3***	***82.6***	***100.0***	43.5	***61.1***	***79.2***
2. Phrasal	21.1	—	5.6	17.6	10.0	47.4	25.0	23.5	4.3	17.4	—	***56.5***	33.3	8.3
3. Nominal	—	5.3	—	5.9	—	—	—	—	—	—	—	—	—	—
4. Adpositional	—	5.3	—	—	10.0	—	5.0	5.9	4.3	—	—	—	5.6	—
5. Other	—	—	—	5.9	5.0	—	—	—	—	—	—	—	—	12.5
1. V—Superordinate	***36.8***	15.8	***33.3***	5.9	***45.0***	10.5	***30.0***	***29.4***	13.0	8.7	18.8	13.0	11.1	***33.3***
2. V—Subordinate	—	5.3	5.6	5.9	—	15.8	—	5.9	4.3	8.7	—	4.3	11.1	4.2
3. V—Cohyponym	10.5	***26.3***	16.7	***23.5***	10.0	5.3	15.0	11.8	***26.1***	17.4	12.5	—	11.1	12.5
4. V—Opposite	—	5.3	5.6	—	5.0	5.3	—	—	—	—	6.3	—	5.6	—
5. V—Associative	***21.1***	***26.3***	16.7	***29.4***	15.0	10.5	15.0	5.9	***39.1***	***21.7***	***56.3***	13.0	***22.2***	16.7
6. V—Unrelated	—	5.3	5.6	—	—	—	10.0	5.9	8.7	8.7	6.3	8.7	—	8.3
7. V—Inflection	10.5	5.3	11.1	5.9	—	5.3	—	11.8	—	17.4	—	4.3	—	4.2
8. V—Phonological	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9. P—Target	10.5	—	—	11.8	—	15.8	15.0	5.9	—	8.7	—	13.0	16.7	—
10. P—Superordinate	—	—	—	—	5.0	5.3	—	11.8	—	—	—	17.4	5.6	4.2
11. P—Subordinate	—	—	—	—	—	—	—	—	—	—	—	4.3	—	—
12. P—Cohyponym	5.3	—	—	—	—	5.3	5.0	—	—	—	—	—	5.6	—
13. P—Opposite	—	—	—	—	—	—	—	—	—	—	—	4.3	—	—
14. P—Associative	5.3	—	—	5.9	5.0	15.8	5.0	5.9	4.3	4.3	—	13.0	—	4.2
15. P—Unrelated	—	—	5.6	—	—	—	—	—	—	—	—	—	5.6	—
16. P—Phonological	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17. P—No Verb	—	—	—	—	—	5.3	—	—	—	4.3	—	4.3	—	—
18. N—Actor	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19. N—Undergoer	—	—	—	5.9	—	—	—	—	—	—	—	—	—	—
20. N—Instrument	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21. N—Associative	—	5.3	—	—	—	—	—	—	—	—	—	—	—	—
22. N—Unrelated	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23. Preposition/Particle	—	5.3	—	—	10.0	—	—	—	—	—	—	—	—	—
24. Adjective/Adverb/Interjection/Direct Speech	—	—	—	—	—	—	5.0	5.9	4.3	—	—	—	5.6	—
25. Neologism	—	—	—	—	5.0	—	—	—	—	—	—	—	—	4.2
26. Gesture	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27. No Response	—	—	—	5.9	—	—	—	—	—	—	—	—	—	8.3

983DR: V-Superordinate
1076GS: P-Superordinate
1312BM: V-Cohyponym
1359AS: No Response
1808VK: V-Associative
1852MV: P-Associative

The remaining six subjects each had two dominant error types, some of which were the same:

615NJ: V-Superordinate and V-Associative
1247HW: V-Associative and V-Unrelated
1566EJ: V-Superordinate and V-Cohyponym
1599EM: V-Superordinate and P-Superordinate
1687RM: V-Superordinate and V-Cohyponym
1976RB: V-Cohyponym and V-Unrelated

Finally, not a single impaired subject had a greater proportion of subordinate than superordinate errors in either the verb category or the phrasal category.

