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Peripheral vision, perceptual asymmetries and visuospatial attention in young, young-old and oldest-old adults

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ABSTRACT

Objectives: The present study investigated possible changes occurring in peripheral vision, perceptual asymmetries and visuospatial attention in oldest-old adults and compared their performance with that of young and young-old adults.
Method: We examined peripheral vision (PV) and perceptual asymmetries in the three age groups for stimuli varying in eccentricity (Experiment 1). In Experiment 2, designed to investigate possible changes in spatial attention, the same participants performed an exogenous orienting attention task.
Results: Experiment 1 showed that the three age groups performed the task similarly but differed in processing speed. Importantly, the oldest-old group showed a different perceptual pattern than the other groups suggesting a lack of specificity in visual asymmetries. Experiment 2 indicated that the validity effects emerged later in the young-old and even later in the oldest-old participants, showing a delayed time course of inhibition of return (IOR). Orienting effects, however, were preserved with age.
Discussion: Taken together, these results indicate that the three age groups displayed similar perceptual and orienting attention patterns, but with differences in processing speed. Importantly, age (only in the oldest-old adults) altered perceptual visual asymmetries. These results suggest that some neural plasticity is still present even in oldest-old adults, but a lack of specificity occurs in advanced age.

1. Introduction

Perceptual and attentional declines may be a cause of the difficulties experienced by older adults to perform activities of daily living, which might have a negative impact on their ability to live independently. In terms of human vision, aging is associated with the slowing-down of processing speed (e.g. Owsley, McGwin, & Searcey, 2013) and declines in pursuing visual targets (Paquete & Fung, 2011), in peripheral vision (Muiños & Ballesteros, 2014), in visual motion (Ball & Sekuler, 1986), in dynamic visual acuity (e.g. Long & Crambert, 1990; Long & Rourke, 1989; Muiños & Ballesteros, 2014), and in performing saccade movements in the correct direction (Butler et al., 1999). However, it is important to note that there are large individual differences in processing speed among older adults. While some individuals show severe deterioration, others perform similarly to young adults (e.g. Ball, Owsley, Sloane, Roenker & Bruni, 1993; Glisky, 2007). On the other hand, visual processing speed improves with practice (Ball, Edwards & Ross, 2007). Unsurprisingly, research has found differences among older adults depending on whether they have a physically active or sedentary lifestyle (e.g. Ballesteros et al., 2013a; Muiños & Ballesteros, 2014; Muiños & Ballesteros, 2015; Voelcker-Rehage, Godde, & Staudinger, 2010).

An active physical and mental lifestyle, cognitive reserve capacity, as well as social and cultural compensatory forces might preserve perceptual and cognitive processing in older adults (for a review, see Ballesteros, Kraft, Santana, & Tziraki (2015)). All these facets contribute to increased optimism about the third age (e.g., Ballesteros & Reales, 2004; Berry et al., 2010; Edwards et al., 2005). However, this positive outlook does not apply to the fourth age. Beyond the age of 80 or 85, a cascade of cognitive and physical declines generally occurs. Although there are oldest-old individuals that live independently and in relatively good health, this period of life is generally associated with pathology, functional impairment, chronic stress, comorbidity, and the end of independent living. Some studies (Baltes & Smith, 2003; Singer, Lindenberger & Baltes, 2003) have shown that the plasticity, adaptability and improvement in certain areas observed in older adults are not reproduced in oldest-old adults. Despite the observed heterogeneity, marked declines occur at this age, when plasticity, capacity of compensation (even with a high reserve capacity), and culture-based resources are reduced or simply become less efficient (Singer, Lindenberger, & Baltes, 2003). Although neural plasticity is present throughout the

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human lifespan, there are age-related costs in cognitive potential and the ability to learn (Baltes & Smith, 2003). Visuospatial attention has been studied in older perceivers (Ball, Beard, Roenker, Miller, & Griggs, 1988; Beurskens & Bock, 2012; Itoh & Fukuda, 2002), but there is a surprising lack of studies investigating these abilities in oldest-old adults.

The aim of the present study was to investigate whether "age" generates different patterns of perceptual and attentional outcomes, or, on the contrary, whether young, young-old and oldest-old participants perform similarly, differing primarily in the time needed to complete the task. To this end, three groups of participants differing in age performed a speeded peripheral vision (PV) task. PV is the ability to detect and respond to information presented at different areas of the visual field (Loran & MacEwen, 1995). Perceptual asymmetries were also investigated (Exp. 1). The same participants then performed a visuospatial orienting attention task (Exp. 2). We expected a pattern of increased RTs from young to oldest-old adults in the PV task. Based on previous findings with young and young-old adults (Muiños & Ballesteros, 2014), we also expected that all participants would be faster when the stimuli were presented at the intermediate eccentricity, followed by the foveal and then the most peripheral locations, and that the three groups would tend to perform worse with shorter interstimulus intervals (ISIs). We found that the visual asymmetries of young and young-old adults were similar and varied as a function of spatial location. The aim of Experiment 1 was to find out whether these asymmetries found in young-old adults are maintained in very old age. If not, this group would not perform faster with stimuli presented along the horizontal than along the vertical meridian, or in the lower than in the upper region of the vertical meridian.

