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Categorization Skills in Right Hemisphere Brain Damage for Common and Goal-Derived Categories

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This study investigated the access and organization of common and goal-derived categories in adults with right hemisphere brain damage using a word fluency task. Common categories are groups of natural object concepts, such as vegetables and fruit, that have a graded structure (Rosch, 1975; Rosch & Mervis, 1975). In such a structure, not all members represent the category equally well; some members will be better examples than others and thus will more typically represent the category. Grossman (1981) observed that right hemisphere brain-damaged (RBD) adults performed similarly to non-brain-damaged (NBD) subjects in regard to the number of items produced and sensitivity to graded structure for common categories on an exemplar generation task. The RBD subjects, however, produced many clusters of items related to the target category. These consisted of atypical items whose referents held less obvious features in common. That is, the examples tended to be less representative and were not from the central portion of the semantic field. Joanette and Goulet (1986) found that RBD subjects named significantly fewer items, as well as fewer acceptable items, on exemplar generation than did normal controls; however, the typicality of responses within a category was not analyzed. Joanette, Goulet, and LeDorze (1988) found no significant differences between RBD patients and NBD controls in the number or pattern of errors produced on a semantic generation task. However, the RBD subjects produced fewer exemplars after the first 30 seconds of the task than did the NBD subjects. During the first 30 seconds, the RBD adult may be able to produce many exemplars because production is

more automatic; that is, the exemplars are strongly linked to the superordinate. After the first 30 seconds, subjects may have to organize the activation of specific semantic information to produce more exemplars. This may be a less automatic process.

Barsalou (1983, 1987) investigated the structure of goal-derived categories. These categories, such as "things to inventory in a store," are constructed for use in specialized, goal-oriented contexts. They possess graded structures but are not as established in memory as common categories because people have had less experience with them. Minimal research has been conducted on RBD adults' knowledge of goal-derived categories. Because these categories may involve a construction process different from that of common categories, RBD adults may have difficulty using them. Specifically, producing goal-derived category exemplars appears to require an organizational strategy to achieve dimensions of the category goal; many diverse concepts and ideas are integrated under one category label. Given the nature of the organizational deficits observed in RBD adults when confronted with a variety of stimuli (Joanette, Goulet, & Hannequin, 1990; Myers, 1986), it may be expected that they will display impairment in generating examples for goal-derived categories. Furthermore, because they have difficulty in attending to critical information (Hough & Pierce, in press; Myers, 1990), RBD adults may fail to respond to the entire referential field of a category, thereby producing more atypical or out-of-set responses.

In the present study, the primary concern was the brain-damaged subjects' sensitivity to graded structure, particularly for goal-derived categories. The number of total and correct category responses, mean typicality ratings, and proportion of responses per typicality range were examined. An analysis of error types and a time production analysis also were conducted.

METHOD

Subjects

Ten adults who suffered right hemisphere brain damage as the result of a single cerebrovascular accident (CVA) and 10 NBD adults participated in the study. Subject characteristics and clinical test data are presented in Table 1. The groups did not differ significantly on age ($t = 1.80$; $p > .09$) or education ($t = 1.04$; $p > .30$). No RBD subject was less than two months post CVA. All subjects were right-handed by self-report. Unilateral neglect, identified through neurologic examination, was reported in 2 of the 10

Table 1. Subject Characteristics and Clinical Test Data

	Subjects	
Characteristics	*Right Hemisphere*	*Non-Brain-Damaged*
Age		
Range	45–79	44–75
Mean	65.80	60.80
SD	11.80	9.12
Years of Education		
Range	6–18	4–16
Mean	9.50	10.20
SD	3.66	3.68
Months post CVA		
Range	2–10	
Mean	5.30	
SD	3.30	
BNT		
Range	25-55	37–59
Mean	40.20	51.80
SD	9.99	6.63
TAWF		
Range	69–113[a]	75–111
Mean	85.00	96.2
SD	14.18	13.78
WAB Quotients		
AQ		
Range	93.8–97.7	
Mean	95.6	
SD	1.50	
CQ		
Range	81.2–95.8	
Mean	90.3	
SD	3.92	

Note: BNT = *Boston Naming Test* scores; TAWF = *Test of Adolescent/Adult Word Finding;* WAB = *Western Aphasia Battery;* AQ = Aphasia Quotient; CQ = Cortical Quotient.
[a]Standard scores.

subjects with right hemisphere brain damage. All brain-damaged subjects were administered the *Western Aphasia Battery* (Kertesz, 1982) to rule out the presence of aphasia and to determine overall cognitive involvement. The *Boston Naming Test* (Kaplan, Goodglass, & Weintraub, 1983) and the *Test of Adolescent/Adult Word Finding* (German, 1990) were administered to examine word retrieval abilities in both groups.