We turn now to Table 3, which shows the error patterns for each subject in the unimpaired group who obtained a Z score between -2 and 0, which corresponds to between 75 and 85% ($n = 14$); in what follows, these subjects will be referred to as ‘‘borderline’’ subjects. With respect to the five broad error categories, the vast majority of subjects (13 of 14) had the verb category as dominant and usually to a very high degree. This is exactly what one would expect given the group level finding that over 80% of the 34 unimpaired subjects’ errors fell into the verb category (see Table 1). The single remaining subject had a dominant error category of the phrasal type.

As for the specific error types in Table 3, the majority of the subjects’ errors were concentrated primarily among the verb types, but there was nevertheless a considerable amount of diversity across the subjects with respect to which specific verb types were dominant. Eight subjects manifested a single dominant error type, and for five of these subjects it was the V-Superordinate type (468JG, 725LH, 1536WV, 1560SP, and 2170SH), whereas for the other three it was the V-Associative type (1707LS, 1713MH, 1897FW). Four other subjects had two dominant error types. These were the same for three subjects—V-Cohyponym and V-Associative (414DM, 580LV, 1621LL)—and for the other subject the two types were V-Superordinate and V-Associative (376MM). For the remaining two subjects no dominant error type emerged (1251UB, 1733RK). Last of all, only one subject had a greater proportion of subordinate than superordinate errors, and this was only in the verb category (1251UB).

DISCUSSION

This study investigated the performance of brain-damaged subjects on a test of verb retrieval for action naming. A separate study found that impaired and unimpaired subjects did not differ in their sensitivity to a variety of stimulus, lexical, and conceptual factors relevant to the test (Kemmerer & Tranel, 2000). For this reason, the main goal of the present study was to determine whether the two groups of subjects manifested theoretically interesting differences in the kinds of errors that they made.

The data indicate that meaningful differences in error patterns did in fact emerge. Although the majority of errors for both groups of subjects involved the production of incorrect verbs, the unimpaired subjects had a significantly greater proportion of errors in the verb category than the impaired subjects, and conversely, the impaired subjects had a significantly greater proportion of errors in the phrasal, nominal, adpositional, and ''other'' categories than the unimpaired subjects. These findings are consistent with several studies of object naming which have found that aphasic subjects with low error rates (i.e., relatively normal subjects) tend to make errors that are closely related to the target words, whereas subjects with high error rates (i.e., impaired subjects) tend to make errors that are more distantly related to the target words (Moerman et al., 1983; Mitchum et al., 1990). This correlation between error rate and error quality suggests that subjects with only mild damage to the lexical system retain an appreciation of most of the semantic and phonological features of words, whereas subjects with fairly severe damage to the system retain a much smaller set of features.

An examination of the specific error types within each broad error category revealed more fine-grained differences between the impaired and unimpaired groups. Within the verb category, the error types for which the unimpaired group far outranked the impaired group were precisely the ones that are semantically quite closely related to the target verb—V-Cohyponym, V-Superordinate, and V-Associative; the only closely related error type for which a difference did not emerge was V-Subordinate. This is a further reflection of the more general point that unimpaired subjects are much more capable of producing responses that are in the neighborhood of the target than impaired subjects.

Within the phrasal category, the impaired group made significantly more errors of the P-No Verb type than the unimpaired group, and this makes sense given that the defining property of the impaired subjects is that they have verb retrieval deficits. This finding may be related to the action naming performance of the single brain-damaged subject described by McCarthy and Warrington (1985). As we noted earlier, this subject frequently produced phrases instead of single words, and her phrases often lacked an appropriate verb, containing either just an auxiliary verb or one of a small set of semantically very general ''filler'' verbs. On the other hand, it is also interesting that the impaired group made a considerably (although not significantly) greater proportion of errors of the P-Superordinate and P-Associative types than the unimpaired group. This suggests that although the impaired subjects made a great many of phrasal errors, on many such occasions they were still able to retrieve verbs that were closely related to the target.

