Functional Skill Learning in Men With Traumatic Brain Injury

Clare G. Giuffrida, Jason A. Demery, Lisa R. Reyes, Brian K. Lebowitz, Robert E. Hanlon

The number of people with traumatic brain injury (TBI) having persistent deficits that compromise their ability to perform everyday skills is increasing. Previous occupation-based studies indicate that computer-based skills using repetitive practice may be a viable option for retraining. We investigated the effects of different practice schedules on skill learning in 6 men with TBI. Participants with significant impairments in processing and fine motor control practiced 3 tasks using a random (n = 3) or a blocked (n = 3) ordered practice schedule. Practice occurred for 55 min/day for 13 days with retention and transfer trials taking place 2 weeks after training. Both groups showed a significant increase in performance during skill acquisition and maintained this performance. Only the random-practice group, however, was able to transfer this learning to another task. The findings provide evidence that people with TBI can improve their everyday skills with randomly structured practice.


Traumatic brain injury (TBI) is one of the leading causes of disability and death in adults and children. Current estimates indicate that close to 1.4 million people in the United States each year sustain a TBI that results in death, hospitalization, or treatment and release from an emergency department (Langlois, Rutland-Brown, & Thomas, 2006). This estimate excludes people who are treated in physicians’ offices, outpatient centers, or military facilities or who receive no treatment at all. In addition, people who have sustained a TBI along with other injuries (e.g., neck and back) may be excluded from the estimate if the focus of treatment is on the more visible injuries. Most at risk for a TBI are people in the 16-to-25 age range; TBI is one of the leading causes of disability for people younger than age 35. Unlike stroke, the rate of which increases with advancing age, TBI affects a younger population and people in the prime of their vocational productivity (Langlois et al., 2006).

Of the nearly 1.4 million people who sustain a TBI, approximately 80,000 to 90,000 have persistent physical, cognitive, behavioral, or social deficits that both compromise their quality of life and result in permanent and long-term disability (Langlois et al., 2006). Current data and research on memory and learning in TBI has indicated that it is the cognitive and psychosocial sequelae associated with TBI more than the physical impairments accompanying it that significantly affect people’s ability to learn new skills and return to work. (Liu, Chan, Lee, Li, & Hui-Chan 2002; McGraw-Hunter, Faw, & Davis, 2006).

People with TBI often manifest cognitive dysfunction characterized by myriad cognitive deficits, including attentional disturbance, learning and memory impairment, and executive dysfunction. This combination of deficits interferes significantly with their ability to learn and retain basic personal care skills, instrumental life skills, and work skills. It is estimated that 5.3 million Americans currently have an ongoing need for assistance to perform activities of daily living (ADLs) such as...
limited research exists regarding whether this knowledge is applicable to a clinical setting for neurologic rehabilitation, particularly for people with TBI. Exploration of skill acquisition, retention, and transfer for improved motor and process skills during functional activities warrants further study to optimize therapy outcomes.

A notable exception to the paucity of research on practice variables in neurologic rehabilitation for functional skills has been the work of Glisky and Schacter (1987, 1989; Glisky, Schacter, & Tulving, 1986). These researchers conducted a series of studies in which memory-impaired participants with etiologies including TBI and herpes encephalitis learned the commands and procedures necessary to effectively operate a basic computer program. In those studies, participants demonstrated the capacity to learn the procedures to effectively operate a personal computer after repetitive training trials and retained the operative procedure across a 1-month retention interval. Glisky (1992, 1995) has also shown that people with memory impairments possess some capacity for transfer to similar tasks when minor variations in materials are introduced. Application of motor learning principles to other patient populations clearly warrants further study.

Researchers in cognitive psychology and motor learning have consistently demonstrated a principle of learning referred to as the contextual interference effect. Contextual interference, a practice phenomenon, occurs when practice is conducted in a randomly ordered practice schedule (i.e., random practice) in contrast to a blocked ordered practice schedule (i.e., blocked practice). A randomly ordered practice schedule represents high task interference, whereas a blocked practice schedule represents low task interference. The contextual interference effect refers to the consistent finding that occurs when comparing randomly ordered and blocked ordered practice schedules (Shea & Zimny, 1983). High contextual interference (i.e., randomly ordered practice schedule) results in depressed performance in acquisition but enhanced performance in retention and transfer. Conversely, low contextual interference (i.e., blocked ordered practice schedule) results in enhanced acquisition but minimized retention and transfer benefits (Shea & Zimny, 1983).