Table 2. Category Labels

Common Categories
Furniture
Fruit
Weapons
Sports
Clothing
Goal-derived Categories
Things to take on a camping trip
Things to take from one's house during a fire
Things to inventory at a store
Things that can float
Things that have a smell

Materials

Five goal-derived and five common categories were presented to each subject. Category labels are presented in Table 2. The common categories were 5 of the 10 categories for which Rosch (1975) has established typicality norms. The goal-derived categories had typicality norms developed by Hough (1988) with NBD middle-aged adults. In determining the typicality of an exemplar, a rating of 1 indicates that a member is the best example of a category, whereas a rating of 7 refers to the most unusual exemplar within a category.

Procedure

Subjects were asked to generate as many examples as possible for each category. No preset time limit was established; subjects took as much time as they needed and signaled the examiner when they had completed. However, exemplar production was timed to allow a breakdown of number and type of category response per time interval. Category labels were provided both auditorily and visually. All responses were hand-recorded and audiotaped.

RESULTS

Separate two-way ANOVAs were conducted on the mean number of total responses and the mean number of accurate responses on the common and goal-derived categories for both groups. Mean performance for both

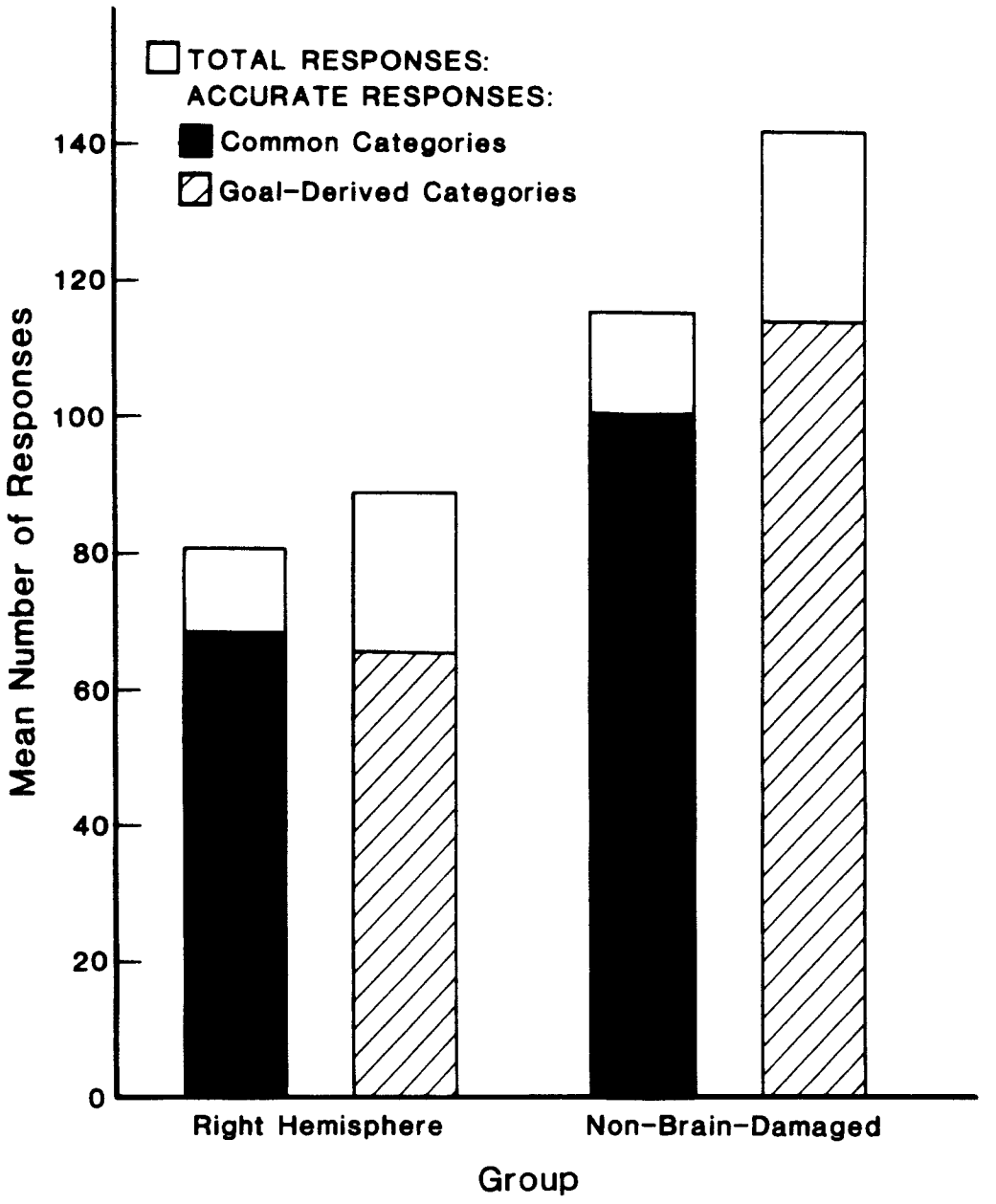

Figure 1. Mean number of total and accurate responses on the common and goal-derived categories for the right hemisphere and non-brain-damaged groups.

analyses is presented in Figure 1. The same pattern of performance was observed for both the total and the accurate responses. The NBD group produced significantly more total [F (1,18) = 13.15; $p < .01$] and accurate responses [F (1,18) = 19.12; $p < .0004$] than the RBD group for both category types. The NBD group produced significantly more total [F (1,18) = 4.72; $p < .05$] and accurate responses [F (1,18) = 5.60; $p < .03$] for the goal-derived

than for the common categories, whereas the RBD subjects showed no significant differences between the two types of categories.

