Adapting a Pedestrian Navigation Simulator to the Elderly

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ABSTRACT
Virtual environments are nowadays broadly used in scientific research about spatial navigation. To ensure the validity of the navigation experiment as well as the safety of the participants, human factors should be taken into account while designing the device. In particular, older participants may face difficulties while navigating a virtual environment due to age-related declines. This paper presents two studies aiming to adapt a pedestrian navigation simulator to the elderly specificities.

CCS Concepts
• Human-centered computing~User interface design • *Social and professional topics~Seniors*

Keywords
Elderly; Virtual Environment; Human Factors.

1. INTRODUCTION
Virtual Environments (VEs) are now increasingly used in scientific research about spatial navigation and orientation, as these devices allow to create big scale ecological environments while controlling more parameters than in Natural Environments (NEs) and ensuring the safety of the participants [[5]]. Moreover, similar navigation performances have been observed between NEs and VEs, whether with young or with older participants [[2]], thereby triggering a high interest for VEs.

If designing an experiment in a VE raises many technical issues, human factors are also important, as humans take a primary active part in VEs. The elderly, in particular, may face significant difficulties while navigating VEs due to perceptual and cognitive declines such as a lower visual acuity and contrast sensitivity [[4]], or lower visuo-spatial abilities [[5]]. The experiment design must take these specificities into account to ensure the experiment validity and the welfare of the participants.

This paper introduces two studies aiming to adapt a pedestrian navigation simulator to the elderly, as well as some comments about the configuration of the simulator.

2. RELATED WORK
Human-Virtual Environment Interaction requires addressing three areas: the human performance efficiency, the health and safety of the participants, and social aspects related to VEs [[4]]. The human performance efficiency consists of designing a VE in which the task performance will not be biased in comparison to the real world. This efficiency relies on the complexity of navigating the virtual environment, the degree of presence felt by the participant (perceived vividness, immersion and interaction) and the user characteristics, such as his spatial skills, ability to move or manipulate objects, personality or age. The issue of health and safety refers to cybersickness, but also to ocular pain and posture disorders. Finally, social aspects refer to the acceptance of VE and the possible misuse or abuse of such devices [[4]].

Designing a navigation experiment in a VE with the elderly raises some issues concerning the task proposed as well as the focused population. As the device will be used to assess, train or improve pedestrians' navigation skills, differences in spatial abilities measured during the experiment must depend on individual characteristics rather than on the VE navigation complexity [[4]]. Furthermore, the age of the participants may cause difficulties due to their possible limited appeal for technology, their sensitiveness to cybersickness [[1]] and their interaction difficulties with the system [[6]]. Some adaptations could limit those risks [[4], [6]].

3. RESEARCH PURPOSES
Taking into consideration the specificities of the pedestrian navigation task and of the population, our main concerns were:

- To foster the ability of the participants to move in the VE with a suitable interaction device
- To support the human performance efficiency by a high degree of presence in the VE
- To limit as much as possible the risk of cybersickness.

4. EXPERIMENTS
Two studies were held in a pedestrian navigation simulator to determine the best suited interaction device to use as well as the degree of presence of the VE. Some adaptations were also made to limit cybersickness and posture disorders.

4.1 Materials
The pedestrian navigation simulator consists of three 47 inch LCD screens displaying a virtual city (cf. Figure 1). For their comfort, participants could sit on a stool or stand up.

ECCE '16, September 05-08, 2016, Nottingham, United Kingdom
ACM 978-1-4503-4244-5/16/09.
http://dx.doi.org/10.1145/2970930.2970959

Figure 1. The pedestrian navigation simulator.

4.2 Interaction device

If some devices exist to interface VEs and active body movements [see e.g. [3]], those are often expensive and cumbersome and may be tiresome for the elderly. Therefore a first study was conducted to determine which interaction device among direction buttons and a joystick was best suited to the navigation task. Two groups of participants were recruited: 10 young people aged 23 to 29 (M= 26.6; SD= 2.06) and 12 older people aged 63 to 78 (M= 72.17; SD= 4.13). Participants were invited to travel a short route in the simulator with both devices and to answer a seven-item questionnaire, based on a six point Likert scale. If older participants globally preferred direction buttons ($\chi^2(12;16)=31.47$; $p<.05$) while younger preferred the joystick ($\chi^2(12;12)=21.75$; $p<.05$), assessment in terms of effort to learn, ease of learn and speed perception do not differ significantly among age groups (all $\chi^2(21)$ ns). But observations and post-activity verbalizations let us know that handling the joystick seems quite evident, even for older participants. In contrast, the reactivity of the buttons leads to twitches and spasmodic images. As a joystick suits continuous tracking tasks that do not require a great deal of precision [[6]], and to limit the cybersickness risk due to twitches, a joystick was chosen as the best interaction device to use in pedestrian navigation simulator for young as well elderly people.

4.3 Degree of presence

To ensure a good human performance efficiency, a second study aimed to determine the degree of presence in the pedestrian simulator by an adapted version of a presence questionnaire [[7]]. It consisted of a twenty-item questionnaire, based on a seven points scale, dealing with topics such as immersion feeling, control, interaction device, realism of the virtual city and visual aspects. Three groups of participants were recruited: 20 young people aged 20 to 35 (M=27.05, SD=5.68), 20 retired people aged 60 to 70 (M=66.61, SD=2.33) and 18 older people aged 71 to 80 (M=74.45, SD=2.74). Results show that participants felt completely or almost completely immersed in the VE (84,48%) and not bothered by the visual quality of the VE (96,55%). Moreover, a high majority of participants (96,94%) report that using a joystick did little or not interfere with their movement in the VE. People aged 71 to 80 reported perceiving the VE to be more realistic ($H(2, N= 58) =7.8$; $p<.02$; SR=739) than the two other groups (young: SR=449; older: SR=523). As a whole, those results reveal a global good rating of the degree of presence of the VE that should foster the efficiency of the experiments held in the pedestrian navigation simulator [[4]].

4.4 Health and safety

In addition to these two studies, some adaptations were made to the simulator to limit the risk of cybersickness and posture disorders. The simulator was installed in a ventilated room to limit heat inconvenience due to the screens. The screens were oriented in order to offer a field of view of 130°, which should help in achieving a feeling of immersion but should not be wide enough to implicate a sensation of motion sickness [[4]]. Moreover participants can adapt the position of the joystick to avoid hurting their forearm while navigating.

5. CONCLUSION

By taking human factors into account, some little adaptations have been done to the pedestrian navigation simulator in order to reduce issues and risks inherent to the use of VEs with the elderly.

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