2012

Facilitating the use of implicit memory and learning in the physical therapy management of individuals with Alzheimer's disease; a case series.

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FACILITATING USE OF IMPLICIT MEMORY AND LEARNING IN THE PHYSICAL THERAPY MANAGEMENT OF INDIVIDUALS WITH ALZHEIMER'S DISEASE: A CASE SERIES

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A DISSERTATION

Submitted to the graduate faculty of The University of Alabama at Birmingham,
in partial fulfillment of the requirements for the degree of
Doctor of Science

BIRMINGHAM, ALABAMA

2012

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ABSTRACT

Background and Purpose: Physical rehabilitation of individuals with Alzheimer's disease (AD) is often complicated by impairments in explicit memory and learning. Rehabilitation strategies that facilitate use of the preserved implicit memory system may be effective in treating patients with AD. The purpose of this case series is to describe the application of these strategies, including high-repetition practice, errorless learning (EL), and spaced retrieval (SR), to the physical therapy management of individuals with moderate AD.

Case Description: Three women aged 89 to 95 years old with moderate AD who resided in an assisted living facility participated in physical therapy to address their mobility limitations.

Intervention: Twelve physical therapy sessions were scheduled over a period of 4 weeks. Interventions were individually designed to address the mobility needs of each patient, and rehabilitation strategies based on implicit learning principles were integrated into the interventions.

Outcomes: All patients participated in at least 10 of the 12 physical therapy sessions. Improvements in performance of objective measures of balance were observed in all patients, although only one patient's balance score exceeded the minimal detectable change (MDC). No significant clinical change was observed in any patients on the Timed Up and Go test (TUG) or self-selected gait speed (ssGS).

Discussion: Principles of implicit learning were integrated into the interventions for these patients with moderate AD. Further research on the effectiveness of EL, SR, and other rehabilitation strategies that facilitate implicit learning of mobility skills in patients with AD is needed to promote optimal physical therapy outcomes in this patient population.

Key Words: Alzheimer's disease; implicit learning; physical therapy

ACKNOWLEDGEMENTS

I would like to acknowledge the many people who have provided support, expert opinion, and encouragement throughout this process. I am grateful to my committee for their willingness to share their time and knowledge to assist me in creating a quality manuscript. I am especially grateful to Matt Ford, committee chair, and Cecilia Graham, program director, for their patience and guidance throughout the dissertation process.

I would also like to thank my husband, Stan, for his encouragement and support during this professional journey. At times, his vision of my professional goals was clearer than my own.

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BACKGROUND AND PURPOSE

Physical therapy management of individuals with Alzheimer's disease (AD) and mobility limitations is complicated by the cognitive impairments that characterize this progressive disease.[1,2] Impaired explicit memory, the conscious recollection of facts, ideas, and events, combined with a decreased capacity for explicit learning and error detection limit the methods by which patients can relearn mobility activities. Physical therapists (PTs) often use explicit verbal instructions, corrective feedback, mental practice, and discovery learning to facilitate improved mobility. Because these methods require use of the explicit learning and the ability to detect errors in performance, they may not be effective to use in individuals with AD, especially those with significantly impaired explicit memory.

A growing body of research suggests that individuals with AD may learn best under conditions that facilitate use of the implicit memory system.[2-4] Implicit learning requires use of the implicit memory system, which remains relatively intact until the late stages of AD.[3-4] Implicit memories are formed with recurrent practice of a task and do not require that the learner develop conscious rules to guide performance.[5] When a patient has learned a skill implicitly, a relatively stable change in knowledge or behavior is observed but the patient may not have conscious awareness of either what was learned or specifically how it was learned. Early research on motor learning in individuals with AD demonstrated that high-repetition, low variability practice conditions optimized implicit learning of laboratory-based motor tasks, such as mirror tracing tests,[6] maze tests,[7] tracking tasks,[8] serial reaction time task (SRTT),[9]and tossing a beanbag at a target.[10] Because these laboratory-based tasks do not simulate the complex functional activities that many patients with AD need to learn or relearn, more recent studies of motor learning in AD have focused on the application of implicit learning principles to the training of individuals with AD in "real-life" functional activities in clinical or naturalistic environments.[11,12] Individuals with AD have demonstrated improved performance of sequential instrumental activities of daily living (IADLs) and mobility tasks when trained under implicit learning conditions.[11,13]

