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APPROPRIATE ENCODING STRATEGIES COMPENSATE FOR DRIVING ABILITIES IN ELDERLY INDIVIDUALS: A VIRTUAL REALITY STUDY

To the Editor: Behavioral studies consistently show that older adults are impaired in spatial navigation.[1–6] These difficulties apparently result from deficits in spatial encoding[7] and could induce driving errors in elderly individuals, especially in a new environment.[8] Thus, deficits in spatial navigation in aging could explain why elderly individuals are more likely than young adults to be involved in car crashes. Deficits in spatial navigation seem to result from impaired encoding processes. Because explicit learning instruction has positive effects on performance in other memory domain (e.g., verbal memory, associative memory), the effects of an appropriate encoding strategy on the ability of elderly individuals to encode the spatial layout of a virtual environment was tested. It was assumed that providing elderly participants with a spatial encoding strategy would improve their learning capacity. Moreover, it was predicted that this strategy would have positive effects on driving abilities in elderly individuals. Some studies have shown that memory performance of elderly adults can be improved using intentional learning instructions.[9]

The purpose of this study was to investigate whether giving elderly individuals appropriate encoding strategies on spatial navigation would improve their spatial learning abilities and have a positive effect on their driving ability.

MATERIALS AND METHODS

Thirty younger (mean age 24.5 ± 2.8) and 63 older (mean age 66.3 ± 5.5) adults participated in the study. All participants were paid and provided written informed consent before participation in accordance with the guidelines of the local ethics committee. Elderly participants were screened for dementia using an extensive neuropsychological examination.

Participants were placed in a driving simulator and asked to drive through a virtual town following an itinerary in three learning trials. Older adults were randomly assigned to standard ($n = 32$) or landmark-based ($n = 31$) encoding conditions, whereas younger adults were tested only under standard learning conditions. Participants in the standard encoding conditions were informed that they would have to recall the route later, whereas participants in the landmark-based encoding group were also instructed to pay attention to salient landmarks along the route.

Immediately and 15 days after the learning phase, participants were asked to recall the route in the reverse direction. Participants subsequently completed additional memory tasks, including free recall and recognition of landmarks and drawing of the path on a two-dimensional map.

Data were analyzed using repeated-measures analysis of variance with group (younger and older subjects with landmark-based and standard encoding instructions) as a between-subjects factor and testing session (immediate vs after 15 days) as a within-subject factor. Post hoc Newman-Keuls analyses were conducted on all significant main effects and interactions.

RESULTS

Older adults in the landmark-based encoding condition tended to perform better than younger subjects ($P = .08$) and had fewer detours than older adults with standard encoding instructions ($P < .001$). Mean time to complete the route did not differ between younger and older adults with landmark-based instructions ($P = .47$), but older adults in the standard encoding condition needed more time to complete the route than the two other groups (young adults: $P = .003$; older landmark-based encoding instructions: $P < .001$).

Older adults with landmark-based instructions recalled as many landmarks as younger subjects ($P = .19$) but significantly more than older adults in the standard condition ($P < .001$). Older adults with landmark-based instructions had an error rate equivalent to that of younger participants in drawing on a two-dimensional map ($P = .40$) but made fewer errors than older adults with standard instructions ($P < .001$). Older adults with landmark-based instructions recognized more landmarks than older adults with standard instructions ($P < .001$) but as many as younger subjects ($P = .75$).