Several comments can be made about the errors that fell into the nominal category. First of all, it is notable that the impaired subjects far outranked the unimpaired subjects for all five of the specific types of nominal errors. This is consistent with several previous studies that have also documented a tendency for aphasic subjects to produce nouns instead of verbs in action naming tests (McCarthy & Warrington, 1985; Kremin, 1994). Why do they produce such responses? One possibility is that, as Goodglass and Wingfield (1997) have suggested, the production of nouns may reflect a natural strategy for triggering activation of the appropriate verb: ‘‘It is possible that patients may attempt to use such circumlocutions as self-prompting devices, much as a normal speaker in a tip-of-the-tongue state may verbalize related but incorrect words, in the hope of being led to the desired response.’’ Another point about the nominal errors is that, from the point of view of linguistic theory, it is interesting that the impaired group made a greater proportion of N-Undergoer errors than N-Actor errors (see Fig. 1). Since the actor is the instigator of a causative action scenario, it might be reasoned that this participant would be more prominent than the undergoer and hence that brain-damaged subjects would tend to name the actor more frequently than the undergoer. However, there is an alternative angle on this. Crosslinguistically, it is well established that there is a much tighter bond between verbs and grammatical objects (which canonically encode undergoers) than between verbs and grammatical subjects (which canonically encode actors) (e.g., Greenberg, 1966; Dryer, 1992). There are several approaches to explaining this difference. First, in a prototypical causative action scenario, the actor brings about some kind of change in the undergoer, but the actor itself remains unchanged; hence the relation between action and undergoer may be conceptually closer than the relation between actor and action (Langacker, 1990). Second, in ongoing discourse, topical or given information is usually expressed in sentences in subject position, and focal or new information is usually expressed in the verb and its complements; hence the tight bond between verb and object may be influenced by pragmatic factors (Lambrecht, 1994; Van Valin & LaPolla, 1997). Both of these considerations may apply to the tendency of the impaired brain-damaged subjects to name undergoers more often than actors. The subjects may attend more to undergoers because these participants are being affected in some way, or they may attend more to undergoers because these participants were different (i.e., new information) in almost all of the pictures, whereas the same actor recurred through many of the pictures.

Turning now to the category of adpositional errors, the main finding was that, compared to the unimpaired subjects, the impaired subjects made a significant proportion of errors that involved a mixture of adjectives, adverbs, interjections, and direct speech. As with the nominal errors, these errors may reflect situations where the subject attempts to trigger activation of the desired word through a self-prompting strategy. This explanation requires further experimentation to test.

Finally, within the category of ''other'' errors, the impaired group outranked the unimpaired group for all three specific error types—Neologism, Gesture, and No Response—but the most pronounced difference was for the No Response error type. Indeed, of the 27 specific error types that were considered, this was the fourth most frequent one for the impaired subjects. Previous studies have also found this kind of response to be common among aphasics, especially those with severe anomia (Mitchum et al., 1990; Breedin & Martin, 1996; Berndt et al., 1997a). Mitchum et al. (1990) point out, however, that it is difficult to interpret the underlying cause of such errors: ''The 'no response' pattern could arise from a disturbance to virtually any point(s) in processing, or it may be evidence of a preserved ability to refrain from producing an erroneous response, possibly based on an intact monitoring system; on the lattter view, 'no response' may reflect an internalized strategy.''

Although the primary goal of this study was to determine whether the impaired and unimpaired groups manifested theoretically meaningful differences in error patterns, another goal was to explore the range of variation in error patterns across individual impaired and ''borderline'' subjects. Roughly a third of the impaired subjects (7 of 19) did not exhibit any dominant type of error. Instead, they made errors that were distributed across a wide range of different types. Such error profiles are difficult to interpret, but they may reflect diffuse damage to several different components of the lexical system—semantic and phonological structures as well as perhaps grammatical category features and binding codes that serve to relate all the information pertinent to specific words.

