New and experimental techniques II : virtual reality

김 현 아
계명대동산병원

Virtual reality in vestibular rehabilitation

Keimyung University Dongsan Hospital
Department of Neurology
Hyun Ah Kim

Vestibular rehabilitation

Habituation
Adaptation
Substitution
Balance and gait exercises

Incorrect performance of exercises
Necessity of active efforts and interest from the patient
→ variability of patients response to therapy

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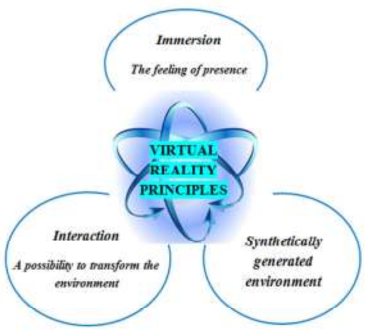
Virtual reality (VR)

an approach to user-computer interface that involves real-time simulation of an environment, scenario, or activity that allows for user interaction via multiple sensory channels.

computer-generated scenario that simulates a realistic experience.

Virtual reality (VR)



Virtual reality (VR)

Virtual environment
Output device
Input device (interface)

Virtual environment

컴퓨터 프로그램을 이용하여 모니터나 head-mounted display (HMD)로 표현되는 환경

2차원과 3차원

가상현실, 증강현실(augmented reality)

VR output devices

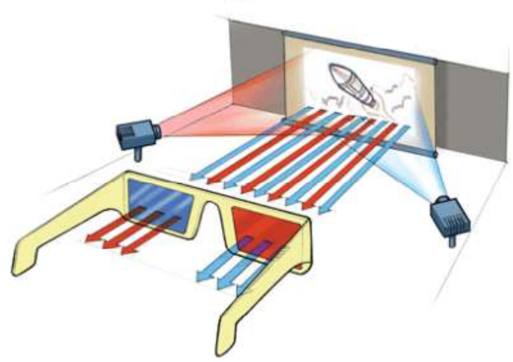
Visual display
- 3D glasses
- Surround displays- large projection screens (CAVE)
- Head mounted displays (HMD)

Haptic display
- Devices built in data gloves and dexterous manipulators simulating kinesthetic and tactile sensations
- Joysticks and desktop mice with kinesthetic feedback
- Exoskeletal hand masters
- Vibrating nodules, inflatable bubbles and electrorheological fluids placed under the surface of a glove

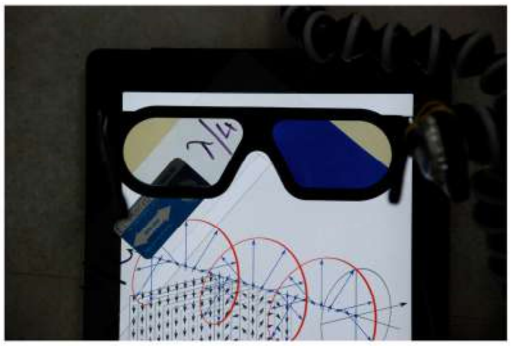
Audio display
- Headphones
- Speakers

3D glasses

3D glasses

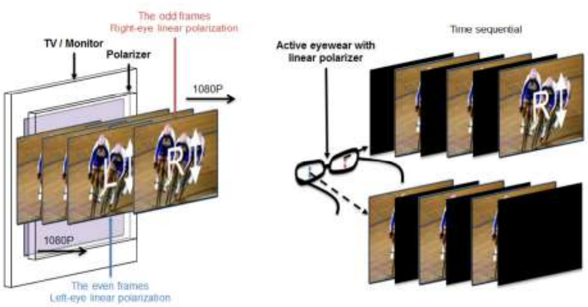


3D glasses



Shutter glasses

Shutter glasses



CAVE

CAVE Automatic Virtual Environment

Head mounted displays (HMD)

VR input devices

Position and orientation tracking devices
- Magnetic trackers
- Acoustic (ultrasonic) trackers
- Optical trackers
- Mechanical trackers

Eye tracking

3D input devices
- 3D mice and bats
- Gloves
- Dexterous manipulators

Desktop input devices
- SpaceBall
- CyberMan
- 2D input devices

Motion Tracking

인터페이스 장치

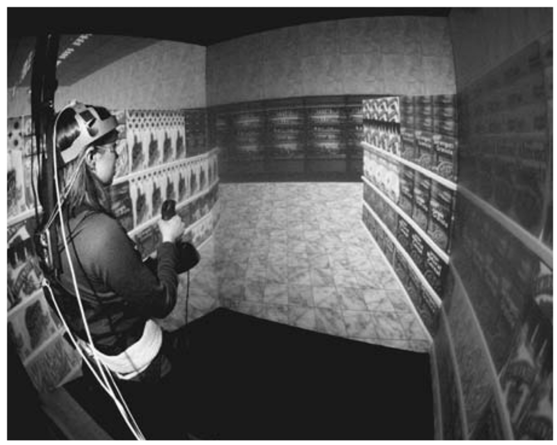
CyberPsychology & Behavior
Volume 9, Number 2, 2006