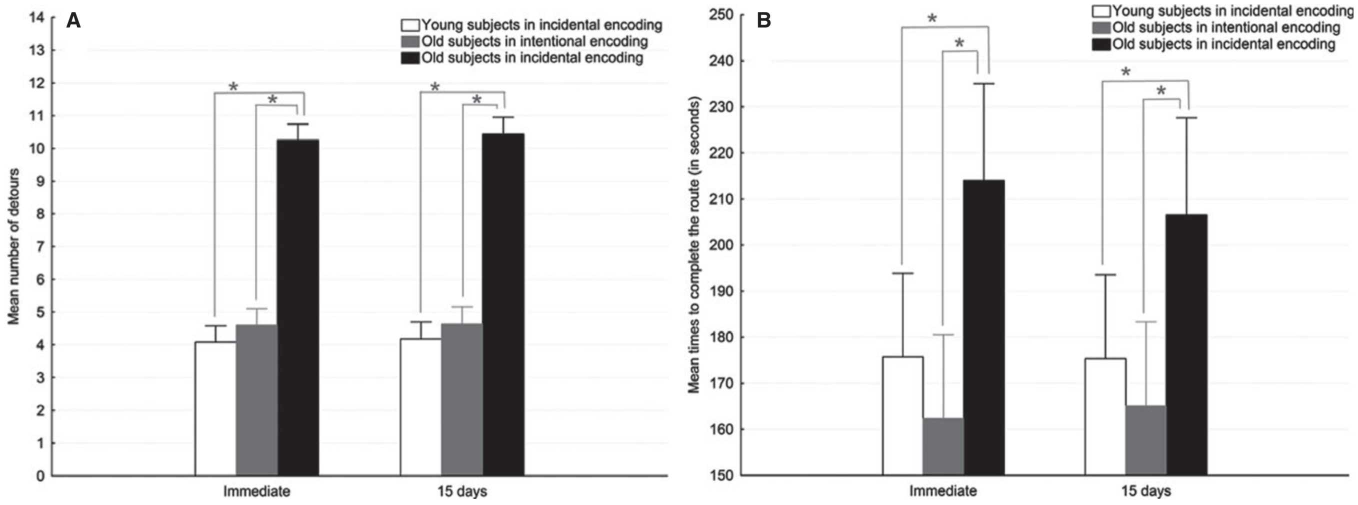

Figure 1. (A) Mean number of detours in young adults with incidental encoding, older adults with intentional encoding, and older adults with incidental encoding during immediate and 15-day delayed recall. (B) Mean time to complete the route in younger adults with incidental encoding, older adults with intentional encoding, and older adults with incidental encoding during immediate and 15-day delayed recall.

Older adults in the landmark-based condition used the brake and accelerator pedals a similar number of times as the younger subjects ($P = .83$) but significantly fewer times than older adults in standard condition ($P < .001$). Mean car speed did not differ between younger adults and older adults with landmark-based instructions ($P = .15$) but was lower in older adults with standard instructions than in the other two groups ($P < .001$ each).

Good performance of older adults with landmark-based instructions remained stable on all tests even after a 15-day delay (Figure 1).

DISCUSSION

Providing landmark-based encoding instructions had positive effects on spatial learning and on driving in elderly individuals. Furthermore, spatial representations remained stable over time, with performance maintained even after 15 days.

These results suggest that age-related difficulties in spatial navigation may be due to declines in self-initiated strategies, leading to disruption of spatial encoding and that providing efficient encoding strategies can compensate for these deficits. The results provide insights into cognitive remediation based on self-initiated strategies. Providing efficient encoding strategies can improve driving behavior in elderly adults.

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SLEEP-DEPENDENT LEARNING OF A FUNCTIONAL MOTOR TASK DECLINES WITH AGE

To the Editor: Although mounting evidence demonstrates that sleep appears to drive motor learning in young adults, the effect of sleep on motor learning across the life span is less clear. Only two studies have demonstrated that middle-aged adults benefit from sleep to enhance motor learning,[1,2] and the effect of sleep on motor learning in older adults has been mixed,[1–7] but the magnitude of sleep-dependent improvement in performance has been found to be less for middle-aged[1] and older adults[4] than for young adults. Furthermore, most studies assessing off-line learning in middle-aged[1] and older adults[1,3–7] have used simple computer-based tasks. Therefore, the effect of sleep in learning a functional motor task across the life span was compared in young,[8] middle-aged, and older[2] adults.

