Gross Motor Activity and Attention in Three Adults With Brain Injury

Ayala Shimelman, Jim Hinojosa

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Objective. In this single-subject study, we evaluated the short-term effects of gross motor activity on the attention behavior of three adults with brain injury. Additionally, observation data were collected on each subject's performance.

Method. The effects of gross motor activity on the subjects' attention behavior was measured by performance on visual letter cancellation tasks. The three subjects with brain injury were a 59-year-old woman, a 52-year-old man, and a 26-year-old woman. Data for each subject were graphed and visually analyzed. Observation data for each subject also were examined.

Results. The results did not indicate meaningful differences in the subjects' performance of letter cancellation tasks after gross motor activity. However, positive changes in scanning and checking behaviors were noted.

Conclusion. This study did not demonstrate improvement in attention behavior after gross motor activity according to the measures used. However, the study supports that observations can help to identify important factors that may influence treatment outcomes. Further study is needed to determine the nature of the relationship between gross motor activity and attention.

Attention is a basic process required for cognitive functioning that is essential for any activity (Ben-Yishay, Piasetsky, & Rattok, 1987; Duchek, 1991; Posner & Rafal, 1987). Brain injury results in changes in cognitive functioning, the most common of which is attention deficit (Ben-Yishay et al., 1987; Posner & Rafal, 1987; Sohlberg & Mateer, 1989). Because of the range and degree of disabilities associated with attention deficits, attention is a major concern of occupational therapists who work with persons with brain injury (Abreu & Hinojosa, 1992; Abreu & Toglia, 1987). Behaviors identified with attention deficits include insufficient alertness, inability to focus and sustain attention while ignoring irrelevant stimuli, and inability to shift attention (Ben-Yishay, Rattok, & Diller, 1979). Further, attention deficits disrupt other cognitive processes, mask residual abilities, and interfere with learning and recovery (Ben-Yishay et al., 1987; Siev, Freishtat, & Zoltan, 1986; Wood, 1984).

Attention is the ability to be aware of and respond to stimuli; to focus on the desired information and ignore irrelevant information; to shift the focus to other information if necessary, and to sustain the focus (Ben-Yishay et al., 1987; Duchek, 1991; Pryse-Phillips & Murray, 1992; Sohlberg & Mateer, 1989). Attention is believed to be regulated through the reticular formation, hypothalamus, hippocampus, amygdala, and frontal cortex (Ayres, 1972; Bracy, 1972; Gronwall, 1987; Luria, 1973). Three dimensions of attention discussed in this article are arousal, selection, and vigilance (Ben-Yishay et al., 1987; Duchek, 1991; Nissen, 1986; Sohlberg & Mateer, 1989; Weinberg & Harper, 1993)

Arousal (sometimes referred to as alertness) is a person's general responsiveness, or readiness to respond to information that needs to be acted upon. It ranges from absence, as in a state of coma, to overarousal, as in hyperactivity (Bracy, 1972; Nissen, 1986; Posner, 1975; Wood, 1984). Deficits in arousal result in insufficient alertness; increased reaction time; fluctuating attention; difficulty to focus, shift, or sustain attention; and perseveration (Ben-Yishay et al., 1987; Sohlberg & Mateer, 1989; Wood, 1984)

Selection is the process by which attention is directed to desired information, while excluding all other information (Ben-Yishay et al., 1987; Duchek, 1991; Nissen, 1986; Posner & Rafal, 1987; Siev et al, 1986). It facilitates information processing through a sensory input or stored memory, so attention can be focused either on the environment or on thought content. Selection enables a person to shut off external stimulation as well as to shift the focus of attention to other information, if needed. Shifting attention involves disengaging attention from one focus, moving it to another, and engaging the new information (Ben-Yishay et al., 1987; Duchek, 1991; Nissen, 1986; Posner & Rafal, 1987). Therefore, deficits in selection result in difficulty in focusing or shifting attention. A person with selection deficit may be distractible (i.e., have...
difficulty in engaging attention on a stimulus), be perseverative (i.e., have difficulty in disengaging attention from a stimulus), or both (Nissen, 1986; Wood, 1984).

