Differences Between Normal and Left Brain Damaged (Aphasic) Subjects on a Nonverbal Problem Solving Task

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Throughout the many years of aphasia research the question has been asked whether or not aphasia is a congitive deficit. Weisenberg and McBride (1935) demonstrated that aphasic subjects showed poorer performance on non-verbal tests than a normal control group did. In 1964, Weinstein discussed aphasic patients' defects in "organization and selection of materials" regardless of the nature of the task. Vygotsky (1962) argued that language has become so closely intertwined with thought that any language deficit would necessarily affect cognition. In 1966, Luria concluded from a problem solving experiment that some of his aphasic patients had difficulty grasping logical as well as grammatical relationships.

Problem solving has been described as an overt or covert behavioral process that generates potentially effective solutions to an identified problem. The process then increases the possibility of choosing the most effective alternative from the available others (D'Zurrilla and Goldfried, 1971). There are four component behaviors involved in the problem solving process: (1) understanding the problem; (2) planning a solution; (3) carrying out the plan; and (4) checking and modifying the results (based on feedback). The similarities between this model of problem solving and the communication process suggest that investigation of the problem solving abilities of aphasic patients may lead to new information about aphasia.

Little research has been done linking problem solving abilities and aphasia. Smith (1980) was concerned with examining nonverbal inferential abilities compared with nonverbal memory in aphasic subjects. Subjects were asked either to infer size of objects or make judgments of size based on previously learned information. Smith concluded that intellectual deficits in aphasia result from problems in short term memory and not logical thinking. It is difficult, however, to separate problem solving deficits from memory deficits in this study.

PURPOSE

The purpose of this investigation was to determine whether or not patients with aphasia demonstrated differences from non-brain-damaged subjects on a nonverbal problem solving task.

SUBJECTS

Eighteen patients exhibiting aphasia and 18 nonaphasic (normal) subjects participated. All aphasic subjects were more than six months post onset of becoming aphasic and all were considered (in their medical records) to be neurologically stable. All had experienced only one episode of brain damage following cerebral vascular accident.

METHOD

Using the "Tower of Hanoi" puzzle (see Figure 1) subjects were seated at a table with the puzzle placed before them. The Tower of Hanoi puzzle consists of three disks which must be moved from peg A to peg C. Only one disk can be moved at a time, and no disk can ever be placed on top of a disk smaller than itself. Each move of the disk by a subject was recorded on a problem behavior graph for later analysis. Seven moves are the fewest possible to complete the puzzle. Solution of the problem requires a degree of planning in selecting moves and generating subgoals that will bring the problem closer to solution.

The experimentor repeated the instructions until each subject had no questions regarding the rules of the task. This was to assure understanding of the task by all subjects.

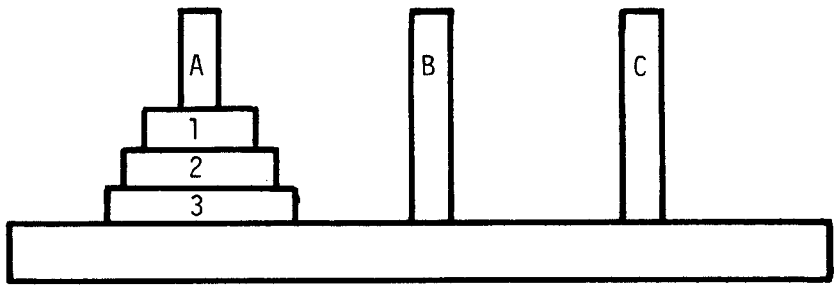

Figure 1. Towers of hanoi problem.

RESULTS

The obtained results indicated that considerable differences existed between the groups (normal and left brain damaged aphasic) in their ability to solve the "Tower of Hanoi" problem. Statistical analyses utilized a Generalized Wilcoxin Procedure (1977) and statistically significant ($p < .01$) differences existed between the groups for the number of moves required to achieve problem solution. The mean number of moves made by the normal group was 7.67 while the mean for the aphasic subjects was 14.67. This mean figure for the group of aphasic subjects is, however, somewhat misleading in that considerable variability of performance was noted for this group. Examination of the data (see Table 1) demonstrated that all normal subjects successfully solved the problem while seven aphasic subjects (39 percent) "gave up" without a solution.

