

Eye-guided video games improve reading in healthy older adults

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ABSTRACT

Aim: This study aimed to explore the effectiveness of a custom-built eye-guided video game to improve visuomotor, visual, and attentional skills involved in reading in healthy older adults.

Method: Forty healthy participants aged over 65 were included in the study. They underwent a battery of cognitive, visual, attentional, and reading tests to assess their initial cognitive performance and register changes after a training period. Only the experimental group (N=19) performed training sessions with three eye-guided video games (*Gamabunta*, *No Remora*, and *Umbrella*); each session lasted 45 minutes and was administered twice a week for 5 weeks. The control group (N=21) underwent the assessments before and after the same time but did not engage in any training.

Results: Only participants in the experimental group improved their reading and visual abilities. Specifically, after the training, they showed a decrease in reading time, a reduction in the number and duration of fixations, and an increase in the amplitude of saccades. Furthermore, improvements in contrast sensitivity and the perception of near vision quality (NAVQ) were registered in the training group after the training. Instead, no changes in attentional parameters were observed.

Conclusion: Our findings indicate that eye-guided video games enhance reading abilities in healthy older individuals, without training reading directly. This could be due to an improvement in basic oculomotor and visual skills.

Keywords: reading, healthy ageing, videogames, oculomotor training, cognitive training, eye movements.

EXTENDED ABSTRACT

Topic

This study addresses the impact of eye-guided custom-built video game-based training on reading abilities in healthy older adults, aiming to explore how visual and attentional functions can be improved and impact reading.

Theoretical focus

Aging involves physiological changes affecting physical and also cognitive abilities, with attention and vision decline, impacting daily life and posing financial and social challenges (e.g. Andersen, 2012; Deary et al., 2009; Hertzog et al., 2008). Maintaining cognitive functioning is beneficial for individuals and society as they live longer, live independently, and incur fewer long-term care costs (Coughlin & Liu, 1989). Among the numerous proposals emerging in the field of effective cognitive training for older adults (e.g. Gates et al., 2020), video games have increasingly been used to slow cognitive decline and even improve specific abilities (Nguyen et al., 2022). They have been shown to improve visual attention (e.g. Feng et al., 2007) and mental rotation ability in older adults (Basak et al., 2008; Gates et al., 2020). Attention, vision, and reading performance are crucial for cognitive training in healthy elderly individuals. However, with age, cognitive processes slow down (Craik, 2016), and the sensory system, including vision, declines (e.g. Andersen, 2012), consequently reducing reading abilities (e.g. Baltes & Lindenberger, 1997). Nevertheless, specific training in late adulthood can improve older adults' performance (Park & Bischof, 2013), such as perceptual learning training (e.g. Chung, 2011) and oculomotor training (e.g. Pavlidis, 1981), which involves visual tasks and explicit eye movements.

This study investigates the effects of video game-based training on reading abilities in healthy older adults. Three custom-built eye-guided video games were created, and they were designed to be adaptable to participants' performance. To verify the effectiveness of the training, a large battery of visual, attentional, and reading tests was administered to two groups of healthy elderly people. The study aimed to find an improvement in reading skills in the experimental group, associated with an improvement in visual skills and focal attention.

Participants

Forty healthy older participants (mean age: 71.4, SD: 6.2, range: 62-84, education mean: 12.3, SD: 4.1, range: 5-20, 21 female and 19 males) were included in the study. Participants were divided into experimental (eye-guided video game training) and control groups. The experimental group consisted of 19 participants (mean age 71.2, SD 5.1; range 64-82; 10F, 9M), while the control group consisted of 21 participants (mean age 71.7, SD 7.2; range 62-84; 11F, 10M). All participants were retired.

