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Question Asking Strategies of Aphasic and Non–Brain-Damaged Subjects

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Problem solving requires conceptualizing, planning, executing, and modifying strategies on the basis of feedback (Allen, Chinsky, Larcen, Lochman, and Selinger, 1976; Lezak, 1983). This executive function is compromised by brain injury (Ben-Yishay and Diller, 1983; Glosser and Goodglass, 1990; Oddy, 1984; Prescott, Loverso, and Selinger, 1984; Selinger, Walker, Prescott, and Davis, 1993), and for some brain-injured persons problem solving may be impaired independent of successful performance on routine activities (Glosser and Goodglass, 1990; Lezak, 1983; Shallice, 1982; Vilkki, 1988).

The language deficits of aphasic subjects may interfere with the examination of their problem-solving skills. Thus, some investigators have used nonverbal tasks such as the *Tower of Hanoi* to examine problem solving of aphasic subjects (Prescott et al., 1984; Prescott, Gruber, Olson, and Fuller, 1987). However, the results of many studies are difficult to evaluate because subjects do not always complete the task or give up (Mertz-Garcia and Stick, 1986; Selinger et al., 1993; Smith, 1980; Vilkki, 1988). It is also possible that some subjects may fail to see a relationship between tasks such as the Tower of Hanoi and past experiences which may reduce their motivation to complete the task.

Ideally, a task to assess problem-solving abilities of aphasic subjects would have simple instructions, minimal verbal output demands, be sufficiently interesting to motivate subjects to perform it, and have some relationship to the subject's past experiences. The 20-questions task, originally used by Mosher and Hornsby (1966) to study mental operations of normal children and adults, appears to meet most of these criteria. In this task the subject is presented with an array of pictures of items from common categories (e.g., animals), and he or she asks yes/no questions to identify a picture the examiner is thinking of. The goal is to identify the target item by asking as few questions as possible.

Subjects' question-asking strategies on the 20-questions task provide information about their problem-solving abilities. Typically, two types of questions, constraint-seeking (CS) and hypothesis-scanning (HS), are used to solve the problem (Denney, Jones, and Krigel, 1979; Mosher and Hornsby, 1966; Siegler, 1977). CS questions (e.g., "Is it alive?") eliminate more than one item from consideration regardless of whether a "yes" or a "no" answer is received and correspondingly reduce the number of questions needed to solve the problem. Conversely, HS questions (e.g., "Is it the saw?") eliminate one item from consideration with a "no" answer but solve the problem with a "yes" answer. Effectiveness of a CS question is determined by the number of items eliminated. Most studies have shown that normal adults and older children begin the 20-questions task with CS questions that eliminate greater, then fewer numbers of items (Mosher and Hornsby, 1966; Siegler, 1977) and ultimately ask HS questions when the target item is more apparent.

Several recent investigations have shown that the 20-questions task provides a convenient, simple, and objective means of assessing problem-solving abilities of brain-injured subjects (Goldstein Levin, 1991; Laine and Butters, 1982; Levin, Culhane, Mendelsohn, Lilly, Bruce, Fletcher, Chapman, Harward, and Eisenberg, 1993). There is, however, no information available on the performance of aphasic subjects on the task. This study compared the performance of aphasic and normal subjects on the 20-questions task.

METHOD

Subjects

Fifteen aphasic (APH) and 12 non–brain-damaged (NBD) adults participated in the study. APH subjects were at least 8 months post onset, and all had incurred aphasia secondary to single left hemisphere lesion following a cerebrovascular accident. Subject characteristics and relevant test data are provided in Table 1.

Experimental Stimuli

Experimental stimuli were 30 black-and-white pictures of items from the six categories of transportation (ten items), animals (five items), food (four items), tools (three items), furniture (five items), and clothing (three items). A different number of pictures were included in the various categories to encourage subjects to adopt a question-asking strategy that would eliminate greater, then fewer numbers of items. Pictures were displayed individually on 2″×2″ cards arranged on a table before the subject in the 6″×5″ matrix shown in Table 2.

