Bilateral Hand Performance With Divided Attention After a Cerebral Vascular Accident

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A divided attention task was used with 10 left or right cerebral vascular accident (CVA) subjects who had return of functional movement in the affected extremities. The primary task was one subtest of the Jebsen Hand Function Test. The secondary task was a foot press to a series of auditory cues. Four measurements were obtained for each subject at intervals of 1 month, 2 months, and 3 months after the stroke. Comparison scores on this procedure were also obtained on 5 normal subjects.

The results indicated that dividing attention in the CVA subjects significantly decreased the performance on the primary task. The performance with the affected limb improved over the 3-month time period and reached a level of performance that was not significantly different from that of the unaffected limb for either the undivided or divided attention task. Implications for occupational therapy environments and consideration of attention limitations are discussed.

Purposeful activity has been defined as goal-directed activity that organizes an adaptive response by directing attention toward the object or task rather than toward the movement (King, 1978). Therefore, involving the patient in certain tasks is pertinent for relearning coordination and skill. New tasks are often complex, requiring considerable attention of the patient. For performance to be functional, portions of the activity may need to become automatic so that the remainder of the patient’s attention can be directed toward other environmental demands. By increasing practice and repetition, movements may become automatic for the patient and not require as much attention.

Cerebral vascular accident (CVA) patients have difficulty attending to critical components of activities, perhaps because they need to monitor the affected limb while performing the task. Tasks that were once automatic now require considerable attention to perform. This especially limits the patients’ functional abilities when they are performing more than one task concurrently.

Few studies have examined the relearning of motor tasks with stroke patients, and most of these studies investigated motor performance in relation to hemispheric function. Studies by Jason (1983a, 1983b) and Heilman, Schwartz, and Geshwind (1975) demonstrated that the generation of motor acts was lateralized to the left hemisphere. Furthermore, certain types of acts like copying, sequencing, and ordering were particularly impaired by patients with left hemispheric damage (Kimura, 1977; Kimura & Archibald, 1974; Kimura, Battison, & Lubert, 1976; Kolb & Milner, 1981; Roy, 1981).

Another important area of motor learning is the role of attention and how it might change as a task is learned. Many times we find it difficult to execute two tasks together although each alone is easy. When learning a new skill, we may only be able to perform it with much concentration and effort. With practice the skill is performed with less attention and is often referred to as automatic.

Attention research originated from the field of experimental psychology and has been devoted mostly to investigations with normal subjects. The design most commonly used to empirically test attention is the dual-task design (Brown, 1962). This is achieved by having the subjects first perform a single or undivided attention task. Then a secondary task is introduced to divide the subject’s attention. Two main measures are obtained: (a) the performance on the undivided attention task and (b) the performance on the divided attention task during the performance of the secondary task. A comparison is then made. If performance is decreased on the divided attention task, then it can be assumed that both tasks require...
attention or that both tasks require more than the subject's limited attentional capacity.

Secondary task techniques have been examined since the early 1900s and have provided an objective measurement in understanding the role of attention in the production of movement (Klein, 1976). Binet (as cited by Klein) found that mental activity interfered with simple motor performance such as the repetitive squeezing of a rubber ball. Welch (1898) documented the same interference with exertion of maximal force and mental activity. Both Binet and Welch demonstrated that even the simplest motor acts require attention.

In recent years, the secondary task technique has been used in a variety of ways to study the role of attention in motor skills (Klein, 1976). It has been used as a probe to measure the attention demands of skills under different conditions (Michon, 1966). It has also been used to occupy the subject's attention, to determine if a particular skill can be performed automatically, or to determine which aspects of the skill do not suffer from the withdrawal of attention (Pew, 1974).

Posner and Keele (as cited by Klein, 1976) studied the attentional demands of simple movements using a probe technique. They found that the initiation of the movement required considerable attention, and these attention demands were not related to movement accuracy. The attention required during the course of movement decreased after the movement was initiated and rose again near the termination of the movement. However, this latter finding may have been due to flaws in the experimental procedure, and it is questionable whether the termination of the movement requires increased attention (Ells, 1975).

