Multisensory reweighting for kinesthesia in older adults

Marie Chancel, Caroline Landelle, Caroline Blanchard, Olivier Felician, Michel Guerraz, Anne Kavounoudias

Submission guidelines for the International workshop on Aging in the Neuro-musculo-skeletal System, 15-17 March, 2016, in Marseille (France)

(1) Title of the abstract: Multisensory reweighting for kinesthesia in older adults

(2) Name of the authors: Marie CHANCEL[1], Caroline LANDELLE[1], Caroline BLANCHARD[1,2], Olivier FELICIAN[3], Michel GUERRAZ[4], Anne KAVOUNOUDIAS[1]

(3) Author affiliations:

1. Aix-Marseille Univ. CNRS, LNIA UMR 7260, Marseille, France
2. University of Nottingham, School of Psychology, NG7 2RD Nottingham, UK
3. Aix-Marseille Univ, Inserm, INS, Marseille, France
4. Univ. Savoie Mont Blanc, CNRS, LPNC, F-73000 Chambéry, France

(4) Address and contact information of the first author : Laboratoire de Neuroscience Intégrative & Adaptative (UMR7260) - 3 Place Victor Hugo - 13003 Marseille.
Tel.: +33 4 13 55 03 65.
Email: marie.chancel@univ-amu.fr

(5) Type of communication:

- ❒ Oral presentation
- ❒ Poster

(6) Key words (5 maximum): **Movement perception**, **Illusions, Muscle proprioception, Vision, Touch**

(7) Summary (10 lines maximum):
To perceive self-hand movements, the central nervous system (CNS) relies on multiple sensory information mainly derived from vision, touch, and muscle proprioception. Using psychophysical approaches, this study investigated how and to what extent the CNS relies on these sensory systems to build kinesthetic percepts when they all decline such as when aging. Illusory movement perceptions were induced by stimulating these three sensory modalities either separately or concomitantly. The perceptual responses reported by 19 healthy elderly adults (60-82 yrs) were compared to those of 12 young adults. Results suggest that reliance on sensory inputs for kinesthetic purposes is profoundly reshaped as early as 60 years old. Older people rely more on visual and tactile afferents for perceiving self-hand movements than younger adults. This could be due to a relative greater muscle proprioception impairment.

Multisensory reweighting for kinesthesia in older adults

Marie CHANCEL[1], Caroline LANDELLE[1], Caroline BLANCHARD[1,2], Olivier FELICIAN[3], Michel GUERRAZ[4], Anne KAVOUNOUDIAS[1]

1. Aix-Marseille Université. CNRS, LNIA UMR 7260, Marseille, France
2. University of Nottingham, School of Psychology, NG7 2RD Nottingham, UK
3. Aix-Marseille Université, Inserm, INS, Marseille, France
4. Université Savoie Mont Blanc, CNRS, LPNC, F-73000 Chambéry, France

email: marie.chancel@univ-amu.fr

Introduction

To perceive self-hand movements, the CNS relies on multiple sensory information mainly derived from vision, touch, and muscle proprioception [1,2]. Aging is associated with decline in all these sensory systems. Impairments of the somatosensory system, including touch and muscle proprioception, have been well described through numerous neurophysiological studies conducted in both animals and humans (see review [3]). Studies show alterations, in the elderly, of structural properties and density of mechanoreceptors, as well as peripheral and central nerve conduction. In the central nervous system, structural alterations such as the reduction of neuronal size, the number of synapses and the grey matter volume [4] with advancing age have been clearly demonstrated. These peripheral and central sensory damages may account for the functional deficits shown in older individuals, such as a decreased ability to perceive a movement [5], or to detect a tactile stimulus applied on the skin surface[6]. Regarding visual motion perception, research shows that older observers are worse to discriminate speed and direction [8].

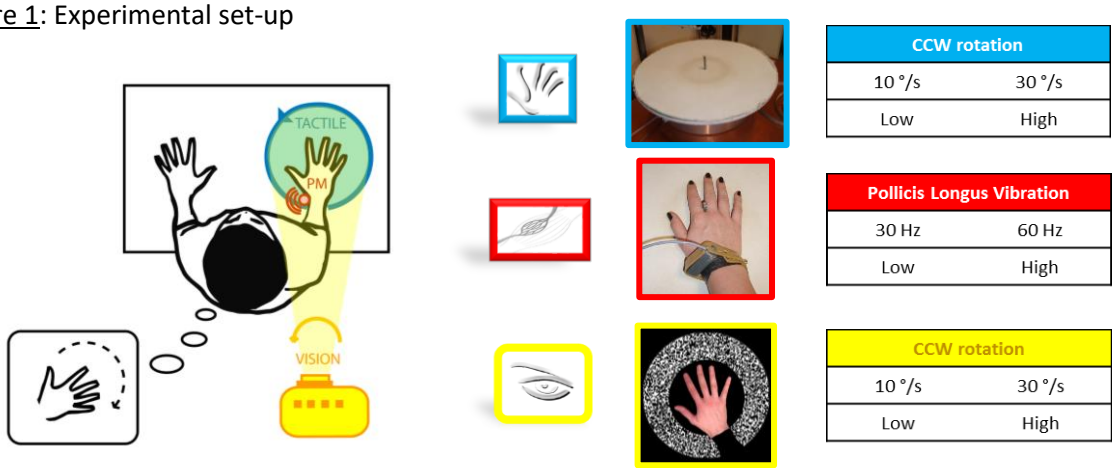
Most of the previous studies examined the alteration of each sensory source in isolation. The present work investigates to what extent such age-related plurimodal impairments are associated with a sensory reweighting to build kinesthetic percepts, and/or whether enhancement of multisensory integration could at least partly overcome the sensory decline.

