Experimental Gerontology 82 (2016) 104–111

Contents lists available at ScienceDirect

Experimental Gerontology

journal homepage: www.elsevier.com/locate/expgero

Is visual function associated with cognitive activity engagement in middle-aged and elderly individuals? A cross-sectional study

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ARTICLE INFO

Article history:
Received 27 January 2016
Received in revised form 14 June 2016
Accepted 15 June 2016
Available online 16 June 2016

Keywords:
Cognition
Visual acuity
Contrast sensitivity
Florida Cognitive Activity Scale
Community living

ABSTRACT

Objective: This study investigated whether visual function is associated with cognitive activity engagement and mild cognitive impairment in middle-aged and elderly individuals.
Method: This cross-sectional study was conducted on 120 individuals aged 50–89. The Florida Cognitive Activity Scale (FCAS) was used to assess cognitive activity engagement. Visual function was assessed by near visual acuity (nVA) and contrast sensitivity (CS), and both combined to obtain a visual function (VF) compound score. Multivariable linear regression models, adjusted for confounders, were used to assess the association between the determinants and FCAS.
Results: After confounder adjustment, nVA was not associated with overall cognitive activity engagement. CS was significantly associated with the FCAS "Higher Cognitive Abilities" subscale score ($B_{HC} = 5.5$ [95% CI 1.3; 9.7]). Adjustment for nVA attenuated the association between CS and engagement in tasks of Higher Cognitive Abilities ($B_{HC} = 4.7$ [95% CI 0.1; 9.3]).
In retired individuals ($N = 87$), the VF compound score was associated with a lower Cognitive Activity Scale score ($B_{CA} = -1.2$ [95% CI −2.3; −0.1]), lower Higher Cognitive Abilities score ($B_{HC} = -0.7$ [95% CI −1.3; −0.1]) and lower Frequent Cognitive Abilities score ($B_{FA} = -0.5$ [95% CI −0.9; −0.1]).
Conclusion: CS, but not nVA, plays a role in engagement in tasks associated with Higher Cognitive Abilities in middle-aged and elderly individuals. In retired individuals, the VF compound score is associated with lower Cognitive Activity score, lower Higher Cognitive Abilities score and lower Frequent Cognitive Abilities score.

1. Introduction

Being able to function and live independently at an older age is an important factor in maintaining good quality of life (QoL) and vitality. It requires good levels of physical function and the cognitive ability to maintain active participation in life and perform the necessary (instrumental) activities of daily living (Alexandre Tda et al., 2014; Rog et al., 2014).

Cognitive function is affected by several factors, among which visual function has shown to be influential in multiple studies. Refractive errors, decreased visual acuity and contrast sensitivity are known to affect cognitive functioning (Ong et al., 2012; Ong et al., 2013; Risacher et al., 2013; See et al., 2011; Toner et al., 2012; Norton et al., 2009).

Poor vision has been associated with a higher risk of cognitive impairment, decreased cognitive function, and an increased risk of late-life dementia (Lin et al., 2004; Sachdev et al., 2012; Elyashiv et al., 2014; Rogers and Langa, 2010). Studies have also shown that poor visual performance in persons with normal cognitive function results in lower test outcomes of standard cognitive assessment tools (Hunt and Bassi, 2010; Wood et al., 2010; Jefferis et al., 2012). Some studies observed an improvement in the Mini-Mental State Examination (MMSE) score after cataract surgery because of improved vision (Gray et al., 2006; Ishii et al., 2008; Tamura et al., 2004), whereas other studies were unable to confirm these results (Hall et al., 2005; Grodstein et al., 2003; Anstey et al., 2006). Most research on visual function and cognition uses standard neuropsychological tests to evaluate cognitive function (Sachdev et al., 2012; Elyashiv et al., 2014; Ishii et al., 2008; Gaynes et al., 2013), many of which are at least partially vision-based assessments.

In addition to evaluating several domains of cognition, it might also be important to measure actual engagement in cognitively challenging tasks because such engagement might enhance cognitive functioning

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http://dx.doi.org/10.1016/j.exger.2016.06.004
0531-5565/

but be inhibited by poor vision (Wilson et al., 2003; Bosma et al., 2002). This measurement is especially important because studies indicate a beneficial effect of cognitively stimulating activities on cognitive function (Pillai et al., 2011; Treiber et al., 2011). In addition, the level of engagement in cognitively stimulating activities might vary between those who are retired and those who are still engaged in working life, with further variability in the cognitive demands associated with specific occupations. To the best of our knowledge, no previous vision-related study has considered whether individuals actually engage in cognitively stimulating activities on a regular basis or addressed the type or frequency of the cognitively challenging tasks performed. The results are highly relevant to providing insight regarding which cognitively stimulating activities individuals actually do or cease to perform and whether visual function plays a role in that process.

The aim of the present study is to investigate whether visual functioning as assessed by visual acuity, contrast sensitivity or both is associated with actual cognitive engagement among middle-aged and elderly individuals.

2. Method

2.1. Study design and population

This cross-sectional population-based study on the relationship between visual function and cognitive function or activity was performed on 120 individuals aged 50–89. The present study on visual function (VF-PROFIEL) is an extension of a larger study on the Preservation of Functioning in the Elderly (PROFIEL) (den Ouden et al., 2013), a longitudinal study on 802 community-living elderly men and women (Muller et al., 2007; Lebrun et al., 2002). Details of the enrollment procedure have been described elsewhere (den Ouden et al., 2013; Muller et al., 2007; Lebrun et al., 2002; Mueller-Schotte et al., 2015). Data collection in the PROFIEL study took place between February 2010 and November 2011, whereas the VF-PROFIEL study was conducted between May 2012 and June 2013.

