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Improved Function After Combined Physical and Mental Practice After Stroke: A Case of Hemiparesis and Apraxia

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Stroke is the third most common cause of death and a leading cause of disability in the United States: It is estimated that 795,000 people experience new or recurrent stroke each year (Lloyd-Jones et al., 2009). Upper-extremity hemiparesis after stroke is a significant disabling consequence of stroke and the condition most commonly treated by occupational therapists (Radomski & Trombly, 2008), because it compromises the ability to perform valued activities of daily living (ADLs). Most studies to date have directed treatment efforts toward hemiparesis, with little consideration given to comorbid disorders that may influence potential rehabilitation benefit.

Ideomotor apraxia (IMA) is a common disorder after left hemisphere stroke, and it has implications for functioning in everyday life. It has been defined as a disorder of learned skilled movements that cannot be attributed to other common stroke deficits, such as primary motor or sensory impairments or language comprehension difficulties (De Renzi, 1989; Rothi & Heilman, 1997). Indirect evidence has suggested that IMA influences functioning in everyday life, as revealed in a positive association between severity of IMA and dependence in daily living skills (Bjørneby & Reinvang, 1985; Hanna-Pladdy, Heilman, & Foundas, 2003; Sundet, Finset, & Reinvang, 1988). Patients with IMA after left hemisphere stroke display spatial and temporal errors in movement trajectories that subsequently affect efficient manipulation of objects in the environment that is required for

independence (Foundas et al., 1995; Hanna-Pladdy et al., 2003). Few studies, however, have examined rehabilitation of apraxia. Although studies have shown efficacy in the treatment of apraxia (Smania et al., 2006; Smania, Girardi, Domenicali, Lora, & Aglioti, 2000), most have used single-case designs (Butler, 2000; Maher, Rothi, & Greenwald, 1991; Pilgrim & Humphreys, 1994), and little evidence has indicated that treatment generalizes in the natural environment beyond the training paradigm. Systematic reviews of apraxia treatment have suggested that evidence is insufficient to support or refute treatment of apraxia and that development of treatment paradigms is in its infancy (Buxbaum et al., 2008; West, Bowen, Hesketh, & Vail, 2008). Despite evidence of the influence of apraxia on daily functioning, few studies have considered the impact of apraxia on motor rehabilitation efforts.

Mental practice is a technique used to enhance physical performance in which a person rehearses a motor task cognitively, in the absence of physical movements. Early studies with healthy people have reported increases in strength (Shelton & Mahoney, 1978; Tynes & McFatter, 1987), endurance (Lee, 1990), and precision and aim (Murphy & Woodfolk, 1987; Wrisberg & Anshel, 1989) when mental practice and physical practice are used in combination. Within the past decade, mental practice has been suggested for use in rehabilitative settings (Jackson, Lafleur, Malouin, Richards, & Doyon, 2001; Page, 2001; Sharma, Pomeroy, & Baron, 2006).

Research involving mental practice has focused on people with stroke, and several earlier studies have suggested that mental practice appears to reduce impairment and improve motor function in acute, subacute, and chronic stroke (Liu, Chan, Lee, & Hui-Chan, 2004b; Page, 2000; Page, Levine, & Leonard, 2005; Page, Levine, Sisto, & Johnston, 2001b). Case studies have noted specific improvements in functional grip and grasp tasks (Page et al., 2001a), gait speed and range of motion of knee (Dickstein, Dunskey, & Marcovitz, 2004), and a foot-sequencing task (Jackson, Doyon, Richards, & Malouin, 2004). Consistent with these data, studies also reported increased affected arm use (Page et al., 2005) and function (Liu, Chan, Lee, & Hui-Chan, 2004a). Mental practice is most effective when combined with overt physical practice of tasks (Bachman, 1990; Gentili, Papaxanthis, & Pozzo, 2006; Sidaway & Trzaska, 2005; Yáguiez et al., 1998). In fact, a randomized, placebo-controlled trial by Page, Levine, & Leonard (2007) concluded that the addition of mental practice to conventional motor therapy significantly decreased impairment and increased movement in the more-affected arm. Recent systematic reviews have also asserted that mental practice as an additional therapy may provide benefits for recovery after stroke (Braun, Beurskens, Borm, Schack, & Wade, 2006; Zimmermann-Schlatter, Schuster, Puhan, Siekierka, & Steurer, 2008).

