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Age differences in path learning: The role of interference in updating spatial information

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ABSTRACT

Spatial orientation is an essential ability, which has shown to decline with aging. Although several researches have focused on the different orientation behaviors and perspectives, few of them have examined the acquisition of multiple paths at the same time. The current study was designed with the intention of investigating age differences in multiple view learning, as well as understanding the difficulty in updating spatial information. Twenty young people, 20 adults and 20 older adults learnt three paths which started and ended from different points of view in the same virtual environment. Results had shown worse performance of the older adults, although all age groups worsened in the last path. These results showed a severe impact on navigation in aging, and were discussed within aging and spatial cognition domain.

1. Introduction

Navigating successfully through the world, localizing new places or inferring shortcuts, are important aspects of human behavior. Even today, targeted effectively in our environment, it remains an indispensable factor to survive in some places in the world. Thereby, given the changing environment around us, we consider it of great interest to analyze how the changing spatial information is updated. In this regard, some studies consider that this process implies a big effort, since it involves combining prior with new information (Mou, Zhang, & McNamara, 2009; Waller, Montello, Richardson, & Hegarty, 2002; Wang & Brockmole, 2003). Furthermore, the success to modulate the updating of spatial information depends not only on individual differences, but also on variables such as the information complexity, similarity in the number of trials, or the time of exposure, among others (Klatzky et al., 1990). In this respect, Cánovas et al. (2011) aimed to see how the acquisition varies along a series of trials in a virtual task presented in navigation modality, focusing on the influence of the number and location of cues on young males and females. They found an acquisition improvement over eight trials in all participants. The research of Livingstone-Lee, Zeman, Gillingham, and Skelton (2014) showed similar results but comparing the effectiveness of different spatial strategies (place maze, cue maze and visible platform maze) in young participants along ten trials. In this study, first the participants were trained to use allocentric or egocentric strategies in a virtual environment analog to the Morris Water Maze. Then they were tested in a dual-strategy maze to discover if they maintained or changed the strategy of the training phase. They found a clear influence of the prior experience on navigational strategy, as a progressive acquisition along the 10 trials of a wayfinding task, regardless of the spatial strategy used.

Therefore, in general, these findings point to the possibility of acquiring both types of spatial information, in the same environment but with prior separate acquisition training. Nevertheless, in all these previous studies, the starting and/or finishing point of the navigation path remained stable throughout the trials. Thereby, the acquisition of the task was easier, due to the fact that one point of reference remains stable (start position or finish) which is very valuable information in wayfinding tasks.

On the other hand, partly due to the increasingly aging population, several researchers have focused on the study of spatial orientation during aging (e.g. Gyselinck et al., 2013; Harris & Wolbers, 2014). Thus, due to the deterioration with age of some cognitive processes such as working memory, executive functions or cognitive control (e.g., Borella, Meneghetti, Ronconi, and De Beni 2014), it is not surprising to observe a decline in the wayfinding task, updating spatial information, inferring distances and directions, learning unfamiliar routes or remembering landmarks (Adler et al., 2014; Grewe et al., 2014; Mou & McNamara, 2002; Vallesi, McIntosh, & Stuss, 2011; Willis,

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1991). To our knowledge, the only research that has approached how the impairments along lifespan affected the updating of spatial information, was a recent study by Harris and Wolbers (2014). Using allocentric and egocentric strategies in a navigation virtual task, participants learned paths with different start and finish positions of the same environment (training trials). Then they assessed three spatial abilities; switching from following learned routes (updating information), finding novel shortcuts, as well as changing strategy. Results point to more problems in the older group both in the training and in all the spatial abilities measured in the testing phase.

In this regard, one factor to consider in the capacity to update spatial information is the interference phenomenon (Cabrera, Chavez, Corley, Kitto, & Butt, 2006; Leung & Zhang, 2004). Specifically, proactive interference is conceived as a negative modulator in the acquisition of information and has been considered to be the deleterious effect of previously remembered information on current memory representations (McGeoch & McDonald, 1931; Postle, Brush, & Nick, 2004). Although to date, analysis of the role of interference in spatial acquisition has hardly been considered, those studies that have been analyzed have demonstrated a high influence of this phenomenon in spatial working memory (Aisenberg, Sapirb, & d'Avossab, 2014; Jonides & Nee, 2006; Rowe, Hasher, & Turcotte, 2008). In this line, Cornoldi, Bassani, Berto, and Mammarella (2007), develop a visuo-spatial working memory task in which participants had to remember the path of dots in a matrix that changes the position of the dots along the trials. Thus, this task allows detection the proactive interference, since to update the position of the dots participants had to inhibit the position of the previous trials. Their results underline the relevance of interference in the acquisition of spatial information and also show the greater difficulty in carrying out the task in the older adult. Similarly, other studies point to a selective impairment in the ability to inhibit irrelevant information during the normal aging process (Gazzaley & D'Esposito, 2007; Vallesi et al., 2011).