In skill learning, acquisition refers to the initial practice period in which people perform an unfamiliar skill to become more proficient at it. Skill acquisition implies that changes occur in the person’s ability to perform the skill. Retention refers to the residual proficiency of a skill after a period without practice, and transfer refers to the effect that a previously practiced skill has on subsequent performance of other similar skills (Schmidt & Lee, 1999).

Contextual interference effects were initially demonstrated in studies of verbal and motor learning (Battig, 1972;
Hiew, 1977; Melton, 1967; Shea & Morgan, 1979), which showed that retention was enhanced when practice occurred under conditions of high contextual interference (i.e., randomly ordered practice). This finding led to the conclusion that practice conducted under conditions of high contextual interference (i.e., random-ordered practice and not blocked-ordered practice) places a greater demand on multiple and variable processing, which in turn facilitates retention and delayed recall. Multiple processing refers to repetitions of the same encodings (e.g., mentally transforming external information to an internal representation) across tasks, whereas variable processing refers to the use of different encodings across trials. For example, repetitively performing a task in the same manner—such as in blocked practice—decreases both the extent of elaboration and the chance for distinctive processing. Elaborative processing provides for the development of multiple retrieval routes for item recall, which facilitates retention. Distinctive processing allows for better discrimination of the to-be-remembered item from other similar items. Random practice is thought to increase the probability that elaborative and distinctive processing will occur.

Following from early studies, research in contextual interference has been repeatedly demonstrated in both experimental and field-based research with normal participants in complex skill learning (Brady 1998; Carnahan, Van Eerd, & Allard, 1990; Horak, 1992; Magill & Hall, 1990). The beneficial effect of high contextual interference on retention has consistently been demonstrated with normal participants in both verbal and motor learning studies.

In response to the consistent demonstration of the differential effect of contextual interference on motor skill learning, researchers in learning (Magill & Hall, 1990; Schmidt, 1988, 1991) and rehabilitation (Gifford, 1998; Mathiowetz & Haugen, 1994; Nicholson, 1996; Poole, 1991; Sabari, 1991) have advocated the use of contextual interference in rehabilitation. Few reports of the effect of contextual interference on motor skill learning for people with neurological impairments are available in the literature; however, contextual interference has been examined in people with stroke and chronic hemiparesis (Hanlon, 1996) and in people with Alzheimer’s disease (Dick, Andel, et al., 2000; Dick, Hsieh, Dick-Muehlke, Davis, & Cotman, 2000).

In the first study of the contextual interference phenomenon with neurologically compromised participants, Hanlon (1996) demonstrated the positive effect of contextual interference on the retention of a multistep functional movement sequence in people who sustained a stroke with chronic hemiparesis. Using their hemiparetic upper limb, participants practiced opening a cupboard door; grasping a ceramic coffee cup; vertically lifting the cup off a timer plate; horizontally transferring the cup to an elevated platform; and, finally, releasing the cup. The results indicated that participants who learned the movement task under conditions of high contextual interference demonstrated significantly better retention of the movement sequence on two separate retention trials compared with participants who learned the task under conditions of low contextual interference and control participants who received no practice. Surprisingly, no significant difference existed between control participants who had no practice on the task, and the participants who had learned the task under conditions of low contextual interference, suggesting limited benefits of blocked practice on retention over time.

We conducted the current study to examine the effect of occupation-based practice and contextual interference on functional skill learning in people with TBI. Although Glisky et al. (1986) demonstrated that people with memory impairments resulting from TBI have the capacity to learn the procedures necessary to operate basic computer programs, minimal research has investigated the effects of different practice conditions on both verbal and procedural learning in patient populations. We were encouraged by the previous work of Hanlon (1996) in teaching movement sequences to people with hemiparetic stroke; however, to our knowledge, no studies have examined the contextual interference effect on functional skill learning for people with TBI are available in the literature.