Subject responses also were evaluated in regard to typicality using Rosch's (1975) and Hough's (1988) norms for the common and goal-derived categories, respectively. Only in-set responses were evaluated. An ANOVA conducted on the mean typicality ratings data revealed significant differences only between category types [F (1,18) = 37.33; $p < .0001$]. Overall typicality means and standard deviations for the common and goal-derived categories were 2.2 ± .1 and 2.5 ± .2, respectively. Regardless of group, mean typicality ratings were significantly higher for the goal-derived categories than for the common ones.

The number of in-set subject responses within a particular typicality range was determined to obtain an additional perspective on subjects' appreciation of category centrality. The typicality ranges chosen were similar to those used by Grossman (1981) and Hough (1988). A repeated measures 2 Arcsin ($\sqrt{p}$) (Daniel, 1987) ANOVA with post hoc contrastive analyses (multiple comparison testing) (Kirk, 1982) on significant effects and interactions was conducted on the responses per typicality range. Significant findings were observed for typicality range, F (5,108) = 170.20; $p < .0001$; group × typicality range, F (5,108) = 2.79, $p < .02$; category type × typicality range, F (5,108) = 26.01, $p < .0001$; and group × category type × typicality range, F (5,108) = 2.38, $p < .03$. The data representing the significant three-way interaction are presented in mean proportions in Table 3. The primary significant findings pertained to typicality ranges 1 and 4: For the RBD group, significantly more common category exemplars fell within typicality range 1 than did goal-derived category exemplars, whereas a significantly higher number of goal-derived category exemplars fell within

Table 3. Mean Proportion of Responses per Typicality Range for the Goal-Derived and Common Categories

	Group			
Ranges	*RH BD+*		*NBD++*	
	Common	Goal-Derived	Common	Goal-Derived
1.00–1.49	.352(.03)*	.216(.03)	.316(.05)	.261(.02)
1.50–1.99	.171(.03)	.161(.04)	.183(.03)	.173(.03)
2.00–2.99	.252(.04)	.255(.04)	.264(.03)	.270(.03)
3.00–3.99	.077(.02)	.202(.03)	.079(.02)	.140(.04)
4.00–4.99	.075(.02)	.088(.02)	.087(.02)	.091(.01)
5.00–7.00	.064(.03)	.061(.01)	.089(.02)	.070(.01)

* Standard deviations are in parentheses.

\+ Right hemisphere brain-damage.

++ Non-brain-damaged.

Range 4 ($p < .01$). Although the NBD group showed a pattern of exemplar production throughout typicality ranges similar to the RBD group's, significant differences between the two category types for typicality ranges 1 and 4 were not observed.

