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Neuropsychologia 44 (2006) 507–517

NEUROPSYCHOLOGIA

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Vision and touch in ageing: Crossmodal selective attention and visuotactile spatial interactions

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Received 17 June 2005; accepted 7 July 2005
Available online 11 August 2005

Abstract

We investigated whether ageing affects crossmodal selective attention (the ability to focus on a relevant sensory modality and ignore an irrelevant modality) and the spatial constraints on such selective processing. Three groups of 24 participants were tested: Young (19–25 years), Young-Old (65–72 years) and Old-Old (76–92 years). The participants had to judge the elevation of vibrotactile targets (upper/index finger and lower/thumb), presented randomly to either hand while ignoring concurrent visual distractors. In a second task, the role of the target and distractor modalities was reversed. Crossmodal selective attention was assessed by comparing performance in the presence versus absence of distractors. Spatial constraints on selective attention were also investigated by comparing the effect of distractors presented on the same versus opposite side as the target. When attending to touch, the addition of visual distractors had a significantly larger effect on error rates in both of the older groups as compared to the Young group. This indicates that ageing has a detrimental effect on crossmodal selective attention. In all three age groups, performance was impaired when the target and distractor were presented at incongruent as compared to congruent elevations in both tasks. This congruency effect was modulated by the relative spatial location of the target and distractor in certain conditions for the Young and the Young-Old group. That is, participants in the two younger age groups found it harder to attend selectively to targets in one modality, when distractor stimuli came from the same side rather than from the opposite side. However, no significant spatial modulation was found in the Old-Old group. This suggests that ageing may also compromise spatial aspects of crossmodal selective attention.

Keywords: Multisensory; Attention; Selection; Posture

1. Introduction

While traditionally researchers have tended to study the senses in isolation, a growing body of research has started to investigate the interactions between the senses (e.g. see the chapters in Calvert, Spence, & Stein, 2004; Spence & Driver, 2004). Most research into selective attention has investigated selection within a single sensory modality (e.g. LaBerge, 1995), however, in daily life, we must coordinate our selective attention across different sensory modalities simultaneously. Research into *crossmodal selective attention*, that is, the ability to attend selectively *to* a particular sensory modality (for a review, see Spence, 2001) has shown that when stimuli are presented concurrently in two different modalities, people can selectively attend to one modality, although there may be interference from stimuli presented in the unattended modality (see below).

Older adults commonly report that they find extraneous stimuli more distracting than they used to, and deficits in selective attention have been observed experimentally (e.g. Rabbitt, 1965; Zeef, Sonke, Kok, Buiten, & Kenemans, 1996). Hasher and Zacks (1988) proposed that inhibitory processes deteriorate with age, that is, people become worse at rejecting irrelevant information as they get older. Their hypothesis has been applied to many other domains of

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0028-3932/$ – see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.neuropsychologia.2005.07.004

cognitive ageing, including selective attention (Kok, 1999; McDowd, Oseas-Kreger, & Filion, 1994). However, the majority of research into ageing and selective attention has involved selection *within* a single sensory modality (i.e. to a particular location or stimulus attribute), so the present study was carried out to investigate whether ageing also affects crossmodal selective attention. Given that different neural mechanisms are thought to be involved in selecting between, rather than within sensory modalities (e.g. Hotting, Rosler, & Roder, 2003; Talsma & Kok, 2001), it might be expected that ageing may have differing effects on these various types of selective attention. Indeed, it has been argued that it may be easier to reject stimuli on the basis of a sensory modality than on the basis of spatial location (Hotting et al., 2003), so crossmodal selective attention may be more resistant to ageing than intramodal selective attention.

