The Effects of Different Treatment Activities on Functional Fine Motor Coordination in Adults With Brain Injury

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Key Words: brain injuries • tests, by title, Jebsen-Taylor Test of Hand Function

Objectives. Occupational therapists frequently work to improve the fine motor coordination skills of adults who have dexterity deficits secondary to brain injury. Most therapists use a combination of tabletop and functional activities to foster improved coordination in these clients. This study examined the effects of puzzle construction and kitchen activities on fine motor coordination in a group of 45 men with brain injury, as measured by pretest and posttest performance on two subtests of the Jebsen-Taylor Test of Hand Function.

Method. Subjects were randomly assigned to either a parquetry block assembly group (n = 22) or a meal preparation group (n = 23).

Results. Subjects in the functional meal preparation group showed significantly greater improvement in dominant-hand dexterity for picking up small objects than subjects in the tabletop puzzle activity group. Other coordination test results were comparable for the two treatment groups.

Conclusion. These findings suggest that functional activities may be better than tabletop activities for fine motor coordination training with this population.

Because sensorimotor sequelae are common after brain injury in adults, occupational therapists working with this population frequently focus on improving the sensorimotor skill components of occupational behaviors. Fine motor coordination is one sensorimotor skill frequently targeted in this type of treatment (Barris, Cordero, & Christiaansen, 1986; Hopkins & Smith, 1988; Kunstaetter, 1988; Neistadt, 1988; Pedretti & Zoltan, 1990; Trombly, 1989). Occupational therapists use two types of activities in coordination retraining for adults with brain injury: tabletop activities, such as pegboards, or puzzles and functional activities, such as meal preparation. Most therapists use a combination of tabletop and functional activities (Hopkins & Smith, 1988; Neistadt, 1988; Trombly, 1989). Are these two types of activities equally effective in promoting improved fine motor coordination in this population? This article examines the effects of puzzle construction and kitchen activities on fine motor coordination in a group of adult men with brain injury, as measured by a functional test of coordination.

Literature Review

Therapists choose tabletop or functional activities for coordination retraining by using activity analyses that identify fine motor coordination as a skill component of a given task. These analyses are supported by a recent correlation study that showed a significant association between coordination test scores and performances on both a tabletop task (parquetry puzzle construction) and a functional task (meal preparation) (Neistadt, 1993). In that study, 54 men with brain injury in long-term rehabilitation programs who were 18 to 55 years of age, with functional use of at least one upper extremity, were given a battery of tests. These tests included a parquetry block puzzle test (the Parquetry Block Test [Neistadt, 1994]), a meal preparation evaluation (the Rabideau Kitchen Evaluation-Revised [RKE-R] [Neistadt, 1992b]), and two subtests of the Jebsen-Taylor Test of Hand Function (Simulated Page Turning and Picking Up Small Objects) (Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969). For the coordination tests, time to complete the test was recorded for both the dominant and nondominant hand for each subtest and each subject. Results showed that all of coordination scores correlated significantly and positively with the Parquetry Block Test scores. Additionally, all of the coordination test scores, except the ones for Picking Up Small Objects with the dominant hand, correlated significantly and positively with the RKE-R scores. These findings suggested that fine motor skills contribute to both parquetry puzzle and kitchen activities and that either tabletop or functional activities might provide focused training in fine motor coordination.

However, the motor-skill learning literature suggests that the functional outcomes of coordination training...
with the two types of activities might be very different. This research has suggested that motor learning is often task specific and that motor skills learned in one activity are not easily transferred to another in adults with or without brain injury (Poole, 1991; Sabari, 1991).

Regarding adults without brain injury, Singer and Cauraugh (1985) have suggested that learning psychomotor tasks involves information analysis, response generation, and feedback use. To address these task performance components, they recommended a five-part strategy to anyone learning new psychomotor tasks: (a) reading, or relaxing and attending; (b) imaging, or picturing oneself performing the task at hand; (c) focusing, or concentrating on one relevant feature of the situation to avoid distractions; (d) executing, or performing the task; and (e) evaluating, or using available feedback from the performance to learn better response patterns. This strategy has been shown effective in improving performance on maze and target-shooting tasks in young adults without disabilities (Brown, Singer, Cauraugh, & Lucariello, 1985; Singer, Cauraugh, Lucariello, & Brown, 1985).

