# The Role of Working Memory and Attention in Older Workers' Learning

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**Abstract—**Nowadays, the aging workforce constitutes a worldwide reality in developed countries due to the population aging phenomenon. Therefore, policymakers consider the role of learning very important for older workers' improvement and development. So, it becomes urgent for the older workers' learning to be enhanced for their personal development first, and then for the general progress of the company. Working memory and attention play a crucial role in older workers' learning and contribute significantly to their active work life. This article presents the concept of working memory and attention, and highlights the significant role of these cognitive skills in the aging workforce learning. Working memory and attention training tools are also presented.

**Keywords—**Aging workforce, working memory, attention, older workers, learning, working memory and attention training

## 1 Introduction

The aging workforce is a growing phenomenon that attracts the interest of corporate leaders, government policymakers, as well as professional associations related to aging [1]. It is difficult to change this worldwide work reality, but it is a real challenge to turn it into a significant productive possibility both for employers and employees [2]. Such a venture could be achieved by the enhancement of older workers' learning. Because, as Deiser [3] claims, a company, in order to succeed and become innovative, needs to turn into a "learning-driven" company. In the case of an aging workforce, we could add "older workers' learning-driven company".

The concept of an older worker varies across contexts and cultures because many factors [4], such as age stereotypes associated with different jobs (Perry et al. 1996, as cited in Truxillo, et al., 2015) [4], and variability in terms of retirement ages and legal protections (e.g., in the United States age-related legal protections begin at age 40), determine who can be considered older [4].

Older workers' learning may be formal or informal [5]. Formal learning means "learning that occurs in an organized and structured environment [...] and is explicitly designated as learning" (CEDEFOP, 2008, p. 85, as cited in Raemdonck et al., 2015) [5], while informal learning is embedded in daily working activities of an employee and may happen unconsciously (Livingstone, 2001; Marsick & Watkins, 2001, as cited in Raemdonck et al., 2015) [5] or in implicit, reactive, or deliberate ways (Eraut, 2007, as cited in Raemdonck et al., 2015) [5].

The present article focuses on the crucial role of the two cognitive skills of working memory and attention in the older workers' learning. Some examples of activities that rely on working memory include remembering a new telephone number, a PIN, or a web address while we are trying to find a pen and paper to write it down, or remembering an unfamiliar foreign name of a person, who has just been introduced to us for long enough to enable us to introduce them to someone else [6], while an example of attention includes navigating an online help forum while talking to a customer [7].

This article also reflects an effort to unite the existing scientific knowledge about the positive effect of working memory and attention in older workers' learning, as well as to give rise to further questioning and to motivate thorough research. Such a research interest in the role of these two cognitive skills in the aging workforce learning could lead to the effective planning of innovative corporate learning programs highlighting the value of the aging workforce in today's competitive environment.

## 2 Working Memory, Attention, and Age

### 2.1 Working memory

Working memory is a brain system responsible for the temporary storage and manipulation of the information necessary for language comprehension, learning, and reasoning, which are complex cognitive tasks [8], [9]. Working memory can hold only a small amount of information, either abstract ideas or objects that can be counted [10]. It has been estimated that adults' working memory capacity is in the range of 3 or 4 objects (Cowan, 2001; Luck & Vogel, 1998; as cited in Cowan 2016, p. 7) [11].

Working memory is differentiated from short-term memory, because these two memory systems represent different cognitive functions [12], since short-term memory is responsible for storing information for a short period of time (e.g., remembering a phone number), while working memory refers to handling information during a complex cognitive process (e.g., remembering numbers while reading a paragraph). Furthermore, working memory is distinguished from short-term memory by its number of components, namely the central executive, the visuospatial sketchpad, the phonological loop, and the episodic buffer [13].

**Central executive:** The central executive is responsible for controlling the memory operating system and integrating it with other parts of the cognitive system [14]. It is of limited capacity and closely related to attention control and the regulation of the flow of information within the working memory [14], [15], as well as retrieving material from more permanent long-term memory systems in working memory. Also, it is fueled by working memory capacity [16].

**Visuospatial sketchpad:** The visuospatial sketchpad is responsible for the temporary storage of visuospatial information (Baddeley, 2000; Buchsbaum et al., 2017; Catinas, 2017; Gathercole, 2008) and their handling (Gathercole, 2008), and is associated with increased activity in the right cerebral hemisphere [17], [14] in areas 6, 19, 40 and 47 [17].

**Phonological loop:** The phonological loop is capable of holding verbal and audio information through two systems, namely the phonological storage and the subvocal rehearsal mechanism [17], [18], which are related to Brodmann areas 40 and 44, respectively [17]. The phonological storage holds information for about 2 seconds [19], while the information in the phonological loop is repeated by the subvocal rehearsal mechanism to get stored in memory [18].

