Nonverbal Problem Solving in Aphasic and Non-Aphasic Patients with Computer Presented and Actual Stimuli

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The relationship of language to other mental or cognitive processes is only partially understood. In the 1960's Vygotsky (1962) described language as the central component of cognition and a mediator of problem solving behaviors. Subsequently, Luria (1980) designated language as a key mediator of mental processes. The manner and extent to which the disruption of language present in aphasia affects cognitive processes is unclear. Luria noted the role of aphasia in producing other cognitive deficits, such as the planning and execution of complex behaviors.

Aphasia can also affect problem solving abilities that are not obviously linguistic--for example, arithmetic skills. Weisenberg and McBride (1935) documented the diminished performance of aphasic subjects on typical non-verbal tests compared with normal subjects. Prescott, Loverso, and Selinger (1984) described their use of a puzzle called the Towers of Hanoi to study the relationship of aphasia to problem solving. The puzzle is a visual problem that does not depend overtly on language skills for its solution. Nevertheless, differences existed between aphasic subjects and their controls in the ability to solve the puzzle. A better understanding of the interaction of language, aphasia and cognition becomes increasingly important as we continue to treat all factors affecting the communicative ability of aphasic patients.

Microcomputers provide an excellent opportunity for pursuing research in problem solving. They offer a standard, highly-controlled medium for generating stimuli and obtaining responses. In addition, microcomputers can generate simulations of real-life activities by providing iconic representation of objects. However, these features present additional barriers to patients by requiring abstract thinking and symbolic formulation, and by increasing response requirements. The importance of understanding the cognitive processing of materials presented by microcomputers grows with the application of microcomputers to treatment and education.

This study evaluated the effects of aphasia on solving a nonverbal problem by using different methods of presentation--microcomputer simulation versus actual wooden object. The purpose of the study was to discover potential differences in performance between aphasic and nonaphasic groups, and in computer versus object presentations of the problem.

METHOD

Subjects. Thirty-four male veterans were subjects. Subjects in the experimental and control groups were matched for age and education. The experimental, or aphasic, group consisted of 17 subjects with aphasia subsequent to left hemispheric CVA. Time post onset was at least 6 months duration. The control group contained 17 subjects without aphasia but diagnosed as having non-neurologic, chronic medical problems. Patients with other central nervous system diseases or documented psychiatric disorders were excluded from the study. Descriptive information for all groups of subjects is presented in Table 1.

Table 1. Age, education and test scores (means, with standard deviations in parentheses) for subjects in the study.

Group	Age	Education	PICA Score Overall	PICA Score Verbal	PICA Score Visual	Prog.Matrices Score
APH-COMP (n=8)	58.75 (15.23)	12.38 (3.34)	11.33 (1.61)	11.23 (3.52)	14.86 (0.29)	25.00 (6.03)
APH-OBJ (n=9)	62.22 (9.63)	10.78 (2.17)	10.82 (1.58)	10.66 (3.54)	14.86 (0.18)	22.71 (11.54)
NBD-COMP (n=8)	68.00 (14.08)	11.38 (4.53)				
NBD-OBJ (n=9)	69.11 (15.50)	12.11 (3.26)				

Note. PICA = Porch Index of Communicative Ability, Prog.Matrices = Raven's Progressive Matrices.

Aphasic and control subjects were randomly assigned to one of two experimental conditions. Both conditions presented the Towers of Hanoi Puzzle for the subjects to solve. In Computer Condition, subjects viewed a computer-generated puzzle presented on a 12-inch green phosphor video screen, and were required to press keys 1, 2, or 3 to manipulate the puzzle. In Objects Condition, subjects were presented with an actual wooden puzzle, about 3" X 7" X 4", and were required to physically move the pieces of the puzzle.

Design and Procedures. The Towers of Hanoi Puzzle (Figure 1) consists of three disks to be moved from Peg A to Peg C. Only one disk can be moved at a time. No disk can be placed on top of a disk smaller than itself. The solution to the puzzle requires at least 7 moves. To solve the task the subjects must plan strategies for solution and execute moves that are goal-oriented.

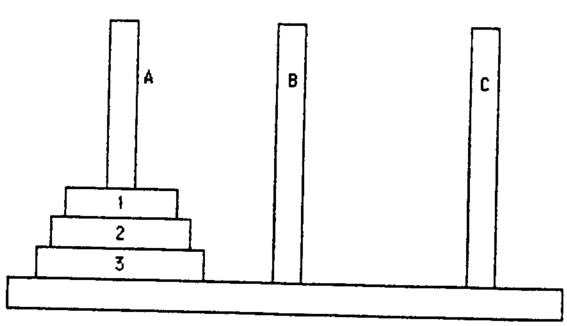

Figure 1. Towers of Hanoi puzzle.