Another study with adults without disabilities, however, has found that improved performance on a new psychomotor task only transfers to similar motor tasks if the strategy has been taught in the context of varied tasks. Singer and Suwanthada (1986) found that subjects given the five-step strategy, with examples of how that strategy could apply to several tasks, showed greater transfer of learning to related tasks than subjects who had been given the strategy with instruction specific to only one task. In this study, 80 university subjects (40 men and 40 women) ranging from 17 to 25 years of age were randomly assigned to five groups balanced in gender and number: a content-dependent strategy (CDS) group, a content-dependent strategy plus reminders (CDSR) group, a content-independent strategy (CIS) group, a content-independent strategy plus reminders (CISR) group, and a control group. A CDS is a strategy used in reference to a specific task, and a CIS is a strategy learned in the context of many example tasks.

Subjects performed underhanded dart throwing as the primary task (throwing darts was the first, more closely related task and shooting soccer balls was the second, less related task). All subjects received 6 practice trials for the primary task followed by five sets of 10 trials. They then had 6 practice trials and three sets of 10 trials each for the first and second related tasks. Rest intervals of 30 sec were given between each set of trials.

Subjects in the CDS and CDSR groups were taught the Singer and Cauraugh five-step strategy at the onset of the experiment, with specific reference to the primary task. Subjects in the CIS and CISR groups were taught the strategy at the onset without reference to any one specific task, but they were given a number of activity examples to illustrate how to use the strategy. The reminders groups (CISR and CDSR) were also verbally cued to use the strategy and were given a chart containing strategy guidelines during intervals between each set. The control group was given only general instructions about the tasks. Analyses of variance (ANOVAs) of performance scores on the three tasks for all groups indicated that all of the strategy-learning conditions were significantly more effective than the control condition for each task. The CIS learning situation was more beneficial than the CDS situation for learning the task more closely related to the primary task, and subjects in the CISR group outperformed those in the other strategy groups in the less related task.

Other researchers have suggested that motor learning is also relatively specific in adults with brain injury, unless training is conducted with a variety of tasks and in a variety of settings (Duncan, 1991; Poole, 1991; Sabari, 1991). Sabari (1991), for example, has said that “persons with hemiplegia need opportunities to practice skills in situations with varying regulatory conditions so that they can develop motor schema that are versatile enough to meet the situations they will encounter in their daily lives” (p. 524). Duncan (1991) has pointed out, with support from patient videotapes, that the balance skills learned by a client with brain injury in one activity do not necessarily transfer to other activities. For example, a client may perform well in repetitive drills in which the therapist challenges the patient’s balance with small pushes but be unable to maintain balance while walking around the kitchen.

If motor learning is task specific with repetition of a single task, then the coordination skills learned in tabletop puzzle or pegboard activities will not necessarily transfer to more functional activities because the movement patterns practiced in the tabletop tasks are too limited. For example, in a parquetry block puzzle task, the blocks could be picked up with the same types of grasps consistently. In contrast, functional activities such as meal preparation require more variety in movement patterns. For example, making a cup of instant coffee with individually packaged coffee and sugar requires a hook grasp to move the faucet and pick up a kettle, a mass grasp to pick up a milk carton, a three-jaw chuck group to handle a spoon, and a pincer grasp to open the coffee and sugar packets. Because this functional activity requires more varied movements than puzzle assembly, does coordination training with a kitchen activity result in greater improvement on tests of functional coordination than coordination training with parquetry block puzzles? This study addresses that question.

**Method**

As part of a previously described treatment outcome study (Neistadt, 1992a), 45 men with traumatic brain injury, 18 to 55 years of age, in long-term rehabilitation programs were given a battery of perceptual–cognitive, functional, and coordination tests before and after receiv-
ing extra treatment with either parquetry puzzle construction or meal preparation activities. This was a pretest–treatment–posttest design. The coordination pretest and posttest results, which have not been reported before, are examined.