Vigilance is the degree of conscious effort invested by a person to maintain attention (Ben-Yishay et al., 1987; Posner, 1975; Pryse-Phillips & Murray, 1992; Sohberg & Mateer, 1989; Weinberg & Harper, 1993). When persons with brain injury are presented with tasks that are cognitively demanding, or with increased amounts of information to process, they may have difficulty with vigilance (Sohberg & Mateer, 1989). A deficit in vigilance results in difficulty focusing attention on a task over time (Gentilini et al., 1985).

Methods commonly used by therapists to promote attention in adults with brain injury emphasize remediation of the person’s specific deficits. They include practicing tasks that require attention to enhance attention behavior. For example, the Orientation Remediation Module requires that a person responds to visual or auditory stimuli presented in a hierarchical order of complexity (Ben-Yishay et al., 1979). The Attention Process Training program requires that a person focus on verbal and visual stimuli with increasing demands on speed, accuracy, and focusing in the presence of distractions (Sohberg & Mateer, 1989). Other methods include environmental structuring, use of cuing techniques, task analysis and adaptation, and external prompting (Siev et al., 1986).

A few studies with children have demonstrated that gross motor activities could enhance aspects of attention. Gutin and DiGennaro (1968) found that 5 min of a step-up task improved performance on a mathematical addition problem by physically fit children. Cratty (1972) described a study from Japan that determined that children who exercised on a bicycle demonstrated improved discrimination abilities. Malory and Charette (1970) found that walking forward, backward, and sideways on an elevated board heightened attention in children with mental retardation, resulting in improved performance on visual discrimination tasks. Finally, daily sensorimotor activity provided to preschoolers improved their performance on digit-span activity (McCormick & Schniebrich, 1971).

In clinical practice, the first author had observed improvements in the attention of adults with brain injury who engaged in gross motor activities. To test this observation, we selected a single-subject ABA reversal design (Barlow & Hersen, 1984; Ottenbacher, 1986) to examine the result of gross motor activities on the attention behaviors of three adults with brain injury as measured by their performance on letter cancellation tasks. This applied scientific inquiry (Mosey, 1992) aims to gain practical information, not to refine or test the theoretical information fundamental to this treatment technique.

Single-subject designs are commonly used to measure individual changes in performance following intervention. They also can be used to study clinical changes, even in populations with a diversity of lesions and behaviors. Single-subject studies do not interfere with the process of intervention, can be designed to be sensitive to individual subject needs, and can incorporate the measurement of observational data.

Method

Subjects

The three subjects in this study came from the population of a day rehabilitation program for adults with brain injury. Each subject provided written informed consent.

Subject 1 was a 59-year-old woman who had sustained an aneurysm. After a craniotomy and therapy in a general hospital and in an inpatient rehabilitation facility, she was admitted to the day rehabilitation program. At the time of the study, she manifested arousal deficits, distractibility, delayed verbal responses, inability to sustain attention for more than a few minutes, and dozing off during treatment sessions. Subject 1 required assistance to maneuver her manual wheelchair.

Subject 2 was a 52-year-old man who had sustained a closed head injury secondary to a fall. After therapy in a general hospital and in an outpatient rehabilitation facility, he was admitted to the day rehabilitation program. He had a history of alcohol abuse but was not drinking at the time of this study. He manifested distractibility, difficulty maintaining the topic of conversation, and a tendency to wander off. He could focus on a task for up to 20 min without stopping. In spite of poor balance, he ambulated with a cane using a slow and unstable gait.

Subject 3 was a 26-year-old woman who had sustained a closed head injury during a motor vehicle accident. Before her admission to the day rehabilitation program, she received therapy in a general hospital and an outpatient rehabilitation facility. She manifested distractibility and difficulty focusing and maintaining attention. When completing a task, she worked quickly and made many errors. She ambulated with a walker.