Table 1. Subject Characteristics and Clinical Test Data

	Subjects	
Characteristics	*APH*	*NBD*
Age		
Range	33–70	42–66
Mean	56	53
SD	10.4	6.10
Years Education		
Range	12–18	12–18
Mean	14.7	14.4
SD	2.25	2.27
RCPM Scores		
Range	20–36	22–36
Mean	29	31
SD	5.36	3.76
PICA Overalls		
Range	64–88	
Mean	77.6	
SD	7.07	
Months Post CVA		
Range	8–177	
Mean	76	
SD	55.08	

Note: PICA = Overall percentile on *Porch Index of Communicative Ability;* RCPM = Score on 36 item *Ravens Colored Progressive Matrices.*

Table 2. Arrangement of Experimental Stimuli

Airplane	Pineapple	Canoe	Boot	Fish
Saw	Dog	Desk	Train	Wrench
Bird	Balloon	Hat	Grapes	Monkey
Corn	Hammer	Blimp	Bike	Clock
Chair	Glasses	Car	Cat	Bread
Jet	Ship	Table	Bed	Motorcycle

Procedures

Each subject was given practice on the 20-questions task with nine pictures that were not included in the experiment. Practice continued until the subject understood the task. If the subject asked other than a yes/no question (e.g., "What is it made of?"), the experimenter provided the following feedback: "That's not a question that I can answer 'yes' or 'no'; please ask

another question." The examiner then ensured that each subject could point to and name all of the experimental pictures. First, the 30 stimuli were presented individually to the subject for naming. Next, the items were presented in groups of six, and the subject was asked to point to the item named by the examiner. Subjects who were unable to name or identify experimental items in the pointing task were not included in the study.

The first 20-questions problem was then presented, preceded by the following instructions: "This is a game like 20 questions. I think of one of these pictures, and you figure out which one it is by asking me questions. You may ask any question you want, but I can only answer 'yes' or 'no.' The goal of the game is for you to find the picture I am thinking of with as few questions as possible. There is no time limit." Subjects were given three problem-solving trials targeting the pictures *bread, boot,* and *chair* in counterbalanced order.

Aphasic subjects were allowed to supplement their oral questions by gesture, writing, or both if this facilitated the asking of yes/no questions. After the subject's questions, the examiner turned over the pictures that were eliminated. For example, if the subject asked, "Is it something to eat?" the four food pictures would be turned over with a "no" answer; all other pictures would be turned over with a "yes" answer. A trial was terminated and considered an unsolved problem if, after 11 questions, the target picture was not identified. This was done by giving a "yes" answer to the eleventh question regardless of whether it identified the target or not. During the three trials the examiner provided the subject with feedback similar to that of the practice period when other than a yes/no question was asked. This was necessary on only one occasion, however. All questions were tape-recorded and transcribed verbatim.

After completing the three trials, each APH subject was asked to group the pictures of the array into their superordinate categories (e.g., tools, furniture). Knowledge of subjects' abilities to access and use category information is integral to solving 20-questions problems. Ideally, it would have been advantageous to know something about subjects' categorization skills before the experiment. It was felt, however, that providing them with this information before the experiment might bias their performance on the task. We also wanted to see if subjects would use category-based information independently as a part of their question-asking strategies.

Data Preparation

The number of problems solved and the number of questions needed to solve each problem were counted for each subject. Questions asked on both the solved and the unsolved problems were categorized from the transcriptions as one of three types following procedures of Laine and Butters (1982). **Constraint-seeking (CS)** questions were defined as those that referred to two or more pictures (e.g., Is it furniture?) but would not solve

the problem with a "yes" answer. **Hypothesis-scanning (HS)** questions constituted those that named specific pictures (e.g., Is it the hammer?) and would solve the problem with a "yes" answer. **Pseudo-constraints (PC)** signified queries phrased as CS questions but focused on an attribute associated with one picture (e.g., Does it use paddles?). Like HS questions PC questions solve the problem with a "yes" answer.

Reliability

Interjudge reliability for categorizations of subjects' questions was determined by having two judges independently categorize a randomly selected sample of 30% of the subjects' questions. Point-to-point agreement between the judges was 94% for all judgements. Point-to-point agreement on CS, HS, and PC judgements was 96%, 100%, and 84%, respectively.