Subject errors were identified and analyzed for both types of categories. The observed error types, their operational definitions, and examples are presented in Table 4. Interjudge percentage of agreement for identifying error types was 92%. Errors were analyzed in a three-way repeated measures ANOVA with contrastive analyses on significant effects and interactions. Only the following four error types were statistically analyzed: out-of-set related responses, out-of-set unrelated responses, hierarchically off responses, and repetitions. There were too few functionally off and jargon responses to subject to a formal analysis. Significant findings were observed for error type, F (3,54) = 23.29, $p < .0001$; category type, F (1,18) = 23.41, $p < .0001$; group × error type, F (3,54) = 4.13, $p < .03$; and error type × category type, F (3,54) = 5.54, $p < .008$. A trend toward significance was observed for the three-way interaction ($p < .065$) (group × category type × error type). This interaction was examined further because of some of the obvious observed differences between the two groups for particular error types on the two category types. Table 5 displays the mean number of errors for each error type for the goal-derived and common categories on both groups. Figure 2 displays the data representing the significant group × error type interaction. Data representing the significant category type × error type interaction are presented in Figure 3.

Several significant results were observed. The RBD group produced significantly more out-of-set unrelated responses than did the NBD group overall; it also produced significantly more of these responses on the goal-derived categories in particular. The NBD group produced significantly more hierarchically off responses than the RBD subjects did overall and also produced significantly more of these responses on the goal-derived categories. Overall, more out-of-set related, out-of-set unrelated, and hierarchically off errors were produced on the goal-derived than on the common categories ($p < .01$).

Subject responses were evaluated in regard to the number of exemplars produced during each minute of the experimental task in a repeated measures 2 Arcsin ($\sqrt{p}$) ANOVA. Significant findings included category type, $F(1,18) = 26.20$, $p < .0001$; time in minutes, $F(4,72) = 292.67$, $p < .0001$; and category type x time, $F(4,72) = 14.99$, $p < .0001$. There were no significant group differences. Figure 4 displays the mean proportion of responses for both category types based on time per minute across groups. Both groups produced significantly more responses for the common than for the goal-derived categories during the first minute of exemplar generation. During all other minutes, both groups produced significantly more responses for the goal-derived categories than for the common categories ($p < .05$).

Table 4. Error Types

Name	*Description*
Out-of-set unrelated	Responses that are outside the category boundary and have no relationship to a given category (e.g., "table" for the category "clothes")
Out-of-set related	Responses that are not category members of a given category but are members of a related category (e.g., "sunglasses" for the category "clothes")
Repetitions	Exact productions of previously produced responses for the same category
Hierarchically off	Responses that are not directly subordinate to the category label (e.g., producing "kitchen chair," "dinette chair," or "vinyl chair" for the category "furniture")
Functionally off	Responses that describe action or function of an object but are not specific referents of the category (e.g., for category, "clothes," producing "something you wear on your head")
Jargon	Nonmeaningful word or unintelligible response

Table 5. Mean Number of Responses per Error Type for the Goal-Derived and Common Categories

	Group			
Error Type	*RBD*[a]		*NBD*[b]	
	Common	Goal-derived	Common	Goal-derived
OSU	1.03 (.70)	3.42(2.32)	.65(1.04)	.95 (.75)
OSR	3.46(2.29)	5.36(2.61)	1.72(1.08)	4.39(2.99)
REP	8.69(5.61)	9.62(6.35)	8.88(5.35)	9.14(6.04)
HO	1.25(1.04)	3.87(3.94)	4.53(2.60)	14.95(9.06)

Note: Standard deviations are in parentheses. OSU = out-of-set unrelated; OSR = out-of-set related; REP = repetition; HO = Hierarchically off.
[a]Right hemisphere brain-damaged.
[b]Non-brain-damaged.

Pearson product-moment correlations were conducted between accuracy performance on the *Boston Naming Test* (BNT), standard scores on the *Test of Adolescent/Adult Word Finding* (TAWF), and the proportion of accurate responses and mean typicality ratings on the common and goal-derived categories for both groups. Table 6 presents the correlation matrices. For both groups, significant correlations of interest were found only between