All of the other subjects exhibited at least one dominant type of error, and for over half of the impaired subjects and nearly all of the borderline subjects it was within the verb category. Despite this commonality at the category level, however, there was still a considerable amount of diversity for both impaired and borderline subjects with regard to which specific error types were dominant. For instance, among the impaired subjects there were seven different error types that were dominant for different subjects, and these included error types from the phrasal and ''other'' categories. This parallels the separate study of factors that influence verb retrieval, since a wide range of individual differences was also found there (Kemmerer & Tranel, 2000).

There are several possible ways to interpret this variation in error patterns. One possibility is that it reflects different kinds of response strategies that may be more or less conscious and deliberate for subjects. For example, some subjects had V-Superordinate errors as dominant, whereas others had V-Associative errors as dominant. It may be that the former subjects typically employ an action naming strategy of using semantically general verbs, while the latter subjects typically prefer to rely on associations of different kinds. It may also be that these different kinds of strategies extend beyond the testing situation to the subjects' everyday communicative behaviors. Further research is needed to test these hypotheses.

Another possibility is that the variation in dominant error types may reflect individual differences in which part of the lexical system is disrupted. For many years researchers have observed that the kinds of naming errors produced by brain-damaged subjects can provide a window onto the nature of the subjects' underlying impairments (Shuell & Jenkins, 1961; Geschwind, 1967; Luria, 1973). For example, subjects with a predominance of semantically related errors and a lack of phonological or neologistic errors are likely to have some kind of disruption of the semantic component (Howard & Orchard-Lisle, 1984; Berndt et al., 1987; Mitchum et al., 1990). A large number of the subjects in the present study fit this pattern, especially among the impaired group. These subjects may have semantic disorders that are severe enough to cause difficulties in accessing the target verb, but not so severe that they prevent the subjects from accessing a verb that bears a close relation to the target. It is important to note, however, that one must be cautious in using semantic errors to infer a disruption of the semantic component because semantic errors can also arise from damage to the mechanisms that map semantic structures onto phonological structures during lexical access (Caramazza & Hillis, 1990). In other words, semantic errors can result from either a representational impairment or a strictly processing impairment.

A final point is that the process by which semantic structures are mapped onto phonological structures may not be implemented by direct connections but instead may be mediated by lexical binding codes that serve as an interface between these two levels of linguistic structure (Gordon, 1997). Based on convergent data from lesion studies and functional neuroimaging studies, Damasio et al. (1996) have suggested that binding codes of this kind subserve the naming of concrete entities and moreover that they are organized in a principled fashion according to semantic parameters. If similar binding codes are involved in action naming, and if they too are organized in terms of semantic parameters, this raises the possibility that action naming errors that are semantically related to the target verbs could emerge not just from damage to the semantic system itself, but alternatively from damage at the level of binding codes. This is an interesting issue that warrants further experimental work.

In conclusion, this study constitutes a novel addition to the existing literature on the analysis of action naming errors made by brain-damaged subjects. The test that was used contains a large number of items, and because data are available on how normal control subjects respond to each item, erroneous responses were clearly identifiable. The analysis of errors was guided by a detailed, theoretically motivated, and reliable error coding system. Finally, a large group of brain-damaged subjects was investigated, allowing us to gather information about general trends as well as individual differences in error patterns.