Although it appears that attention is required for performance when a voluntary motor task is learned, it is also a well-known and documented phenomenon that, given sufficient practice, voluntary acts appear to lose their reliance on attention and can be performed automatically (Stelmach & Larish, 1980). A common example of this automatic behavior can be seen in the person who repetitively drives a vehicle with standard transmission. The movements necessary for shifting the gear level and pushing the clutch with the foot are so habitual that the motions still occur when the person begins driving a car with an automatic transmission. The most probable explanation for skilled movements that appear to be carried out automatically is that, with practice, the proprioceptive feedback from the movement becomes redundant, and attention toward the monitoring of this feedback is no longer necessary (Marteniuk, 1976).

The stroke patient with a hemiplegic limb presents a problem in motor relearning. Therefore, the study of attention and movement should be applied to the stroke population. The literature does not cite any studies that investigate CVA damage with divided attention tasks. On the other hand, there have been several studies of lateralization and motor performance in stroke patients. The research on attention demands and movement in normal subjects is also considerable. A natural progression would be to carry out studies investigating the attention demands of movement with patients who have had CVAs. Furthermore, many patients have some movement in the hemiplegic limb, but how the patterns of automatic movement are affected has yet to be investigated. Because of the significance of motor performance with CVA patients, this study examined automatic behaviors in relation to attention factors.

The following hypotheses were tested: (a) There would be a difference in performance on the task between left-CVA and right-CVA subjects, (b) performance would be worse on the divided attention task than on the undivided attention task for the normal control group and both groups of patients, and (c) performance with the affected limb of the CVA subjects would improve over a 3-month time period but would not reach the level of performance of the unaffected limb on either the undivided or divided attention tasks.

### Methods

#### Subjects

The experimental subjects were 10 CVA patients from a home health care population who volunteered for this study. The control group was composed of 5 normal, age-equivalent volunteer subjects (see Table 1).

Experimental subjects were selected after meeting the following research criteria:

1. more than 65 years old
2. right-handed prior to CVA
3. lateralized CVA to either left or right hemisphere (confirmed by conventional brain scan, computerized axial tomography, or electroencephalogram)
4. no previous cerebral vascular trauma
5. intact sensation of affected upper extremity
6. no deficits of apraxia, hemianopsia, or visual/spatial dysfunction

### Table 1

<table>
<thead>
<tr>
<th>Subject Group</th>
<th>Mean Age (years)</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left-hemisphere CVA</td>
<td>74.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Right-hemisphere CVA</td>
<td>81.0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Control (normal)</td>
<td>75.4</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

...
7. Function of the affected upper extremity relatively independent from synergy
8. Functional ability of one lower extremity to perform tapping task for 20 seconds with accuracy to auditory cues
9. Hearing observed to be within normal limits

The hospital stay for the experimental subjects varied from 2 to 4 weeks; all had been admitted to the same hospital. At the time of this study, each subject was living at home and receiving occupational therapy three times a week for 45 minutes per session from the examiner. An informed consent form was signed by each subject. The procedures for the study were approved by the Committee on Human Research of Colorado State University.

**Apparatus**

The apparatus for the undivided attention task (primary task) consisted of five full (1 lb) No. 303 cans placed in front of a board clamped to the desk in front of the subject, 5 in. from the front edge of the desk. The cans were spaced 2 in. apart (subtest 7 of Jebson Hand Function Test, Jebson, 1969).

The divided attention task (secondary task) required a foot tapping board, a recorded cassette tape (1-min length) of musical 1-second tones (randomly spaced with an average interstimulus interval of 2.5 seconds), in addition to the 1 lb cans.

The foot tapping board was constructed of ¥1/4-in. plywood with a base measuring 2 ft by 1 ft. An automatic release foot lever (wood paddle, 4 in. by 6 in.) was attached to a counter hinge, and this lever component was placed 1 ft from the end of the base. Foot placement was adjustable, according to the subject's comfort level for the task. Tapping occurred as the heel of the foot remained on the board and the toe pressed the counting lever. After each press, the subject lifted the toe and the foot lever returned to the original position. The toe maintained contact with the lever continuously during this task.