**Episodic buffer:** The episodic buffer is an information storage system [17] that binds information from the visuospatial sketchpad, the phonological loop, and long-term memory [18] into coherent episodes, which can be consciously retrieved. It is of limited capacity [17], which depends on the episodes' or information chunks' number that someone can hold [20], and it is controlled by the central executive [17]. Also, it provides a connection between the subsystems of working memory, the long-term memory, and the central executive, allowing interaction between them [20].

### 2.2 Attention

Attention constitutes a selection mechanism that allows choosing information processing related to a specific task over irrelevant information [21], and underlies our awareness of the world and the regulation of our feelings and thoughts [22]. In particular, it selects certain events or objects to focus on, and during the information processing, it remains focused. Also, while attention focusing on an event or object, the attention distraction is inhibited. Noteworthy is the fact that these aspects of attention change developmentally throughout infancy [23].

Attention is of great importance in our routine tasks. Many experiments have demonstrated its significance for the perception of things that are clearly visible in our field of view. That means attention helps us perceive an easily visible nearby stimulus while being focused on one task, and so to avoid inattentional blindness [13], which refers to the failure to notice the existence of an unexpected item [24] (see the Daniel Simons and Christopher Chabris's film (1999) in which a person in a gorilla suit walked unnoticed through a "basketball" team, as cited in Goldstein, 2011) [13]. Also, attention helps us to avoid change blindness that is, the failure to see changes that are easily noticed [25]. Our ability to see changes is very useful to cope with everyday practical tasks, for example, to monitor the movement of nearby drivers or pedestrians, to notice sudden changes in posture or location of people in front of us or even notice that the sky is going dark [25].

### 2.3 Age-related changes in working memory and attention

Working memory capacity declines with increasing age (Craik & Salthouse, 2000, as cited in McNab, Zeidman, Rutledge, Smittenaar, Brown, Adams & Dolan, 2015) [26]. The limited working memory capacity is closely related to our ability to exclude distractors during encoding (Vogel & Machizawa, 2004; McNab & Klingberg, 2008, as cited in McNab et al., 2015) [26], in which focused attention is involved. Older adults, compared with younger adults, are in a greater reliance on focused attention while encoding a working memory task without distraction [26].

In addition, De Beni and Pallatino (2004) [27] showed that working memory updating declines through age. Working memory updating is the ability that allows refreshing memory and learning. This ability is required, for example, when holiday plans need to change due to the sudden change in weather, so we update the schedule, the destination, and the list of things to take. Reduction in memory capacity and resources and impairment of suppression and inhibition mechanisms are involved in working memory updating decline [27]. Furthermore, according to Brown and Brockmole (2010) [28], visual working memory declines with age. More specifically, the ability to maintain or *bind* the appropriate associations between elements of related information, for example, different combinations of visual features such as colour, luminance, shape, size.

The age-related working memory changes are linked with the aging of the prefrontal cortex, a part of the brain very important for working memory (Braver et al., 1997, as cited in Pliatsikas, Veríssimo, Babcock, Pullman, Glei, Weinstein, Goldman, & Ullman, 2019) [29] (Linderberger, Burzynsca & Nagel, 2013; Raz et al., 2005, Tisserand et al., 2002, Tisserand & Jolles, 2003, West, 1996, as cited in Logie & Morris, 2014) [30]. Also, it has been shown that these age-related changes in working memory are associated with a general slower cognitive processing (Salthouse, 1996, as cited in Pliatsikas et al., 2019) [29], as well as with a decline in attentional resources (Craik & Byrd, 1982, as cited in Pliatsikas et al., 2019) [29].

Moreover, Lezak, Howieson, Bigler, and Tranel (2012, as cited in Murman, 2015) [31] point out that performance on complex attentional tasks such as selective or divided attention declines with age. Selective attention refers to the ability to focus on specific information in an environment and ignore the irrelevant ones. Divided attention refers to the ability to focus on different tasks simultaneously [31] (e.g., navigating an online help forum while talking to a customer) [7]. Also, it is noteworthy that correlations found in the study of Lufi, Segev, Blum, Rosen, and Haimov (2015) [32] regarding the age's effect on the attention level, showed that previous schooling, current reading, and time spent watching television are associated with the attention level.

## 3 Working Memory and Attention in Older Workers' Learning

Aging workforces across the world have led to government measures to retain and upskill older workers (Dymock, Billett, Klieve, Johnson, & Martin, 2012) [33], while employers attempt to convince them to remain in the labor force (Armstrong-Stassen & Schlosser, 2008) [34]. Therefore, it is required for the workplace to be more attractive so that older workers want to continue working. Learning is the main factor of making the workplace appealing to aging workers. Because, if the older workers do not learn, their knowledge and skills related to their work can become outdated (Armstrong-Stassen et al., 2008) [34].

