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The Relationship between Eye Position and Body Movement during Navigation in a Complex Building

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Problem

The importance of the body in designing Human Computer Interaction (HCI) under embodied spatial cognition is investigated. Specifically, if the body, instead of the eye, was to be utilised to perceive spatial information when navigating in a complex building.

Fig. 1: The setup – 1.VR headset; 2.Touch Screen; 3. Wide-cam; 4. Fix band; 5. Backpack; 6. MacBook

Motivation

HCI research has addressed how to design tools that effectively alter human mind [1]. Recent works have addressed relevant approaches such as the work Spider-Vision that modifies the visual sense [2] and the work addressing out-of-body experi-ences [3]. Here, we investigate the relationship between the body and its perception of the environment [4]. We ask: what if we change how and what we see by changing the eye po-sition? How will the body navigate in space?

We carried out a study which investigated how participants navigate through a complex building using a specifically designed device that interrupts the deep eye-body connections. The aim is to replace human eyes and make participants rely more on their bodily sensations in navigation. By placing the device on other locations in the body, the eye position was changed. Four eye positions were tested by participants with an average age of 25.

Proposed Approach

A device for simulating the visual system was developed. VR Headset was chosen to provide immersive visual experience to participants UP limit their vision to the screen displaying live feed from the webcam only. Qualitative and quantitative methods were used to identify how the body movement differed after the eye position was changed, four types of data were collected

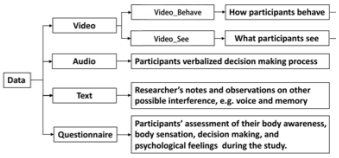

Fig. 2: Four types of data collected for analysis

References

[1] Kirsh, D., 2013. Embodied cognition and the magical future of interaction design. ACM Trans. Comput.-Hum. Interact. 20, 1, 3.
[2] Fan, K. & Huber, J. & Nanayakkara, S., Inami, M. 2014. SpiderVision: Extending the human field of view for augmented awareness. ACM International Conference Proceeding Series.
[3] Thomas K., Boldt R., Hoppe, M., Knierim, P., Funk, M.. 2016. Exploring the Optimal Point of View in Third Person Out-of-Body Experiences. In Proceedings of PETRA '16 ACM,USA.
[4] Goldstein, B., 1981. The Ecology of L.L. Gibson's' Perception. Leonardo 14 (3). p. 191-195.

Methodology

37 participants were invited to wear the headset and the webcam-eye (the new eye position). During the navigation, they could:

do whatever they want to help them understand their new eye position and were encouraged them to move as natural as possible and verbalize their thoughts when making any decisions, e.g., why they turn at corners.

if they feel physically uncomfortable or too lost to finish the test, they had to report it and officially stop the study. No other limitations of movement speed, duration or movement strategies were set.

after finishing the route, they were asked to provide feedbacks and fill out a questionnaire to assess their performance in the test.

the study ended with navigating through the selected building again without the headset using their own eyes to provide a comparison.

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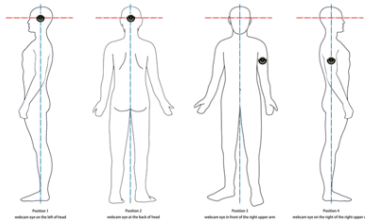
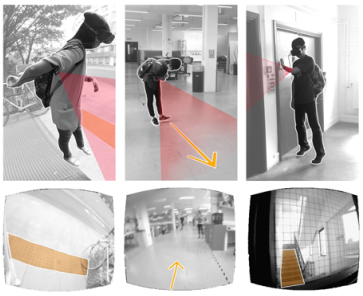


Fig. 3: (a) Participant seeing pavement on the ground in eye position Bod_RU_F. (b) Participant seeing the arrow on the ground with her arm (current eye position) in Bod_RU_R.. (c). Participant seeing staircase higher than his current eye level in Bod_RU_R.



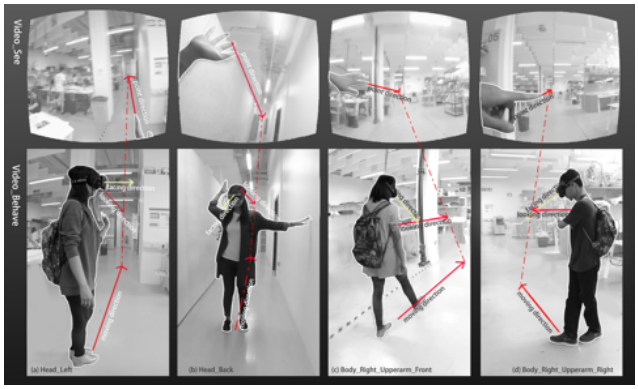


Fig. 4: The upper row shows participants' view of the environments. The lower row shows their moving body and bodily actions.. Participants use their hands as guidance. – eye position from left to right: H_L, H_B, Bod_RU_F, Bod_RU_R.

Fig.. 5: The upper row shows participants' moving body and bodily actions.. The lower row shows their view of the environments. (Left). Participant tries to keep away from the object in space –. eye position: Bod_RU_R.. (right). Participant keeps away from the object in space with hands & arms fully stretched – eye position: H_L.

Conclusion

Findings of this study indicated that the participants not only use their eyes, but their bodies to gain spatial information for navigation.. After eye position was changed, repetitive hand and arm movement were observed, and unusual movement of foot and neck naturally appeared.. To adjust the changed body movement to the environment and continue navigating, participants developed new moving strategies accordingly.

To navigate through the study environment with their current eyes, participants had to remould their existing cognitive approaches. Based on the video footages, three learning phases were observed: the arousing phase, adapting phase, and applying phase. Each phase had its navigating strategies with the corresponding trajectory patterns.. Each approach developed corresponding navigation strategies. Visual perception dominated, assisted by proprioception

Arousal Phase: Strategies to Understand the Current Eye Position
Adapting Phase: Strategies to Rebuild Coordination
Applying Phase: Strategies to Navigate Efficiently

In general, the change of the eye position challenged participants' spatial cognition and affected their navigation behaviour.. Some of them even stepped into space that they rarely entered in their normal eye position. The speed of spatial cognition slowed down but also varied in rate. To rematch what they see with their bodily behaviour, participants started to use unusual body movements.