The purpose of this study was to determine how acquisition, retention, and transfer of skills differed among groups of participants with TBI who originally learned by using either a randomly ordered practice schedule (i.e., high contextual interference) or a blocked ordered practice schedule (i.e., low contextual interference). Our first prediction was that all participants, regardless of type of practice schedule used, would significantly improve in skill acquisition (i.e., touch-typing, inputting digits on an adding machine, learning subway stops) and in the number of recalled subway stops when performance at baseline was compared with performance at the end of practice. Our second prediction was that participants who practiced using a randomly ordered practice schedule would acquire significantly less skill and recall fewer subway stops by the end of practice compared with participants who practiced using a blocked ordered practice schedule. Our third prediction was that participants who practiced using a randomly ordered practice schedule would retain a significantly greater amount of skill and subway stop information at follow-up compared with participants who practiced using a blocked ordered practice schedule. Finally, our fourth prediction was that participants who practiced using a randomly ordered practice schedule would transfer typing skills to a typing dictation task significantly better than participants who originally practiced using a blocked ordered practice schedule.
Method

Participants

We recruited 6 right-handed men (mean age = 28 years) who sustained chronic cognitive impairments after severe TBI (as defined by a Glasgow Coma Scale score of <9 on hospital admission; Teasdale & Jennett, 1974) via newsletter from the Brain Injury Association, Missouri State Chapter. Participants met inclusion criteria for the study if they had sustained a single TBI; were ≥18 months postinjury; and had no premorbid history of chronic substance abuse, learning disability, attention deficit disorder, or severe psychiatric illness (e.g., schizophrenia or bipolar disorder). Two participants experienced penetrating head injuries from gunshot wounds that were not combat related. Four participants sustained closed head injuries after motor vehicle–motor vehicle (n = 2), motor vehicle–train (n = 1), and motor vehicle–pedestrian (n = 1) accidents. For the entire sample (N = 6), the average time postinjury was 105 months (range = 18–276), and level of education was 11.5 years. Because of the study’s premise, participants could not have had extensive prior exposure to touch-typing or use of a computer. All participants were single, financially dependent, and not gainfully employed at the time of the study.

Procedure

All participants underwent comprehensive neuropsychological testing to confirm the presence of chronic neurocognitive impairments (Table 1). After neuropsychological testing, participants were assigned to one of two groups (e.g., random or blocked ordered practice) on the basis of age, years of education, IQ, and type of brain injury (e.g., penetrating head injury or closed head injury).

Participants assigned to the randomly ordered practice group (i.e., high contextual interference) practiced three experimental tasks for 13 days. Participants completed the following three tasks each day: (1) 30 min of programmed instruction in touch-typing using a computer-based typing tutorial program (Typing Tutor, 1996), (2) 15 min of rapidly inputting five- and six-digit sequences (e.g., $325.87) into an adding machine (this task was intended to simulate the use of a cash register), and (3) 10 min learning a subway schedule presented in a paired-associate format. On this task, participants were required to learn legitimate subway stops and their respective departure times (e.g., Convention Center: 8:06 a.m.). We used two forms of this task (Lists A and B) to ensure that verbal learning continued to serve as an interference factor for the typing and adding machine tasks after List A had been learned without error. Once List A had been learned, List B was introduced. All practice trials lasted 5 min, and tasks were quasi-randomized to maximize intratask interference.

Participants assigned to the blocked ordered practice group (i.e., low contextual interference) practiced using a modified blocked-practice schedule on the previously mentioned experimental tasks (typing, adding machine, and subway stop) for 13 days. For each of the three tasks, participants completed practice trials consecutively to minimize intratask interference. We also counterbalanced the order of all experimental tasks between participants to control for practice effects (see Table 2).