For the normal group the maximum number of moves required for solution of the problem was 11. Seventeen percent or three of the normal group required eleven moves to achieve solution while all others required the minimum number of possible moves (seven). For the aphasic subject group, one subject "gave up" after spending considerable amount of time looking at the problem but making only two moves. Another subject finally achieved solution after 50 moves.

Table 1. Problem solving performance by normal and left brain damaged (aphasic) subject groups.

	n	n	n	n	n
Normal	18	15	3	--	--
Percent of Total	100	83	17	--	--
Brain Damaged	18	4	4	7	3
Percent of Total	100	22	22	39	17

	$\bar{x}$ Number of Moves	Range Number of Moves	Number Fluent Aphasic	Number Non-Fluent Aphasic
Normal	7.67	7 - 11	--	--
Brain Damaged	14.67	2 - 50	5	13

As previously indicated the maximum number of moves required for the normal subjects was eleven. Fifty-six percent or ten subjects in the aphasic group failed to solve the problem in at least eleven moves and/or "gave up" without achieving problem solution.

Five of the aphasic patients were considered by the hospital staff speech and language pathologists to exhibit fluent aphasia while 13 were considered to be nonfluent. One fluent aphasic patient required seven moves and two of the five fluent patients solved the problem in 11 moves. The two remaining fluent subjects required 27 and 50 moves respectively with only the latter achieving solution. Of the thirteen nonfluent aphasic subjects, five solved the problem in 11 moves or less, the normal range. Five nonfluent subjects gave up and three required more than 11 moves to solution. For the fluent subjects then, 60% (3) functioned within the normal range while 40% (2) did not. For the nonfluent subjects 38% (5) functioned within the normal range while 62% (8) did not.

Overall scores on the *Porch Index of Communicative Ability* were used to estimate severity of aphasia. Subjects were divided into three severity groups. Those at or above the 75th percentile were the least involved; those at the 50th to 74th percentile made up a middle severity group, and those below the 49th percentile were considered to be the most severely involved. For the seven patients in the least severe group (39% of the total), four solved the problem in 11 moves or less and three required more than 11 moves. Eight subjects fell into the middle group; four of these subjects solved the problem within the normal range (maximum of 11 moves) and four subjects did not. Three subjects fell into the most severely involved group and all required more than 11 moves.

In summary, the aphasic group of subjects required significantly ($p < .01$) more moves than the normal group and did not always achieve problem solution. For the subjects in the aphasic group that achieved problem solution, eight (45%) did so within the normal range, eleven moves or less. Severity of aphasia and fluency/nonfluency comparisons within the aphasic subject group are difficult to interpret because of the small numbers of subjects within each subgroup.

In addition, an estimate of probability of task completion was computed for the number of moves made by a subject using a stochastic moving process procedure (BMDP1L; 1977). These results indicated that subject moves made beyond eleven became random, or that the probability of problem solution beyond 11 moves is .5.

CONCLUSION

The data obtained in this study indicated that differences existed between aphasic and normal groups relative to their ability to solve the problem studied. The "Tower of Hanoi" problem is different from the problem studied by Luria (1966) in that it is not a "verbal" problem and it is different from that studied by Smith (1980) in that memory does not appear to be a confounding variable. These data suggest that cognitive differences exist between aphasic and nonaphasic subjects. This conclusion suggests the need for research that will determine whether or not problem solving abilities can be taught to aphasic patients. That these abilities can be taught to normals has been demonstrated by Allen, Chinsky, Larcen, Lochman, and Selinger (1976). If problem solving deficits can be remediated in aphasic patients this area represents considerable potential for unmet rehabilitation needs. Chapey (1981) has stated that "...mildly impaired individuals are only impaired in their divergent semantic behavior. Persons with severe aphasia will be impaired in both convergent and divergent semantic behavior." For our patients success or failure on this convergent problem solving task was about evenly split regardless of severity of aphasia (eight patients above the PICA 50th percentile solved the problem while seven did not). Our data suggest a need for methodologies to measure and describe problem solving deficits. Among questions to be answered are whether or not aphasic patients do poorly on nonverbal problem solving tasks because of poor verbal mediation. Will work on nonverbal problem solving have an impact on patient verbal skills? Finally, research needs to be conducted to determine the effects of improved problem solving abilities on general or pragmatic functioning by aphasic adults as well as with nonaphasic brain damaged adults.