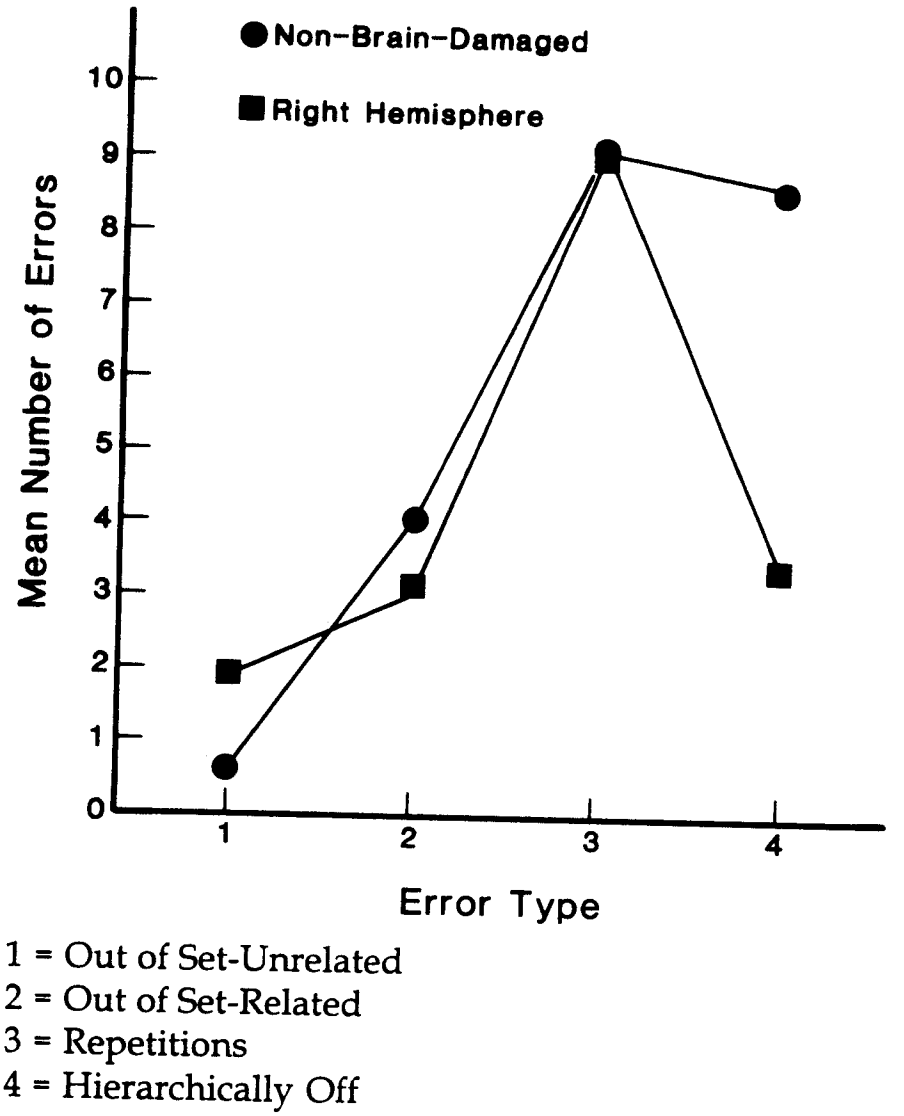

Figure 2. Mean number of errors per error type for the non-brain-damaged and the right hemisphere groups across category type.

the TAWF and BNT. For the NBD group only, a significant correlation was observed between the proportion of accuracy for both category types. For the RBD group only, a significant correlation was found between the proportion of accuracy for common categories and both the TAWF and the BNT. Overall, the results suggest that accuracy for goal-derived categories was related to accuracy for common categories only for the NBD group. Accuracy for the two category types was not related for the RBD group. Not surprisingly, significant correlational findings were not observed between the standardized tests and accuracy for either category type for