The presence of IMA with hemiparesis could conceivably limit the rehabilitation benefit of otherwise efficacious treatment interventions. We evaluated whether combined physical and mental practice would increase functional performance and self-perception of performance in a patient with hemiparesis and concomitant IMA after stroke. This study is of particular interest to occupational therapists, because patients after stroke may present with comorbid disorders that exacerbate interference with the ability to live independently and to engage in meaningful occupation.

Method

Patient Selection

Inclusion/exclusion criteria were based on prior research (Page, Levine, & Hill, 2007; Page, Levine, & Leonard, 2007; Page et al., 2005). Potential candidates were screened from the University of Kansas Medical Center's stroke registry using the following inclusion criteria: (1) age 18 yr and <75 yr; (2) single stroke experienced >6 mo before enrollment; (3) ability to actively flex at least 10° from neutral at the more-affected wrist and the metacarpophalangeal and interphalangeal joints of two digits; (4) presence of apraxia as indicated with <70% on a revised abbreviated version of the Florida Apraxia battery gesture-to-verbal command task (Hanna-Pladdy, Heilman, & Foundas, 2001; Hanna-Pladdy et al., 2003); (5) absence of dementia, as indicated by a score of 24 on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975). Exclusion criteria were (1) history of >1 stroke; (2) excessive pain in the more-affected arm, as defined by a score of 4 on a 10-point visual analog scale; (3) history of concurrent, unstable medical condition; and (4) current participation in any rehabilitation or drug studies.

Case Description

The patient was a 44-yr-old White man who experienced a single stroke 7 mo before enrollment. His past medical history is significant for a patent foramen ovale. On admission to a local hospital, a computed tomography scan revealed an acute ischemic infarct in the distribution of the distal left middle cerebral and left anterior cerebral artery. He received approximately 30 days of inpatient rehabilitation (3 hr/day, 5 days/wk), including concurrent speech, physical, and occupational therapy. He is a right-handed, native English speaker with 14 yr of formal education. At the time of initial assessment, the patient reported problems with writing, math, and more hemiparesis in the right arm than in the right leg.

Instruments

The Arm Motor Ability Test (AMAT; Kopp et al., 1997) is a 13-item test that measures deficits in ADLs. The AMAT is a valid, stable, and reliable scale, and it correlates positively with other stroke-specific functional scales (Kopp et al., 1997). It rates ADLs according to a Functional Ability Scale (FAS; 0 = *does not attempt to use more-affected arm*; 1 = more-affected arm does not participate functionally, however attempt is made to use more-affected arm; 2 = more-affected arm is used for minor readjustments or as a helper/stabilizer in bilateral tasks; 3 = movement is influenced by synergy, performed very slowly, or with effort; 4 = movement is close to normal, but slightly slower; may lack precision and fluidity; 5 = movement appears normal or comparable to less-affected arm). AMAT tasks include ADLs such as use of a knife and fork, eating with a spoon, combing hair, and tying shoelaces. Time to complete each task is recorded to the nearest tenth of a second. Although FAS scores and time-to-complete tasks were obtained for each task, summed scores were used in our analysis.

The Canadian Occupational Performance Measure (COPM; Carswell et al., 2004) is a semistructured interview used to identify occupational performance problems. It is confirmed as being useful in helping to guide treatment. The COPM has been reported to be

a valid, reliable, clinically useful, and responsive outcome measure for occupational therapists and researchers (Carswell et al., 2004). The assessment records the client's responses to questions in three main categories: self-care, productivity, and leisure. The client is then asked to rate the importance of each item on a scale ranging from 1 to 10 (1 = *not important at all*; 10 = *extremely important*). Once the top five activities are determined, each is rated according to perceived performance (1 = *not able to do it*; 10 = *able to do it extremely well*) and satisfaction with performance (1 = *not satisfied at all*; 10 = *completely satisfied*). Performance and satisfaction scores are summed and divided by the number of problems identified (5), and this total score is used in the analysis. This subjective measure detects and tracks changes in the client's own perception of performance and satisfaction.

Similar to protocols in previous investigations, an abbreviated version of the Florida Apraxia battery gesture-to-verbal command task was used to assess the severity of IMA (Hanna-Pladdy et al., 2001, 2003). The patient used only the ipsilesional upper extremity during testing, so that motor impairment did not influence apraxia performance. The patient was asked to pantomime or gesture a set of 10 transitive tasks (e.g., "show me how to use a hammer to drive a nail into a wall"). Two trained judges scored responses on a severity scale ranging from 0 to 6 (0 = *no response, unrecognizable*, 1 to 2 = *severely degraded*, 3 = *moderately degraded*, 4 to 5 = *mild impairment*, 6 = *perfect*). The number of errors was considered in determining severity of IMA; lower scores indicated greater severity. Percentages were derived by subtracting the number of errors from the total possible, then dividing by the total possible.

