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ScienceDirect
Behavioural Brain Research 183 (2007) 118–122
BEHAVIOURAL BRAIN RESEARCH
www.elsevier.com/locate/bbr

Short communication

Older adults can learn to learn new motor skills

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Received 22 March 2007; received in revised form 18 May 2007; accepted 21 May 2007
Available online 24 May 2007

Abstract

Many studies have demonstrated that aging is associated with declines in skill acquisition. In the current study, we tested whether older adults could acquire general, transferable knowledge about skill learning processes. Older adult participants learned five different motor tasks. Two older adult control groups performed the same number of trials, but learned only one task. The experimental group exhibited faster learning than that seen in the control groups. These data demonstrate that older adults can learn to learn new motor skills.

Keywords: Motor skill; Visuomotor adaptation; Adult

The capacity to acquire new motor skills is essential for adaptive motor function throughout the lifespan. Many studies have documented that older adults show reduced rates of skill learning, and in many cases, even when provided with extended practice, their performance levels do not reach those of young adults [9,20,22,31,33,34,36,38]. In addition to examining the learning process itself, many studies make use of transfer tests to determine the generalizability and flexibility of the acquired representation. *Generalization of learning* can be tested by having participants adapt to a perturbation and then transfer to either a new effector [29,40], new workspace [44], or new mode of movement (i.e. from continuous tracking to discrete pointing movements [1]). *Savings of learning* [28,32,45] can be tested by having participants adapt to a perturbation, wash out the effects of learning, and then re-adapt to the same or a similar distortion. This allows the determination of whether subjects can make use of the previously acquired motor memory to learn something new. Recent work has also demonstrated that people can *learn to learn* new motor skills [7,35,37]. In this case, participants acquire multiple unrelated motor tasks (adapt to a gain change, visual rotation, sequence learning, etc.) successively, with the end result that they show faster learning than naïve participants do. This provides evidence that people can acquire something very general and transferable about the learning process itself. Similar findings have been documented for discrimination problem solving in rhesus monkeys [19] and humans [14]. Over multiple experiences with the same problem type, participants gradually acquired a strategy that could then be applied to quickly solve new problems of the same type.

Despite age-related decrements in sensorimotor adaptation [9,16,31,38,39], older adults are able to generalize adaptive improvements to new modes of movement [3,4]. Additionally, our work has recently shown that older adults exhibit the same magnitude of savings of learning as young adults when they adapt manual aiming movements to three subsequent rotations of the visual feedback display [39]. There is also evidence that older adults can learn to learn new motor skills [5,6]. In these studies, older and young adult participants first adapted arm movements to a left–right visual rearrangement, and then transferred to the left–right distortion combined with an up–down reversal. Older adults actually demonstrated stronger learning to learn effects than the younger adults.

It is currently unclear whether this learning to learn phenomenon in older adults extends to different types of skills as well, as has been shown for younger adults [37]. Specifically, it is not known whether multiple visuomotor adaptation

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doi:10.1016/j.bbr.2007.05.024

Table 1
Group demographics

Group	Age range	Mean age*	MMSE	No. of meds	Years of education	Hours exercise per week	Gender ratio
ML	66.0–80.0	74.9 (3.7)	29.0 (1.0)	1.3 (1.1)	16.4 (2.2)	4.9 (3.0)	8F, 11M
GL	65.3–76.6	72.8 (4.5)	29.2 (0.4)	1.3 (1.2)	15.8 (2.4)	2.8 (2.2)	3F, 6M
SL	66.5–76.4	70.6 (3.6)	29.8 (0.5)	1.4 (0.9)	15.3 (1.5)	3.6 (2.8)	6F, 3M

Mean values are presented, with standard deviations in parentheses. MMSE is the Mini-Mental State Exam score [17], No. of meds is the average number of medications taken per day.