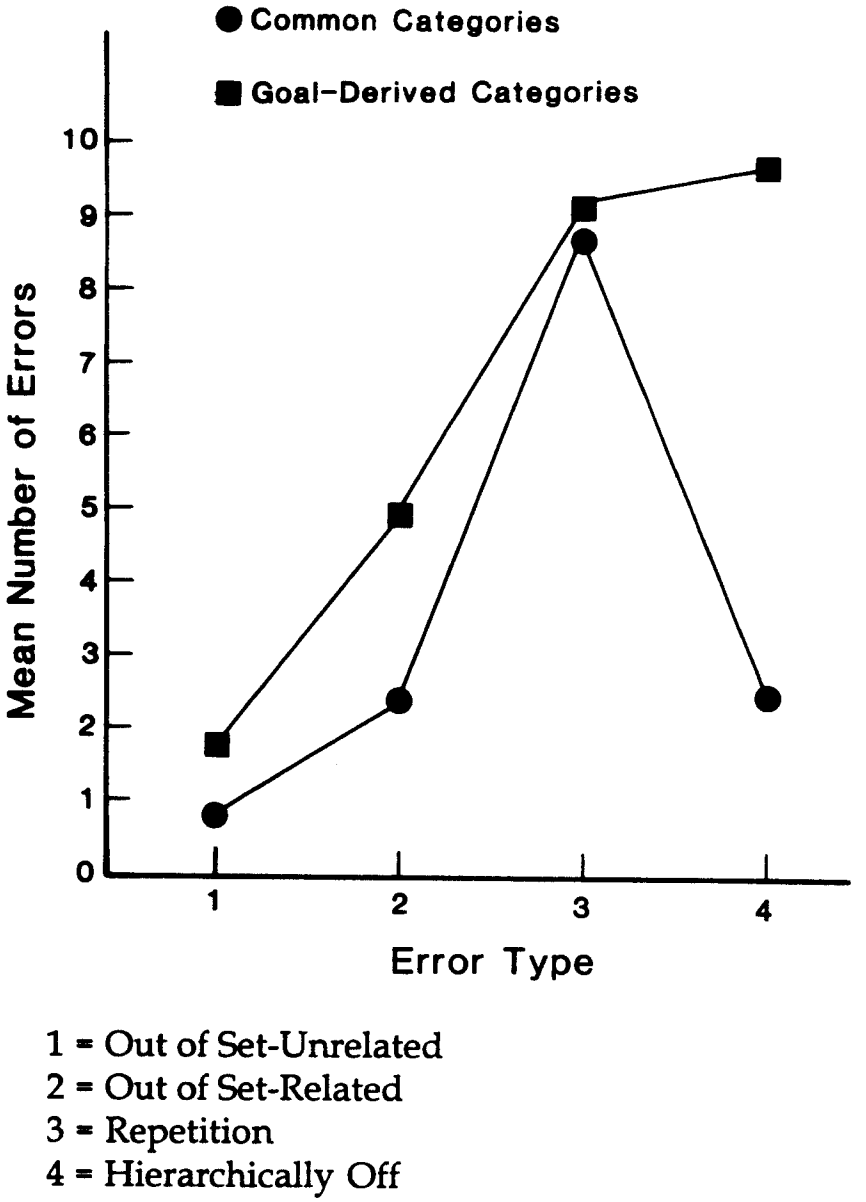

Figure 3. Mean number of errors per error type for the common and goal-derived categories across groups.

the NBD group. Interestingly, however, significant correlations were found between accuracy and standardized test results, for the RBD group, but only for the common categories. These results may suggest that exemplar generation for common categories is an appropriate measure of word retrieval skills, at least for adults with right hemisphere brain damage.

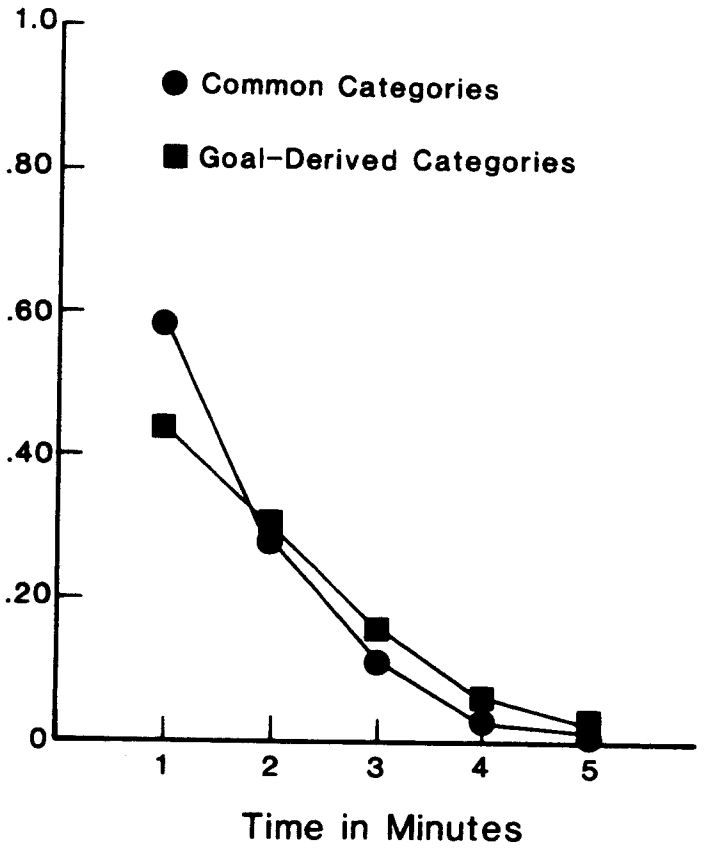

Figure 4. Mean proportion of responses per minute for the common and goal-derived categories across group.