Instruments

Attention behaviors were measured by six letter cancellation tasks prepared for the study. Our tasks were based on commonly used paper-and-pencil letter cancellation tasks (Duchek, 1991; Gentilini et al., 1985; Posner, 1975). No reliability or validity data were found for letter cancellation tasks. Task 1 was designed to measure focusing attention; Tasks 2 and 3 measured shifting attention; Task 4 measured focusing attention with distracting stimuli; and Tasks 5 and 6 measured shifting attention with distracting stimuli. Different target letters were used for each task and for each session to minimize the familiarity with the task. The first three cancellation tasks each consisted of a single sheet of paper with 19 letters arranged in 19 lines. The subjects were instructed to cross out a given letter on Task 1, two given letters on Task 2, and every
other given letter on Task 3. The final three cancellation tasks were identical to the first three except that visual distractions of superimposed intersecting lines were drawn across the page. The instructions were to cross out a given letter on Task 4, two given letters on Task 5, and every other given letter on Task 6.

For each letter cancellation task, the time to complete the task was measured in seconds with a stopwatch, and the number of errors, failure to cross out a given letter, or crossing out a letter that was not a given letter, was counted. While the subject performed the cancellation tasks, the examiner recorded the subject's behaviors and noted when the subject discontinued eye contact with the task, paused, or talked. Observation notes included the number and nature of interruptions, description of the subject's scanning style, and environmental conditions.

Procedure

The ABA design of this study was as follows: (a) baseline measures of attention were taken in Phase 1 (A); (b) Phase 2 (B) was the study's treatment segment; and (c) attention was measured again in Phase 3 (A). During Phase 1, subjects completed the 6 letter cancellation tasks after 15 min of occupational therapy in an individualized program that included activities of daily living (ADL) training and table-top activities. No gross motor activities were included. For example, Subjects 1 and 2 completed 3 weeks (six sessions) and Subject 3, who started the study later, completed 2 weeks (four sessions). Hence, Phase 1 included four to seven sessions, depending on the subject's attendance in the day program. The occupational therapy sessions were twice a week at the same time.

During the treatment sessions of Phase 2, subjects received 15 min of gross motor activity consisting of 5 min each of throwing and catching a ball, tossing a balloon, and throwing bean bags into a container before completing the six letter cancellation tasks. These gross motor activities were selected on the basis of the subjects' physical disabilities and limitations. This phase included seven sessions for all subjects.

In Phase 3, subjects again completed six letter cancellation tasks after 15 min of occupational therapy without gross motor activities. This phase included four sessions. The subjects were interviewed during the final session to obtain comments on their impressions and reactions to the experiences. The letter cancellation tasks and occupational therapy activities were administered by the first author.

Data Analysis

Data were graphed and evaluated by visual analysis and by mean comparisons (Kazdin, 1982; Ottenbacher, 1986).

Data for each session were plotted on three graphs: (a) total time to complete tasks, (b) total number of errors on the tasks, and (c) total number of interruptions during the tasks. Data were analyzed with a sigma level, which is similar to a standard deviation band, but the numerator of the equation is divided by N rather than N - 1. The use of sigma level is a more appropriate statistical analysis tool for interpreting time series experiments where serial dependency of adjacent observations is often a problem (Pfadt, Cohen, Sudhalter, Romanczyk, & Wheeler, 1992). The two standard deviation band method (Ottenbacher, 1986) was not used because it relies on the assumption of independence of observations, which is violated due to serial dependency in time series data with a resulting exaggeration of the size of the standard deviation and an increase in Type I errors (Cook & Campbell, 1979). Because of the lack of reliability and validity information on letter cancellation tasks, test-retest reliability coefficients on baseline data for each subject were calculated to provide a reliability estimate. Finally, calculations were computed by dividing each subject's baseline readings for each of the three variables (i.e., performance time, errors, and interruptions) into two sets, systematically combining the data for each subject into one dataset consisting of two columns of figures and then calculating the Pearson product-moment correlation for each dataset.