1.1. Rationale and aim of the current study

Previous studies had focused on changing strategies in young and older groups over the trials in spatial tasks when either the start and/or the goal remains stable (Harris & Wolbers, 2014; Iglói, Zaoui, Berthoz, & Rondi-Reig, 2009; Livingstone-Lee et al., 2014). Since, to the best of our knowledge, no previous study has focused on the study of changing spatial information over paths exploring age-related differences, it has become for us a really interesting issue to address.

For that purpose, we developed a virtual environment labyrinth, inspired in the characteristics of the Tolman (1948), reproducing a botanical garden. In this labyrinth three paths were created that start and end in different points (in order to change the environment perspective in each path). Nowadays many researchers are carrying out spatial navigation studies using virtual reality, providing a better understanding of the spatial impairments both in normal or pathological aging (Akinlofa, O'Brian-Holt, & Elyan, 2014; Cohen & Hegarty, 2014; Martens & Antonenko, 2012). Given previous studies that point to a deterioration with age in updating spatial information (Harris & Wolbers, 2014), as well as the higher demand that implies combining prior with new information (Mou et al., 2009), we hypothesize that i) older adults will have a general worse performance compared with young and adults, ii) but at the same time all age groups would have a worse performance along the paths.

2. Method

2.1. Participants

A group of 20 young people (16 females and 4 males) (M = 21 years, SD = 0.56, range = 19–30 years), a group of 20 adults (17 females and 3 males) (M = 44.80 years, SD = 1.92, range = 31–55 years) and a group of 20 older adults (16 females and 4 males) (M = 64.15 years, SD = 1.49, range = 56–80 years) voluntarily took part in the experiment. We excluded patients with cerebrovascular disease, mild cognitive impairment, Alzheimer disease and mental disorders. None of the participants had an occupation that could have trained visuo-spatial skills, e.g. they were not pilots or taxi-drivers. All participants were native Spanish speakers.

The study was carried out with full respect for the fundamental principles established in the Helsinki Declaration, the Convention of the Council of Europe on human rights and biomedicine, in the UNESCO Universal Declaration on the Human Genome and Human Rights as well as the requirements of Spanish law in the field of biomedical research, the protection of personal data and bioethics.

2.2. Experimental setting and materials

2.2.1. Sample screening test

In order to discard those results in spatial memory may be determined by intelligence, mental status or cognitive processes, several cognitive tests indicated below were also performed.

2.2.1.1. Fototest (Carnero-Pardo & Montoro-Ríos, 2004). This is a brief cognitive test for detecting mild cognitive impairment and dementia. This test assesses several cognitive domains such as memory, language and executive functions, allowing us to rule out that none of the participants show cognitive impairment. It is divided into three sections, denomination (six questions giving one point for each correct answer), verbal fluency (one point for each correct item), and memory (the spontaneously remembered items scored with 2 points and remembered with help 1 point). This test is not influenced by the educational level of the subject and has proven internal consistency (Cronbach's alpha 0.94), high test–retest reliability (intraclass correlation coefficient [ICC] 0.89 ± 0.04) and interobserver (ICC = 0.98 ± 0.01) (Carnero-Pardo, Sáez-Zea, Montiel-Navarro, Feria-Vilar, & Gurpegui, 2012).

2.2.1.2. WAIS-III (Wechsler, 1997). Two tasks were chosen measuring the degree of acquisition, retention and retrieval of general information acquired from culture, as well as visual perception, organization, concentration and visual recognition of objects. So the following sub-test was chosen:

Information in order to ensure that participants had no problems in verbal comprehension or long-term memory.

Picture completion in order to evaluate the perceptual organization, as well as the ability to recognize familiar objects and to distinguish essential details of the secondary. *Scoring was according to WAIS-III scoring criteria* (Wechsler, 1997, 1999). Moreover, all these subtests allow us to obtain an IQ score for all the participants, to ensure that there were no differences in intelligence that can skew the results of the virtual environment task.

2.2.1.3. Visual object and space perception battery (VOSP; Warrington & James, 1991). This test ascertains that there is no impairment in the recognition of the space environment. Besides, this test has no cultural baggage, and has been developed, validated and standardized in the Psychology Department of the National Hospital for Neurology and Neurosurgery, Queen Square, London. Of this battery of tests specifically those that allow the evaluation of spatial perception were performed:

Dot counting consists in identifying the number of dots presented in 10 stimulus cards.

Position discrimination consists of two squares (one up and one down) each with a dot inside. The task is to indicate whether the two points lie in exactly the same position or vary.

Number location was based on the same configuration as the previous test, but in this case, the top square contains random numbers