The enhancement of working memory and attention functioning can contribute effectively to the older workers' learning improvement because working memory and attention play a prominent role in learning. In particular, working memory contributes significantly to faster learning (Collins et al., 2017; Seger & Cincotta, 2006, as cited in van de Vijver & Ligneul, 2020) [35], that is, working memory declines in older adults may slow down their learning process, as well as attention declines in older adults lead to their worse performance on tasks requiring attention (McDowd & Shaw, 2000, as cited in Kraiger, 2017) [7] and thus, to negative learning results. Additionally, working memory is very important for learning reinforcement and thus, for behavioral updating, which in turn, is of great significance for the individuals' successful interaction with their environment [35], and in our case, the working environment. The age-related changes in learning reinforcement, depending on the learning timescale, are closely related to working memory declines [35].

Also, attention declines in older adults may affect associative learning (Kruschke, 2003; Mackintosh, 1975; Pearce & Hall, 1980; Pearce & Mackintosh, 2010, as cited in Mutter, Holder, Mashburn, & Luna, 2018) [36], that is, the learning processes that rely on cue-outcome associations (Rescorla & Wagner, 1972, as cited in Mutter et al., 2018), the acquisition of which requires focusing on relevant stimuli and ignoring the irrelevant ones [36]. Older adults are insufficient in this acquisition (Mutter et al., 2006, 2009, 2012; Mutter & Williams, 2004, as cited in Mutter et al., 2018) [36].

Regarding the role of attention in older adults' learning, selective and divided attention are of great significance for their positive learning results. In particular, selective attention is very important for older adults' learning, because older learners are more susceptible to distractions and they cannot easily inhibit irrelevant information (Hasher, Zacks & May, 1999; Kim, Hasher, & Zacks, 2007, as cited in Kraiger, 2017) [7]. Consequently, they have difficulties in learning when the distractions are high (e.g., noisy classrooms or on-the-job training) or learning goals are not evident [7]. Divided attention is absolutely notable for older adults' dual-task performance and their further fulfilling everyday job responsibilities [7].

Furthermore, the diminution of working memory capacity in older adults affects cognitive processing speed (Salthouse, 1996, as cited in Kraiger, 2017) [7], which means that they show slower reaction time and further time to process new information [7], as well as difficulties in performing complex cognitive operations [37]. The older adults' difficulties in more complex tasks may be interpreted by their declined working memory performance because working memory is associated with higher-order cognitive processes, such as the control of complex cognition, monitoring and regulating performance, and goal-directed behavior (McCabe et al. 2010, as cited in Kraiger, 2017) [7].

Therefore, considering all the above learning difficulties of older learners due to their working memory and attention declines, the need for working memory and attention training for integration into the education and corporate learning programs for aging workers becomes imperative. Below, we present some effective means of training working memory and attention in the elderly that could be incorporated and adapted in corporate learning environments to improve older workers' learning.

Working memory training in older workers could be done using different tools such as ARAM (Attentive Rehabilitation of Attention and Memory) (Nejati, Shahidi, & Helmi, 2016; Kazazi, Shati, Mortazavi, Nejati, & Foroughan, 2021) [38], [39], Cogmed QM (www.cogmed.com) (Aksayli, Salab, & Gobet, 2019) [40], a set of guidelines and exercises in the form of a Working Memory Training DVD Set for the elderly (Brito, Manhães, França, & Marins, 2019) [41], SMART (Smartphone-based brain Anti-aging and memory Reinforcement Training) (Oh, Seo, Lee, Song, & Shin, 2017) [42], and the Maine Understanding Sensory Integration & Cognition (MUSIC) Project (MacAulay, Edelman, Boeve, Sprangers, & Halpin, 2019) [43].

ARAM (Attentive Rehabilitation of Attention and Memory) is a software application that concludes ten progressive (Kazazi et al., 2021) [39] joyful computer-based tasks (Nejati et al., 2016) [38] and is part of Neurocognitive Joyful Attentive Training Intervention, that is, a tool for cognitive rehabilitation (Nejati et al., 2016; Kazazi et al., 2021) [38], [39]. Also, the ARAM tasks are designed based on the hierarchical model of attention (Sohlberg & Mateer, 1989 as cited in Kazazi et al., 2021) [39] and Baddeley's working memory model (Baddeley & Hitch, 1974, as cited in Kazazi et al., 2021) [39].