**Procedure**

Each subject was tested under four different experimental conditions. Subjects were tested in a quiet room of their home where seated at a table or desk 29 in. high. The first two conditions required each subject to perform the primary task, once with the left hand and then with the right hand. This task was administered according to the Jebson Hand Function Test (subtest 7). The procedures from this standardized test were as follows: Five 1 lb cans were placed as described above. The subject was instructed to place one hand on the table. When the subject heard the command "Go!", he or she stood the cans on the board as fast as possible. Subjects began with the can nearest to the hand being tested. Timing was from the command “Go!” to the release of the fifth can. This was considered the primary task in this experiment.

The next two measurements consisted of performance on the Jebson Hand Function subtest 7 with concurrent performance of the secondary foot tapping task. The secondary task was used to divide the subject's attention and was administered by placing the foot tapping board in correct position under the subject's preferred foot. The subject was seated in the same position he or she assumed when performing only the primary task. The foot tapping was performed to a series of randomly spaced auditory cues from the recorded cassette tape. Tape initiation varied with each trial, so there was no learning effect within subjects.

Performance was timed for the Jebson subtest while the subject's attention was divided with the secondary task. This provided a measurement of left-hand performance and right-hand performance with undivided and divided scores for each. Performance on the foot tap was not recorded but was observed to make sure subjects actually performed the task. Each set of four scores obtained from each CVA subject was gathered at intervals of 1 month after the CVA, at 2 months after the CVA, and at 3 months after the CVA, yielding a total of 12 measures. The control group subjects only performed the tasks once, yielding a total of four measures. However, to assess the progress of the CVA subjects, the control group data were also compared with the 3rd-month CVA data. A practice trial was administered prior to each procedure.

**Results**

A within-subjects, repeated measures analysis of variance (ANOVA) was performed on the control group data for the variables of attention and hand. A significant main effect was found for the variable of attention ($F = 26.15; df = 1,4; p < .01$). It took subjects longer to perform the task under divided attention.
conditions than under undivided attention conditions. There was no significant main effect for the variable of hand. Also, there was no significant interaction between hand and attention. Therefore, within the control group, performing a divided attention task decreased performance.

To determine the effects of the experimental variables (CVA hemisphere, attention, hand, and time) on the experimental subjects, a four-factor, mixed ANOVA was performed. There was no significant main effect for site of lesion. Figure 1 demonstrates the significant main effect for attention ($F = 40.27; df = 1.8; p < .001$). This indicated that among subjects who have either right or left CVA, performance was better with an undivided attention task than with a divided attention task.

A significant main effect was found for hand ($F = 5.22; df = 1.8; p < .05$) indicating that the unaffected hand was significantly better than the affected hand on performance of the task for the experimental subjects averaged over all other variables. More important, however, was the significant interaction effect between the variables of hand and time ($F = 3.91; df = 2.16; p < .05$). This interaction (see Figure 2) indicated that although there were significant differences between hands for Months 1 and 2, by the 3rd month these differences had disappeared (Newman-Keuls post hoc test). There were no other significant interaction effects.

To compare the performance of the control group with that of the two experimental groups, two different analyses were performed. In the first analysis, performance data from the control group were compared with the 1st-month data of the experimental groups. This was done to achieve a baseline measurement from which to judge possible improvement by the two experimental groups for later comparison of task performance. A 3-factor, mixed ANOVA analyzed the factors of hemisphere (no damage, left-side damage, and right-side damage), attention (undivided, divided), and hand (unaffected, affected). There were significant main effects for hemisphere (see shaded blocks in Figure 3) ($F = 6.33; df = 2.12; p < .02$), indicating that the control group's overall performance was significantly better than the 1st-month performance by the two experimental groups.

There were also significant main effects for attention ($F = 60.78; df = 2.12; p < .01$), with divided attention slower than undivided attention, and hand ($F = 7.18; df = 2.12; p < .02$) with affected hand slower than unaffected hand.

A second ANOVA compared the control group data with the 3rd-month data of the two experimental groups to determine the relative improvement of these two experimental groups over time. The results of this analysis showed no significant main effects for hemisphere. This is shown in Figure 3 (unshaded blocks). There was a significant main effect for attention ($F = 42.82; df = 1.12; p < .01$) as expected. Interestingly enough, there was no significant main effect for hand ($p < .08$) although this difference approached significance.