APPENDIX: ERROR CODING SYSTEM

Category 1: Verb Errors

This category consists of eight error types that involve single verbs or verb–particle constructions (e.g., *refusing* → *pushing away*).[3] When the response includes two verbs given as separate attempts to name the depicted action, the one that is semantically more specific or more closely related to either the target verb or the stimulus picture is selected for classification. Thus, for *crumbled (cookie)* → *broke up, chipped,* the verb that is selected for classification is *chipped* because it is more closely related to the target verb than *broke up.*

1. V-Superordinate

Definition: Response is a single verb that is superordinate to the target verb. Its semantic structure has fewer features and is more general than that of the target verb. The kind of action denoted by the target verb entails the kind of action denoted by the response verb, and sometimes it is possible to say that the former kind of action is ''a way of doing'' the latter kind of action.

Example: *slicing* → *cutting*

Comment: This error type includes verbs that are not necessarily superordinate to the target verb in the technical semantic sense, but that are superordinate in the context of the stimulus picture—e.g., *winding (toy)* → *playing*

2. V-Subordinate

Definition: Response is a single verb that is subordinate to the target verb. Its semantic structure has more features and is more specific than that of the target verb. The kind of action denoted by the response verb entails the kind of action denoted by the target verb, and sometimes it is possible to say that the former kind of action is ''a way of doing'' the latter kind of action.

Example: *walking* → *striding*

Comment: This error type includes verbs that are not necessarily subordinate to the target verb in the technical semantic sense, but that are subordinate in the context of the stimulus picture—e.g., *shaking (hands)* → *clasping*

3. V-Cohyponym

Definition: Response is a single verb that is a cohyponym of the target verb. Its semantic structure is (1) at roughly the same level of taxonomic specificity as the target verb and (2) very closely related in content to the target verb, although not necessarily a synonym or near synonym.

Example: *knitting* → *crocheting*

Comment: This error type is analogous to what other researchers have called ''coordinate'' errors (e.g., Mitchum et al., 1990; Berndt et al., 1997a).

[3] Verb–particle constructions are treated here as encoding single action concepts (Ackerman & Webelhuth, 1998).

4. V-Opposite

Definition: Response is a single verb that is semantically the opposite of the target verb.
Examples
(a) Opposite action: *pushing* → *pulling*
(b) Thematic role reversal within same action: *receiving* → *giving*

5. V-Associative

Definition: Response is a single verb that is associated with either the target verb or the stimulus picture in a way not covered by the previous error types.
Examples:

(a) The action denoted by the response verb is in the same conceptual ''frame'' (Fillmore 1977, 1982; Lakoff, 1987; Lehrer & Kittay, 1992) as the action denoted by the target verb. Some (but not all) subtypes are as follows:
Cause: *refusing (food)* → *dieting*
Effect: *squeezing (lemon)* → *squirting*
Purpose: *mounting (horse)* → *riding*
Co-occurrence: *curling (hair)* → *drying*
(b) The action denoted by the response verb is perceptually associated with the stimulus picture—e.g., *interviewing* → *holding (microphone).*

6. V-Unrelated

Definition: Response is a single verb that does not appear to be related to either the target verb or the stimulus picture.
Example: *galloping* → *watching*

7. V-Inflection

Definition: Response is the target verb but without the correct inflection.
Examples:
(a) No inflection: *blowing* → *blow*
(b) Wrong inflection: *laminating* → *laminated*
Comment: For some errors it is impossible to determine whether the response is a verb with an omitted inflection or instead a noun (e.g., *race, mail, hammer, light*); these errors are arbitrarily classified as verbs with omitted inflections.

8. V-Phonological

Definition: Response appears to be the target verb but the sound structure is ill-formed. To qualify, the response must contain at least 50% of the right phonemes in the right linear order.
Example: *saluting* → *booting*
Comment: No attempt is made to distinguish between phonological and articulatory-phonetic errors since it is not possible to tell them apart reliably without analyzing the physiological, acoustic, and auditory-perceptual features of the responses (Kent & Rosenbek, 1983; Shinn & Blumstein, 1983).