Table 1. Demographic Variables and Neuropsychological Performance Scores Between Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Random Practice</th>
<th>Blocked Practice</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>27.7</td>
<td>28.0</td>
<td>.95</td>
</tr>
<tr>
<td>Education</td>
<td>11.3</td>
<td>11.7</td>
<td>.80</td>
</tr>
<tr>
<td>Time postinjury (months)</td>
<td>66.0</td>
<td>144.7</td>
<td>.39</td>
</tr>
<tr>
<td>WAIS–R (deviation IQ score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Scale IQ</td>
<td>81.0</td>
<td>80.0</td>
<td>.78</td>
</tr>
<tr>
<td>Verbal IQ</td>
<td>82.7</td>
<td>81.7</td>
<td>.80</td>
</tr>
<tr>
<td>Performance IQ</td>
<td>81.7</td>
<td>81.0</td>
<td>.89</td>
</tr>
<tr>
<td>Digit Symbol (ACSS)</td>
<td>5.3</td>
<td>4.3</td>
<td>.60</td>
</tr>
<tr>
<td>WMS–R (percentile score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>25th</td>
<td>34th</td>
<td>.70</td>
</tr>
<tr>
<td>Digit Span Backward</td>
<td>11th</td>
<td>13th</td>
<td>.82</td>
</tr>
<tr>
<td>Logical Memory I</td>
<td>38th</td>
<td>16th</td>
<td>.33</td>
</tr>
<tr>
<td>Logical Memory II</td>
<td>27th</td>
<td>14th</td>
<td>.54</td>
</tr>
<tr>
<td>CVLT (percentile score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List A Trials 1-5 (Overall)</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.79</td>
</tr>
<tr>
<td>List A Trial 1</td>
<td>4th</td>
<td>2nd</td>
<td>.64</td>
</tr>
<tr>
<td>List A Trial 5</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.42</td>
</tr>
<tr>
<td>List B Trial 1</td>
<td>1st</td>
<td>2nd</td>
<td>.74</td>
</tr>
<tr>
<td>List A short-delay free recall</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.49</td>
</tr>
<tr>
<td>List A long-delay free recall</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.82</td>
</tr>
<tr>
<td>Recognition hits</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.58</td>
</tr>
<tr>
<td>TMT (percentile score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part A</td>
<td>1st</td>
<td>2nd</td>
<td>.88</td>
</tr>
<tr>
<td>Part B</td>
<td>2nd</td>
<td>&lt;1st</td>
<td>.42</td>
</tr>
<tr>
<td>WCST (percentile score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perseverative responses</td>
<td>25th</td>
<td>23rd</td>
<td>.87</td>
</tr>
<tr>
<td>Nonperseverative errors</td>
<td>26th</td>
<td>21st</td>
<td>.72</td>
</tr>
<tr>
<td>CT (percentile score): total</td>
<td>8th</td>
<td>5th</td>
<td>.56</td>
</tr>
<tr>
<td>FTI (percentile score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant hand</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.61</td>
</tr>
<tr>
<td>Nondominant hand</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.49</td>
</tr>
<tr>
<td>GPT (percentile score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant hand</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.76</td>
</tr>
<tr>
<td>Nondominant hand</td>
<td>&lt;1st</td>
<td>&lt;1st</td>
<td>.53</td>
</tr>
</tbody>
</table>

Note. WAIS–R = Wechsler Adult Intelligence Scale–Revised; ACSS = Age Corrected Scaled Score; WMS–R = Wechsler Memory Scale–Revised; CVLT = California Verbal Learning Test (16-item version); TMT = Trail Making Test; WCST = Wisconsin Card Sorting Test; CT = Category Test; FTT = Finger Tapping Test; GPT = Grooved Pegboard Test.
The total amount of time spent on the experimental tasks for both groups was 55 min/day for 13 consecutive days. We chose the 55 min/day duration of practice to facilitate skill acquisition without inducing significant fatigue. Participants completed baseline trials on all tasks after verbal instructions were given. Comprehension of instructions was confirmed by having participants recite the task demands to the experimenter, and clarification was provided if necessary. After each day of practice, summary scores for each task were obtained. A summary score for performance at the end of the 13 practice sessions consisted of the average performance across Trials 11, 12, and 13 because peak performance on some tasks did not always occur on the last practice day. Participants performed a retention trial on all tasks 2 weeks after practice had ended so that we could determine whether they had maintained skills and subway stop information. Participants did not receive augmented feedback about their performance during the retention trial. Immediately after the completion of the retention trial, we conducted a skill transfer trial to determine the extent to which the recently acquired touch-typing skills were transferable to a typing dictation task. Transfer was done for the touch-typing task only. The transfer trial required the participant to sit at a computer keyboard and monitor while the examiner read a passage to him. The participant was instructed to touch-type to dictation for 5 consecutive min; the dependent variable was the number of correctly typed words per minute.