Errorless learning (EL), a learning paradigm based on the implicit learning principles of high repetition and low variability practice conditions, is a promising rehabilitation strategy for physical therapists to use in managing patients with AD.[14,15] In the EL paradigm, practice conditions are designed to prevent or minimize inaccurate performance during the learning process. Because individuals with AD may not be able to form conscious rules for correct performance of a task (i.e. explicit learning), they are not likely to benefit from making errors during practice or receiving corrective feedback. Instead, repetitive practice without errors may consolidate memory of correct performance within the implicit memory system. Therefore, it is thought that EL conditions may be preferable to trial-and-error (TE) learning conditions in individuals with AD.[11, 16] Because errors are eliminated or reduced in EL training sessions, an additional benefit of EL is that patients are successful throughout the session, which may reduce frustration and increase participation by the patient. Interventions based on the EL paradigm have been effective in teaching individuals with AD to use a mobile phone,[17]eat more independently,[18] find the correct route in a residential facility,[19] and perform sequential IADLs.[11]

In clinical practice, PTs may encounter barriers to integrating the principles of implicit learning and, more specifically, EL into the physical therapy management of patients with AD. The real-world constraints of clinical practice include limited treatment times, behavioral and neuropsychological symptoms that are common in the later stages of AD, and unpredictable clinical and naturalistic environments. These constraints may limit the feasibility of task-training under implicit learning conditions. The purpose of this prospective case series is to describe the clinical decision-making process of a physical therapist who integrated principles of implicit learning into the individualized physical therapy plan of care of three patients with moderate AD.

METHODS

Patient Description and Selection

Three residents were recruited from the memory care unit or assisted living unit of a senior retirement center. Two nurse managers identified residents who they thought would benefit from physical therapy intervention and who met the inclusion criteria of 1) diagnosis of AD or probable AD, 2) ability to sit unsupported for 5 minutes, 3) ability to follow a one-step simple motor command in English, and 4) a decline in mobility in the last 6 months. Persons were excluded if they had a history of any severe cardiopulmonary, musculoskeletal, or other neurological condition that may adversely affect postural stability and ability to participate in therapy sessions, a diagnosis of vascular dementia or chronic dementia other than probable AD, a history of chronic alcoholism or psychiatric disorder that may affect cognitive function, or were currently participating in a physical rehabilitation program. All study protocols were approved by the Institutional Review Board of the University of Alabama at Birmingham**.** Each participant and their legally authorized representative provided written informed consent for participation. The physician for each participant provided a written physician's referral for physical therapy prior to the initial examination.

The PT collected demographic, medical, and social history from the patient, family members, nursing staff, and medical charts kept at the facility. The PT administered the Mini-Mental Status Examination (MMSE) [20] on the date of the initial examination to assess current cognitive function. The PT also rated each participant on the Functional Assessment Staging Tool (FAST) [21] with information provided by the nursing staff to classify the level of dementia. Characteristics of each patient are summarized in Table 1.

Table 1

Patient Characteristics

	Patient 1	Patient 2	Patient 3
Age, y	90	89	95
Gender	Female	Female	Female
MMSE	14/30	12/30	11/30
FAST	5 (moderate dementia)	5 (moderate dementia)	6d (moderately severe dementia)

MMSE = Mini-Mental State Examination; FAST = Functional Assessment Staging Tool

Procedure

The initial PT examination and treatment sessions were conducted in each patient's naturalistic setting, which included a private bedroom and bathroom and common areas (i.e., hallway and dining room). A naturalistic treatment setting was chosen rather than a private clinic area because familiar settings are thought to decrease stress and behavioral symptoms in individuals with dementia which may facilitate greater learning.[22]

Mobility and balance outcome measures were administered to each patient during the initial evaluation and final treatment session. The Timed Up and Go Test (TUG)[23] and self-selected gait speed were chosen to objectively measure mobility because 1) the test-retest reliability and minimal detectable change (MDC) of these measures have been determined in the AD population,[24] and 2) the measures are feasible to administer in a naturalistic environment in which minimal equipment and space is available. Other mobility and balance outcome measures were administered based on the individual patient's baseline functional status. The clinical decision-making process for selection of these measures is discussed with each individual case.