In Experiment 2, we examined whether the oldest-old group processed visual attentional cues similarly to the younger groups in an exogenous orienting attention task. As orienting attention to an exogenous cue is largely preserved with age (e.g., Brodeur & Enns, 1997; Hartley, Kieley, & Slabach, 1990), we expected a similar orienting attention pattern in the three age groups, with a facilitation for valid trials with short SOAs, and shorter RTs for invalid trials with long SOAs. We also expected age-related differences in the time course of the inhibition of return (IOR), which is usually delayed in older compared to young adults (e.g. Bao, Zhou, & Fu, 2004; Castel et al., 2003; Langley et al., 2001). The question addressed here is whether the oldest-old group would differ from the young-old participants.

2. Experiment 1: investigating peripheral vision (PV) and perceptual asymmetries in the very old

PV is crucial for the analysis of the environment, but this ability deteriorates with age. Older adults perform worse than younger adults, especially at larger eccentricities (e.g. Ball et al., 1988; Beurskens & Bock, 2012; Itoh & Fukuda, 2002; Muiños & Ballesteros, 2014). The decline in the ability to process peripheral signals might have negative consequences for everyday situations such as walking or driving.

Perceivers need more time to detect stimuli that are farther away from fixation (Berkley, Kitterle, & Watkins, 1975; Carrasco & Chang, 1995; Carrasco, Evert, Chang, & Katz, 1995). This deterioration of performance at PV areas has been attributed to the physiological properties of the retina (e.g., reduction in spatial resolution and contrast sensitivity with eccentricity), as visual acuity decreases rapidly from 5° of visual angle from fixation (Anderson, Zlatkova, & Demirel, 2002). Normally sighted old adults usually require more time to process visual targets, especially those appearing at the periphery of the visual field. However, this age-related shrinking of the visual field may be interpreted as a decline of perceptual and attentional skills (e.g., Seiple, Szlyk, Yang, & Holopigian, 1996). This PV decline is considered as a deterioration of the effectiveness at which information from a cluttered scene is extracted, rather than a reduction of the visual field itself (Sekuler, Bennett, & Mamelak, 2000).

Studies conducted with young adults have shown visual asymmetries across the visual field. Observers are usually faster detecting stimuli presented along the horizontal than the vertical meridian, and those presented in the lower than in the upper region of the vertical meridian (Carrasco, Talgar, & Cameron, 2001). Some studies with older adults have also found that participants were faster detecting stimuli at lower areas of visual field (Katz & Sommer, 1986; Spry & Johnson, 2001), at lower and left areas (Silva, D'Almeida, Oliveiros, Mateus & Castelo-Branco, 2014), and stimuli presented along the horizontal, and at lower areas of visual field (Muiños & Ballesteros, 2014). However, visual asymmetries have mainly been investigated in young and young-old adults, and little is known about possible changes in visual asymmetries across the visual field at a very old age.

2.1. Method

2.1.1. Participants

Sixty-eight volunteers with normal or corrected-to-normal vision participated in the present study. Twenty-three were young adults (M = 21.8 years; SD = 1.34; range = 19–24 years), 23 were young-old adults (M = 69.65 years; SD = 6.37; range = 62–79 years), and 22 were oldest-old adults (M = 85.48 years; SD = 4.61; range = 80–98 years). The young adults were undergraduate students who participated for course credit. The young-old and oldest-old participants were recruited by announcements. None of them suffered general health or mental problems, or low visual acuity. All participants signed an informed consent form for participation in the study, which was approved by the Ethical Review Board of the Universidad Nacional de Educación a Distancia.

2.2. Apparatus and stimuli

Near visual acuity was assessed by a Snellen chart. If visual acuity was below 0.6 (decimal units), no further testing was performed. Refractive error readings were obtained using a calibrated auto-refractometer (model RM-A3000B; Topcon Corp., Japan). The spherical equivalent refractive error (SEQ) was obtained by adding half the cylinder to the spherical component. SEQ ≥ +0.50 D was classified as hyperopia and myopia was ≥− −0.50 D. As physiological measures, pulse rate and oxygen saturation (SaO_2) were both assessed using an OXYM4100 finger pulse oximeter (Contec Medical Systems, Co.). Participants performed a series of screening tests, including the Mini-Mental State Examination test (MMSE; Folstein, Folstein, & McHugh, 1975, inclusion criteria: score >27), the Yesavage Geriatric Depression Scale (Martínez et al., 2002, inclusion criteria: score <10), the Blessed Dementia Rating Scale (Lozano et al., 1999, inclusion criteria: scores between 0 and 1), and the Global Deterioration Scale (GDS; Reisberg Ferris, DeLeón, & crook, 1988, inclusion criteria: score <1). None of the participants were excluded. All the old participants live an independent life in the community. Participants were not compensated for participation in the study

The stimuli consisted of black dots of 1° of visual angle presented on the computer screen on a light gray background. A fixation cross appeared at the center of the computer screen while a dot presented for 150 ms appeared and disappeared at random locations within the visual field. The dots appeared randomly at three different eccentricities (3°, 6° and 12°) from fixation along equally spaced radial arms (2 horizontal, 2 vertical, and 4 oblique). To avoid anticipation, four different interstimulus intervals (ISI) were used at random (700, 1500, 2000 and 2500 ms). The task consisted of pressing a red key on the keyboard when the stimulus appeared. The experiment was programmed with E-Prime software v2.0 (Schneider, Eschman, & Zuccolotto, 2002) and was conducted on a 19-in. Sony Multiscan G420 CRT monitor connected to a personal computer, with a refresh rate of 120 Hz. The program recorded RTs from stimulus onset to key pressing.