Twenty-four young (25.7 ± 2.8),[8] 20 middle-aged (48.0 ± 3.7), and 20 older (70.4 ± 3.8) adults[2] practiced a novel walking task. In brief, the task involved walking around an irregular elliptical pathway while performing a mental subtraction task. Participants were randomized into two groups; a sleep group that slept between practice and the retention test and a no-sleep group that stayed awake. Actigraphy was used to capture sleep data for some participants.

Although the three age groups demonstrated significant sleep-dependent off-line learning of a functional motor task, the results indicated a significant difference in off-line motor learning between the three age groups ($F_{2,58} = 3.39$, $P = .04$). Post hoc Fisher least significant difference (LSD) testing demonstrated that this difference was significant between the young and older adult groups ($P = .02$) but not between the young and middle-aged groups ($P = .06$). Middle-aged and older adults groups did not differ ($P = .63$; Figure 1A). A post hoc Pearson correlation was conducted between off-line learning score for the time around the path and age. A negative significant correlation was found between age and off-line learning (correlation coefficient (r) = −0.54, $P = .002$; Figure 1B), indicating that off-line learning declines with advancing age.

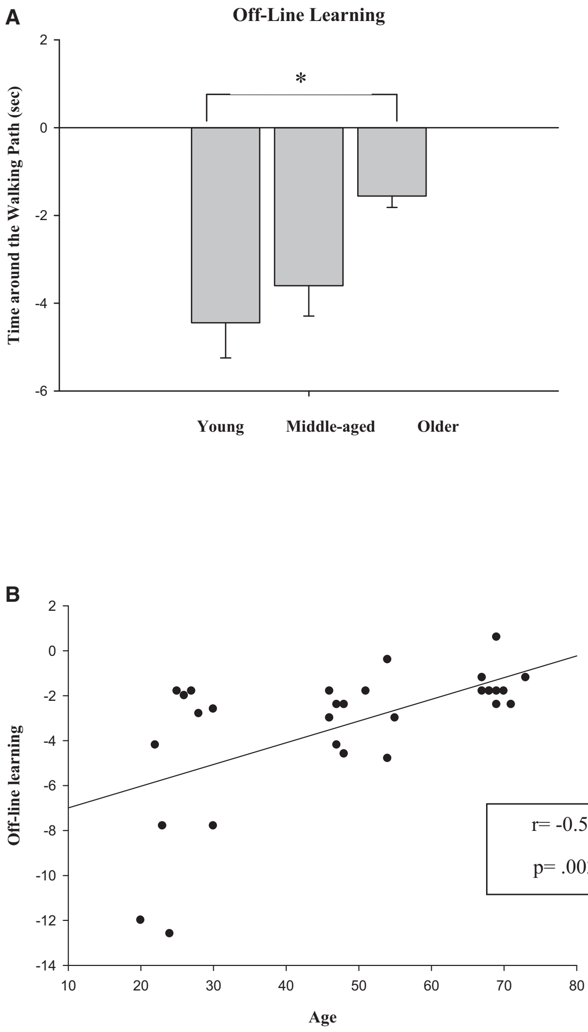

Figure 1. (A) Age-related change in sleep-dependent off-line learning of a functional motor task. Error bars are standard errors of the mean. (B) Correlation between off-line learning for time around the walking path (primary outcome measure) and age (*$P < .05$).

The results indicated no significant differences between the three age groups in Pittsburgh Sleep Quality Index (PSQI; $P = .50$), average sleep 1 week before testing ($P = .18$), total sleep time ($P = .20$), sleep latency ($P = .09$), sleep efficiency ($P = .41$), or number of awakenings ($P = .26$). The off-line motor learning score for time around the walking path was significantly correlated with sleep efficiency ($r = 0.60$, $P = .007$) and PSQI ($r = -0.62$, $P = .002$) across the age groups. Weak nonsignificant correlations were found between off-line learning and sleep latency ($r = -0.36$, $P = .09$), number of awakenings ($r = -0.24$, $P = .28$), and average sleep 1 week before practice ($r = 0.38$, $P = .08$).

This study demonstrates that young, middle-aged, and older adults benefit from sleep to enhance motor skill