Virtually Walking? Developing Exertion Interfaces for Locomotor Rehabilitation

Wendy Powell
University of Portsmouth
Eldon building
Winston Churchill Avenue
Portsmouth PO1 2DJ
wendy.powell@port.ac.uk

CHI 2008, April 05-10 2008, Florence, Italy
ACM 1-xxxxxxxxxxxxxxxxxx.

Abstract
Exertion interfaces are physically demanding, enabling the introduction of exercise to the traditionally sedentary gaming community. When linked with suitable software they may also be used for rehabilitation, promoting a higher level of effort than more traditional rehabilitation techniques. However, exertion interfaces, and treadmill interfaces in particular, are associated with complex perceptual changes and stimulate a physical response which may not always be what is expected or desirable. It is suggested that systematic analysis of the interplay of conscious perception and subconscious response in exertion interaction will better inform the development of these interfaces, enabling their full potential to be realised.

Keywords
Virtual Reality, rehabilitation, treadmill, exertion interface, optimization, perception, response

ACM Classification Keywords
H5.2. [Information interfaces and presentation (e.g., HCI)]: User interfaces---Input devices and strategies (e.g., mouse, touchscreen)

Introduction
For some time, HCI design has focussed on minimising the physical effort required for interaction. Advances in

mouse and keyboard design, as well as increasing sophistication in interaction techniques such as voice recognition, have successfully reduced the incidence of HCI-related illness and injury [1]. However, more recently, rising levels of obesity and other health concerns have prompted the development of more physically challenging (exertion) interfaces to address increasingly sedentary lifestyles (e.g. Sony EyeToy®, Nintendo Wii™). Whilst exertion interfaces can indeed enhance gaming and promote increased fitness, their range of application could be much wider, providing the potential for significant motor rehabilitation opportunities.

Exertion Interfaces and Rehabilitation

Rehabilitation after illness or injury very often requires repetitive exercise or activity, and it can be difficult to engage patients in therapy that may be perceived as boring, difficult or painful. In recent years, Virtual Reality has been demonstrated to have potential as a tool to enhance physical rehabilitation [2]. Interfaces have been tested for use in such diverse applications as balance retraining after brain injury [3], upper limb rehabilitation [4] and improving compliance in children with cerebral palsy [5].

Locomotor (walking) rehabilitation

An area of particular medical concern is locomotor rehabilitation. Slow walking is a common consequence of illness or injury, often persisting even after completion of traditional rehabilitation programs. This often leads to difficulty reintegrating into the community and an inability to carry out the normal activities of daily living. There is evidence, however, that treadmill training programs may be able to improve walking speeds in this group [6, 7]. Moreover, recent studies have suggested that the use of Virtual Reality (VR) may be able to improve engagement[8], decrease perception of pain [9] and subconsciously increase walking speeds [10] during therapy.

Although it therefore seems logical to use a treadmill interfaced to VR to enhance locomotor rehabilitation, recent evidence suggests that there seems to be a distortion in the perception of movement when walking on a treadmill [11-13] and that this effect may be exacerbated when the treadmill is interfaced to a virtual environment [14].

In a gaming context this is unlikely to be a problem, since gamers are familiar with a mismatch between their physical actions and their virtual actions in the game. However, one goal of rehabilitation is to enable accurate reproduction of real-world tasks, and so it is important to create a natural and intuitive interface between the user and the virtual environment. In order to do this, it is necessary to understand the perceptions and responses between a user and the environment when using a treadmill-mediated exertion interface.

Preliminary studies have demonstrated that there is a clear correlation between the rate of optic (visual) flow in the virtual environment, and the walking speed of the user, with a decrease in the rate of optic flow producing an increase in walking speed [10]. This suggests that direct manipulation of the optic flow rates may be able to stimulate the faster walk speeds required for rehabilitation, as well as having the potential to promote higher levels of effort in exertion gaming. It has also been noted that there is a marked alteration in the perception of visual progress when walking in a virtual world [15], suggesting that a "correctly" calibrated interface may not actually be perceived as realistic. This has implications for the design of these interfaces if the aim is for immersion and believability to maximise their exercise and rehabilitation potential.