DISCUSSION

In general, although the adults with right hemisphere brain damage produced fewer total and accurate responses for the common categories than the NBD subjects did, the two groups showed a similar overall pattern of performance for this category type. This finding is in agreement with Grossman (1981) and overall may be related to the construction of common categories. These categories appear to consist of actual structures for which an individual has a relatively defined representation in memory. Frequent processing of category information gives rise to the structures for these categories. Thus, the construction process for common categories may involve *automatic* access to the lexicon because of this familiarity with the category information. It is possible, therefore, that generation of category exemplars for common categories is not highly dependent on completely intact directed attentional or organizational skills. These skills

Table 6. Correlation Matrices: Task Performance and Standardized Naming Tests

Right Hemisphere

	MT-C	MT-GD	BNT	TAWF	PRO-C	PRO-GD
MT-C		.260	.152	.022	.316	.178
MT-GD			.141	.078	.165	.276
BNT				.591*	.927+	.237
TAWF					.559*	.433
PRO-C						.297
PRO-GD						

Non-Brain-Damaged

	MT-C	MT-GD	BNT	TAWF	PRO-C	PRO-GD
MT-C		.021	.173	.028	.357	.192
MT-GD			.153	.056	.142	.293
BNT				.881+	.372	.432
TAWF					.255	.458
PRO-C						.751+
PRO-GD						

MT-C: Mean typicality-common
MT-GD: Mean typicality-goal-derived
BNT: Boston Naming Test
TAWF: Test of Adolescent/Adult Word Finding
PRO-C: Proportion of accurate responses-common
PRO-GD: Proportion of accurate responses-goal-derived

+ = Highly significant ($p < .01$)
** = Moderately significant ($.01 < p < .05$)
* = Mildly significant ($.05 < p < .10$)

have been frequently cited as deficient areas for the RBD population (Hough, 1990; Joanette, Goulet, & Hannequin, 1990; Joanette, Goulet, Ska, & Nespoulous, 1986; Myers, 1986). Consequently, damage to the right hemisphere does not appear to affect the construction of common categories.

For the goal-derived categories, the RBD adults produced significantly fewer total and accurate responses than the NBD subjects did. More importantly, however, they showed a pattern of performance qualitatively different from that of the NBD subjects for the goal-derived categories. Other investigations have shown that normal aging adults produce more exemplars for goal-derived than for common categories (Hough & Snow, 1989) and produce more hierarchically off responses for goal-derived than for common categories (Hough, in press). Aphasic adults also have shown this pattern and have been observed to perform sim-

ilarly to NBD adults on exemplar generation for goal-derived categories (Hough, in press; Hough & Pierce, 1988). In the current study, the RBD group showed no difference between category types in regard to the number of either total or accurate responses. Furthermore, although this group showed increased production of out-of-set unrelated errors and reduced production of hierarchically off errors for both category types compared to the NBD subjects, this pattern was significantly more apparent for the goal-derived categories. It is possible that right hemisphere brain damage inhibits the production of hierarchically off responses, particularly for goal-derived categories. The production of these responses by NBD adults may be an actual strategy used to produce more exemplars or to prime memory for production of other in-set responses.

The nature of goal-derived categories may have influenced the RBD subjects' performance. Whereas common categories may consist of defined entities represented in memory, goal-derived category construction appears to involve an actual creation process based on an individual's needs. This category development rests on an organized series of steps that a person must undertake to achieve the goal. Specifically, goal-derived category construction involves a generate-test process in which individuals rely on their previous knowledge and experience to produce dimensions relevant to the goal of a particular category. Persons use the associative structure of related well-established categories, such as common categories, to compare and then generate possible instances of a less established category. Normally aged as well as aphasic adults appear able to use their previous knowledge and experience and apply this information to current situations to achieve goal-derived category goals.