Cogmed QM is a commercial cognitive-training computerized program designed to boost older adults' working memory capacity, cognitive ability, and everyday functioning (Aksayli et al., 2019) [40]. It consists of 25-, 30-, and 45-minute sessions over five weeks and includes gamified verbal and visuospatial working memory tasks that require trainees to recall longer sequences of information increasingly. Furthermore, Cogmed QM's interface is less visually appealing, and trainees are required to be more concentrated (Aksayli et al., 2019) [40].

Brito, Manhães, França, and Marins (2019) [41] developed a set of guidelines and exercises in the form of a Working Memory Training DVD set for the elderly, which requires a TV set and a DVD player. It is composed of three DVDs: the first contains three modules with information about memorizing techniques, practices, and lifestyles that are beneficial to memory, while the second and third consist of a set of five modules, each with practical exercises in increasing degrees of difficulty. These exercises include strategies for memorizing numbers (e.g., addresses, phone numbers, etc.), people's names, lists (e.g., shopping lists), and identifying hidden pictures in images, among others (Brito et al., 2019) [41].

SMART (Smartphone-based brain Anti-aging and memory Reinforcement Training) is a smartphone application that tends to improve user's working memory and attention. It consists of ten training tasks: one attention-shifting task, one word-list task, and eight tasks tiered according to three difficulty levels, allowing users to tackle more challenging tasks as they progress. Each module takes an average of five minutes to complete; however, the range may fluctuate from three to seven minutes depending on the nature and difficulty level of the particular task (Oh et al., 2017) [42].

Another effective means of enhancing working memory in the elderly is the Maine Understanding Sensory Integration & Cognition (MUSIC) Project that was developed by MacAulay, Edelman, Boeve, Sprangers, and Halpin, (2019) [43] to enhance cognitive function in older adults. Because of this, music training has been associated with frontal lobe function and higher visuospatial, working memory and executive function performance across the life span (Bergman Nutley, Darki & Klingberg, 2014; Bidelman & Alain, 2015; Bugos et al., 2007, 2015; Hanna-Pladdy & MacKay, 2011; Moussard et al., 2016, as cited in MacAulay et al., 2019) [43]. The MUSIC Project provided 12 one-hour weekly music lessons in an economical group format using an inexpensive, portable recorder. Each group session was approximately 45 minutes and each group chapter included vignettes to describe the learning objectives and musical literacy skills, finger placement and notation charts, and psychoeducational vignettes with motivational stories to normalize the challenge of learning to play a musical instrument, and practice in developing motor memory, providing information on cognitive aging, arthritis, and hand stretch exercises to help with arthritis pain (MacAulay et al., 2019) [43].

Additionally, video games such as "Tetris" and "Medal of Honor – Rising Sun" (MOH) (Belchior, Marsiske, Sisco, Yam, Bavelier, Ball, & Mann, 2013) [44] could be effective means of training older workers' attention. "Medal of Honor – Rising Sun" (MOH) is a "first-person shooter" video game, while "Tetris" is composed of four blocks each – falling down the playing field. The object of the game is to manipulate these tetrominoes to create a horizontal line of blocks without gaps. When such a line is created, it disappears, and the blocks above (if any) fall. As the game progresses, the tetrominoes fall faster, and the game ends when the stack of tetrominoes reaches the top of the playing field (Belchior, et al., 2013) [44].

Furthermore, the Attention Training Application (ATA) (Hill, Mogle, Colancecco, Dick, Hannan, & Lin, 2015) [45] could contribute to older workers' attention training. ATA is an application based on the adaptive dual n-back training paradigm for older adults using mobile technology. Dual n-back training consists of simultaneous presentation of visual stimuli on a computer screen. In each trial, the participant must identify when either a spoken letter or a square position matched the one that appeared n trials back (Hill et al., 2015) [45]. Jaeggi, Studer-Luethi, Buschkuehl, Su, Jonides, and Perrig (2010, as cited in Hill et al., 2015) [45] argue that such training tasks need individuals to participate repeatedly over long periods of time.

## 4 Conclusion

To conclude, the value of aging workers to the company and the society generally [46] is substantial. So, the need for their existing learning skills and abilities to be enhanced is imperative. The role of working memory and attention is crucial for effective aging workers' learning. These two cognitive skills allow a perspective of planning innovative corporate learning programs targeting the enhancement of older workers' cognitive abilities that are of great significance for their work performance. It would be advisable for working memory and attention training programs and seminars to be incorporated into education and corporate learning programs. However, further research is needed on the key factors that may affect the older workers' working memory and attention functioning in the working environments to be identified and delineated. We hope the present article triggers policy makers and human resource managers towards the ideal planning of effective corporate learning programs to exploit the aging workforce value to the fullest extent.

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