Subjects viewed videotaped instructions on how to manipulate the puzzle. The videotape demonstrated manipulation of the puzzle in the appropriate condition. That is, subjects in the Computer Condition watched a videotape with the computer as the puzzle medium, and subjects in the Object Condition watched a videotape with the wooden object as the puzzle medium. The experimenter then reviewed the instructions with each subject to assure the subject's understanding before presenting him with the actual task. The experimenter began timing the subject as soon as the subject sat down at the table to perform the task. The task continued until the subject solved the puzzle or insisted that he was unable to reach a solution

RESULTS

The 2 X 2 design was analyzed with analyses of variance and t-tests. The dependent measures consisted of whether the subject was able to solve the puzzle, the number of legal moves made, the number of illegal moves attempted, the total number of moves executed, the total time used to complete the puzzle, and the average time per move.

Subjects Solving the Puzzle. Only one control subject was unable to solve the puzzle. He was using the object and quit after 17 moves. The other 16 control subjects in both conditions solved the puzzle in seven to 26 moves. Six (or 35%) of the aphasic subjects in both conditions were unable to solve the puzzle. Table 2 summarizes these results. The difference in performance between subject groups for both conditions combined was significant [$F(1,30)=4.63$, $p < .05$]. When conditions were examined separately, aphasic performance was worse than that of control subjects' in the Computer Condition ($t=2.049$, $df=14$, $p < .03$). The two groups did not differ significantly in the Object Condition. This was probably due to one control subject not solving the puzzle, compounded by the small number of subjects per cell (9).

Table 2. Proportion of patients solving puzzle.

Group	CONDITIONS Computer	Object	Average for Conditions
Aphasic	0.63	0.67	0.65
Non-Brain-Damaged	1.00	0.89	0.94
Average for Both Groups	0.81	0.78	0.79

Average Number of Moves per Subject. When all moves, legal and illegal (Table 3) were considered, the aphasic group initiated more moves than the control group (25.47 versus 13.76; $F(1,30)=6.96$, $p < .02$). When the total number of moves for all aphasic and control subjects was combined, there were no statistically significant differences between the number of moves per condition.

Table 3. Average number of moves, illegal moves, legal moves, total time, and average time (min:sec) per move for subjects in this study.

Measure	Group	Condition Computer	Object	Average
ALL MOVES				
	Aphasic	27.63	23.56	25.47
	Non-brain-damaged	12.25	15.11	13.76
	Average: Both groups	19.94	19.33	19.62
ILLEGAL MOVES				
	Aphasic	11.88	4.56	8.00
	Non-brain-damaged	1.63	2.00	1.82
	Average: Both groups	6.75	3.28	4.91
LEGAL MOVES				
	Aphasic	15.75	19.00	17.47
	Non-brain-damaged	10.53	13.11	11.94
	Average: Both groups	13.19	16.06	14.71
TOTAL TIME				
	Aphasic	21:41	6:26	13:37
	Non-brain-damaged	3:30	2:40	3:03
	Average: Both groups	12:35	4:33	8:20
TIME PER MOVE				
	Aphasic	00:46	00:16	00:32
	Non-brain-damaged	00:17	00:09	00:13
	Average: Both groups	00:31	00:15	00:23

Aphasic subjects attempted more illegal moves (Table 3) than control subjects [$F(1,30)=14.36, p < .001$], especially when using the computer [$F(1,30)=5.55, p < .03$]. When only legal moves were considered (Table 3), aphasic subjects still required more moves than control subjects for the Computer Condition ($t=2.023$, $df=14$, $p=.03$). No significant difference was found between subject groups when comparing number of legal moves for the Object Condition.

Time for Completion. Clear differences arose between groups when the time required for completion was examined (Table 3). The aphasic group required more time to do the puzzle than the non-brain-damaged group (13 min., 37 sec. versus 3 min., 3 sec.) [$F(1,30)=15.80$, $p < .001$]. When time for all aphasic and control subjects was combined, subjects averaged more time when using the computer (12 min., 35 sec. versus 4 min., 33 sec.) [$F(1,30)=9.13$, $p < .01$]. Much of this difference between conditions resulted from the aphasic subjects who required considerably more time to solve the problem on the computer (over 21-1/2 min.) than aphasic subjects using the object. Control subjects solving the puzzle required considerably less time than the aphasic group when using either the object or the computer [$F(1,30)=7.33$, $p < .02$].