**Discussion**

The results of this research demonstrated that implementing a control group of subjects with no CVAs was useful not only in enabling comparisons over time between experimental and control groups to monitor improvement but also in verifying the procedure as effective in dividing attention. It was determined that the control group subjects performed better on the undivided attention task than on the divided attention task. There was no CVA factor in the control group, thus it was expected that there might be a difference in performance related to hand dominance. This did not prove to be correct. The control subjects did not demonstrate more difficulty in performing the task with one hand or the other. This possibly indicated that the tasks (can displacement and tapping with the foot) were equal in their utilization of right and left hemisphere functioning. According to recent research (McFarland & Ashton, 1975), when there was a verbal component to the task, the performance was enhanced when the left hand was used and impaired.
when the right hand was used. The opposite effect was reported when a spatial task was used. The primary and secondary tasks in this experiment were designed to eliminate verbal components and minimize the spatial elements.

The first hypothesis, which stated that there would be a difference in performance between left- and right-CVA patients, was not supported. It might be expected that a left CVA would cause more general (bilateral) movement problems than a right CVA. The studies that have supported this idea were directed at the area of apraxia and demonstrated that left-hemisphere damage resulted in poor movement control bilaterally (apraxia) (Kimura, 1977; Mateer, 1977; Wyke, 1967; Wyke, 1968). The conclusion that the subjects were screened for apraxia problems; subjects were not included if there were indications of apraxia.

Within both experimental groups (left and right CVA), the subjects performed better on the undivided attention task than on the divided attention task. This finding supported the second hypothesis, yielding considerable implications for the rehabilitation of CVA patients.

The most important finding of this research was that the affected hand improved over time. By the 3rd month, the performance of the affected hand was not significantly different from the performance of the nonaffected hand, regardless of whether attention was divided or undivided. Therefore, the third hypothesis was not supported. It could be speculated that this improvement occurred because of the therapy being received, but this conclusion could not be drawn from this study. If there had been a CVA group not receiving therapy, the data might have supported this conclusion. Further research could address this issue by including a no-treatment CVA group to examine the effectiveness of various therapeutic techniques. A second possible explanation is that the improvement of the affected hand occurred because of a spontaneous recovery of the damaged area of the brain. This explanation could only be tested by having a CVA group receiving no treatment or practice. Another possible explanation is that the subjects performed many bilateral tasks and practiced for the current task situation.

This study should form a basis for further expansive research. The sample size was considered a limitation in that there were only 7 left-CVA patients and 3 right-CVA patients. However, this was realistically difficult to alter. Locating stroke subjects who met the screening criteria proved to be a difficult task. Another limitation was not having the control group perform the task at 1 month, 2 months, and 3 months. It could be postulated that practice would have improved their performance over time. This seems unlikely, however, since the scores on the nonaffected hand for the CVA groups remained relatively stable over time.

Further research should include an experimental group who received no occupational therapy. It would also be beneficial to extend the time variable to 6 months. There is also a need for using a variety of tasks in comparing attention and motor performance. It is recognized that the tasks used in this study are not easily generalizable to all occupational therapy activities.

When planning treatment, it is imperative that professionals facilitate maximum performance by structuring and simplifying the environment. It seems necessary to eliminate all extraneous stimuli so that attention can be directed to the task at hand. Activity analysis must also include an analysis of the environment in which the activity takes place. Many times, therapists assume that a CVA patient can perform a component of a task "automatically." Because therapists often lack knowledge about attention and automatic movement, extra stress may be placed on the patient. It follows that stress results in information from the environment not being integrated or adapted. King (1978) proposed that one of the presuppositions of occupational therapy is that for adaptation to occur, movement must be organized below the level of consciousness, with conscious attention being directed to objects or tasks. Therapists should be aware that at least initially, CVA patients may not be able to direct conscious attention in the same manner as do patients with other diagnoses. Therefore, simplifying or reducing the environmental inputs may allow the stroke patient to become more efficient with the hemiplegic limb so that more complex tasks can then be added.

Because of the improvement noted over 3 months, the question of the best time to start therapy must be addressed. Most third-party payers will reimburse rehabilitation after a CVA for 2-3 months. If further research could demonstrate that improvement continues beyond this 3-month period and that the improvement is related to treatment, there may be justification for more long-term rehabilitation.

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References