Participants in the VF-PROFIEL study visited the research center for an extensive visual assessment. All study participants provided written informed consent prior to study enrollment. The study protocols for the PROFIEL study and the VF-PROFIEL extension were approved by the Institutional Review Board of the University Medical Center Utrecht (METC 09-248). The current cross-sectional study was based on the data of the VF-PROFIEL study.

2.2. Data collection

2.2.1. Determinants

Whereas visual acuity tests the ability of the eye to discern detail, contrast sensitivity tests the ability to differentiate objects from their background. Although both measurements are taken separately in practice, both are effective simultaneously in the eye. To account for this effect, a visual function compound score combining visual acuity measurement and contrast sensitivity measurements was calculated.

2.2.1.1. Visual acuity. Using Landolt C optotypes, monocular and binocular visual acuities were assessed with presenting correction at distance (6 m) and near (40 cm). Binocular near visual acuity was used to reflect functional vision because research in the elderly indicates that vision function in daily life is better reflected by binocular assessment (Schneck et al., 2010). Near visual acuity was chosen above distance visual acuity to account for the nature of the items included in the FCAS, in which the majority of tasks are to be performed at distances of 30–50 cm. Because visual acuity worse than 20/40 is frequently associated with difficulty in reading small print, better near visual acuity was defined as equal to or higher than 20/40 Snellen acuity (lower than or equal to 0.3 logMAR), and poorer near visual acuity was defined as worse than 20/40 (higher than 0.3 logMAR). For statistical analysis, decimal visual acuity values were converted to the logarithm of the minimum angle of resolution (logMAR). Lower logMAR values indicate better performance.

2.2.1.2. Contrast sensitivity (CS). The Pelli-Robson Contrast Sensitivity Chart (Clement Clarke, Harlow, UK) was used to obtain monocular and binocular CS. At a distance of 1 m, the participant attempted to identify letters equivalent to a visual acuity of 20/100 with diminishing contrast from the upper left to the lower right corner of the chart. The letter group with the least contrast, for which at least 2 of 3 letters were correctly identified, was noted as the CS-threshold in log-units. Higher log(s) values indicate better performance.

2.2.1.3. Visual function. A compound score for near visual function was computed. This combined score of visual acuity and contrast sensitivity was calculated to discriminate between participants with worse (poor visual acuity and poor contrast sensitivity) and better (good visual acuity and good contrast sensitivity) visual function. First, individual test scores for near visual acuity and contrast sensitivity were transformed into a standardized z-score [z-score = (test score − mean test score) / SD]. Prior to calculating the compound score, the CS z-scores, where higher scores indicate better function, were re-scaled (1 - z-score) to allow for the same scaling direction as the near visual acuity scale. Second, the individual z-scores were summed to calculate the compound score. Lower compound scores correspond to individuals with both good visual acuity and good contrast sensitivity, whereas higher scores indicate poor visual acuity and poor contrast sensitivity.

2.2.2. Outcome variables

2.2.2.1. Cognitive engagement. The Florida Cognitive Activities Scale (FCAS) was used to study cognitive engagement. It is a validated 25-item scale that examines the degree of active participation in a spectrum of activities varying in their cognitive demands in the elderly population, i.e., reading books or short stories or walking or driving in unfamiliar places requiring a map (Schinka et al., 2010; Dotson et al., 2008; Schinka et al., 2005). Engagement in each activity is rated on a 5-point scale ranging from 0 (never did this activity/used to do, but not in the past year) to 4 (perform the activity every day). Following the scoring directions, the overall score of the FCAS, known as the *Cognitive Activity Scale* score, was calculated by converting the answers for each activity to a 100-point scale, with 100 representing the highest possible activity level and 0 representing no involvement in activities. Two subscales, the *Higher Cognitive Abilities* score (0–40) and *Frequent Cognitive Abilities* score (0 − 32), were calculated to provide insight regarding the involvement in activities with high cognitive demands (i.e., playing chess, solving crossword puzzles, preparing meals from new recipes) and the most frequently performed activities from the 25-item Cognitive Activity scale. Furthermore, the subscale *Cognitive Activity Maintenance* ratio was determined by dividing the number of activities performed in the past 12 months by the number of activities ever performed. The Cognitive Activity Maintenance score (0–1) provides information on behavioral change in the year prior to data collection. The FCAS had good internal consistency in an elderly Caucasian population and an African American population, with $\alpha = 0.65$ and $\alpha = 0.68$, respectively (Dotson et al., 2008; Schinka et al., 2005). The external validity of the Cognitive Activity Scale with the Mini-Mental State Examination (MMSE) varied between $\alpha = 0.35$ and $\alpha = 0.43$ (Dotson et al., 2008; Schinka et al., 2005).

2.2.3. Other measurements

2.2.3.1. General characteristics. During the PROFIEL study visits, information on age, gender, education, smoking status, (instrumental) activities of daily living, and number of chronic diseases was collected using a questionnaire. *Education* was categorized as low, middle or high (including university) based on the International Standard Classification