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Examining motor learning in older adults using analogy instruction

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A B S T R A C T

Objective: Previous studies have reported that analogy promotes stable motor performance under cognitively demanding situations such as stress and fatigue. However, it is unclear whether analogy is useful for motor learning among older adults, or whether the benefits of motor learning by analogy can be generalized to older adults. The present study examined these questions.
Methods and design: Groups of young and older table tennis novices learnt to perform a forehand topspin stroke in table tennis, receiving either analogy instruction or a set of explicit instructions. Afterwards, participants were asked to perform a motor task in three testing situations: dual-task, immediate retention and skill consolidation. Motor performance was assessed using a validated scoring system.
Results: Motor performance induced by analogy instruction was comparable to that induced by explicit instruction in both young and older adults. In addition, similar to young adults, the older analogy-instructed participants demonstrated more robust motor performance than their explicitly instructed counterparts in dual-task, immediate retention and skill consolidation testing situations.
Conclusions: Analogy instruction aided older adults in acquiring new motor skills, and the benefits of analogy to reduce the cognitive demand of motor learning can be generalized to the older population.

1. Introduction

Motor learning, a process by which relatively permanent changes are made in the capability for movement (Schmidt, 1988), is an essential process throughout the lifespan. While children typically acquire fundamental motor skills to develop the competency to perform a range of functional motor tasks (Sullivan, Kantak, & Burtner, 2008), older adults commonly learn new motor skills or relearn known motor skills to improve their psychological wellbeing, or to support their autonomy. Unfortunately, declining motor learning abilities with aging, manifesting as a slower rate of learning and reduced performance, are well documented (Bo, Borza, & Seidler, 2009; Fraser, Li, & Penhune, 2009; McNay & Willingham, 1998; Serbruyns et al., 2015; Voelcker-Rehage, 2008). Although the acquisition of simple motor tasks appears not to be affected by aging, owing to sensory adaptation (Seidler, 2007a) and learning strategies (Rabbitt, 1997), a decline in motor learning in complex tasks has been shown with aging (Bo et al., 2009; Curran, 1997; Shea, Park, & Braden, 2006). For example, Curran et al. (1997) found that older adults (age range: 60–79) improved more slowly than young adults in a serial reaction time (SRT) task. Shea et al. (2006) reported that the ability to organize individual elements of movement sequences into subsequences was less efficient in older adults (age range: 65–68) compared with young adults. Converging evidence from various fields (e.g., cognitive science and neuroscience) suggests that this age-related decline in motor learning might be associated with impairments in sensorimotor and cognitive functioning, including working memory (Anguera, Reuter-Lorenz, Willingham, & Seidler, 2010; Bo et al., 2009; Colcombe & Kramer, 2003; Craik & Grady, 2002; Reuter-Lorenz et al., 2000; Voelcker-Rehage, 2008).

Working memory is a cognitive system that holds and manipulates information while performing cognitive operations (Baddeley, 1986), and is essential in motor learning. During motor

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learning tasks, instructions are often given by teachers or coaches to convey relevant information to learners (Hodges & Franks, 2002). Learners then use cognitive resources from working memory to process and manipulate the instructional information. Given a declining capacity for working memory with age (Balota, Dolan, & Duchek, 2000; Verhaeghen & Salthouse, 1997), older adults may encounter difficulty comprehending instructions. Moreover, if the amount of information conveyed by instructions exceeds the cognitive capacity of learners, learning may be less effective (Wulf & Weigelt, 1997). Therefore, instructions involving less cognitive demand are preferable for older populations to acquire motor skills. In this context, analogy may provide an appropriate method.

Analogy is a form of instruction that aids the learning of a new concept by relating it to a fundamentally similar concept (Gentner, 1983; Gentner, Anggoro, & Klibanoff, 2011; Schustack & Anderson, 1979). This technique is commonly used by sport coaches to convey motor skill information to learners. For example, swimming coaches may teach their students to 'kick like a dolphin' when they learn the butterfly swimming stroke, or rope skipping instructors may ask learners to 'jump like a rabbit' when they skip the rope. Using analogy instruction can help recipients to easily understand the techniques required to perform the skill effectively. In addition to facilitating understanding of instructions, previous studies have also shown that performance induced by analogy instruction is more robust than when induced by explicit instructions in cognitively demanding situations, such as psychological stress or dual-task conditions (Komar, Chow, Chollet, & Seifert, 2014; Lam, Maxwell, & Masters, 2009; Law, Masters, Bray, Eves, & Bardswell, 2003; Poolton, Masters, & Maxwell, 2007). For instance, in a motor learning study of table tennis, Liao and Masters (2001) taught a group of table tennis novices to perform a forehand topspin stroke with either analogy instructions or explicit instructions. The results showed that analogy instructed learners maintained stable table tennis skill, even under stressful experimental conditions, compared with explicitly instructed learners (Liao & Masters, 2001).

