Using Motor Imagery Therapy to Improve Movement Efficiency and Reduce Fall Injury Risk

Carl Gabbard* and Ashley Fox*

1Professor, Director of Motor Development Lab, Texas A&M University, USA
2Undergraduate Research Fellow, Texas A&M University, USA

Abstract

Physiotherapy interventions have proven to play an important role in preventing and rehabilitating fall injury in the elderly. An important goal of such programs is to modify risk factors and thereby reduce the likelihood for future falls. Recent research observations suggest that one such factor is the ability to mentally represent and plan movements, an ability that declines with advancing age. In addition to physiotherapy exercise for balance, mobility and stabilizing strength, the use of motor imagery practice, a form of mental representation, has gained interest in the clinical community. Recent research findings highlight the merits of combining physiotherapy with motor imagery practice. Such practice has the potential to help the individual maintain motor (action) planning networks while recovering from brain and/or muscle injury. Another, more proactive approach, is to use motor imagery practice to improve action planning and subsequent movement efficiency. This brief review highlights research findings on mental representation and motor imagery, notes implications for the elderly, and provides recommendations for practice strategies to improve motor planning and potentially reduce risk of movement-related injury.

Keywords: Mental representation; Aging; Motor imagery; Action representation; Action planning

Introduction

The ability to mentally represent and effectively plan motor actions underscores one's successful intentions and lowers injury risk. Recent research findings highlight the fact that as individuals enter older adulthood, the ability to mentally represent their intentions and successfully plan actions, declines. With the present article, we focus on the potential of using motor imagery practice, a form of mental representation, to improve motor planning and potentially reduce the risk of fall injury. The idea being that in addition to physiotherapy exercises, motor imagery practice can aid in reducing fall injury risk. With that understanding, we can develop strategies to improve motor representation among people, especially the elderly. The development of such strategies can lead to enhanced quality of life for this growing population in the US. With this paper, we will: (1) briefly review the idea of mental representation associated with action planning and motor imagery, (2) discuss the difficulty that has been described with older adults, (3) provide a summary of selected studies testing various practice methodologies using motor imagery, and finally, (4) provide strategies for motor imagery practice.

Mentally Representing Action and Motor Imagery

Mental representation

The ability to mentally represent one's intentions is a central issue for understanding cognitive and motor behavior across the lifespan. Mental representation has been described as an internal cognitive construct that represents external reality. One commonly associated form of mental representation is motor imagery, a key modality for the creation of representations [1]. Motor imagery, the focus of this paper, involves the creation of representations involving action in the context of movement planning and subsequent execution, that is, action representation. Most motor programming theories support the notion that action representation is a key feature in effective action planning. One prominent view contends that action representation involves an internal (forward) model, which is a neural system that mentally simulates the dynamic behavior of the body in relation to the environment [2-4]. The theory proposes that internal models make predictions (estimates) about the mapping of the self to parameters of the external world. The result is processes that enable successful planning and execution of action. Accompanying the forward model propositions, and central to the discussion here, is the widely acknowledged observation that simulation in the form of motor imagery provides a window into the process of action representation [5-8].

Motor Imagery (MI)