Few studies have directly investigated the effect of ageing on crossmodal selective attention. However, the results of several ERP studies in which participants passively receive stimuli while ignoring the stimulation or carrying out an unrelated task suggest that older participants may have more difficulty in inhibiting the processing of stimuli in an irrelevant modality (e.g. Diaz & Amenedo, 1998; Valeriani, Ranghi, & Giaquinto, 2003). In a skin conductance study, cited in McDowd et al. (1994), participants had to attend to either lights or tones while ignoring distractors presented in both modalities. Young participants exhibited the greatest galvanic responses to the target stimuli, smaller responses for same-modality distractors, and the smallest responses for different modality distractors. However, older adults exhibited this pattern of results only for auditory targets. For visual targets, responses were equivalent for visual and auditory distractors, suggesting that the older adults were not able to use the modality difference to assist their attentional selection. Thus, the first aim of the present study was to investigate whether age affects the ability to selectively attend to touch or vision, while ignoring the other modality. That is, to try and replicate this unpublished result and extend the finding to a different pair of sensory modalities.

The *crossmodal congruency task* provides one method of examining interactions between touch and vision (see Maravita, Spence, & Driver, 2003, for a recent review). Participants typically hold two foam cubes (one in each hand), each embedded with two vibrotactile stimulators and two LEDs, such that the participant may see a light close to, or feel a vibration presented to, the index finger or thumb of either hand. Participants make elevation judgments (upper: finger, lower: thumb) concerning vibrations, while attempting to ignore simultaneously presented visual distractors. *Congruency effects* (CEs) are typically observed with participants responding more rapidly and accurately when the distractors are congruent (i.e. presented from the same elevation) compared to incongruent (i.e. presented from the opposite elevation) to the target. This indicates that people are unable to ignore visual stimuli entirely, when attending to touch. Furthermore, these CEs are greater when the target and distractor are presented on the same side as compared to the opposite side of space (Spence, Pavani, & Driver, 2004), demonstrating that there are *spatial constraints* on crossmodal selective attention. This is likely to be a consequence (at least in part) of the tendency to integrate visual and tactile information originating from the same external location in space (Spence et al., 2004). When participants carried out the same task with their hands crossed, the interactions were found to remap such that the lights on the left side of space now interfered most with the right hand (Spence et al., 2004). This *remapping* requires the additional integration of proprioceptive information regarding where the body is located in space. In the reverse task, the congruency of vibrotactile distractors has also been shown to affect visual judgments (Walton & Spence, 2004) and this effect is greater when targets and distractors are presented from the same side of space (Spence & Walton, 2005).

The second aim of the present study was to investigate whether age affects these spatial constraints on crossmodal selective attention. To our knowledge, this is the first investigation of these multisensory spatial processes, however, the results of recent studies suggest that age affects crossmodal temporal processing (Lustig & Meck, 2001; Virsu, Lahti-Nuuttila, & Laasonen, 2003). In addition, Golob, Miranda, Johnson, and Starr (2001) used evoked potentials to examine crossmodal refractory periods and observed that older participants showed a reduced effect of a visual stimulus on a subsequent auditory stimulus. However, in all these studies, the stimuli in the different sensory modalities were presented from different spatial locations (Golob et al., 2001) and so it remains unclear whether the deficits reported arise from the difficulty associated with attending to multiple sensory modalities or multiple spatial locations (see Spence & Driver, 1997). Interestingly, when Cienkowski and Carney (2002) studied audiovisual integration using the McGurk illusion (and when they presented the auditory and visual stimuli from the same location) they found no effect of age on the number of 'fused' responses.

In the present study, we addressed three questions: first, does age affect the ability to attend to a relevant modality (touch or vision) and ignore an irrelevant modality? This is the first time that this crossmodal ability has been investigated in ageing. Second, are the spatial constraints on crossmodal selective attention affected by ageing; that is, do participants find distractors on the same side as the target more distracting than distractors on the opposite side? Third, does the updating of spatial interactions with changes in body posture become more problematic with age? It was hypothesised that this process would be affected by ageing given Axelrod, Thompson, and Cohen's (1968) observation that older participants showed poorer temporal resolution for electrical stimuli presented to the two hands and showed a greater decrement than the young group when their hands were placed further apart or crossed over the midline (see also, Aglioti, Smania, & Peru, 1999). Here, participants carried out speeded eleva-