Procedures

After obtaining informed consent, approved by the Institutional Review Board of the University of Kansas Medical Center, a research team member administered the AMAT and COPM (PRE). Postassessments occurred immediately after intervention (POST1) and again 4 wk after intervention ended (POST2). POST2 determined whether treatment benefit persisted in the absence of intervention.

Intervention consisted of physical and mental practice of two specific tasks: reaching for and grasping a cup and turning pages in a book. Of the mental practice tasks previously studied (Page, Levine, & Hill, 2007; Page et al., 2001a, 2005), these tasks were chosen because they are common activities, do not require use of the dominant hand, and involve different types of movements. The intervention took place 3 times per week in 60-min sessions for 6 consecutive wk. The patient practiced (1) reaching and grasping a cup for the first 3 wk and (2) turning pages in a book for the remaining 3 wk.

Physical Practice

The first 30 min of each session involved physical practice of the task. The patient practiced tasks with his moreaffected arm using actual objects (i.e., cups and books). During this time, we graded the task to appropriately challenge the patient (e.g., began by reaching for an empty cup, later moved to a cup half-full of water, and finally used a full cup). Interventions included obtaining and moving a cup to and from surfaces at various heights, transferring liquids from container to cup, and practicing larger activities encompassing the target task

(e.g., preparing and drinking a cup of tea). Whole-task practice and part-task practice were incorporated into treatment. Part-task practice consisted of decomposing the target task into a sequence of smaller steps and focusing practice on the smaller steps that the patient found difficult. Rest periods were included as needed or as requested by the patient, particularly before beginning the mental practice.

Mental Practice

The second 30 min of each session consisted of mental practice corresponding to physical practice (i.e., mental practice of reaching for and grasping a cup after physical practice of the same task). Guided mental practice using audiotape for instructions was used, because this approach has been used in previous studies for people with stroke who exhibit hemiparesis or hemiplegia (Page, Levine, & Hill, 2007; Page, Levine, & Leonard, 2007; Page, Levine, Sisto, & Johnston, 2001b; Page et al., 2001a, 2005). Mental practice occurred in a quiet room; the patient was seated and listened to a 30-min mental practice audio-tape. The initial 5-min segment of the tape encouraged a progressive relaxation of muscles as the patient imagined experiencing a relaxing environment (e.g., a warm beach). The next 20-min segment consisted of actual mental practice of the specific task practiced that day in therapy (i.e., mental practice of reaching for a cup after physically practicing reaching for a cup). The mental practice audiotape emphasized both visual and kinesthetic information while guiding the patient through all steps necessary to perform the actual movement. The final 5-min segment allowed the patient to reorient to the surrounding environment. The patient was encouraged to listen to the mental practice audiotape in its entirety without disruption. The therapy session for that day concluded when the audiotape ended.

Results

During the course of the intervention, the patient complained of minor fatigue, increased frustration with more challenging tasks, and boredom. Regardless, the patient attended all treatment sessions, was agreeable to treatment suggestions, and reported actively engaging in each mental practice session. Comparison of AMAT and COPM scores before and after intervention was used to determine change in functional performance and self-perception of performance.

Before intervention, the patient exhibited decreased efficiency in performing ADLs, as evidenced by AMAT scores (Table 1). Scores from the COPM reflected lower perceived performance and satisfaction than the patient's performance on the AMAT indicated. The patient reported diminished performance in tasks such as clipping his nails, managing finances, and woodworking, along with difficulty with driving and with doing laundry (Table 2). In addition, low satisfaction scores with his current performance were recorded for all tasks identified in the COPM. The patient presented with moderate-to-severe IMA, which was determined by a gesture-to-verbal command score of 31 of 60 (51.67%).

After intervention, the patient demonstrated improvements in functional performance as measured by the AMAT, specifically with tasks involving reaching and bringing items toward the body such as the knife-and-fork task, eating a sandwich, eating with a spoon, drinking from a mug, combing hair, using the telephone, and wiping up spilled water.

Composite AMAT data are presented in Table 1. The composite FAS component score of the AMAT before intervention was 79, compared with 95 at POST1.

The composite time taken to complete all AMAT tasks decreased. The patient required 302.9 s to complete all tasks before the intervention and 211.7 s after the intervention. Scores obtained 4 wk after completion of the intervention (POST2) are also notable, because the FAS score improved to 102 and the time required to complete all tasks decreased to 183.1 s.