The ability to imagine future events and estimate consequences is an essential part of the human cognition process. MI is defined as an internal rehearsal or reenactment of movements from a first-person perspective without any overt physical movement. From another perspective, MI, also known as kinesthetic imagery, is an active cognitive process during which the representation of a specific action is internally reproduced in working memory without any overt motor output [9]. In addition to the reasonable case that MI is a reflection of action representation and motor planning; studies have found that there is a high correlation between real and simulated movements [10-13]. Furthermore, evidence has been reported showing that MI follows the basic tenets of Fitts' Law [14,15]. That is, simulated movement duration, like actual movement, increases with increasing task complexity. As opposed to visual imagery, defined as the internal enactment or reenactment of perceptual experiences [16], neuroimaging and neuropsychological studies indicate that MI is more affected by biomechanical (kinesthetic) constraints that are commonly associated with action processing [15,17].
One of the interesting hypothesized features of motor imagery is its role in the prediction of one's actions [11,12]. Suddendorf and Moore [18] note, "The ability to imagine future events is an essential part of human cognition" (p. 295). Imagery allows us to generate specific predictions based upon past experience and allows us to answer 'what if' questions by making explicit and accessible the likely consequences of a specific action. Mental simulations generate knowledge about specific past events, and therefore make specific predictions [19]. One of the important aspects of an action plan is the ability to predict the outcome and consequences of intended actions. Imagining an action can serve several useful goals to that endeavor. According to Bourgeois and Coello [20], motor representation can be viewed as a component of a predictive system, which includes a neural process that simulates through motor imagery the dynamic behavior of the body in relation to the environment. This line of reasoning presents noteworthy developmental issues associated with a person's cognitive understanding of environmental (perceptual) information and consequences, and one's physical capabilities.

Mental representation in the elderly

Recent observations indicate that the ability to mentally represent motor actions declines with advancing age [21-29]. The following are a few brief summaries of that work in regard to the general decline with age. Mulder et al. [24] compared young and older adults on vividness of movement imagery via questionnaire. The researchers found that older adults were slightly worse than their younger counterparts, especially from a first person perspective. Although not examined with that study, a possible link between level of physical activity and imagery ability was suggested. The assertion was that physical exercise in the elderly might help preserve brain structures and mechanisms (frequently mentioned is the parietal cortex) associated with mental representation. Personnier et al. [25], used a mental chronometry paradigm to compare imagined and executed arm pointing actions between young and older adults. They reported that although it appeared that older adults displayed the ability to mentally represent action via use of motor imagery, their ability progressively deteriorated with advancing age as evidenced by the declining quality of their MI (i.e. isochrony between executed and imagined movements). The authors concluded that there was a likelihood of weakness in the formulation of internal models of action in the elderly. Testing the ability to mentally simulate/plan a complex movement’s appears well preserved with aging. However, advanced reaction time. In a more recent review of this body of research [27], Saimpont et al. [26] reported that the elderly experienced significant reaction time. In a more recent review of this body of research [27], Saimpont et al. [26] reported that the elderly experienced significant reaction time. In a more recent review of this body of research [27], Saimpont et al. [26] reported that the elderly experienced significant reaction time.

Over estimation (Over optimistic?)

Using the estimation of reach paradigm, Gabbard et al. [37] reported that younger adults (mean age 20 years) were significantly more accurate than older adults (mean age 77 years) when estimating reach in peripersonal and extra personal space from a seating position. Whereas, both groups made more errors in extrapersonal space, the values were significantly higher for the older group; that is, they over estimated to a greater extent. Caçola et al. [38] reported that accuracy decreased as age increased when estimating reachability in peripersonal and extrapersonal space using a 40 cm tool; the population ranged from 55 to 92 years. Lafargue et al. [39] also comparing young and older adults, reported a failure of the older group to update their internal model when asked to judge in advance whether or not they could stand on an inclined plane. As predicted, the older adults significantly overestimated their capabilities. A similar finding of overestimation with advanced aging was reported by Noël et al. [40] and Sakurai et al. [41]. Both studies examined estimation of ability to step over an obstacle. In their conclusions, Noël et al. noted that the overestimation could be a major risk of falls in the elderly.

To summarize, it would appear that older persons have difficulty estimating possible movement outcomes and updating internal models, resulting in dissociation between perception and action, a condition that may promote risky motor planning and execution.