The PT designed an individualized plan of care that included training of mobility and balance tasks that directly addressed individual patient impairments and activity limitations. To facilitate active participation by each patient and reliance on implicit memories of prior motor learning, the PT selected tasks that were functionally relevant and used objects familiar to the patient. [25] The number of tasks was limited so that each task could be practiced multiple times. The practice schedule was blocked in the same order each session to limit variation and provide a familiar routine for the patients. Rehabilitation strategies that promote EL were incorporated into the task training, when possible (see Table 2).

Table 2

Rehabilitation Strategies to Promote Errorless Learning (EL)[11,16,18,26-28]

Strategy	Brief Description
Feedforward Instruction	·PT provides verbal and/or manual cues prior to patient performing the task or each step in a sequential task
Modeling	·PT demonstrates the task prior to patient performing the task ·For a sequential task, the PT demonstrates a step; patient practices the step; upon patient's successful performance, additional steps are demonstrated and practiced
Physical assistance	·PT provides hand-over-hand guidance or other physical assistance during practice to ensure accurate performance of the task
Modify task variables	·PT initially decreases the difficulty of task by modifying task variables, such as speed or distance; when patient performs without errors, PT increases challenge of task
Spaced retrieval (SR)	·PT asks a prompt question; the patient verbally recalls the answer to the question and performs the associated motor task (i.e, recall test); upon correct performance, the time interval between recall tests is increased; upon incorrect performance, the PT verbalizes the correct answer, the patient immediately repeats the answer, and the time interval of the last successful recall test is repeated.

It was decided prospectively that each patient would receive 12 physical therapy visits over a period of 4 weeks. This visit frequency and duration of episode of care were chosen to simulate the real-world constraint of limited treatment frequency and duration due to third-party payment practices. Based on clinical experience, this visit frequency and duration of episode of care is typically reimbursed by third party payers if medical necessity and skilled PT services are adequately documented. Based on the training frequency and number of practice trials reported in published studies of motor learning in AD, [8,11] it was decided that 12 visits would be sufficient to provide high-repetition practice to facilitate implicit learning of the intervention tasks. Treatment sessions were to last no longer than 60 minutes to simulate the time constraints in a typical clinical practice. The PT did not seek payment from any party for physical therapy services provided to these patients.

CASES

Patient 1: History

The patient was a 90 year-old woman who resided in the memory care unit. She had fallen one month prior to the initial examination. A staff member found the patient on the floor in a narrow space between her bed and wall. Her medical history included placement of a demand pacemaker and longstanding hypertension which was recently uncontrolled and required a change in her antihypertensive medications.

The patient's son resided locally and took her to church every Sunday. He reported that she had recently become unsteady when walking in the church. His goal for the patient was to improve her ability to walk through the busy church. The nursing staff reported that the participant was independent in all ADLs. She ambulated independently without an assistive device throughout the memory care unit. During the initial interview with the patient, she demonstrated limited recall of recent life events, reported no problems with mobility, and did not recollect any previous falls.

Patient 1: Clinical Impression and Examination

Given the patient's impaired declarative memory as reflected in the patient interview, task-training interventions to improve mobility using implicit learning strategies were warranted. Further clinical examination was conducted to identify underlying impairments and specific mobility limitations that would be addressed by the plan of care.

The patient was alert and oriented to self and place but demonstrated impaired registration, recall, and mathematical calculation on the MMSE. She was inconsistently able to follow a multiple-step motor command, as she was unable to follow commands to resist manual forces applied by the PT during manual muscle testing. Active range of motion of all extremities was grossly without deficit. The patient was able to roll independently in all directions on her bed. Supine to sit and sit to stand were independent when performed as distinct transitions. However, when the patient was asked to get out of bed, she quickly transitioned from supine to standing, requiring contact guard assistance due to excessive postural sway in initial standing. Sit to stand from the bedside chair and toilet was independent, although it was noted that the patient positioned her legs against the chair for support as she stood.