Thus, the aphasic subjects working with the computer required an average of over 21 minutes, compared with less than 7 minutes for any of the other combinations of subjects and conditions.

Average time per move was calculated by dividing the number of legal moves by the total time. Aphasic subjects demonstrated the highest average time per move (46 sec.) while performing in the Computer Condition (Table 3). When compared with the other groups, this interaction was statistically significant [$F(1,30)=7.31$, $p < .02$]. For both conditions, aphasic subjects demonstrated greater time per move than control subjects [$F(1,30)=17.09$, $p < .001$]. When subject groups were combined and conditions compared, the Computer Condition required greater average time per move than the Object Condition [$F(1,30)=20.33$, $p < .01$].

CONCLUSIONS

The results suggest impaired performance by aphasic patients when compared with a control group on a nonverbal task, regardless of the medium used to present the task. Six differences were found between aphasic and control groups: aphasic subjects achieved fewer solutions, required more time to complete the puzzle, required more moves, attempted more illegal moves, and on the average required more time per move than control subjects. Additionally, the results demonstrate that using the computer and all it entails rather than the actual wooden object requires more time for aphasic patients to perform the task and results in increased errors when measured by illegal moves. These results highlight two issues: The appropriate use of computers as a rehabilitative tool and the role of aphasia in executing nonverbal, goal-directed behaviors.

This study could not evaluate whether the increased performance time on the computer resulted from difficulty in perceiving the task when presented in a two-dimensional, iconic format, or in using the computer keyboard to execute the task. Both limitations are inherent in what is currently the standard microcomputer configuration. The puzzle as a wooden object is three dimensional and uses familiar, natural hand movements to move the pieces directly. The computer requires that the subject use a two-dimensional representation and translate movement of the pieces into key presses. These conceptual permutations appear to increase delay and difficulty for aphasic subjects. Although a valuable tool in rehabilitation, the results emphasize limitations of the computer with aphasic patients.

The results also suggest that nonverbal problem solving is diminished in aphasic subjects using either an object or a computer as the medium for the task. The reason for this relationship remains a theoretical issue, however. Does language mediate even the most overtly nonverbal tasks, or is language merely one of many behavioral manifestations affected when brain structures are impaired? This study along with others points to the pervasive role of language in goal related activities.

REFERENCES

Katz, R.C. Aphasia Treatment and Microcomputers. San Diego, CA: College Hill Press/Little-Brown, 1986.

Luria, A.R. Higher Cortical Functions in Man. New York: Basic Books, 1980.

Prescott, T.E., Loverso, F.L., and Selinger, M. Differences between normal and left brain damaged (aphasic) subjects on a nonverbal problem solving task. In R.H. Brookshire (Ed.), Clinical Aphasiology: Conference Proceedings, 1984 (pp. 235-238). Minneapolis, MN: BRK Publishers, Inc., 1984.

Vygotsky, L.S. Thought and Language. Cambridge, Massachusetts: MIT Press, 1962.

Weisenberg, T.M. and McBride, K.E. Aphasia: A Clinical and Psychological Study. New York: Commonwealth Fund, 1935.

DISCUSSION

Q: Was a clinician present with the subjects when they were using the computer to solve the puzzle?

A: Yes. The two conditions were identical in all aspects except for the use of the microcomputer and the objects as the puzzle medium. The role of the clinician in both conditions was the same: to record performance and respond to illegal moves. In the computer condition, the clinician also was responsible for orienting the subject to the computer keyboard and display.

Q: In many studies, rather than comparing the effects of the clinician and the computer, we are comparing clinician only and computer with clinician present. Are we yet to demonstrate that we don't need a clinician present when an aphasic patient is using the computer? Do we need a clinician present when an aphasic patient is using a computer?

A: Some patients are capable of successfully using the computer with a certain degree of independence, and this has been demonstrated by a number of microcomputer studies, some presented over the past few years at CAC. In these studies, experimenters were present during the computer session, but did not provide subjects with any assistance once basic computer operating skills were demonstrated.

Whether or not a clinician should be present during computerized treatment is another question. The answer depends entirely on the patient and the software. Initially, no patient should be left alone with the computer, just as a patient should not be left unsupervised to work with any other form of treatment material. Once familiar with the computer and a particular treatment program, most clinicians can determine whether or not the patient could work without constant supervision. Severely impaired patients may be able to work with simple drills and mildly impaired patients may be able to work with complex, interactive programs. As software becomes more sophisticated, though, the responsibilities of the attending clinician will become more complex, especially from the perspective of providing and modifying treatment and evaluating performance. These responsibilities can best be accomplished by an experienced clinician.