Goal-derived category construction may depend on the ability to make inferences. That is, to develop a goal-derived category, an individual must recognize the primary dimensions of the category and recognize their relationship to one another and to the category context or goal. It has been suggested that individuals with right hemisphere brain damage possess deficient inferential skills (Brownell, Potter, Bihrle, & Gardner, 1986; Joanette, Goulet, Ska, & Nespoulous, 1986; Mackisack, Myers, & Duffy, 1987; McDonald & Wales, 1986; Myers, 1986, 1990). Recently, it has been hypothesized that an inference failure may underlie most of the communication disorders associated with right hemisphere brain damage (Myers, 1990). This impairment may at times disrupt the necessary sequence of events involved in achieving goal-derived category objectives. That is, RBD individuals may not be able consistently to determine the relationship between key elements of a goal-derived category. Furthermore, they may have difficulty relating their previous knowledge and experience to achieve the goal of the goal-derived category in the current context. Consequently, they (a) produce more out-of-set responses that are unrelated to reaching the category objective; (b) produce a small number

of hierarchically off responses, which may inhibit additional production of in-set goal-derived category responses; and (c) produce a greater proportion of atypical responses than NBD subjects do, although they produce fewer responses overall. Thus, it is possible that difficulties with inferential relationships may disrupt RBD adults' ability to generate exemplars consistently throughout the typicality spectrum for goal-derived categories. Their exemplar production patterns across the referential fields of goal-derived categories differ from the patterns of NBD adults. Inferencing ability may be less relevant to the construction of common categories because they are defined constructs in memory involving more automatic access to the lexicon.

Alternative explanations for the underlying bases of deficits observed after right hemisphere brain damage may be applicable to interpreting the current findings. As was previously mentioned, one of the hallmark behavioral characteristics of adults with right hemisphere brain damage is impaired organizational skills. Because these individuals may lack an organizing principle or have poor organizational strategies, they may fail to organize goal-derived category information in a logical pattern, thereby producing many tangential responses. They may verbalize relevant, less relevant, and irrelevant details in trying to achieve the goal of the goal-derived category. Consequently, they produce more atypical and out-of-set exemplars in attempting to organize dimensions relevant to the goal-derived category.

Another possible explanation for the present results relates to a generalized impairment in semantic processing. Although research findings have been unclear as to whether RBD adults display a true lexico-semantic processing deficit (Brownell, 1988; Joanette & Goulet, 1988; Joanette, Goulet, & Hannequin, 1990), this population has been observed to exhibit decreased performance on a variety of lexical and semantic tasks. Adults with right hemisphere brain damage have been observed to identify or produce literal rather than figurative or metaphoric interpretations for contexts or situations (Myers & Linebaugh, 1981; Winner & Gardner, 1977) and choose denotative rather than connotative meanings of words (Brownell, Potter, Michelow, & Gardner, 1984; Brownell, Simpson, Bihrle, Potter, & Gardner, 1990; Gardner & Denes, 1973). In conjunction with the present findings, these results suggest that RBD adults may have difficulty interpreting information beyond the perceptual level. This may occur because of problems integrating or combining semantic cues or associations, which appear to be necessary for the adequate construction of a goal-derived category.

Another possible underlying basis for the current observations may be a deficit in directed attention. RBD adults may be able to focus their attention to perceive or name exemplars but have difficulty combining or relating exemplars to one another to achieve the goal of a goal-derived

category. It's possible that these individuals do not attend to the context or cues of the category label, particularly when it is not a defined representation in memory, as is the case for goal-derived categories.

Finally, the underlying basis for the present findings may be related to the *controlled* or *conscious* activation or access of the semantic component of the lexicon in constructing goal-derived categories. As was stated previously, common category construction may involve only *automatic* activation of the lexicon. Either hemisphere appears to be capable of this type of activation (Chiarello, 1985, 1988b; Joanette & Goulet, 1988); hence, RBD adults displayed minimal deficits in generating exemplars for common categories as they relied on their intact left hemisphere in undertaking this task. Controlled activation of the lexicon may be required for the appropriate generation of goal-derived category exemplars. This type of activation sometimes may involve the integration or semantic facilitation of both hemispheres to varying degrees. However, each hemisphere is unique in its semantic system, with the left hemisphere having a more focal, selective semantic system and the right hemisphere having a diffuse, nonselective system (Chiarello, 1985, 1988a). In the construction of goal-derived categories, there frequently is revision of the initial interpretation of the category goal or supplementation of this interpretation throughout the exemplar generation process. Right hemisphere brain damage may result in overreliance on the left hemisphere's selective semantic system, thus yielding limited interpretations of goal-derived category labels.

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