Implications and therapeutic applications

According to the Centers for Disease Control and Prevention website, "Each year, one in every three adults age 65 and older falls." "Among older adults (those 65 or older), falls are the leading cause of injury death." These statistics display the critical need to better understand the factors that constrain the elderly in regard to mental representation and movement planning. Understanding these factors, like the connection between reaching and falling, can allow for the development of strategies to enhance movement efficiency and lower associated injury risk.
In support of the reach-fall link, four of 16 items on the Activities-Specific Balance Confidence (ABC) Scale [42] are reach-specific questions. This test is commonly cited as a self-report subjective measure of perceived balance confidence in performing various movement activities without falling. With the elderly, compared to younger adults, there is a higher risk of falling during reach actions. For example, if an older adult either significantly underestimates or overestimates a reach target (e.g., drinking glass, table, and railing), they may have more difficulty than a younger person in maintaining postural control, often resulting in a fall.

One proven effective therapy strategy for the recovery of motor planning and control is MI practice. Use of MI has been documented as an effective tool for: sport/motor performance [43-46], brain injury [47], stroke [48-51] and other neuromotor impairments, e.g., [52]. In the context of neurological impairment, the literature suggests that one of the key agents in movement recovery is use of MI to stimulate otherwise non-active or impaired neural pathways. In addition, Wohldmann et al. [53] reported evidence to support the hypothesis that mental practice strengthens abstract mental representation that does not involve specific effectors. That is, such practice strengthens ‘central’ features of the representation as well as representation of specific body part processes, such as the hand and fingers.

Of the training studies reviewed, unfortunately little has been reported using older adults. One particular study was conducted by Gutman et al. [48], who tested the effectiveness of MI practice with a group of older persons (mean age 69 years) with chronic hemiparesis. Practice involved performance of sit to stand and reaching to grasp movements. The researchers found that MI practice has a positive effect on actual execution.

Strategies for improving motor imagery ability

As noted earlier, information on motor imagery training with the elderly is sparse. Based in large part on the literature and our experience with such training, although individual differences and capabilities should be a significant consideration, the target age group recommendation is 65 to 85 years. In regard to training strategies for specific impairments associated with stroke for example, once again the recommendation is 65 to 85 years. In regard to training strategies for the elderly. Physical practice affords the opportunity to practice both imagined and actual execution movements. The researchers found that MI practice has a positive effect on actual execution.

Clear and effective script of instructions: The script of instructions should be used in early practice phases and needs to be as specific as possible. For example: “Watch and feel your hand and fingers reaching and grasping the mug. How will you grab the mug and how fast will you move as not to spill its contents!”

Goal-setting: This is an important element of practice and a strategy that can be induced via the script, verbally, or in combination as reinforcement.

First person internalizing: That is, focus on the self as the mental image of the intended action. This state is the first component in the actor-object dyad. Part of this dyad is an understanding of one’s physical capabilities and potential consequences. Ask the participant to consider the consequences if he or she were to miss-plan (over- or underestimate) the event. What will you fall into? Do you feel confident in your ability to gain stability if you have to adjust your position quickly?

Concentrate on the effectors: This is the specific part of the self that is linked with the target. For example, focus on the arm/hand when intending to reach and grasp an object.

Focus on the visual cues (target/object/goal): Concentrate on the end point of the intended action–the target. For example, where does my hand need to be to grasp the object securely? With tasks such aiming at a target, when timing is a factor, auditory cues in the form of a metronome have been effective.

Reinforcement on kinesthetically ‘feeling’ execution of movement: Research indicates clearly that ‘feeling’ rather than just seeing oneself perform the action promotes better mental representation for movement via internalization.

Combine physiotherapy with mental practice: By practicing actual movements, participants gain a better understanding of their physical capabilities and develop movement endurance, a problem that is common in the elderly. Physical practice affords the opportunity to test one’s capabilities. Furthermore, research shows that mental practice combined with physical practice enhances actual performance outcome [55,56].

Summary

The intent of this paper was to bring attention to the benefits of motor imagery and propose potential use of motor imagery practice (therapy) in the physiotherapy setting. Research indicates that such practice can improve motor planning, subsequently reducing the risk of fall injury, especially in the elderly. Whereas motor imagery practice can be a stand-alone program, there is good evidence that when used in combination with physical practice, results for improved overall motor performance can be significant.

References


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