* A group main effect in mean age at $P < 0.05$. Tukey's HSD follow up comparisons revealed that the ML and SL groups were significantly different ($P < 0.05$).

experiences would result in enhanced sequence learning for older adults, since this process is both neurally and strategically different from visuomotor adaptation. For example, data suggest that sequence learning relies more heavily on basal ganglia and medial motor cortex circuitry, while adaptation engages the cerebellar and parietal regions to a greater extent [11,18,21,24,26,27,42], although both types of learning may rely on overlapping neural substrates in the earliest minutes of training [12,13]. Thus, the purpose of these experiments was to determine whether adaptation to multiple visuomotor distortions would enhance adaptation to a new visuomotor distortion, and would also facilitate the acquisition of a movement sequence for older adults. Older adults exhibit greater deficits for visuomotor adaptation tasks than for sequence learning [38], raising the possibility that facilitation between the two classes of learning may also be impaired with advancing age. The current study examined whether this was indeed the case.

We tested 37 older adult participants in this study. They were assigned to one of three groups: multiple learning (ML), gain adaptation only (GL), and sequence learning only (SL). The age and demographic characteristics of the three groups are presented in Table 1. All participants signed an institution-approved consent form prior to partaking in the study. They were compensated for their participation, which took an average of 4 h over 2 testing days.

The procedures have been reported previously [37]. Participants moved a manual joystick device to hit targets presented on a computer screen, with real time feedback display of joystick location. The joystick was secured to the table in front of participants, placed at their body midline. Movements were always initiated from the central start target (0.8 cm in diameter) and made to targets (0.8 cm in diameter) that appeared 4.8 cm up, right, down, or left of the start position. Participants were instructed to move the cursor representing the joystick position into the target as quickly as possible upon target appearance and to hold the cursor within the target until it disappeared (3 s following its appearance). At this point, participants were instructed to release their grip on the spring-loaded joystick, which returned to the center for the next trial. The subsequent trial began 2 s later.

The ML group learned five motor tasks over two test sessions, conducted within approximately 48 h of each other. On Day 1, they adapted to three different visuomotor distortions: 15°, 30°, and 45° counterclockwise rotations of the feedback display about the start location. Washout trials were given between each adaptive experience to restore performance to baseline levels. The details of trial presentation, and the results from this portion of the study, are reported in Seidler [37].

On the second testing day, the ML group first adapted to a change in the gain of display of their movements; we increased the size of displayed movements by a factor of 1.5. The ML group then learned a repeating sequence of movements. The sequence blocks consisted of the following repeating target sequence: up, left, right, down. This was not just a simple four-element sequence, however. Participants were required to return to the central start position between each target (passively), increasing the effective sequence length to eight elements. Moreover, the relatively long interval between stimuli (4 s) in the current study in comparison to other investigations of sequence learning also impacts expression of learning [47]. We selected this longer interval in order to allow time for these older adults to make movements to the targets, even under the distorted visual feedback conditions. The details of block and trial presentation for Day 2 testing are presented in Table 2. The GL and SL groups performed the same number of trials on Day 1 as the ML group, except that they did not receive any trials in which the feedback display was rotated. However, the GL and SL groups performed the baseline aiming task in all other blocks on Day 2.

Participants were not informed in advance as to whether or not the upcoming block contained a learning stimulus (rotation, gain change, or sequence). They were instructed to hit the target as rapidly as possible, and to attempt to minimize both reaction time (RT) and movement time. Following the first sequence block, ML and SL participants were probed about their awareness of the existence of the sequence (the GL group did not perform the sequence). We asked them the following questions: “Did you notice anything different about the last block? If so, what?” Following the final sequence block, we asked participants: “Did you notice the sequential target presentation over the last three blocks?” They were asked to attempt to report the target sequence regardless of whether they had noticed its existence.

We analyzed the joystick data offline, using custom software routines. We first filtered the data with a dual-pass Butterworth digital filter [48] using a cutoff frequency of 10 Hz. Then we computed the resultant joystick path by taking the square root of the sum of the squared x and y coordinate data at each time point. The tangential velocity profile was computed via differentiation of the resultant path. Movement onset and offset were calculated by applying the optimal algorithm of Teasdale et al. [46] to this velocity profile for each movement. We computed the RT by subtracting the time of the stimulus presentation from