Learning and Motivation 57 (2017) 48–60

Contents lists available at ScienceDirect

Learning and Motivation

journal homepage: www.elsevier.com/locate/l&m

Working memory decline in normal aging: Is it really worse in space than in color?

Giuliana Klencklen, Pamela Banta Lavenex, Catherine Brandner, Pierre Lavenex*

Laboratory of Brain Cognitive Development, Institute of Psychology, University of Lausanne, Switzerland

ARTICLE INFO

Article history:
Received 24 January 2017
Accepted 24 January 2017

Keywords:
Allocentric spatial memory
Color memory
Memory capacity
Short-term memory
Healthy aging

ABSTRACT

Aging is associated with a variety of changes in cognitive capacities, including a decline in working memory performance. Nevertheless, visuo-spatial working memory has been shown to exhibit a greater age-related decline than verbal working memory. Here, we assessed age-related changes in allocentric spatial working memory and color working memory. We tested 20–30-year-old and 65–75-year-old adults on four memory tasks requiring participants to learn, on a repeated-trial basis (i.e., reference memory) or a trial-unique basis (i.e., working memory), the locations or colors of three pads among 18 pads distributed in a real-world laboratory environment. Older adults performed worse than young adults on all memory tasks, but especially on working memory tasks. Some measures, including the older adults' relative decrease in the number of correct choices before erring (CBE), as compared to young adults, and the number of trials with the first or first two choices correct, may suggest a greater age-related decline in allocentric spatial than color working memory. In contrast, the total number of disks visited to find the goals, the absolute decrease in CBE in older adults, the number of errorless trials and the number of trials with the first three choices correct revealed no age-related differences in working memory performance for spatial versus color information. We discuss how, depending on the measures used to evaluate memory performance, age-related declines in working memory may appear greater for spatial information because allocentric spatial memory may have quantitatively greater representational demands (i.e., require more bits of information) than color memory.

1. Introduction

Normal aging, in absence of evidence of mild cognitive impairment (MCI) or dementia, is associated with a variety of changes in cognitive capacities, one of which is an overall decline in working memory performance (Fabiani, 2012). Working memory refers to a brain system that enables temporary storage and manipulation of the information necessary for language comprehension, learning, and reasoning (Baddeley, 1992). Working memory can be evaluated by testing the ability of individuals to remember and use trial-unique information that must be distinguished from information acquired on previous trials, and is resistant to interference and distraction during the retention interval (Banta Lavenex, Colombo, Ribordy

* Corresponding author at: Institute of Psychology, University of Lausanne, CH-1015 Lausanne, Switzerland.
E-mail addresses: giuliana.klencklen@unil.ch (G. Klencklen), pamela.bantalavenex@unil.ch (P. Banta Lavenex), catherine.brandner@unil.ch (C. Brandner), pierre.lavenex@unil.ch (P. Lavenex).

http://dx.doi.org/10.1016/j.lmot.2017.01.007

Lambert, & Lavenex, 2014; Bizon, Foster, Alexander, & Glisky, 2012; Spellman et al., 2015). Trial-unique procedures aimed at testing working memory are distinguished from repeated-trial procedures in which the information to be memorized remains constant over time, and which serve to evaluate what has been called reference memory (Banta Lavenex et al., 2014; Lee, Tucci, Sovrano, & Vallortigara, 2015; Morris, Hagan, & Rawlins, 1986; Olton, Becker, & Handelmann, 1979). In addition, information to be processed in working memory may be separated into distinct components including verbal, visual and spatial information, and, over the years, a number of experimental studies have reported evidence supporting the view that different types of information may be processed by different temporary storage systems (Baddeley, 2007, 2012; Logie, 2011; Logie & Marchetti, 1991).