Results

We obtained the following dependent variables for each participant: mean words per minute for the touch-typing task, mean number of correctly computed digit sequences for the adding machine task, and mean number of correctly recalled paired associates on the subway task. In addition, we obtained the number of correctly typed words per minute on the transfer task (i.e., typing dictation).

For acquisition and retention, we performed a 2 (practice group) × 3 (tasks) analysis of variance (ANOVA) with repeated measures on the task factor. For transfer, we performed a 2 (practice group) × 2 (transfer trials) split-plot factorial ANOVA. To compare performance from the end of practice to retention, we used the average performance over the last 3 practice trials (i.e., Trials 11–13) to account for intertrial variability of peak performance.

Acquisition

We performed the analyses (1) to determine whether, regardless of type of practice schedule used, significant improvement occurred in skill acquisition (e.g., touch-typing and inputting digits on an adding machine) and in the number of recalled subway stops when performance at baseline was compared with performance at the end of the 13 practice sessions (Prediction 1) and (2) to determine whether type of practice schedule (e.g., random vs. blocked) differentially affected the level of procedural skills (e.g., touch-typing or adding machine) or verbal material (e.g., subway schedule) acquired by the end of practice (Prediction 2).

Touch-typing. All participants, regardless of type of practice schedule, showed statistically significant improvement in touch-typing skill when we compared baseline performance with performance at the end of practice (trial main effect; $F[1, 12] = 10.26, p < .001$; Figure 1); however, the group main effect and Group × Trial interaction were nonsignificant.

Adding machine. We also observed statistically significant improvements in the ability to correctly input digit sequences from baseline to the end of practice ($F[1, 12] = 14.16, p < .001$); however, the group main effect and Group × Trial interaction were nonsignificant.

Subway schedule. Finally, participants recalled significantly more subway stops and departure times at the end of practice than at baseline ($F[1, 12] = 3.77, p < .001$), but again the group main effect and Group × Trial interaction were nonsignificant.

Retention

We performed these analyses to determine whether type of schedule during practice (e.g., random vs. blocked) affected the amount of procedural skills or verbal material retained at retention (Prediction 3).

Touch-typing. When we measured retention 2 weeks after practice had ended, the group and trial main effects and Group × Trial interaction were nonsignificant, indicating that all participants maintained at 2 weeks what they had
acquired by the end of practice, regardless of the type of practice schedule that was initially used (Figure 2).

**Adding machine.** Likewise, results from the group and trial main effects and the Group × Trial interaction were nonsignificant and indicated that all participants maintained at 2 weeks what they had acquired by the end of practice (Figure 2).

**Subway schedule.** The group and trial main effects and Group × Trial interaction were nonsignificant, indicating that at 2 weeks all participants remembered the subway stops and associated departure times that they had learned by the end of practice (Figure 2).

**Transfer**

We performed this analysis to determine whether type of schedule used during practice differentially affected transfer of touch-typing skills to a different but functionally related task (e.g., typing dictation). Because transfer refers to the effect that a previously practiced skill has on subsequent performance of other skills (Schmidt & Lee, 1999), we compared performance at 2 weeks with performance at transfer. Additionally, we tested performance from baseline to transfer to determine whether performance on the transfer task was significantly better than touch-typing at baseline, thereby indicating skill generalization.

The Group × Transfer Trial interaction and the group main effect were nonsignificant; however, results showed a significant main effect of trial when performance at retention was compared with performance on the transfer task ($F[1, 4] = 13.54, p < .05$). This finding indicates that participants, regardless of type of practice schedule, typed significantly fewer words per minute on the transfer task than they typed.
at the 2-week retention trial; however, a further analysis showed a Group × Trial interaction trend when we compared touch-typing performance at baseline with that at the transfer trial \( (F[1, 4] = 4.97, p = .09) \), indicating that participants who originally practiced touch-typing using a randomly ordered practice schedule performed better on the transfer task than did participants who originally practiced using a blocked ordered practice schedule (Figure 3).