RESULTS

APH and NBD subjects solved 24/45 (53%) and 35/36 (97%) of the problems, respectively (Table 3). The mean number of problems solved by the NBD subjects was 2.92 ($\underline{SD}$ = .289). The mean for the APH subjects was 1.60 ($\underline{SD}$ = 1.29). These means were significantly different ($\underline{F}$ (1, 25) = 11.79; $\underline{p} < .01$). Eleven NBD and six APH subjects solved all of the problems. Four APH subjects (subjects 2, 6, 8, 14) solved no problems and were not included in this or any of the data analyses.

Number of questions

Table 3 shows the number of questions asked for each solved problem and the mean number of questions per solved problem for APH and NBD subjects and groups. The mean number of questions used by APH group was 6.88 (Range = 5.0 – 10.0; $\underline{SD}$ = 1.36). The mean number of questions for the NBD subjects was 6.80 (Range = 6.0 – 8.0; $\underline{SD}$ = .591). Although the group means were not significantly different ($\underline{F}$ (1, 21) = .077; $\underline{p} > .05$), it is clear from the data in Table 3 that the mean for the APH group may have been affected by the fact that the mean values for 5 subjects (subjects 4, 7, 10, 13, 15) were based on fewer problem-solving trials.

Types of questions

Table 4 gives the mean percentages of CS and HS questions asked by APH and NBD subjects for the solved problems. Because subjects seldom asked PC questions, and these questions are similar to HS questions, HS and PC

Table 3. Number of Questions Used on Solved Problems, and Mean Number of Questions Per Solved Problem by Aphasic (APH) and Non–Brain-Damaged (NBD) Subjects and Groups. Subjects Not Solving any Problems Were Not Included in the Data Analysis. (U = unsolved problem.)

	Subjects							
	APH				*NBD*			
	Questions/Trial				*Questions/Trial*			
#	*1*	*2*	*3*	*Mean*	*1*	*2*	*3*	*Mean*
1	5	8	5	6.0	5	5	9	6.3
2	U	U	U		7	4	9	6.7
3	8	7	5	6.7	5	8	7	6.7
4	U	U	8	8.0	5	7	10	7.3
5	7	6	7	6.7	7	6	8	7.0
6	U	U	U		7	7	5	7.3
7	U	7	9	8.0	7	6	6	7.3
8	U	U	U		8	6	6	7.0
9	8	11	11	10.0	6	9	9	8.0
10	U	U	6	6.0	9	6	6	7.0
11	6	5	8	6.3	U	6	9	7.5
12	7	8	6	7.0	7	6	5	6.0
13	U	6	U	6.0				
14	U	U	U					
15	U	U	5	5.0				
$\bar{X}$:	6.83	7.25	7.00	6.88	6.45	6.33	7.50	6.79
SD:	1.17	1.83	2.00	1.36	1.21	1.30	1.73	.59

questions were summed for the analysis. The APH group used CS questions 53.36% of the time (Range = 0% – 89%; SD = 29.7%) whereas the NBD subjects exercised this strategy on 74.25% of their question-asking efforts (Range = 52% – 96%; SD = 9.18). Conversely, the APH group used HS questions on 46.80% of their efforts (Range = 11% – 100%; SD = 29.69), and the NBD group employed HS questions 25.75% of the time (Range = 4% – 31%; SD = 9.18). Unpaired t-tests comparing each set of means revealed significant differences between the groups for CS ($t = -2.323$; $p < .05$) and HS ($t = 2.323$; $p < .05$) questions.

Effectiveness of CS questions. The number of items eliminated by a CS question and the order in which the subject asks his or her CS questions reflects the capacity to plan. The number of pictures eliminated by sub-

Table 4. Mean Percentages of Constraint-Seeking (CS) and Hypothesis-Scanning (HS) Questions for Aphasic (APH) and Non–Brain-Damaged Subjects for Solved Problems