One recent study examined the use of analogy in motor skill acquisition among an older population (Kleynen et al., 2014). Kleynen et al. (2014) reported that older stroke survivors exhibited improvements in walking speed following analogy instruction. However, the study involved a small sample size and only two of three participants showed a significant improvement (Kleynen et al., 2014). As such, it remains unclear whether analogy-based methods are applicable for motor learning by older adults. Importantly, it is currently not clear whether the motor learning benefits induced by analogy instruction shown in previous studies (i.e., robust performance under cognitive demanding situations, Lam et al., 2009; Liao & Masters, 2001) can be generalized to older adults. The present study sought to clarify this question.

We examined the motor learning involved in performing a forehand topspin stroke in table tennis, based on the method used in Liao and Masters" (2001) study. Both young and older adults were instructed to perform the motor skill with two sets of instructions (explicit or analogy) in the learning phase. Following the learning phase, participants were required to perform the motor task under three testing conditions: the dual-task (DT), immediate retention (IR) and skill consolidation (SC) tests. We predicted that older participants would exhibit a slower learning rate than young adults, and that the analogy instruction groups of all ages would benefit more than the explicit instruction groups, showing more robust performance under dual-task test conditions and sustained performance in both immediate and long-term retention tests.

2. Methods

2.1. Participants

Thirty-six young adults (mean age = 21.9, SD = 2.3 years, range: 18–26) and 34 older adults (mean age = 66.9, SD = 4.6 years, range: 60–76) participated in the present study. All participants reported that they were right-handed, had no neurological diseases, no back pain, no chronic pain of the right forearm, shoulder or hand, and reported that they did not have any prior experience in table tennis. All participants also scored 24 or above in the Cantonese version of the Mini-Mental State Examination (Chiu, Lee, Chung, & Kwong, 1994), attained 20/20 vision in the visual acuity test (Ferris, Kassoff, Bresnick, & Bailey, 1982) with either corrective glasses or no glasses and scored 12 or above in the Digit-Span Memory Test (both forward and backward spans, Wechsler, Coalson, & Raiford, 2008). Participants received a full debrief and small financial reward upon the completion of the study. Human Research Ethics Committee of the Education University of Hong Kong approved the present study.

2.2. Apparatus

Two cameras (Model: G15, Canon) were positioned to record motor skill performance throughout the study. As in Liao and Masters' (2001) study, a table tennis ball machine (Donic/Newgy Robo-Pong 2000) was used to deliver a table tennis ball (DHS Three Star Ping Pong) from the opposite end of a standard table tennis table. The position of the ball machine was identical to that in the previous study (Liao & Masters, 2001). The frequency of ball delivery was 25 balls per minute for both young and older adults (Liao & Masters, 2001). The scoring system was identical to that in Liao and Masters' (2001) study, where the table was divided into different scoring regions and participants were asked to hit the table tennis ball to the region with the highest score as accurately as possible.

2.3. Design and procedure

The study consisted of two sessions, conducted 2 days apart. The first session started with the completion of the screening tests (digit-span memory test; MMSE-C) and a general introduction of the table tennis task and the scoring system. This was followed by the demonstration of the shake hand grip and the standard standing position (Tepper, Rosario, & Pruyn, 2002) to ensure that all participants used the same grip and standing position. All participants were then presented with a diagram showing the rotation of the ball in a topspin stroke. If the participant could not perform the topspin stroke, they received no score and were presented with the diagram again.

Participants were then randomly assigned to one of two instruction groups (analogy instruction group and explicit instruction group). In the analogy instruction group, participants were instructed to move the racket as if it was traveling up the side of a mountain (Poolton et al., 2007). In the explicit instruction group, participants were asked to follow instructions taken from a teaching manual (see Table 1). Participants then started the learning phase. Participants were required to perform 180 strokes in six blocks of 30 trials. A 3-min rest period was allowed between blocks. Upon completion of the learning phase, participants were asked to complete a verbal protocol questionnaire (refer to Appendix I), which required them to recall any techniques or strategies that they used during the learning phase (Liao & Masters,