Methods

Illusory sensations of right hand rotation were induced by stimulating separately or simultaneously the three modalities at two intensity levels. For this purpose, mechanical vibrations were applied to the pollicis longus muscle group in the subjects' wrists (proprioceptive stimulation), and a textured disk was rotated under the palmar skin of the subjects' right hands (tactile stimulation) while a background visual scene was projected onto the rotating disk (visual stimulation). The elicited kinesthetic illusions were copied by the subjects in real time.

The perceptual responses of 19 healthy elderly adults (60-82 yrs) were compared to those of 12 young adults.

Figure 1: Experimental set-up



Results

1. At each level of intensity, the younger adults reported similar velocity and latency of hand rotation illusions in either modality stimulated. The older adults reported more salient and faster illusions for the visual and tactile conditions than for the muscle proprioceptive one.
2. Compared to those in the younger group, visual and tactile illusions were significantly more salient and faster in the older group. The onset latency of the illusions increased gradually with age. In contrast, the vibration-induced illusions were significantly less frequently evoked, less salient and more delayed in older adults.
3. For the three modalities confounded, increasing the intensity level of stimulation resulted in a smaller increase of illusion velocity in older adults than in younger adults.
4. Lastly, the velocity increase of illusory movement perception observed during multimodal stimulation in the elderly group was of the same order as that observed in the younger group.

Discussion

Very few studies have investigated the possibility of adaptive responses developed by the central nervous system in the elderly to compensate for multisensory system deterioration.

A first hypothesis is that sensory system impairments in elderly people may be partly overcome by improving the central integrative processing of multisensory inputs. In a previous study, Liaurenti and colleagues[9] found that during visual and auditory discrimination tasks older individuals may take greater advantage of redundant audio-visual stimuli than younger adults by increasing the efficiency of the integrative processing. Although such increase was not evidenced in the present results, the multisensory benefit was found similar between older and younger participants.

Alternatively, we found that the weighting of sensory modalities might change with aging: elderly people might rely more on visual and tactile afferents for perceiving self-hand movements than younger adults due to a relative greater impairment of muscle proprioception.

Conclusion

All in all, this study shows that reliance on sensory inputs for kinesthetic purposes is profoundly reshaped as early as 60 years old. Future studies should be conducted to confirm whether such multisensory reweighting is functionally adaptive.

References

1. Blanchard, C., Roll, R., Roll, J. P. & Kavounoudias, A. Combined contribution of tactile and proprioceptive feedback to hand movement perception. *Brain Res* **1382,** 219–29 (2011).
2. Blanchard, C., Roll, R., Roll, J. P. & Kavounoudias, A. Differential contributions of vision, touch and muscle proprioception to the coding of hand movements. *PLoS One* **8,** e62475 (2013).
3. Goble, D. J., Coxon, J. P., Wenderoth, N., Van Impe, A. & Swinnen, S. P. Proprioceptive sensibility in the elderly: degeneration, functional consequences and plastic-adaptive processes. *Neurosci Biobehav Rev* **33,** 271–8 (2009).
4. Good, C. D. *et al.* A voxel-based morphometric study of ageing in 465 normal adult human brains. *Neuroimage* **14,** 21–36 (2001).
5. Skinner, H. B., Barrack, R. L. & Cook, S. D. Age-related decline in proprioception. *Clin Orthop Relat Res* 208–11 (1984).
6. Desrosiers, J., Hebert, R., Bravo, G. & Rochette, A. Age-related changes in upper extremity performance of elderly people: a longitudinal study. *Exp Gerontol* **34,** 393–405 (1999).
7. Owsley, C., Sekuler, R. & Siemsen, D. Contrast sensitivity throughout adulthood. *Vis. Res* **23,** 689–99 (1983).
8. Bennett, P. J., Sekuler, R. & Sekuler, A. B. The effects of aging on motion detection and direction identification. *Vis. Res* **47,** 799–809 (2007).
9. Laurienti, P. J., Burdette, J. H., Maldjian, J. A. & Wallace, M. T. Enhanced multisensory integration in older adults. *Neurobiol. Aging* **27,** 1155–1163 (2006).