The patient ambulated independently in her room without the use of an assistive device, but she was observed to hold onto the wall or bed when she walked in the narrow area between her bed and wall. She maintained her balance while performing ADLs at her sink, but she was observed to have a wide base of support (BOS). The patient ambulated independently from her bedroom to the dining room without signs of exertion. However, she stopped walking when a cognitive task (i.e., conversing with the PT or other residents) was introduced.

On initial examination, the patient's ssGS was 1.38 meters/second (m/s), which was significantly faster than norms for the mild-moderate AD population.[24] Her score on the TUG was 12.94 seconds, slightly less than the cut-off score of 13.5 seconds which is predictive of high fall risk in community-dwelling older adults.[29] The Berg Balance Scale (BBS) [30] was administered to objectively measure the patient's static and dynamic standing balance at baseline and after the intervention. The BBS is a valid and reliable measure that evaluates 14 mobility and balance tasks that are relevant to the participant's daily life.[30,31] The patient scored a 41/56 on the BBS, indicating a minimal risk for falls.[32] During administration of the BBS, she had difficulty standing with her feet together, was unable to stand in a tandem position, and required physical assistance to regain her balance when placing her foot on a stool.

Patient 1: Clinical Impression and Intervention

The patient's impaired static and dynamic standing balance was most evident in mobility tasks that required a narrow base of support (BOS) or attention to a concurrent cognitive task. Therefore, mobility and balance intervention tasks were selected that could be performed under dual-task conditions and challenged the patient's balance by requiring a narrow BOS. During task-training, the PT used modeling, feed-forward instruction, and concurrent tactile cues and intentionally limited explicit instructions and feedback to facilitate implicit learning of the tasks. The PT decided to use the EL-based strategy of spaced-retrieval (SR) to teach the patient to slow the transition from supine to standing, as the patient consistently demonstrated postural instability upon initial standing. The patient successfully completed a short verbal recall screening test, indicating that she was an appropriate candidate for use of SR.[33] A description of the interventions, specific implicit learning strategies incorporated into the interventions, and rules for progression for this patient are summarized in Table 3.

Table 3

Interventions for Patient 1

Task	Description	Implicit Learning Strategies Used	Progression
Dual-task walking	Ambulated in common hallway (physical task) while naming objects in a category (cognitive task)	High-repetition (12-15 minutes with seated rest breaks as requested by patient); Concurrent cognitive task to decrease attention to physical task; PT walked beside patient, modeling faster gait speed	Increased repetitions (measured in distance) with each subsequent session as patient tolerated
Dual-task static standing with narrow BOS	Stood with feet placed on visual targets on the floor (physical task) while conversing with PT (cognitive task) for 2 minutes	High-repetition (2-3 two-minute trials each session); Concurrent cognitive task to decrease attention to physical task; BOS was initially widened to reduce the number of errors (i.e, loss of balance)	BOS was narrowed by one inch at each visit if the patient had no errors during practice trials on the prior visit
Walking with narrow BOS	Walked in narrow space between bed and wall with close supervision of PT	High-repetition (10 repetitions each session); Constant conditions	No progression planned for this task
Step-ups	Stepped on/off bathroom scale with both feet alternately	High-repetition (3-4 minutes each session); Constant conditions; Provided rest break when performance declined to reduce number of errors; Familiar task with use of familiar object	Fewer rest breaks provided as performance improved between sessions
Supine to Stand	Practiced slow transition from supine to stand by sitting on edge of bed prior to standing	SR technique was used. PT provided prompt question: "What should you do before you get out of bed?" Participant responded with correct answer: "Sit for a little bit" and demonstrated by sitting on edge of bed for at least 30 seconds before standing; High repetition (5-12 repetitions)	Time interval between recall tests increased upon successful performance