Subjects					
	APH			*NBD*	
	CS	*HS*		*CS*	*HS*
1	89	11	1	86	14
3	76	24	2	78	22
4	0	100	3	76	24
5	59	41	4	77	23
7	0	100	5	63	37
9	55	45	6	79	21
10	83	17	7	69	31
11	59	31	8	52	48
12	71	29	9	74	26
13	50	50	10	81	19
15	45	55	11	75	25
			12	81	19
Range:	0–89	11–100		52–86	14–48
Mean:	53.36	46.80		74.25	25.75
SD:	29.68	31.16		9.18	9.18

jects' first, second, and third CS questions across the solved problems was counted and averaged. Figure 1, which gives the composite means for APH and NBD groups, shows that NBD subjects responded predictably. Specifically, they eliminated greater, then fewer numbers of pictures with successive CS questions. The APH group, however, eliminated approximately the same number of pictures with each question. ANOVA results demonstrated significant main effects for groups ($F(1, 19) = 9.74$; $p < .01$) and questions ($F(2, 38) = 6.107$; $p < .01$); there was no significant group by question interaction. Figure 1 also shows that the largest difference between the groups was the number of pictures eliminated by the first CS question.

After the subject has identified the target's category with a CS question, he or she may narrow the choices further with additional CS questions. For example, asking the question "Is it fruit?" after receiving a "yes" answer to "Is it food?" is more effective than asking the HS question "Is it bread?" because it eliminates two pictures rather than one. Mosher and Hornsby (1966) pointed out that the former question serves a narrowing function by

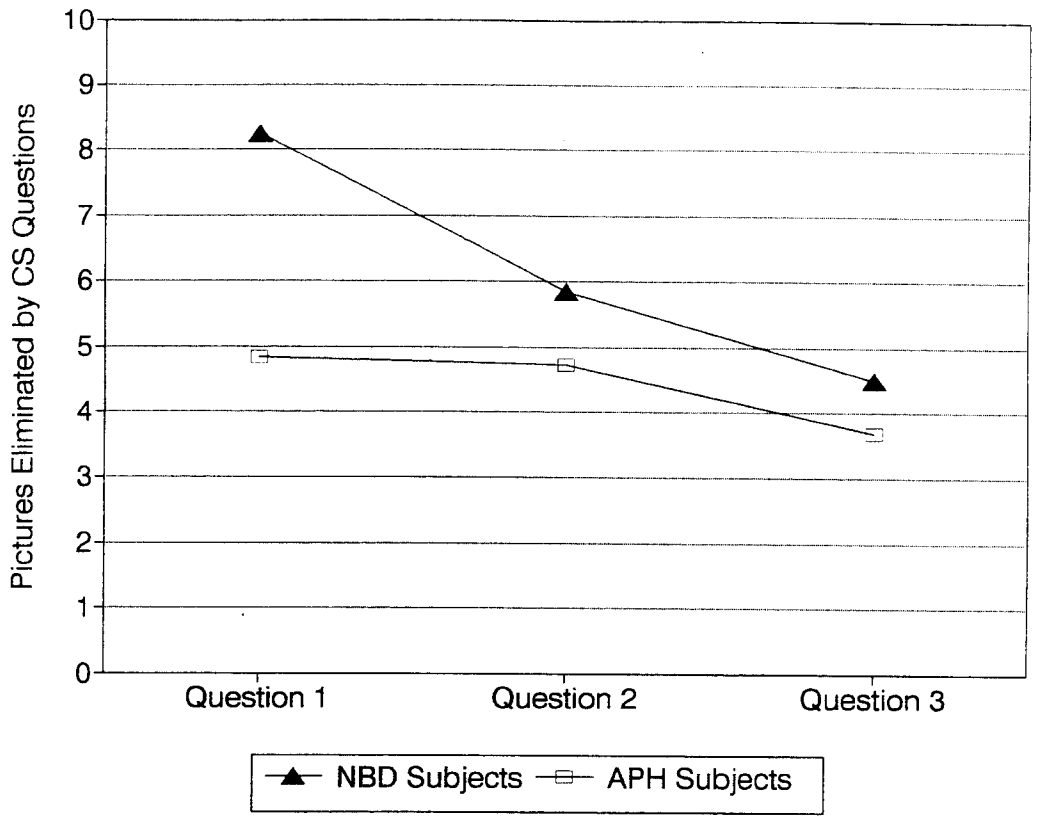

Figure 1. Mean number of pictures targeted by APH and NBD subjects' first, second, and third CS questions for the solved problems.

further restricting the domain. Results revealed that APH subjects used narrowing on only 4/24 (16%) opportunities. Although the NBD subjects did not always use a narrowing strategy, they employed this strategy on 15/35 opportunities (43%).