Methods

An initial screening was conducted with all participants to assess their general cognitive abilities, and a visual and neuropsychological assessment was conducted before and after five weeks. Initial screening involved the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005; Santangelo et al., 2015) and the Cognitive Reserve Index questionnaire (CRI-q) (Nucci et al., 2012). Visual and neuropsychological assessments pre- and post-training included tests that assess oculomotor performances using eye-tracking in reading (Judica & De Luca, 2005), contrast sensitivity (Pelli Robson Contrast-Sensitivity) (Pelli et al., 1988), the perception and satisfaction of near visual abilities

(NAVQ) (Zeri et al., 2017), Rapid Serial Visual Presentation (RSVP) (Primativo et al., 2016), visual acuity (Radner Test) (Calossi et al., 2014), and attention (Focus Attention Test) (Albonico et al., 2016, 2017; Maringelli & Umiltà, 1998). Only participants in the experimental group underwent the training with eye-guided videogames. The oculomotor assessment and training were performed using the Eye Link 1000 eye tracker, and eye movement data were processed using EyeLink Data Viewer software from SR Research Ltd. Before starting each training session, a standard nine-point calibration procedure was conducted. Each training period consisted of three custom-built (Neotenia LTD, Cusano Milanino, Italy) eye-guided video games to train saccades, fixations, and pursuit movements. In detail, the first eye-controlled video game was “Gamabunta”, for training attention, saccades, and fixations. In this scenario, there was a frog avatar, and the goal was to eat healthy locusts, jump on them, and avoid enemies and unhealthy locusts. The second videogame was “No Remora”, aimed to train attention and pursuit, in which the avatar was a Remora fish who needed to clean up dirty sharks. Finally, the third eye-guided video game was “Umbrella”, which was played in a 3D environment to train attention, fixations, saccades, and pursuit. The avatar was a hang glider, and participants had to maneuver it to follow and reach closed umbrella targets, avoiding the impact of obstacles and distractors. For each game, the parameters could be adjusted through training as participants improve. Participants in the experimental group performed ten sessions, each made of 45 minutes (each game lasted 15 minutes), two times a week over five weeks. The control group did not receive training. After five weeks, neuropsychological and visual assessments were conducted for both groups. Concerning statistical analysis, the aim was to evaluate the effectiveness of eye-guided video game training in improving reading. A linear mixed model ANOVA using the between fixed factor Group with two levels (Experimental, Control), the within fixed factor Session with two levels (Pre- and Post), and the random factor ID, was employed. A post-hoc test with Holm correction was performed to compare specific conditions.

Findings

This research aimed to train visual, attentional, and oculomotor skills, for enhancing reading performance in older adults. The most important finding of the study is the improvement in reading abilities in the experimental group specifically (interaction = $p < 0.005$). In detail, after training, the experimental group showed a decrease in reading time (post-hoc = $p < 0.01$). On the other hand, the control group did not have a significant difference in reading time between pre- and post-session. Furthermore, after training, only the participants in the experimental group showed a reduction in the number of fixations (interaction = $p < 0.005$; post-hoc = $p < 0.001$), a reduction in the duration of fixations (interaction = $p < 0.001$; post-hoc = $p < 0.05$), and an increase in the amplitude of saccades (interaction = $p < 0.001$; post-hoc = $p < 0.05$). In contrast, after five weeks period, the control group showed a mirror pattern, with an increase in the number of fixations (interaction = $p < 0.005$; post-hoc = not significant), an increase in fixation duration (interaction = $p < 0.001$; post-hoc = $p < 0.001$), and a decrease in the saccade's amplitude (interaction = $p < 0.001$; post-hoc = $p < 0.001$). The second result concerns visual performance, where a significant improvement in contrast sensitivity was observed after training in the experimental group (interaction = $p < 0.005$; post-hoc = $p < 0.001$) but not in the control group (interaction = $p < 0.005$; post-hoc = not significant). This finding is consistent with research showing that intensive training in action video games improves contrast sensitivity in young adult video game players (Li et al., 2009). In addition to contrast sensitivity, the perception and satisfaction of near vision quality (NAVQ) also improved in the experimental group after training (interaction = $p < 0.05$). Instead, focal attention did not show significant improvement in the

experimental group. Additional paradigms are needed to confirm the impact of attentional skills on the reading of older adults, specifically the relationship between eye-guided cognitive training and focal attention.

In summary, this study used video games and eye-tracking technology to improve the reading skills of older adults. Taken together, these findings suggest that custom-built eye-guided video game training led to improvements in reading and oculomotor performance, emphasizing the potential benefits of this approach for cognitive enrichment in healthy older adults.

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