PT = physical therapist; BOS = base of support; SR= Spaced retrieval

Patient 1: Outcomes

Patient 1 participated in all 12 planned treatment sessions. Functional outcome measures were administered again during the final session and are reported in Table 6. Her score on the BBS was 50/56. The increase in BBS score from baseline was 9 points, which is greater than the reported minimal detectable change (MDC) of 7.4 points.[31] Her scores on the TUG and ssGS did not change significantly from baseline. Initially, the patient was unable to verbalize that she was to “sit for a little bit” before rising to stand from supine on a 5-second recall test. By the third visit, she could verbally recall this correct response 30 minutes after the presentation of the information, but she did not spontaneously perform the associated motor task (i.e., sit on the edge of the bed before standing). On the sixth visit, she consistently demonstrated correct performance of both verbal recall and motor performance. On subsequent visits, she was able to verbally recall the correct response without prompting but did not spontaneously perform the transition correctly.

Patient 2: History

The patient was an 89 year-old woman who resided in the memory care unit. The nursing staff reported that she had fallen several times over the past several months after being hospitalized with pneumonia. Her medical history included osteoporosis, severe kyphoscoliotic deformity, coronary artery disease, hypertension, anxiety, and severe bilateral hearing loss. She wore bilateral hearing aids. She was prescribed an anxiolytic due to occasional episodes of anxiety and agitation.

The patient was widowed and had no family in the area. The staff reported that she ambulated independently with a wheeled walker from her bedroom to the dining room for meals three times per day but rarely left her room otherwise. The patient was reportedly independent in all ADLs. During the initial patient interview, she denied any history of falls but stated that she always used a walker for standing and walking.

Patient 2: Clinical Impression and Examination

Like Patient 1, this patient demonstrated significant impairments in declarative memory, suggesting she would benefit from use of implicit learning strategies. Given this patient's recent fall history, further examination was indicated to determine her current level of fall risk and modifiable risk factors. Based on her past history of anxiety and agitation, there was some concern that the patient would not participate actively in the examination due to its unfamiliar nature.

The patient was alert and oriented to self and her state of residence only. On the MMSE, she demonstrated intact registration, but recall and mathematical calculation were impaired. The patient had a severe hearing impairment that was still evident with use of hearing aids. She became anxious when she could not understand verbal instructions. The patient was able to follow a motor command with written instructions. She had a severe fixed thoracic kyphosis but was able to achieve a horizontal visual gaze by actively extending the cervical spine. The patient was able to roll in all directions on her bed and transitioned supine to and from sitting independently. She required multiple attempts to transition from sit to stand. During stand to sit, she did not use her upper extremities for support, and the descent was uncontrolled. Although the patient grimaced upon sitting, she verbally denied pain during the transition.

The patient ambulated independently with a walker. On initial examination, the patient's ssGS with use of a walker was 0.70 m/s, and her TUG score was 17.39 seconds. Both ssGS and TUG score indicated a high fall risk.[29,34] The Performance-Oriented Mobility Assessment (POMA) [35] was also administered to measure the patient's performance in gait and balance. Given the patient's severe hearing loss and history of osteoporosis, it was decided that the POMA was more appropriate than the BBS to use with this patient. The POMA requires fewer verbal cues than the BBS and does not require the patient to pick an object off the floor, which could potentially injure the osteoporotic spine if performed incorrectly. The patient scored 8/16 on the balance section (POMA-b) and 9/12 on the gait section (POMA-g). Her combined score (POMA-total) was 17/28, indicative of high fall risk.[35] During administration of the POMA, she lost her balance in a posterior direction upon mild external perturbation (i.e., sternal nudge) in static standing, demonstrating an inefficient motor ankle strategy.