Results

Estimated test–retest reliability coefficients computed with the Pearson correlation coefficient for each of the three variables across subjects were: \( r = .97 \) for performance time in seconds, \( r = .76 \) for total number of errors, and \( r = .89 \) for total number of interruptions.

After visual inspection of the graphs, we noted no clear changes in trend or level of performance in the three study phases or on the different letter cancellation tasks. Though we observed mean changes in total per-

Table 1
Means of Response Time, Errors, and Interruptions on Letter Cancellation Tasks for Each Subject

<table>
<thead>
<tr>
<th>Subject</th>
<th>Phase 1 (A) Baseline</th>
<th>Phase 2 (B) Treatment</th>
<th>Phase 3 (A) Reversal to Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>Time in seconds</td>
<td>Errors</td>
<td>Interruptions</td>
</tr>
<tr>
<td>Subject 2</td>
<td>Time in seconds</td>
<td>Errors</td>
<td>Interruptions</td>
</tr>
<tr>
<td>Subject 3</td>
<td>Time in seconds</td>
<td>Errors</td>
<td>Interruptions</td>
</tr>
</tbody>
</table>
formance time, errors, and interruptions scores for all three subjects, the fluctuations in time and accuracy performance were too variable to suggest a trend (see Table 1). In Phase 2, no difference was demonstrated in either level or variability of performance ability in any of the tasks, for any of the subjects. In Phase 3, the number of interruptions dropped and stabilized for all three subjects. Changes in time and accuracy were in different directions for each subject. Though letter cancellation tasks involving visual distractions (Tasks 4 through 6) required more time than those not involving distractions (Tasks 1 through 3), performance of all six tasks did not vary in the different phases.

From the observation notes we saw changes in the scanning style of all three subjects, starting 2 to 3 weeks after the intervention was introduced. Changes occurred in systematic scanning—left-to-right patterns, top-to-bottom patterns, alternating every line, and reviewing and checking for missed target letters—during and after the initial scan. The changes observed were (a) adopting a more efficient scanning style and (b) initiating or increasing checking behavior. We noted some improvement for two subjects in the clinic with regard to speed, vigilance, and visuospatial skills as they participated in ADL and table-top activities such as jigsaw puzzles and Chinese checkers. These observations were supported with reports about one subject’s improved ADL performance at home.

When interviewed at the end of the study, all subjects commented that they believed that accuracy was more important than speed when completing the letter cancellation tasks. In addition, Subject 2 reported an improvement in memory, but no such improvement had been noticed in the clinic or at home in daily activities.

Subject 1

Subject 1’s performance time increased slightly in Phase 2, but by Phase 3 it declined, although not as low as in Phase 1 levels (see Figure 1). The change is more evident when comparing her total time rather than her individual time scores. In the three phases, she made relatively few errors on the letter cancellation tasks but had a high number of interruptions (see Figures 2 and 3).

From the beginning, Subject 1 checked her task performance by going over the same rows again. During the fifth session in Phase 2, she started systematically checking errors by going over the sheet again, in different directions, sometimes crossing out the letters again. Often this checking required more time than the task itself. This procedure lengthened her performance time, but did not necessarily affect the number of errors.

During Phase 1, Subject 1 scanned the sheet from top to bottom, going down the column and then up to start the next column from the top. After the second session in Phase 2, she started scanning from top to bot-

Figure 1. Performance time in seconds for three subjects.

Figure 2. Total number of errors.
Subject 2

Subject 2’s performance speed increased during Phase 2 and declined and stopped in Phase 3, but not to Phase 1 levels (see Figure 1). In all phases, Subject 2 required more time to complete the tasks that contained distractions. He showed no meaningful change in letter cancellation task performance between phases. Subject 2’s total number of errors and interruptions fluctuated among the individual letter cancellation tasks; however, mean total error and total interruptions decreased over the phases (see Figures 2 and 3). Subject 2’s Phase 3 data revealed a gradual decline in interruption rate and a variable error rate.

