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A cognitive training intervention improves modality-specific attention in a randomized controlled trial of healthy older adults

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Abstract

Age-related deficits in cognitive and sensory function can result in increased distraction from background sensory stimuli. This randomized controlled trial investigated the effects of a cognitive training intervention aimed at helping healthy older adults suppress irrelevant auditory and visual stimuli. Sixty-six participants received 8 weeks of either the modality-specific attention training program or an educational lecture control program. Participants who completed the intervention program had larger improvements in modality-specific selective attention following training than controls. These improvements also correlated with reductions in bimodal integration during selective attention. Further, the intervention group showed larger improvements than the control group in non-trained domains such as processing speed and dual-task completion, demonstrating the utility of modality-specific attention training for improving cognitive function in healthy older adults.

Keywords: Attention; Distraction; Cognitive aging; Auditory; Visual; Training

1. Introduction

Normal aging is accompanied by changes in many sensory and cognitive domains, causing impairments in memory, communication, balance, and mobility that can lead to difficulty performing basic activities of daily living (Cahn-Weiner et al., 2000; Hedden and Gabrieli, 2004; Owsley and McGwin, 2004; Wood et al., 2005; Murphy et al., 2006; Inzitari et al., 2007; Maki et al., 2008). Thus, a major goal of aging research is to develop methods for maintaining independence and quality of life for older adults. Because the brain retains some plasticity with age, interventions aimed at training cognitive abilities may provide a means for maintaining or strengthening cognitive skills in healthy older adults (Kempermann et al., 2002; Jones et al., 2006; Acevedo and Loewenstein, 2007). In fact, several cognitive training programs have been shown to be effective at improving healthy older adults' memory, reasoning, speed of processing, and dual-task performance (Ball et al., 2002; Edwards et al., 2005; Bherer et al., 2006; Mahncke et al., 2006; Willis et al., 2006; Erickson et al., 2007).

Although the neural mechanisms that underlie age-related cognitive decline remain equivocal, age-related reductions in brain volume (Raz et al., 2004) and cortical thickness (Salat et al., 2004) are most pronounced in the prefrontal cortex, and executive processes supported by the prefrontal cortex, including attention, inhibition, and working memory, are highly susceptible to age-related declines (West, 1999; Grady and Craik, 2000; Andres et al., 2008). Deficits in these executive functions can impair older adults' performance on a broad range of cognitive tasks, as age-related increases in distraction from task-irrelevant visual stimuli, sounds, and speech can interfere with processing information that is relevant to the task (Alain and Woods, 1999; Tun et al., 2002; McPhee et al., 2004; Andres et al., 2006; Healey et al., 2008). For example, older adults' responses to visual stimuli are slowed more than younger adults' when the visual stimulus is preceded by a novel sound (Andres et al., 2006).

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In addition to the cognitive factors that influence older adults' task performance, age-related declines in sensory acuity and alterations in how stimuli from different sensory modalities are integrated together can also play a role in functional abilities (Wood et al., 2005; Murphy et al., 2006). Murphy et al. (2006) demonstrated that the comprehension and memory deficits that older adults experience when processing two-person conversations can be eliminated by compensating for older adults hearing difficulties. However, older adults still performed worse than younger adults when the two talkers were spatially separated (Murphy et al., 2006). These results indicate that although ameliorating basic sensory impairments can improve older adults' ability to process sensory information, additional means may be required to minimize age-related deficits.

Enhancing the sensory signals that older adults receive from the environment is one method for recovering function; another technique is to reduce the amount of background noise being processed along with the relevant sensory information. Older adults exhibit enhanced integration of information from multiple sensory modalities compared to younger adults (Laurienti et al., 2006; Peiffer et al., 2007; Diederich et al., 2008). The inappropriate integration of irrelevant or non-matching sensory stimuli can serve to increase noise and interfere with processing of relevant information (Alain and Woods, 1999; Strupp et al., 1999; Andres et al., 2006). One cognitive mechanism for reducing such cross-modal noise is modality-specific selective attention, which allows us to focus on information in one modality by suppressing the processing of stimuli in the ignored modality (Spence and Driver, 1997; Spence et al., 2001). Selective attention to either the auditory or visual modality has been demonstrated to eliminate the integration of congruent audiovisual stimuli in younger adults (Talsma et al., 2007; Mozolic et al., 2008); however, older adults still demonstrate increased multisensory integration during selective attention (Hugenschmidt et al., 2009), and it is unknown whether improving selective attention in older adults could reduce susceptibility to distraction from irrelevant sensory stimuli.

Our goal for this study was to investigate the effects of selective attention training in healthy older adults. The training program was designed to improve participants' ability to suppress background auditory and visual stimuli in an effort to decrease the amount of distraction experienced by older adults, and consequently improve their ability to process relevant information. Our hypothesis was that successful completion of the training program would reduce the influence of an ignored sensory modality on tasks that require modality-specific selective attention. Additionally, we investigated whether improvements would generalize to a wide variety of cognitive tasks, with the idea that improved sensory processing could have a positive effect on a broad range of cognitive functions that rely on the suppression of cross-modal noise.

2. Methods

2.1. Participants

Participants were recruited from the community for this randomized, controlled, single-blind study. All study procedures were approved by and conducted in accordance with the Wake Forest University School of Medicine Institutional Review Board. All participants signed an informed consent and were compensated approximately US$ 20 per hour for their participation in the study. Seventy-five adults between the age of 65 and 75 were screened for eligibility. Sixty-six of these participants (mean age = 69.4, 35 women) were determined to be eligible for the study and were subsequently randomized to either the treatment or the control group. Randomization was completed in blocks of 8–10 subjects and stratified based on gender. Exclusion criteria included any of the following: visual acuity less than 20/40 with corrective lenses; colorblindness; hearing loss greater than 50 dB at 1000 or 2000 Hz; dementia or mild cognitive impairment indicated by a score on the Mini-Mental Status Exam that was below the 5th percentile for participant age and education level (Bravo and Hebert, 1997); current substance abuse indicated by a score greater than 10 on the Alcohol Use Disorders Identification Test or an evaluation of participant medical history; untreated depression, evaluated using the Medical Care Corporation survey (www.mccare.com); previous brain surgery or CNS trauma, neurological disorder, or use of antipsychotic and/or antiepileptic drugs, as determined by an evaluation of participant medical history. Demographic data for participants are summarized in Table 1.

2.2. Design

Following eligibility screening and randomization, all participants completed a battery of behavioral tests to evaluate baseline functioning in several cognitive domains. Within 1 week of this behavioral testing session, all participants began 8 weeks of training. For both the treatment and control training programs, participants came to the laboratory for 1 h each week (total training time = 8 h). Within 1 week of completing their respective training programs, all participants were again administered the same battery of behavioral tests that they had completed prior to training. Participants also completed subsequent follow-up exams out to one month post-training, and

Table 1
Demographic data for participants in the treatment and control groups.

	Treatment	Control	*p*-Value
Age (years)	69.4 (3.2)	69.4 (2.5)	1.00
Sex (# females)	17	18	
Education (years)	15.6 (2.2)	16 (3.4)	0.18
MMSE (score)	28.3 (1.5)	28.5 (1.9)	0.66

Demographic data did not differ for participants randomized to the treatment and control groups on a 2-tailed *t*-test. Mean values are presented with standard deviations in parentheses.