Patient 2: Clinical Impression and Intervention

Specific mobility and balance tasks were selected for intervention to improve the patient's motor ankle strategy in response to perturbation, controlled descent of the stand to sit transition, and gait speed. Poor eccentric control of the stand to sit transition was a primary concern due to both increased fall risk and increased risk of vertebral fracture in this patient with osteoporosis. This patient, unlike Patient 1, had a hearing impairment that limited the PT's ability to use verbal instruction as an implicit learning strategy. Therefore, the PT used modeling, concurrent tactile cues, and hand-over-hand guidance to promote correct performance and implicit learning of the tasks. The PT decided to use a SR strategy to teach the patient to use her upper extremities for support during the stand to sit transition. Although the patient successfully completed the SR screening test when the prompt question and correct response were provided to her in a written format, she demonstrated agitation during the SR intervention on the second treatment session. At that time, the PT decided to replace the SR strategy with modeling and hand-over-hand guidance, as these were tolerated better by the patient. A description of the mobility and balance tasks, specific implicit learning strategies incorporated into the task-training, and rules for progression for Patient 2 are summarized in Table 4.

Table 4

Interventions for Patient 2

Task	Description	Implicit Learning Strategies Used	Progression
Single- and Dual-task walking	Ambulated in common hallway (physical task) while counting backwards (cognitive task)	High-repetition (10-12 minutes with seated rest breaks as requested by patient); PT walked beside patient, modeling faster gait speed; PT provided tactile cues to patient's back to facilitate increased gait speed	Increased repetitions (measured in distance) with each subsequent session as patient tolerated
Stand to sit transition	Practiced controlled descent with upper extremity support on patient's bedside chair	Initially, SR technique was used. PT provided written prompt question: "What should you do before you sit down?" Participant responded with correct answer: "Put my hands on the chair", then demonstrated associated motor response as she sits.	Time interval between recall tests increased upon successful performance
		PT modeled stand to sit, placing hands on chair, followed by patient practicing transition with PT providing hand-over-hand guidance of hands on chair; High-repetition (10-15 repetitions)	Tested performance at beginning of each session; if performance was successful, eliminated modeling and guidance for remainder of practice trials until patient made an error
Standing Anterior/ Posterior sway	Standing with upper extremities supported on walker as needed, alternately lean body anterior until heels rise from floor, then posterior until toes rise from floor.	High-repetition (10-20 repetitions); PT modeled task prior to and concurrent to patient's practice trials	Increased from 1 set of 10 to 2 sets of 10 when patient able to perform one set without error

PT = physical therapist

Patient 2: Outcomes

Patient 2 participated in each of the 12 planned treatment sessions over 4 weeks, although two sessions were rescheduled due to patient's refusal to participate. Functional outcome measures were administered during the final session and are reported in Table 6. Her score on the POMA-total increased from a 17/28 on initial evaluation to a 21/28 due to an increase of 4 points on the POMA-b. This change was one point less than the reported MDC of 5 points for the POMA-total.[36] Her score on the TUG and ssGS did not change significantly. During the final session, the patient was observed to spontaneously place her hands on her bedside chair during the stand to sit transition on 3 of 3 trials. Descent was controlled, and the patient did not grimace upon sitting.

Patient 3: History

The patient was a 95 year-old woman who resided in the assisted living unit. Although she had no history of falls, the nursing staff reported that the patient had recently demonstrated increased shuffling and slower gait, and shortness of breath when walking to the dining room. Her medical history included hypothyroidism, urge incontinence, and hypertension.

The patient was widowed and had one daughter who lived in the area. The daughter ate lunch with the patient on a daily basis and agreed with the nursing staff that her mother's mobility had recently declined. The daughter's goal for the patient was to maintain her ability to walk independently. The nursing staff stated that the patient ambulated independently in her room without a device but used a four-wheeled walker to ambulate to the dining room for meals three times per day. The patient required assistance for dressing and bathing, but occasionally refused to participate in assisted

ADLs. During the initial patient interview, she agreed with the nursing staff's report of her current mobility status.

Patient 3: Clinical Impression and Examination

As with the first two patients, this patient also demonstrated significant impairments in declarative memory, suggesting she would benefit from use of implicit learning strategies. Further examination was indicated to identify her specific mobility problems and related impairments. Based on her past history of refusal to participate in assisted ADLs, there was some concern that the patient would not participate actively in the PT examination.

The patient was alert and oriented to self and season of the year only. On the MMSE, she demonstrated intact registration, but recall, mathematical calculation, writing, and drawing were impaired. The patient was able to follow a motor command consistently. She demonstrated impairments in expressive language, occasionally having difficulty with word-finding. The patient was able to roll in all directions on her bed. Transitions of supine to and from sit, and sit to and from stand were independent when she used her upper extremities for support.