Subjects

The average age for the entire sample was 33.2 years of age (SD = 9.1), and the average length of time since brain injury was 7.9 years (SD = 6.5). The average educational level was 11.2 years (SD = 1.75). Forty-two subjects had traumatic brain injury (1 had open brain injury and 41 had closed head injury), and 3 subjects had experienced anoxia. All subjects were independent in mobility (29 were ambulatory; 16 used manual wheelchairs). Five subjects were left-handed (4 premorbidly and 1 postmorbidly), and 40 were right-handed (all premorbidly).

Subjects were recruited from 10 brain injury programs in Massachusetts. Eight of these programs were residential (36 subjects), and 2 were outpatient programs (9 subjects). Information on diagnosis, time since injury, age, and educational level was obtained from the subjects' medical records. Information on handedness was obtained by interview with the subjects.

Subjects were randomly assigned to either a parquetry puzzle (n = 22) or meal preparation (n = 23) treatment group. The two groups were comparable in initial perceptual, functional, and coordination test scores and in all demographics except age. The mean age of the meal preparation group was significantly lower than that of the parquetry block group (t = 3.21, df = 43, p = 0.0025). Both groups scored below the norms for their age group on all of the initial coordination tests: average times for adults without disabilities in this age range would be approximately 5 sec for the page-turning tests, dominant and nondominant, and approximately 7 sec for the small objects tests, dominant and nondominant (Jebsen et al., 1969) (see Table 1).

Instruments

All subjects were given the following pretests: the Line Bisection Test (Lezak, 1983), two subtests of the Jebsen-Taylor Hand Function Test (Simulated Page Turning and Picking Up Small Objects) (Jebsen et al., 1969), the Wechsler Adult Intelligence Scale–Revised (WAIS-R) Block Design Test (Wechsler, 1981), the Parquetry Block Test (Neistadt, 1994), and the RKE-R (Neistadt, 1992b). The Line Bisection Test, which involves bisecting 20 lines that are equally distributed across both visual fields, was given to eliminate subjects with unilateral neglect. The other four tests were also given at posttest. The WAIS-R Block Design Test is a standardized, reliable, valid test of constructional abilities that involves constructing block designs of four or nine cubes each from model design cards. The Parquetry Block Test, another evaluation of constructional skills, involves constructing 4 block designs of 32 blocks each from model design cards. The RKE-R is a valid and reliable evaluation of meal preparation skill that involves subject preparation of a simple meal (a cold sandwich with two fillings and a hot instant beverage). The WAIS-R Block Design Test, Parquetry Block Test, and the RKE-R are described in more detail elsewhere (Neistadt, 1992a, 1992b, 1994).

Table 1
Pretest Coordination Scores for the Two Treatment Groups

<table>
<thead>
<tr>
<th>Coordination Test</th>
<th>Treatment Group Scores (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parquetry Block</td>
</tr>
<tr>
<td>Simulated Page Turning, Dominant Hand</td>
<td>13.01 (n = 22)</td>
</tr>
<tr>
<td></td>
<td>11.99 (n = 22)</td>
</tr>
<tr>
<td>Simulated Page Turning, Nondominant Hand</td>
<td>20.32 (n = 19)</td>
</tr>
<tr>
<td></td>
<td>25.11 (n = 22)</td>
</tr>
<tr>
<td>Picking Up Small Objects, Dominant Hand</td>
<td>17.53 (n = 22)</td>
</tr>
<tr>
<td></td>
<td>12.19 (n = 22)</td>
</tr>
<tr>
<td>Picking Up Small Objects, Nondominant Hand</td>
<td>31.33 (n = 18)</td>
</tr>
<tr>
<td></td>
<td>35.89 (n = 19)</td>
</tr>
</tbody>
</table>

Note. Some subjects did not have sufficient hand control to complete all tests.

