Aging Effects on Motor Learning

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Synonyms
Skill acquisition in the elderly

Definition
Motor learning, also referred to as skill acquisition, has been described as the processes associated with practice or experience that lead to a relatively permanent change in one’s capability for responding. Older adults show impairments in skill acquisition when compared to their younger counterparts; that is, they learn at a slower rate and typically do not attain the same performance level as young adults, despite extended task practice. Recent work has identified many of the factors underlying age deficits in motor learning, paving the way for new rehabilitative interventions.

Theoretical Background
The study of motor learning has a rich history, spanning more than 100 years. Recent technological advancements in neuroimaging have provided researchers with the ability to map time-varying networks of brain activity to theories regarding changes in motor behavior. A greater understanding of the cognitive and neural underpinnings of skill acquisition in young adults has led to an enhanced understanding of the mechanisms of age-related learning deficits.

Motor learning researchers have typically classified learning into two distinct categories: sensorimotor adaptation and sequence learning. Sensorimotor adaptation involves the modification of one’s movements to compensate for changes in sensory inputs or motor output characteristics. Motor sequence learning involves the progressive association between isolated elements of movement, eventually allowing for rapid sequence execution. These two types of skill learning are thought to rely on distinct underlying neural substrates and cognitive strategies at different stages of the learning process (cf. Doyon et al. 2003).

The early stage of motor learning is associated with engagement of the dorsolateral prefrontal and parietal cortices, and is susceptible to interference from secondary cognitive tasks. We have recently shown that, while young adults engage spatial working memory during the early stage of sensorimotor adaptation, age-related deficits in adaptation are associated with a failure to engage spatial working memory processes (Anguera et al. 2011). An extensive literature demonstrates that older adults rely more on cognitive resources for the control of simple actions than young adults; in terms of motor learning, however, it appears that older adults are less likely to engage the relevant cognitive processes (cf. Anguera et al. 2011; Bo et al. 2009).

In terms of motor sequence learning, we have recently reported that older adults exhibit a slower rate of learning and form shorter chunk lengths associating individual movement elements (Bo et al. 2009). In addition, older adults exhibit an overall reduction in both working memory capacity and sequence chunking patterns, indicating that working memory impairments partially explain age-related deficits in motor sequence learning. In combination, these two examples document that age-related cognitive deficits affect motor learning ability.

Important Scientific Research and Open Questions
We have demonstrated an important role for spatial working memory in the two major types of motor skill learning. Moreover, age-related spatial working memory deficits contribute to declines in skill acquisition. However, it is likely that other cognitive and sensorimotor physiological processes also play a role (cf. Seidler et al. 2010). An important future direction will be to measure and take into account both peripheral and central neurophysiological changes that occur with senescence to better understand how each contributes to deficits in motor learning. Moreover, approaches to
improve motor learning performance in older adults, such as working memory training or the provision of alternate strategies, are potential avenues that could facilitate meaningful interventions that would improve one’s quality of life.

The use of brain imaging techniques to study changes in brain structure and function with age has contributed greatly to our understanding of performance declines with age. Such work suggests that older adults recruit compensatory brain networks to maintain cognitive task performance. While some studies report evidence of compensatory recruitment for motor control as well, there is no evidence that older adults exhibit over-activation of brain regions when learning new motor skills. In fact, our recent findings have demonstrated that older adults show a failure to effectively engage essential cognitive processes during the early learning period (Anguera et al. 2011). Clearly, additional brain imaging studies need to be performed to provide a deeper understanding of the neural mechanisms of motor learning in aging.

The older adult population in the USA in 2030 has been projected to be nearly twice as large as it was in 2000. This dramatic shift in population demographics will result in an increased need for programs and interventions that not only improve activities of daily living, but also spur a faster recovery for individuals afflicted with an injury or neurological insult. Novel rehabilitative strategies based on motor learning principles have shown to be effective. For example, individuals affected by stroke that underwent mental motor training have reported better functionality in their upper extremities and greater gains in activities of daily living than those seen with standard physiotherapy (Page et al. 2009). Broader-based interventions have led to improvements in both cognitive and motor function in older adults (Williamson et al. 2009). Such approaches, based on current mechanistic understandings of motor learning and brain plasticity, may extend independent living and quality of life.

Cross-References
▶ Implicit Sequence Learning
▶ Procedural Learning
▶ Sensorimotor Adaptation
▶ Sequence Learning

References