Self-perception of performance (COPM) scores reflected outcomes similar to those on the AMAT. The patient reported improved ability in clipping nails, managing finances, and participating in woodworking activities at POST1 (Table 2). Satisfaction scores associated with the performance of these tasks also increased. The changes continued to be evident at POST2, with slightly improved scores in some areas; however, the driving and laundry goals identified by the patient showed no change from PRE to POST1 or POST2.

Gesture-to-verbal command scores indicated the continued presence of IMA at all assessment time points. The percentages derived from scores were 51% at PRE to 60% at POST1 and 63.3% at POST2.

Discussion

The primary purpose of this single-case report was to examine change in functional performance of ADLs and self-perception of performance in someone with concurrent hemiparesis and IMA after stroke. After physical with mental practice, the patient showed increases in measures of functional performance and self-perception of performance, despite persistent IMA. We assessed apraxia severity by evaluating change in scores on the gesture-to-verbal command test, and the patient exhibited persistent IMA with scores clinically unchanged from PRE to POST1 and POST2. The observed changes in the AMAT revealed improvements in functional ability scores associated with decreased time needed to complete tasks at POST1 (Table 1). This patient demonstrated an improved ability to bring objects from lower surfaces to higher ones (i.e., tasks involving primarily elbow flexion with some shoulder flexion), perhaps because one of the training tasks involved practicing bringing a cup toward the mouth. Improved fine motor abilities were also noted, as evaluated by AMAT tasks involving picking objects up from a table's surface.

Although an increase in FAS scores of the AMAT was observed, the patient exhibited decreased FAS scores in some tasks at POST1. A composite decrease in time was observed, even though the patient took longer to complete certain tasks. These findings are important, given the relationship between FAS and time, two components of the AMAT. The most desirable outcome in the present setting is to obtain a higher FAS score with decreased time (an inverse relationship). The possibility of a direct relationship (i.e., increased FAS with increased time or decreased FAS with decreased time), however, must be considered. In this study, the patient demonstrated a direct relationship of FAS and time on multiple occasions. As additional effort was exerted to achieve a higher FAS score, the time required to

complete the task increased. This relationship was observed in 7 of 11 total tasks and may underlie some changes observed in FAS scores and time.

Examining the subcomponents of AMAT tasks did not reveal a consistent pattern or type of task that displayed this relationship. Moreover, most bilateral tasks exhibited this relationship, suggesting that perhaps bilateral integration during two-handed motor tasks plays a role in both quality and timing of such tasks. Despite variability among individual AMAT items, composite AMAT scores do identify an inverse relationship (an increase in FAS score associated with a decrease in time), supporting a therapeutic benefit for this intervention as described by these outcome measures.

COPM scores also improved from PRE to POST1. The patient reported a perceived increased ability to perform some activities, whereas others remained unchanged. Of the five activities listed in Table 2, three showed positive change in scores on both performance and satisfaction, because the patient was able to readily engage in those activities. The patient reported inadequate balance to carry laundry up and down a flight of stairs and, thus, chose not to participate in this activity. In addition, the patient required physician's approval to resume driving; in this case, permission was not granted until a later date. Accordingly, COPM scores accurately reflected the patient's circumstances. The laundry and driving tasks, however, were not appropriate problems for gauging improvements from the intervention. Other changes in scores from the COPM are positive because the patient reported increased confidence and ability to perform the activities. Although increased self-perception of and satisfaction with performance are important, such perceptions should ideally be substantiated by a comparable increase in functional performance. The scores from the AMAT and COPM indicate that the patient experienced an increase in both functional performance and self-perception of performance.

Scores obtained at POST2 from the AMAT and COPM were compared with scores from POST1 to assess sustained changes in functional performance and self-perception of performance. The patient did not partake in any form of rehabilitation during the 4 wk between POST1 and POST2, including the treatment intervention described in this study. In the absence of the treatment intervention, the patient demonstrated improvements in scores obtained 4 wk after completion of the intervention phase of the study, suggesting that the patient continued to improve on the primary outcome measures.

The changes noted on AMAT scores are clinically relevant. Improvements revealed that the patient was more able to perform tasks at POST1 and POST2 than at PRE. In addition, the patient demonstrated increased efficiency with the tasks, as indicated by higher FAS scores associated with decreased time. Although the patient did not demonstrate clinically important changes between assessment time points on the COPM (designated as two or more points), a steady increase in scores is evident across time.