The patient ambulated independently in her bedroom without a device with short step lengths noted bilaterally. Neither swing foot passed the toe of the stance foot, although both feet cleared the floor during swing phase. The patient ambulated independently in the common hallway with a walker. No significant differences in the gait pattern were noted with use of a four-wheeled walker. On initial examination, the patient's ssGS with use of a walker was 0.53 m/s. The patient's score on the TUG was

18.61 seconds. Her TUG score and ssGS indicated a high fall risk.[29, 34] The BBS was selected as a measure of static and dynamic balance. Her score on the BBS was 28/56, indicating a high fall risk.[32] During administration of the BBS, she was noted to have difficulty with tasks that required a narrow BOS. She required physical assistance to keep from falling while attempting to place foot on a stool or stand in a tandem position.

Patient 3: Clinical Impression and Intervention

It was hypothesized that the patient's static and dynamic standing balance impairments contributed to decreased gait speed and short step length. Her difficulty maintaining a narrow BOS and single-limb stance was thought to result in a prolonged double-stance time in gait. Therefore, mobility and balance tasks were selected that addressed these impairments. The PT used feed-forward and concurrent verbal instruction to promote implicit learning of the tasks and intentionally limited explicit instructions and feedback. A description of the mobility and balance tasks, specific implicit learning strategies incorporated into the task-training, and rules for progression for Patient 3 are summarized in Table 5.

Table 5

Interventions for Patient 3

Task	Description	Implicit Learning Strategies Used	Progression
Gait training	Ambulated in bedroom without use of walker	High-repetition (10-12 minutes with seated rest breaks as requested by patient); PT provided feedforward and concurrent verbal cues to take "big steps";	Increased repetitions (measured in distance) with each subsequent session as patient tolerated
Static standing with narrow BOS	Stood with feet placed on visual targets on the floor for 2 minutes	High-repetition (4-8 minutes each session); BOS was sufficient to reduce the number of errors (i.e, loss of balance);	BOS was narrowed by one inch after each successful (i.e., no loss of balance) trial

Patient 3: Outcomes

Patient 3 participated in 10 of the 12 scheduled treatment sessions over 4 weeks, with a progressive decline in active participation noted throughout the episode of care. Although the patient was unable to verbally recall past treatment sessions or the name of the PT, she verbalized displeasure with the PT to the nurse on the sixth treatment session. Treatment sessions were structured based on the patient's willingness to participate in a particular task. At times, engaging the patient in verbal reminiscence of an early life event was effective in increasing the patient's participation in a motor task. Functional outcome measures were administered during the last two sessions and are reported in Table 6. Her BBS score improved, although the five point change from baseline was less than the MDC of 7.4 points reported for the BBS.[31] Her TUG score and ssGS did not change significantly.

Table 6

Patient Outcomes

	TUG (seconds) pre-training	*TUG (seconds) post-training*	*ssGS (m/s) pre-training*	*ssGS (m/s) post-training*	*BBS pre-training*	*BBS post-training*	*POMA pre-training*	*POMA post-training*
Patient 1	12.9	13.1	1.38	1.28	41/56	50/56	Not tested	Not tested
Patient 2	17.4	22.2	0.70	0.73	Not tested	Not tested	17/28 total; balance 8/16; gait 9/12	21/28 total; balance 12/16; gait 9/12
Patient 3	18.6	20.77	0.53	0.38	28/56	33/56	Not tested	Not tested

TUG = Timed Up and Go test; ssGS = self-selected gait speed; BBS = Berg Balance Scale; POMA = Performance-Oriented Mobility Assessment

DISCUSSION

The implicit learning principle of high-repetition practice proved to be the most feasible to integrate into the plan of care for all three patients. Addressing the mobility limitations most meaningful to the patient and caregivers and limiting the number of tasks addressed in each session allowed for higher-repetition practice of each task. Selecting functionally-relevant tasks that incorporate strengthening and balance components may limit the number of interventions that a PT needs to address in a treatment session, thereby allowing more time for high-repetition practice. For example, Patient 1 performed step-ups on her bathroom scale that incorporated hip and knee extensor strengthening and single-limb stance into a single task that was functionally-relevant for the patient. She seemed to enjoy watching how the numbers displayed on the scale fluctuated between steps, potentially increasing her compliance with the high-repetition practice.