The Jebsen-Taylor Test of Hand Function

The Jebsen-Taylor Test is a standardized test of coordination that includes seven subtests: (a) Writing, (b) turning over 3-in. × 5-in. index cards (Simulated Page Turning), (c) Picking Up Small Objects, (d) Simulated Feeding, (e) Stacking Checkers, (f) Picking Up Large Light Objects, and (g) Picking Up Large Heavy Objects. This test was developed to measure functional coordination. Two subtests were given as part of this study (Simulated Page Turning and Picking Up Small Objects) to give an indication of upper-extremity motor involvement for all subjects. These tests were chosen because they measure rapid alternating movements and fine motor dexterity, and because they are simple, routine motor tasks that are not taxing in terms of motor planning.

The Jebsen-Taylor Test was standardized on 300 subjects without disabilities, 30 men and 30 women in each of the following age groups: 20 to 29 years, 30 to 39 years, 40 to 49 years, 50 to 59 years, and 60 to 94 years of age. A test-retest study with 26 clients with stable hand disabilities yielded a Pearson product-moment correlation for Simulated Page Turning of 0.91 for the dominant hand and 0.78 for the nondominant hand. For Picking Up Small Objects, the coefficients were 0.93 for the dominant hand and 0.85 for the nondominant hand. All of these values were significant at p < 0.01 (Jebsen et al., 1969).
In Simulated Page Turning, five index cards, ruled on one side only, were placed in a horizontal row 2 in. apart on a table in front of the client. Each card was oriented vertically, 5 in. from the front table edge. Subjects were asked to turn the cards over one at a time, in sequence, as quickly as possible, first with one hand and then the other, starting each time with the card furthest across the midline.

In Picking Up Small Objects, an empty 1-lb coffee can was placed directly in front of the subject, 5 in. from the front of the table. Two 1-in. paper clips oriented vertically, two regular-sized bottle caps (placed with the inside of the cap facing up), and two U.S. pennies were placed in a horizontal row to the left of the can, with the paper clips farthest from and the pennies nearest the can. Subjects were instructed to pick up the objects with their left hands, one at a time, in order, and drop them in the can, starting with the furthest paper clip. They were to work as quickly as possible. This procedure was repeated with the right hand, with the objects placed to the right of the can (Jebesen et al., 1969).

Time scores were recorded for each subtest, with timing starting when the subject began the test and ending when the subject completed the task. Separate time scores were recorded for each hand for both tests.

Procedure
I recruited all subjects and trained the independent evaluators and therapists. All evaluators and therapists had previous experience with adults with brain injury. Thirteen of the evaluators were senior-year or master’s degree-level occupational therapy students, 2 were registered occupational therapists, and 1 was a rehabilitation counselor. I trained all 16 evaluators until they demonstrated competency with the standardized administration procedures and scoring for each evaluation. Another occupational therapist, four master’s degree-level occupational therapy students, and I provided all treatments. I checked weekly to ensure that interventions were being conducted as intended by interviewing therapists and reviewing treatment documentation.

Because of unforeseen circumstances, one evaluator was aware of the treatment group assignment of two subjects (one in each treatment group) at posttest. (Both of these subjects showed marked improvement on all posttest measures.) Otherwise, evaluators were blind to subjects’ group assignments, and therapists were blind to subjects’ pretest scores during the course of the study.

Evaluation
Subjects were evaluated in their treatment facilities. All subjects were evaluated at posttest by the same evaluator who administered their pretests. The evaluation battery lasted between 1 and 2 hr per client and was generally conducted in short sessions dispersed over 2 to 3 consecutive days. The order of tests was based on pragmatic considerations such as the availability of rooms and subjects. The kitchen evaluations were conducted in occupational therapy kitchens, and the other tests were conducted in quiet areas.

Treatment
Subjects received three 30-min individual treatment sessions per week for 6 weeks, in addition to their regular rehabilitation programs. Therapists were provided with written protocols for treatment and received weekly supervision from me. All therapists except one treated an equal number of kitchen and parquetry block subjects. One therapist had one more subject in her functional group than in her perceptual skill group.