Category 2: Phrasal Errors

This category consists of nine error types that involve different kinds of phrases. The first of these is for phrases that contain some form of the target verb; then there are several error types that involve a phrase with a verb that bears some kind of semantic or phonological relation to the target verb; finally, the last error type is for phrases that contain no verb at all. Each of these error types is listed and exemplified below. It is crucial to note that for virtually all phrasal responses, only the verbal complex (i.e., the main verb plus any auxiliaries, particles, negative markers, or incorporated nouns) is considered for purposes of error classification; other phrasal material is ignored regardless of whether it is relevant or irrelevant to the target verb or the stimulus picture. Thus, for *laminating* → *putting seal on cards,* the response is coded as P-Superordinate rather than P-Cohyponym because *seal on cards* is ignored, leaving only *putting,* which is superordinate to *laminating.* The rationale for the decision to disregard nonverbal phrasal material was that one of the aims of this study is to explore the variety of ways in which brain-damaged subjects substitute nontarget verbs for target verbs. The content of circumlocutions is extraneous to this goal, even though it is intrinsically interesting and could shed light on the degree to which the subject understands the depicted action. Despite the focus on verbs in phrasal errors, however, these errors are still treated as being distinct from single verb errors. This is because the instructions for the Action Naming Test state that a single verb should be given for each picture and that phrasal responses should be avoided (see *Procedures*). In the list of phrasal error types below, no definitions are given because the meanings of the error types are either self-explanatory or were explained earlier in the definitions of the error types involving single verbs. It is important to keep in mind that for the phrasal error types that specify semantic relations, such as P-Superordinate, the semantic label applies only to the meaning of the verb, not to the content of the whole phrase.

9. P-Target

Example: *kicking* → *kick it*

Comment: This error type includes phrases in which the stem of the target verb occurs in the syntactic context of a noun—e.g., *kissing* → *giving a kiss.* This coding decision was based in part on previous research which suggests that homophonous nouns and verbs share the same phonological representation (Dell, 1990; Jescheniak & Levelt, 1994) and that verb retrieval is facilitated by the existence of a homophonous noun (Kremin, 1994; Jonkers & Bastiaanse, 1996, 1998; Kemmerer & Tranel, 2000). Given these findings, we reasoned that if a brain-damaged subject is able to produce the phonological form of the target verb but in the syntactic context of a noun, they should still get some kind of credit. This is also the motivation for treating single words that are ambiguous between nound and verbs (e.g., *kiss*) as being uninflected verbs (see error type 7).

10. P-Superordinate

Example: *slicing* → *cutting up the apples*

11. P-Subordinate

Example: *removed (glove from hand)* → *take it off*

12. P-Cohyponym

Example: receiving → getting the one

13. P-Opposite

Example: *ducking, dodging, avoiding (ball) → trying to catch*

14. P-Associative

Examples:
(a) Same conceptual frame as target verb
Cause: *slouching → she's pooped*
Effect: *roping (calf) → turning him*
Purpose: *mounting (horse) → going to ride*
Co-occurrence: *looking (while shading eyes) → trying to keep sun out*
(b) Perceptual relation to stimulus picture: *marching → carrying a flag*

15. P-Unrelated

Example: *tiptoeing → putting the lock*

16. P-Phonological

Example: *washing → watching hands*

17. P-No Verb

Examples
(a) Noncopular phrases: *bouncing → ball up and down*
(b) Copular phrases[4]
Locative: *swimming → he's in water*
Equative: *shooting → it's a gun*
Attributive: *flexing → she's strong*
Deictic: *crumbled → there it is*

Category 3: Nominal Errors

This category consists of five error types that involve the production of a noun instead of a verb. These error types are distinguished from each other by the role that the entity referred to by the noun plays in the depicted action and more generally by whether the noun does or does not bear a conceptual relation to the target verb or the stimulus picture.