Subject 2 also demonstrated a change in scanning style. During Phase 1, he scanned from left to right, returning to the beginning of the next line. During the second session of Phase 2, he started scanning from left to right and right to left, alternately. Starting at the 5th session in Phase 2, he began checking his work and continued to do so throughout the rest of the study.

Subject 3

Subject 3’s performance speed was initially fast but decreased in Phases 2 and 3, with time needed to complete the letter cancellation tasks increasing from phase to phase (see Figure 1). The total number of errors decreased across the phases, but because of fluctuations in individual task performances, no trend was noted in errors (see Figure 2). Except for 2 interruptions in the 1st session, Subject 3 demonstrated good on-task behavior during all three phases (see Figure 3).

Subject 3’s initial scanning style was disorganized because she looked for letters in random order. In Phase 2, she started scanning the sheet line by line from left to right and right to left, alternately. During Phase 3, she started to sporadically scan line by line on some letter cancellation tasks and returned to her previous disorganized style on others. Subject 3 started to check her work during Phase 2 but only inconsistently.

Discussion

We have found in this single-subject study that gross motor activity did not influence the performance of three adults with brain injury in six tasks involving attention. The subjects differ in age, medical history, and type of attention deficits. Although all subjects demonstrated changes in scanning and checking behavior during the second phase, no meaningful changes in performance time, number of errors, and number of interruptions were measured (see Table 1). The means for total errors and interruptions steadily decreased across the three phases. Given the number of times each subject took the letter cancellation tasks (Subjects 1 and 2, 102 times; Subject 3, 90 times), it is possible that this result reflects a practice effect on the letter cancellation tasks.

Letter cancellation tasks, such as those used in this study, are commonly used in measuring and remediating attention deficits (Gentiliny et al., 1985). However, these tasks are not standardized. We were unable to find norms for persons without disabilities or for persons with brain injury on these tasks, nor could we find validity or reliability data on them. Therefore, we used each subject’s baseline data to calculate test–retest reliability coefficients and provided a reliability estimate. The estimated test–retest reliability coefficients ($r = .97$ for time, $r = .76$ for errors, and $r = .89$ for interruptions) suggest that the letter cancellation tasks used were consistent measures of performance.

A comparison of the total means scores with individual test scores (see Table 1) indicates that some minor
changes in attention may have occurred from phase to phase. However, no significant differences were noted between the performance on letter cancellation tasks requiring focusing, shifting, or maintaining attention.

The finding that gross motor activities did not improve attention may have been influenced by the activities used. The activities involved trunk and upper extremity actions, which require rhythmic physical effort that could strain the cardiovascular and respiratory systems of persons with physical disabilities. Subjects 1 and 2 complained of fatigue during these activities and needed to rest during the sessions. When interviewed, all three subjects commented that they enjoyed the activities but found the tossing of the balloon, which was the least straining activity, most enjoyable. It is possible that the effort extended on the gross motor activities was more harmful than helpful to the performance on the six letter cancellation tasks.

After Subject 1 was observed to check her work, the other two subjects were given the suggestion to check their work if they needed to. This option may have changed the nature of the study, and instead of measuring attention, we may have measured initiation and use of compensatory strategies. Because subjects were allowed to check their work, time measurements included checking time. The error count did not include errors corrected while working on the task. All subjects appeared to sacrifice speed to gain accuracy, although they were instructed to be both quick and accurate. One cannot generalize the findings of this study; however, it provides preliminary information about the relationship between gross motor activity and attention.

Conclusion
The results of this study did not demonstrate improvement in attention after gross motor activity according to the measures used. However, positive changes in attention behaviors observed after the intervention of gross motor activity indicate the need for further study to determine the nature of the relationship between gross motor activity and attention. In the rehabilitation of persons with brain injury, observations can help to identify important factors that may influence treatment outcomes. The discrepancy between results by observation and results measured by formal instruments can define importance of observation in clinical research as a source of meaningful data. ▲

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References


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