Therapists used the same cuing and feedback approach with all subjects. When subjects encountered difficulties in the treatment tasks, they were led through a collaborative problem-solving process by a series of therapist questions: (a) What do you see in the block design or kitchen? Does anything that you see remind you of what you have to do next? (b) What steps are you going to take to complete your puzzle or make your snack? The therapists also gave examples of how this problem-solving approach could be used in other tasks.

Singer and Cauraugh’s (1985) five-part strategy was the basis for this cuing and feedback method. The question “What do you see?” was a form of readying; it directed subjects’ attention to the task and to the perceptual features of the task. The idea of focusing initial attention on the perceptual features of the task is supported by research suggesting that people rely heavily on visuospatial skills in the initial stages of learning psychomotor tasks (Fleishman & Rich, 1963). The question “What steps are you going to take [to complete this task]?” was a form of imaging: it encouraged subjects to plan and possibly imagine how they would perform the treatment tasks. The subjects’ performances were the executing step, and the feedback from the therapists was the evaluating step.

The focusing step was not included because one aim of treatment with this population is to promote skill in divided attention, that is, the ability to consider more than one aspect of a situation at a time (Lezak, 1983).

The inclusion of examples about other applications of the problem-solving approach was an attempt to facilitate the transfer of learning from treatment to other tasks. The aim of these cuing and feedback procedures was to help subjects discover their own strategies for task completion.

Results
A series of analyses were performed, and a significance level of 0.05 was used for all analyses. First, t tests were
performed to determine whether the two treatment groups were comparable in terms of age, education, years since brain injury, and pretest scores. As reported above, the two groups were significantly different only in terms of age. However, because age did not correlate significantly with any of the coordination pretest or difference scores, age was not used as an independent variable in the ANOVAs that were performed to determine the relative effects of the two types of treatment activities on fine motor coordination. Four ANOVAs were performed, one for each of the coordination test scores: Simulated Page Turning, dominant hand; Simulated Page Turning, nondominant hand; Picking Up Small Objects, dominant hand; and Picking Up Small Objects, nondominant hand. In each of these analyses, the type of treatment activity was the independent variable, and the difference between pretest and posttest scores on the coordination tests was the dependent variable. Because the two treatment groups were not significantly different on any of the coordination tests at pretest, analysis of the difference scores is appropriate.

Table 2 shows the mean changes and standard deviations for each coordination test for the two treatment groups. For Simulated Page Turning with the dominant hand, Simulated Page Turning with the nondominant hand, and Picking Up Small Objects with the nondominant hand, there was no significant difference in improvement between the two treatment groups \(F = 0.20, p = 0.6555; F = 1.84, p = 0.1823; \) and \(F = 1.27, p = 0.2651;\) respectively). For Picking Up Small Objects with the dominant hand, there was a significant difference in improvement between the two treatment groups, with the meal preparation group showing significantly more improvement than the parquetry block group \(F = 5.23, p = 0.0271).\)

Discussion

This study suggests that functional activities may be slightly more effective than tabletop activities in promoting fine motor coordination in persons with brain injury. Subjects in the meal preparation group made significantly more improvement on Picking Up Small Objects for the dominant hand than subjects in the parquetry block group. Although subjects in the two treatment groups made comparable changes on the other three coordination tests, this significant difference in a test measuring dexterity of the dominant hand shows the functional meal preparation activity to have an advantage over the tabletop parquetry block activity. This finding is supported by the literature, which suggests that motor learning for adults with and without brain injury is fairly task specific unless tasks and learning circumstances are varied (Duncan, 1991; Poole, 1991; Sabari, 1991; Singer & Suwanthada, 1986). In other words, the motor patterns that subjects learned in the Parquetry Block Test did not significantly contribute to improved dominant-hand dexterity with picking up small objects. However, the movement patterns that subjects learned in meal preparation tasks did improve dominant-hand dexterity for picking up small objects. Treatment with meal preparation tasks may have been slightly better than parquetry block tasks in terms of fine motor coordination training because, as suggested above, the former tasks required more varied movement patterns than the latter tasks.