18. N-Actor

Definition: Response is a single noun that refers to the actor in the depicted action. Semantically, the actor of an event is the entity that performs, instigates, or controls it; and syntactically, actors are canonically expressed in English as subject noun phrases (Van Valin & LaPolla, 1997).
Example: *galloping → racehorse*

[4] In some syntactic theories, especially those grounded in crosslinguistic typology, copular constructions are considered to involve a different kind of predication than verbal constructions (e.g., Hengevelt, 1992). Hence these kinds of constructions are classified here as P–No Verb.

19. N-Undergoer

Definition: Response is a single noun that refers to the undergoer in the depicted action. Semantically, the undergoer of an event is the entity that is affected by it in some way; and syntactically, undergoers are canonically expressed in English as object noun phrases (Van Valin & Lapolla, 1997).

Example: *kicking* → *ball*

20. N-Instrument

Definition: Response is a single noun that refers to the instrument in the depicted action. Semantically, an instrument is an entity that an actor uses to bring about some kind of change in an undergoer; and syntactically, instruments are canonically expressed in English as the object of an oblique *with* phrase (Van Valin & LaPolla, 1997).

Example: *cutting* → *scissors*

21. N-Associative

Definition: Response is a single noun that is associated with either the target verb or the stimulus picture in a way not covered by the previous error types.

Examples

(a) Same conceptual frame as target verb: *saluting* → *service*

(b) Perceptual relation to stimulus picture: *knitting* → *needlework*

Comment: This error type includes nouns that are nominalizations of the target verb—e.g., *hugging, celebrating* → *celebration.*

22. N-Unrelated

Definition: Response is a single noun that does not appear to be related to either the target verb or the stimulus picture.

Example: *(horses) racing* → *bathroom*

Category 4: Adpositional Errors

This category consists of just two error types. These are for errors that involve parts of speech that are neither verbs nor nouns.

23. Preposition / Verb Particle

Definition: Response is a single word that is either a preposition or a verb particle.

Example: *mounting (horse)* → *up*

Comment: No attempt is made to distinguish between prepositions and verb particles because the syntactic context necessary to disambiguate them is not present.[5]

[5] Particles can occur without an object (e.g., *She stood up*), whereas prepositions must take objects (e.g., *He fell asleep on the couch* vs. **He fell asleep on*). In addition, particles can undergo so-called particle shift (e.g., *He called up his friend* → *He called his friend up*), whereas prepositions cannot (e.g., *She ran up the stairs* → **She ran the stairs up*), and prepositional phrases can be preposed (e.g., *She ran up the stairs* → *Up the stairs she ran*), whereas particle+object combinations cannot (e.g., *He called up his friend* → **Up his friend he called*).

24. Adjective / Adverb / Interjection / Direct Speech

Definition: Response is a single word or an idiomatic expression that falls into any of the following categories.

Examples:

(a) Adjective: *hugging* → *jubilant*

(b) Adverb: *straddling* → *there*

(c) Interjection: *ducking (ball)* → *ouch*

(d) Direct speech: *refusing (food)* → *no thanks*

Category 5: Other Errors

This category consists of three error types that are used to code neologistic responses, gestural responses, and the lack of any kind of response.

25. Neologism

Definition: Response is a single word that is not an existing word of English either because it is phonologically unrecognizable (less that 50% of the phonemes of a recognizable word) or because it is a morphologically derived word that is structurally well-formed but is not ‘‘listed’’ as an item in the lexicon (cf. Di Sciullo & Williams, 1987).

Examples:

(a) phonological neologism: *spinning (yarn)* → *acking*

(b) morphological neologism: *erasing* → *erasement*

26. Gesture

Definition: Response is some kind of physical gesture in lieu of a linguistic utterance.

Example: *scratching (arm)* → subject imitates action shown in stimulus picture

27. No Response

Definition: Subject indicates that they don’t know what the correct verb is.

Examples:

(a) No response at all, either linguistic or gestural

(b) Statement that they don’t know the answer, such as *don’t know, can’t say it, there’s a name for it,* or *stumped*

(c) Stated failure to recognize the depicted action, such as *can’t see* or *what’s that?*

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