Summary

It is clear that Human-Computer Interaction via exertion interfaces differs greatly both in perception and response from conventional interaction techniques, and a very different approach is necessary in order to investigate these novel interactions. It seems likely that these complex interactions are not unique to treadmill interfaces, but rather may reflect a wider issue with exertion interfaces in general. Physical interaction with the virtual environments raises questions of depth perception, lack of sensory cues, speed distortions and unexpected physical responses, which may require a new approach to the integration of software and hardware. Further discussion of these issues amongst researchers from a variety of backgrounds and encompassing a number of different exertion interfaces is crucial if we are to further our understanding of this promising area of interface development.

References

[1] Bergman, E. and E. Johnson, *Toward accessible human-computer interaction*, in *Advances in human-computer interaction (vol. 5)*. 1995, Ablex Publishing Corp. p. 87-113.

[2] Holden, M.K., *Virtual environments for motor rehabilitation: review.* Cyberpsychol Behav, 2005. **8**(3): p. 187-211; discussion 212-9.

[3] Thornton, M., et al., *Benefits of activity and virtual reality based balance exercise programmes for adults with traumatic brain injury: Perceptions of participants and their caregivers.* Brain Injury, 2005. **19**(12): p. 989-1000.

[4] Crosbie, J.H., et al., *Virtual Reality Rehabilitation in Chronic Stroke: Two Case Studies.* Annual Review of CyberTherapy and Telemedicine, 2006. **4**.

[5] Bryanton, C., et al., *Feasibility, motivation, and selective motor control: virtual reality compared to conventional home exercise in children with cerebral palsy.* CyberPsychology and Behavior, 2006. **9**(2): p. 123-8.

[6] Ada, L., et al., *A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomized trial.* Arch Phys Med Rehabil, 2003. **84**(10): p. 1486-91.

[7] Boian, R.F., et al. *Street crossing using a virtual environment mobility simulator*. in *IWVR 2004*. 2004. Lausanne, Switzerland.

[8] Rizzo, A. and G.J. Kim, *A SWOT analysis of the field of virtual reality rehabilitation and therapy.* Presence-Teleoperators and Virtual Environments, 2005. **14**(2): p. 119-146.

[9] Hoffman, H., G., Richards, T.L., Coda, B., Bills, A.R., Blough, D., Richards, A.L., Sharar, S.R., *Modulation of thermal pain-related brain activity with virtual reality: evidence from fMRI.* Neuroreport, 2004. **15**(8): p. 1245-1248.

[10] Powell, W., et al., *Optic Flow with a Stereoscopic Display: Sustained Influence on Speed of Locomotion.* Annual Review of CyberTherapy and Telemedicine, 2006. **4**: p. 65-70.

[11] Banton, T., et al., *The Perception of Walking Speed in a Virtual Environment.* Presence: Teleoperators & Virtual Environments, 2005. **14**(4): p. 394-406.

[12] Durgin, F.H., K. Gigone, and R. Scott, *Perception of visual speed while moving.* J Exp Psychol Hum Percept Perform, 2005. **31**(2): p. 339-53.

[13] Distler, H.K., et al. *The perception of absolute speed during self-motion*. in *European conference on visual perception*. 1998. Oxford, UK.

[14] Durgin, F.H., C. Reed, and C. Tigue, *Step frequency and perceived self-motion.* ACM Trans. Appl. Percept., 2007. **4**(1): p. 5.

[15] Powell, W., et al., *Software Gearing in a Virtual Environment: The Effect on Perception of Optic Flow.* Annual Review of CyberTherapy and Telemedicine, 2007. **5**: p. 99-106.