The comparable improvements made by the two treatment groups on the other three functional coordination tests, Picking Up Small Objects with the nondominant hand and Page Turning with the dominant and nondominant hands, suggests that the functional meal preparation tasks were as effective as the tabletop task for these types of dexterity. This finding and the finding that meal preparation has an advantage over the parquetry block task for dominant hand dexterity in picking up small objects run counter to therapists’ activity analysis-based assumption that tabletop tasks provide more focused training in fine motor coordination than functional activities. This assumption is partially supported by the results of a correlation study (Neistadt, 1993) in which the Parquetry Block Test correlated significantly with performance on all four of the coordination tests used in this coordination study, and the meal preparation tasks correlated significantly with only three out of four of those tests. The Parquetry Block Test, therefore, appears to be more strongly associated with functional coordination than the meal preparation task. However, that association does not necessarily mean that training on the parquetry task will improve coordination more than training on kitchen tasks because no definitive conclusions can be drawn about the causes underlying the association. It is possible that subjects in the coordination study were better able to compensate for their motor deficits in familiar meal preparation tasks than in the relatively unfamiliar Parquetry Block Test. That compensation, due to overlearned motor patterns, could have lessened the association between the coordination and meal preparation.

The American Journal of Occupational Therapy

Table 2

<table>
<thead>
<tr>
<th>Coordination Test</th>
<th>Treatment Group Scores (sec)</th>
<th>Parquetry Block</th>
<th>Meal Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Simulated Page Turning,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant Hand</td>
<td>-1.20</td>
<td>11.21</td>
<td>-0.07</td>
</tr>
<tr>
<td>Simulated Page Turning,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nondominant Hand</td>
<td>-6.07</td>
<td>18.25</td>
<td>2.49</td>
</tr>
<tr>
<td>Picking Up Small Objects,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant Hand</td>
<td>5.01</td>
<td>10.46</td>
<td>-4.37</td>
</tr>
<tr>
<td>Picking Up Small Objects,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nondominant Hand</td>
<td>-11.95</td>
<td>33.68</td>
<td>-3.71</td>
</tr>
</tbody>
</table>

Note: Scores represent the posttest scores minus the pretest scores, so negative change scores represent improvement.\(^9\) These change scores were significantly different \(p < 0.02\).
test performances. A lesser association, then, can be caused by factors other than the importance of coordination to a particular task. The danger of deciding on treatment activities on the basis of correlation studies is demonstrated by the results of this coordination study, in which training with puzzle tasks did not improve fine motor coordination more than training with kitchen tasks.

This study's collective findings call into question occupational therapists' frequent use of pegboards and puzzles to improve fine motor coordination in adults with dexterity deficits secondary to brain injury. Functional activities appear to be a better choice to achieve that goal. The use of functional activities in treatment for coordination deficits has the added advantage of giving clients maximal practice in activities essential to community independence within ever shortening rehabilitation stays. Adults with brain injury often have difficulty relearning self-care and community living skills because of cognitive perceptual problems. Additional practice with these activities to achieve fine motor coordination training would foster better learning of these activities of daily living (Neistadt, 1992a; Toglia, 1991).

This study examined the relative effectiveness of only two activities, parquetry block assembly and meal preparation, on improvement of fine motor coordination in adult men with brain injury. Further research needs to be performed to examine the relative effectiveness of other tabletop and functional activities that occupational therapists use for fine motor coordination training. Additionally, studies including women and other age and diagnostic groups would be helpful in delineating treatment recommendations for other client populations with fine motor coordination deficits.

Conclusion

This study examined the effects of puzzle construction and kitchen activities on fine motor coordination in a group of men with brain injury as measured by a functional test of coordination. Findings suggested that functional activities such as meal preparation may be more effective in promoting functional fine motor coordination skills than tabletop activities such as puzzle construction. Further research exploring the relative dexterity outcomes for other tabletop and functional activities is needed so that occupational therapists can critically examine this area of practice.

References