Discussion

In this study, we addressed four predictions. First, we expected participants to demonstrate skill acquisition on all tasks (e.g., touch-typing, adding machine, and subway schedule) regardless of practice conditions. Second, we hypothesized that participants who learned under conditions of high contextual interference or randomly ordered practice would acquire less skill or type fewer words per minute at the end of training than participants learning under the blocked ordered practice schedule would. Third, we hypothesized that participants would have greater skill retention practicing under the randomly ordered practice schedule as opposed to the blocked ordered practice schedule. Finally, our fourth prediction was that participants who practiced under a randomly ordered practice schedule would demonstrate greater skill transfer to the typing dictation task, a similar but unpracticed skill, than would those who practiced under the blocked ordered practice schedule.

As expected, both groups showed gains in all tasks when performance at the end of skill acquisition was compared with that at baseline (first prediction). This finding demonstrates that participants had the potential to learn both motor tasks (touch-typing and adding machine) and verbal tasks (subway schedule). Although both practice groups did improve in performance, the acquisition results (second prediction) did not support significant differences in performance between the two practice groups across practice and learning trials. Central to contextual interference effects is the finding that participants in the blocked-practice group typically demonstrated better performance in acquisition than did participants in the random-practice group. Also central to contextual interference effects is that participants in the random-practice group, as the result of a cognitively demanding practice context, performed better in subsequent tests of skill retention and transfer than did participants undertaking blocked practice. Unexpectedly, both groups maintained performance for all three tasks across retention trials (third prediction). For the typing dictation task, typing performance was reduced relative to the end of skill acquisition when data for the group were collapsed across practice conditions. When comparing typing dictation to baseline (fourth prediction), however, the random-practice group demonstrated enhanced performance with the typing dictation task compared with the blocked-practice group. Between-groups analyses indicated that participants who practiced typing on a random schedule were able to maintain their gains and transfer those skills to the typing dictation task, but blocked-practice learners were not, suggesting that participants who practiced on a random schedule had developed and maintained the capability to respond to the newly acquired task demands.

Although the contextual effect was not fully supported, the findings indicate that people who sustain TBI and are left with severe impairments in memory and fine motor control may still be capable of making improvements in learning, retaining, and transferring novel skills. These findings further substantiate findings in previous work (Glisky, 1992, 1995; Glisky et al., 1986) suggesting that training people with neurological impairments in functionally based computer skills may be a viable option for vocational retraining.

In examining skill learning for using the adding machine and learning the subway schedule, contextual interference predictions were not supported. In this study, the significant interaction effect suggests that performance varied across
practice groups and learning tests but not consistently or significantly as we expected. Across all learning conditions, however, participants in the random-practice group did demonstrate more of a trend toward improved performance than did the blocked-practice group. This study partially supports contextual interference effects, most notably the differences in performance between the random and blocked-practice groups on the transfer task. However, several factors mediating contextual interference may have affected participant outcomes during practice and retention.

In a critique of contextual interference research, Newell and McDonald (1992) presented evidence that practice schedule effects are task specific and vary across tasks depending on the perceptual and motor attributes of the specific task and the practice context. Tasks used for this study were similar and different in their motor and verbal learning characteristics. Prior studies focused on motor or verbal learning but not combinations of both motor and verbal learning. Touch-typing and use of the adding machine involved motor learning of letter and number patterns to develop keyboarding skills. The motor learning for these tasks was similar. The subway schedule task involved verbal learning of places and times for subway stops. The typing dictation transfer task incorporated both motor and verbal learning characteristics. Similarities and differences among these tasks may have differentially enhanced or interfered with the expected practice effects. In future research of this practice phenomenon, task analysis should be examined and used more systematically to further the application of the contextual interference effect.

Aside from task characteristics, certain individual characteristics or client factors are present in people with TBI that are also known to mediate or interact with the contextual interference effect. For example, amount of cognitive effort, intrinsic interest, experience, motivation, attention, anxiety, and self-efficacy (Ollis, Button, & Fairweather, 2005) has been shown to reduce the effects of random practice on typical participants’ skill learning. Decreased attention is a client factor for people with TBI. It has been demonstrated that people with TBI perform differently when using automatic and controlled processing in skill learning (Schmitter-Edgecombe, 2006). Several researchers have shown that automatic cognitive processes intact before injury generally show recovery by 1 year postinjury. However, the cognitive automatic processes in novel skill learning differ for people with TBI and for nonclinical populations. People with TBI have more difficulty remembering across practice trials. Therefore, their learning is enhanced when similar repetitive responses are made across practice conditions to support learning leading to automaticity. Because the touch-typing task was a novel skill for our participants, automatization of the skill and, consequently generalization to the typing dictation task may have been compromised. Also, controlled cognitive processing is more significantly impaired after TBI. These differences in automatic and controlled cognitive processing in people with TBI may account for the unexpected results for Predictions 2 and 3 and warrant further study.