The effect of IMA on rehabilitation has been neglected, despite the fact that 30%–50% of patients with left hemisphere stroke display persistent IMA (De Renzi, Motti, & Nichelli, 1980; Donkervoort, Dekker, van den Ende, Stehmann-Saris, & Deelman, 2000; Kertesz & Ferrio, 1984). In the current study, the patient exhibited persistent skilled movement deficits

(i.e., IMA) at all assessment points yet was able to demonstrate improvements in the AMAT and COPM. This finding accords with previous work suggesting that patients with IMA are able to benefit from traditional rehabilitation, although their improvement may not be comparable to that of patients without IMA (Unsal-Delialioglu, Kurt, Kaya, Culha, & Ozel, 2008). The results in Unsal-Delialioglu et al. (2008) should be carefully considered, however, because the study failed to define and control for type of rehabilitation intervention. The current study overcomes this limitation by using a specific rehabilitation intervention (i.e., physical with mental practice) to study whether a person can improve on functional measures after stroke despite persistent IMA.

Taken together, these findings are relevant, because therapists and clinical researchers must remember that IMA is indeed a persistent disorder after stroke. More important, the presence of IMA in addition to hemiparesis may reduce effectiveness of rehabilitation interventions deemed successful in people with hemiparesis alone. This patient's extent of apraxia did not hinder his ability to make clinically significant improvements on measures of functional performance and self-perception of performance after treatment consisting of physical with mental practice of tasks.

Limitations and Future Research

Our preliminary data support the concept that a patient may derive benefit from treatment of hemiparesis even if IMA persists. It is unclear, however, to what degree IMA influences rehabilitation potential and whether the patient in this study would have demonstrated greater gains without comorbid IMA. Further research is warranted to explore the potential efficacy of using mental practice (efficacious motor rehabilitation techniques) in light of comorbid IMA or other disorders that may directly affect functional motor performance.

Although the patient's improvements were marked, a single-case report prohibits inferences from results obtained for an individual. In addition, with this design, we cannot be certain that the patient would have made greater functional gains in the absence of IMA. A training effect could account for the improvements observed, limiting a clear attribution to the intervention applied here. Future studies should ensure adequate ability to perform mental practice using appropriate measures. The same investigator performed all treatment and assessments, which contributes to potential bias of results. As suggested by Sunderland and Shinner (2007), IMA may be a hidden barrier to rehabilitation; therefore, future studies should include larger sample sizes with proper control groups (e.g., patients with either hemiparesis or IMA) to further examine the effects of IMA on rehabilitation benefit. Despite these shortcomings, the findings of this study represent an initial step toward considering treatment of patients with stroke presenting with multiple disorders that may affect their potential to benefit from rehabilitation efforts. ♦

Acknowledgments

This study describes change in functional performance and self-perception after participation in combined training with physical practice followed by mental practice. The patient was a 44-yr-old White man who experienced a single left ischemic stroke 7 mo before enrollment in the study. He engaged in physical and mental practice of two functional tasks: (1) reaching for and grasping a cup and (2) turning pages in a book with the more-affected arm. Practice took place 3 times per week during 60-min sessions for 6 consecutive wk. Primary outcome measures were

the Arm Motor Ability Test (AMAT) and the Canadian Occupational Performance Measure (COPM). An abbreviated version of the Florida Apraxia Battery gesture-to-verbal command test approximated severity of ideomotor apraxia. After intervention, the patient demonstrated increased functional performance (AMAT) and self-perception of performance (COPM) despite persistent ideomotor apraxia. The results of this single-case report indicate functional benefit from traditional rehabilitation techniques despite comorbid, persisting ideomotor apraxia.

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Table 1

Arm Motor Ability Test: Composite Scores Before and After Intervention

Component	PRE	POST1	POST2
Functional Ability Scale	79	95	102
Time to complete tasks, s	302.9	211.7	183.1

Note. PRE = before intervention; POST1 = immediately after intervention; POST2 = 4 wk after intervention ended.

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Table 2

COPM Scores Before and After Intervention

Occupational Performance Problem	PRE		POST1		POST2	
	COPM-P	COPM-S	COPM-P	COPM-S	COPM-P	COPM-S
Clipping nails	1	1	5	5	7	7
Driving	1	1	1	1	1	1
Managing finances	4	1	5	2	6	2
Woodworking	4	1	5	1	7	2
Laundry	1	2	1	2	1	2
COPM-P	2.5		3.4		4.4	
COPM-S	1.2		2.2		2.8	

Note. PRE = before intervention; POST1 = immediately after intervention; POST2 = 4 wk after intervention ended; COPM-P = Canadian Occupational Performance Measure-Performance subscale; COPM-S = Canadian Occupational Performance Measure-Satisfaction subscale.

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