Accordingly, a number of studies evaluated whether age-related declines in working memory performance differ based on the type of information to be remembered. In support of this view, it has been reported that visuo-spatial working memory exhibits a greater age-related decline than verbal working memory (Chen, Hale, & Myerson, 2003; Jenkins, Myerson, Joerding, & Hale, 2000; Myerson, Hale, Rhee, & Jenkins, 1999; Salthouse, 1995; Shelton et al., 1982). For example, Jenkins et al. (2000) tested young (18–24 years) and older (62–77 years) adults on a letter span task and a location span task presented on a computer screen. The letters were consonants, whereas the locations were represented by a 2.5×2.5 cm cross, presented in the center of one of sixteen cells of a 4×4 unfilled matrix (15×15 cm). In addition, participants performed these primary tasks, while sometimes performing a concurrent secondary task, including a verbal task or a visuo-spatial task. Older adults performed worse than young adults on all working memory tasks, irrespective of the type of material (verbal or spatial) or secondary task (none, verbal or spatial). However, Jenkins et al. (2000) reported a greater age-related performance difference in the memory span for locations (about 3 locations; 4.62 for older adults vs 7.58 for young adults) than in the memory span for letters (about 2 letters; 4.39 vs 6.46, respectively). These results were consistent with those of Myerson et al. (1999), who tested young (18–22 years) and older (63–69 years) adults on a digit span task and a location span task (with and without secondary tasks), and reported that older adults remembered on average one less digit (6.01 vs 6.98) and 2.4 fewer locations than young adults (3.96 vs 6.34). Interestingly, Chen et al. (2003) tested young (18–22 years) and older (65–75 years) adults on different object and location memory tasks. The object working memory tasks involved the presentation of shapes or textures, whereas the location working memory tasks involved the presentation of two dots defining a distance or the presentation of distinct textured dots defining specific locations. Although, in contrast to their previous studies (Jenkins et al., 2000; Myerson et al., 1999), Chen et al. (2003) did not find age-related differences in performance in the non-spatial working memory tasks, they again found that young adults outperformed older adults on the location tasks. Altogether, these results suggested that the age-related decline in working memory performance may differentially affect the maintenance of verbal, visual and spatial information (Myerson, Emery, White, & Hale, 2003).

It is important to note, however, that previous studies assessing visuo-spatial working memory in aging have utilised classical neuropsychological paradigms in which stimuli are presented on computer screens. They were thus limited to the assessment of egocentric spatial representations, which differ from the type of spatial representations an individual may build when moving about in a real-world environment. Indeed, the brain can represent locations via distinct spatial representation systems (Banta Lavenex & Lavenex, 2009; Burgess, 2006; O'Keefe & Nadel, 1978). Over the short term, and when an observer's position is fixed in relation to an array of locations, egocentric (viewpoint-dependent, hippocampus-independent) coding is the most reliable, and allocentric (viewpoint-independent, hippocampus-dependent) encoding is unnecessary (Banta Lavenex & Lavenex, 2009). However, once the observer begins to move in the world, hippocampus-dependent allocentric spatial coding becomes critical to spatial memory processing (Banta Lavenex et al., 2014). It is therefore important to expand the investigation of age-related changes in working memory performance to compare the allocentric spatial working memory capacity of young and older adults. Moreover, whether the visuo-spatial component of working memory can and should be further subdivided into separable components, one for maintaining the visual features of the stimuli, such as shapes, textures or colors, and the other for maintaining their spatial locations, remains a matter of debate (Baddeley, 2012; Banta Lavenex et al., 2014; Chen et al., 2003). It is thus also important to compare potential age-related changes in allocentric spatial working memory with age-related changes in working memory in another visual domain, such as that for color.

Finally, previous studies of age-related changes in working memory performance did not compare the performance of the same participants on memory tasks where the same type of information can be acquired over repeated trials: i.e., on reference memory tasks (Banta Lavenex et al., 2014; Lee et al., 2015; Morris et al., 1986; Olton et al., 1979). Such comparison is important in order to shed light on the specific cognitive processes that may be particularly affected in normal aging, beyond working memory (Fabiani, 2012). Here, we tested whether there are: (1) different age-related declines in working memory, as compared to reference memory, for allocentric spatial and color information; and (2) greater age-related declines in allocentric spatial working memory than in color working memory.

2. Material and methods

2.1. Participants

Thirty-four young adults (16 males) aged 20–30 years (M = 24.15, SD = 3.46) and thirty-five older adults (18 males) aged 65–75 years (M = 69.26, SD = 3.02) took part in the study. Participants were recruited via personal connections, email postings on social networks, and via flyers distributed through local senior organisations. Care was taken to recruit participants from