Unsolved Problems

On the unsolved problems APH subjects asked HS questions (82%) almost exclusively. When HS and PC questions were combined they accounted for 88% of the questions asked on the unsolved problems by the APH subjects.

Categorization Task

While the APH subjects differed in their ability to employ CS question methodologies in solving 20-questions problems, no APH subject had dif-

ficulty grouping the stimulus items into superordinate categories after the experiment was over. Reactions from some of the APH subjects when doing the category-sorting task provide some insights on their use of CS questions during the 20-questions task. These are summarized in the discussion.

Problem Solving and Language Testing

To determine if APH subjects' performance on the 20-questions task was related to the severity of their language deficits, correlation coefficients were computed between subjects' overall Porch Index of Communicative Ability (PICA; Porch, 1981) scores and the percentage of CS questions and the number of problems solved. In both instances the obtained correlations were low and nonsignificant (PICA = CS; $\underline{r} = .03$; PICA = # problems solved; $\underline{r} = -.23$).

DISCUSSION

APH subjects were impaired on the 20-questions task in comparison to NBD subjects. They solved significantly fewer problems and employed different, less effective strategies in solving problems than the NBD subjects. NBD subjects and APH subjects who solved problems used approximately the same number of questions to arrive at solutions, but group differences may have been obscured by the fact that some APH subjects solved problems by guessing.

The most obvious differences between APH and NBD groups were in how they used CS questions to solve problems. Some APH subjects used no CS questions whatsoever. Others asked CS questions, but their questions eliminated fewer items than those of the NBD subjects. In addition, APH subjects seldom used a narrowing strategy. The APH subjects who did use narrowing were those who solved all 20-questions problems and performed most like the NBD group. Asking CS questions that eliminate fewer items may indicate difficulty in planning, conceptualizing the task, or both; lack of narrowing may reflect a problem in switching from one category-based strategy to another.

It is possible that APH subjects who did not use CS questions were steered towards asking HS questions by having to point to and name the experimental stimuli prior to administration of the 20-questions trials. Inability to retrieve category labels (e.g., food, transportation) may also have influenced the use and the effectiveness of their CS questions. That all the APH subjects performed the category sorting task flawlessly does not necessarily mean that all could retrieve category labels to ask CS questions. For example, not being able to access the label "transportation"

could cause an APH subject to ask a less (e.g., "Does it have wheels?") rather than the more effective ("Is it transportation?") question. Different numbers of items were included in the six semantic categories to see if subjects would opt to ask some CS questions before others in solving 20-questions problems. In this study the question, "Is it transportation?" would be an advantageous early question because it would eliminate more items from consideration than other questions. This was the first or second question asked by the NBD subjects on 17/35 of their solved problems. This was not the case for the APH subjects.

Responses from some APH subjects indicate that they may have improved their performance on the 20-questions task with more trials, training, or both. For example, three subjects (subjects 10, 13, and 15) solved the problem on the third trial by using some CS questions. When performing the category sorting task, one subject said, "Oh darn," as if to suggest he regretted not using a category-based approach to the task. Another pointed to each item in the tool category saying, "That, that, and that is one thing." He then wrote the names of the various categories and listed the individual items below.

We cannot rule out completely that language deficits interfered with 20-questions task performance of some APH subjects. Nevertheless, all APH subjects identified and named the experimental stimuli, and grouped items into appropriate superordinate categories. Correlations among PICA scores and 20-questions task performance were not significant. Observation of APH subjects who used no CS questions (subjects 2, 6, 8, 14) and those fortunate enough to solve a problem using HS questions (subjects 4 and 7) suggests that impaired problem solving may be responsible for poor 20-questions performance. For example, subjects 2, 6, and 14 had a history of asking their clinician for help with nonroutine tasks (e.g., filing for a property tax exemption). Subjects 4 and 7 relied on their wives for most problem-solving endeavors. In performing the category-sorting task, none of these subjects showed any awareness that using a category elimination or any other strategy would have aided them in solving 20-questions problems. We are thus inclined to interpret their inferior performance on the 20-questions to defective problem solving rather than their language deficits.

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