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DISCUSSION

Q: I think you've got a real unique methodology here for studying the relationship between language and problem solving skills but I have a question relative to your explanations regarding your findings as to whether or not it would be the result of a linguistic or aphasic impairment or brain damage in general. Did you consider collecting some data on a right brain damaged group and would you care to comment on what your feeling is relative to explaining this result?

A: We suggested in the paper that we need to study other brain damaged groups. Of course we need to test right brain damaged subjects and see how they do. People that I've shown this problem to immediately say "that's a right brain task." But if it's a right brain task you've got to remember that the people who couldn't solve this problem had intact right brains. The question that we have to pursue is whether or not thought mediates language or language mediates thought. I don't know that this comes close to answering that question but it does suggest that people who have left brain damage have difficulty with this kind of nonverbal task. Why they have the difficulty remains to be seen for future studies.

Q: Were subjects allowed to ask for repetition of instructions once the task was under way?

A: No but subjects did understand. We spent time with the subjects before we started and subjects demonstrated that they did remember the rules.

Q: What do you think would happen if you changed the rules? Instead of looking at size maybe color. Do you think that would change your results at all?

A: I don't know. I guess I don't think so.

Q: Would you comment on features that distinguished the group that solved the problem from those who didn't in the aphasic group. Do you have any feeling about the difference between those folks?

A: We really tried to look for that, but I don't have a feel for the differences. We were trying to get at that with the idea of it being a severity issue. There were people who, by those severity measures, were mildly impaired who did poorly and people who were severely impaired who did well. I can think of a couple of people who didn't have much verbal output. I don't know if it was related to what they did premorbidly or not. One guy had been a house builder. He sat down, looked at the problem, didn't hesitate, made seven moves and solved the problem. I don't know if that's because he was used to looking at those kinds of relationships or what. The patients were really variable. You couldn't really predict what a patient would do on this task.

Q: Did you screen for limb apraxia and/or nonverbal memory?

A: No.

Q: Did you have any indications that auditory comprehension maybe had something to do with these performances? Not in the sense that subjects weren't able to understand directions but if there were any relationships between the degree of auditory comprehension deficit and performance.

A: No - we didn't see that kind of relationship but we didn't look at it very formally either. We just went over the directions and people still solved this problem after a lot of moves. One guy got it after 50 moves and if I remember correctly that patient was a fluent aphasic. I know that's not necessarily an indication of poor understanding but it did seem the patients were able to comprehend the task. There didn't seem to be a relationship between deficit, severity, comprehension, etc. and task performance.

C: We have to be careful in saying these are cognitive deficits in aphasia when it may be a function of where that lesion is that goes along with being aphasic. You could have aphasic patients who could do this task, as you did, and didn't show a cognitive deficit and other aphasic patients who happened to have, say a prefrontal extension of the lesion and can't do it because the damage is up front and not because he's aphasic.

Q: The suggestion was that we may have to be training problem solving in folks like this. Did you try to train any of these folks?

A: No we didn't try to train them but this is what we'd like to get into. We want to try to develop some kind of measure of problem solving ability if we can and then see if learning those skills improves their speech and language ability. When we talk about strategies we are teaching patients strategies and we are really teaching them problem solving. So if they really are learning the strategy and if learning the strategy is really the thing that makes them bridge the gap then maybe that's what we ought to be doing all the time.

C: You would expect those who responded quickly to perhaps take more trials, because they do make mistakes, but complete the overall task perhaps in an equal amount of time. Time may be a sensitive measure more so than even language.

C: I have a comment in general. When people say cognitive I'm not really sure what that means and I go back to Wepman's classification system and somebody who's global is cognitively impaired. I don't think cognition means comprehension but I think they're closely allied.