Applying the EL paradigm to interventions in the plan of care was not always feasible, as some mobility and balance tasks were more readily trained under EL conditions than others, depending on the characteristics of the task. The discrete task of the stand to sit transition practiced by Patient 2 was more easily modified to practice under EL conditions than the continuous task of walking with increased step length practiced by Patient 3. Tasks that were already being performed by the patients in their daily routine, such as the supine to stand transition practiced by Patient 1, were performed under EL conditions during the treatment sessions. However, the patient also performed the task with errors throughout the remainder of the day when no caregivers were present, potentially negating the effect of the EL practice during the treatment sessions. It seems that discrete tasks and sequential tasks with discrete steps that are not practiced outside of therapy sessions in “error-full” conditions are most applicable for training under EL conditions.

Although the EL-based technique of SR has received little attention in the physical therapy literature, the outcomes from this case series suggest that SR may be effective in teaching patients with AD new mobility strategies. By the sixth visit, Patient 1 was able to successfully recall that she should sit on the edge of bed during the supine to stand transition after a 24-hour delay in practice. Performing the desired strategy resulted in improved stability upon initial standing. However, her spontaneous performance of this strategy during the supine to stand transition remained inconsistent throughout the episode of care. Training the patient’s caregivers to practice the technique throughout the day may have increased her learning of the desired mobility strategy. Research suggests that caregiver participation in SR training and carry-over into the patient’s daily routine may be a key component to the success of the SR technique.[37,38] Unfortunately, caregiver participation was not feasible in the case of Patient 1, as caregiver staffing of the memory care unit was inconsistent throughout the episode of care. Further research is needed to determine to what extent mobility skills can be relearned by individuals in various stages of AD using SR techniques.

Although intervention effectiveness cannot be determined in a case series, it is worthy to note that all patients improved their performance on objective measures of balance, although only one exceeded the MDC for either the BBS or POMA. No significant clinical change was observed in any patients on the Timed Up and Go test (TUG) or self-selected gait speed (ssGS). Given that individuals with AD are not able to transfer learning of one task to another, it may be that the TUG and ssGS measures are not sensitive to the motor learning that occurred in these patients. For example, on the final treatment session, Patient 2 consistently used her upper extremities for support when performing the sit to and from stand transitions in her bedside chair. However, she did not use this mobility strategy during testing on the same day when performing the TUG with a different chair in a hallway.

To date, few studies in the physical therapy literature have attempted to bridge the gap between motor learning and cognitive rehabilitation research on AD and the physical therapy management of this patient population. The heterogeneity of the AD population in the domains of cognitive, physical, and behavioral function make it difficult to generalize the research findings of well-controlled studies with stringent inclusion criteria to individual patients often encountered in clinical practice. The patients described in this case series would likely be excluded from many AD studies based on their medical comorbidities, behavioral symptoms, or disease severity. However, this case series demonstrates that it is feasible to apply the knowledge gained from these studies of implicit learning to the physical therapy management of complex patients in the moderate to moderately-severe stages of AD. Further research on the effectiveness of EL, SR, and other rehabilitation strategies that facilitate implicit learning of mobility skills in patients with AD is needed to promote optimal physical therapy outcomes in this patient population.

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APPENDIX

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Institutional Review Board for Human Use

Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on September 29, 2013. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator:	WHITE, LAURA W
Co-Investigator(s):	
Protocol Number:	**X101103001**
Protocol Title:	*Acquisition of Functional Motor Skills in Individuals with Alzheimer's Disease*

The IRB reviewed and approved the above named project on 5/18/11. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.

IRB Approval Date: 5-18-11

Date IRB Approval Issued: 5/18/11

Marilyn Doss
Marilyn Doss, M.A.
Vice Chair of the Institutional Review
Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.

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