In a study focused on learning and retrieval, DeLuca, Schultheis, Madigan, Christodoulou, and Averill (2000) found that people with TBI had problems with learning information and not with retrieval mechanisms. On the basis of these findings about processing and learning differences, motor learning principles, as they apply to typical performance, may be compromised for this population.

A person’s propensity to impulsivity and reflectivity, commonly disrupted by TBI, is another client factor that influences response to the practice schedule (Jelsma & Van Merrienboer, 1989). Participants’ degree of impulsivity was not controlled for in this study, however, and may have influenced participants’ task performance across the different practice groups. Examining contextual interference in people with mental retardation, Porrett and O’Brien (1991) found no differences between practice groups. They reasoned that participants were engaged in active processing in both practice groups given the cognitive difficulties interfering with their information processing. It is likely that specific individual characteristics of the participants with TBI in our study lessened the expected differences in performance demonstrated in previous studies with typical participants. In future studies, variables shown to influence contextual interference with typical participants will need to be more systematically controlled to determine whether these same factors influence skill learning in participants with TBI.

We conducted 6-month follow-up telephone interviews with 5 of the 6 participants to inquire about their recollection of their experience in the study and about their current vocational status. One participant was lost to follow-up and could not be contacted. The interviews revealed that 2 participants were able to independently recall all (three of three) of the tasks in the study, 1 participant recalled most (two of three) of the tasks, and 1 participant recalled one of the tasks. The fifth participant did not recall any of the tasks. Three of 5 participants reported that they continued to use the skills learned in the study at home or at work. An unexpected finding from the study was that 4 of 5 participants reported that their experience in the study positively changed their view about their abilities after their TBI. One participant reported, “It made me care about myself a lot more.” Another stated, “It gave me a better outlook on myself and helped my self-esteem also.” A third participant reported, “It made me see that I could do stuff that I never thought I’d be able to do.
again and that made me feel pretty darn good.” This third participant had become employed full time by a national car rental company, but it was unclear whether the skills he learned in the study had any influence on his current occupational status. Another participant indicated that he began working after the study as a bagger at a grocery store. These comments suggest that acquiring new skills had a positive effect on self-esteem, which may warrant further study.

In this study, we found that people with TBI can learn functional skills regardless of practice schedule. Although not all motor learning principles in this study yielded the expected results, the type of practice did affect the transfer of performance. The transfer task represented generalizability of learning, which is an important factor in relearning. When learning a novel skill, the random-practice group did demonstrate better transfer than the blocked-practice group when performing a new skill incorporating both verbal and motor components. Moreover, previously mentioned differences in automatic and controlled cognitive processing for people with TBI need to be taken into consideration when designing future research studies. These differences are potentially significant in designing optimal treatment sessions focusing on relearning basic ADL or vocational skills.

One limitation of this study was the small sample size. Future studies should be conducted using larger sample sizes to ensure that adequate power to detect between-group differences is obtained across all phases of acquisition, retention, and transfer. In addition, the inclusion of comparison groups of people without TBI who also practice under blocked and random practice conditions would provide information about potential differences in rates of skill acquisition, retention, and transfer between groups. Another consideration is our selection of both verbal (e.g., subway schedule) and nonverbal (e.g., adding machine) tasks as interference tasks for touch-typing. In our attempt to select functionally relevant tasks, we may have chosen tasks (e.g., use of adding machine) that yielded different magnitudes of interference when touch-typing followed the adding machine task versus the subway schedule task. Future studies should select tasks that are functionally relevant and minimize contextual divergence; systematically control for client factors specific to people with TBI, such as automatic and controlled processing; and further examine the application of motor learning principles in occupational therapy interventions for people with TBI.

Acknowledgments

This project was funded by a grant through the James S. McDonnell Foundation. We thank Kimberly Maugher, Tanya Marchand, and Christine Cannon for reviewing and providing important editorial changes.

References