Responses to a Virtual Reality Grocery Store in Persons with and without Vestibular Dysfunction

SUSAN L. WHITNEY, Ph.D.,[1,2] PATRICK J. SPARTO, Ph.D.,[1-3] LARRY F. HODGES, Ph.D.,[4] SABARISH V. BABU, M.S.,[4] JOSEPH M. FURMAN, M.D., Ph.D.,[1-3] and MARK S. REDFERN, Ph.D.[1-3]

ABSTRACT

People with vestibular dysfunction often complain of having difficulty walking in visually complex environments. Virtual reality (VR) may serve as a useful therapeutic tool for providing physical therapy to these people. The purpose of this pilot project was to explore the ability of people with and without vestibular dysfunction to use and tolerate virtual environments that can be used in physical therapy. We have chosen grocery store environments, which often elicit complaints from patients. Two patients and three control subjects were asked to stand and navigate in VR grocery stores while finding products. Perceived discomfort, simulator sickness symptoms, distance traveled, and speed of head movement were recorded. Symptoms and discomfort increased in one subject with vestibular dysfunction. The older subjects traveled a shorter distance and had greater speed of head movements compared with young subjects. Environments with a greater number of products resulted in more head movements and a shorter distance traveled.



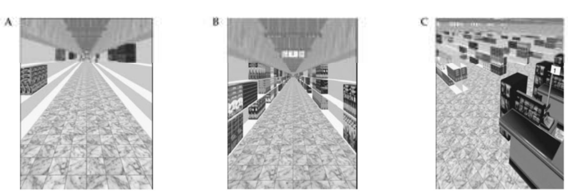


FIG. 2. Layout of virtual grocery stores. (A) One aisle, sparse products. (B) One aisle, dense products. (C) Six aisles, dense products.

Table 1: Main characteristics of the studies.

Study	Patients/ages	Vestibular problem	Type of virtual reality device	Measurements of efficacity
dos Santos et al. (2009) ACTA ORL [31]	n = 8 (18–60 years, mean 41 years)	Chronic vestibular dysfunction	Balance Rehabilitation Unit (BRU) with virtual reality glasses projecting visual stimuli	(i) Dizziness Handicap Index (DHI) (ii) Vertigo analogic Scale (VAS) (iii) Stabilisation limits (LOS) (iv) Audiometer (tonal, vocal) (v) Impedance (vi) Vectonystagmography (vii) Posturography
Rodrigues et al. (2009) Rev Equilibro Corporal e Saude [32]	n = 10 (24–76 years, mean 51 years)	Chronic vestibular disorder secondary to Ménière's disease	Balance Rehabilitation Unit (BRU) with visual stimuli (glasses)	(i) DHI (ii) VAS (iii) LOS (iv) Computerized Posturography
Viirre and Sitarz (2002) Laryngoscope [33]	n = 15 (age n/a) (i) n = 9 patients (ii) n = 6 controls	Vertigo symptoms for more than 6 months (with no improvement for at least 6 months)	Head-mounted Display (HMD) much like a visor with mounted video screens	(i) DHI (ii) Vestibuloocular reflex (VOR)
Pavlou et al. (2012) J Vestib Res [34]	n = 16 (18–75 years, mean 49 years) (i) n = 11 (Group S = static virtual reality) (ii) n = 5 (Group D = dynamic virtual reality) (iii) n = 5 Group DI (5 patients from Group S who had also dynamic treatment)	Confirmed peripheral vestibular deficit (caloric test and/or rotational test on ENG)	ReaCtoR in the Department of Computer Science: immersive projection theatre (IPT). 3 rear projected vertical screens (3 m × 2.2 m)	(i) Situational Vertigo Questionnaire (ii) Beck Depression Inventory (iii) Beck Anxiety Inventory (iv) Fear Questionnaire (v) Dynamic Gait Index (DGI) (vi) Virtual reality exercise symptom scores (VRCESS)
Sparrer et al. (2013) Acta Otolaryngol [35]	n = 71 (28–84 years, mean 43 years) (i) n = 37 patients (ii) n = 34 controls	Acute vestibular neuritis (sudden, spontaneous, and unilateral loss of peripheral vestibular function within 48 h of the onset of vertigo)	Wii Fit balance board with image on screen	(i) DHI (ii) Wii Fit age (iii) Sensory Organization Test (SOT) (iv) Vertigo Symptom Scale (VSS) (v) Tinetti questionnaire
Whitney et al. (2009) Physical Therapy Reviews [36]	n = 12 (18–80 years, mean 52 years)	Vestibular disorders with dizziness and loss of balance	Treadmill in a virtual grocery store on a screen	(i) DHI (ii) Activities-specific Balance Confidence Scale (ABC) (iii) Dynamic Gait Index (DGI) (iv) Timed Up and Go (TUG) (v) Sensory Organization Test (SOT)
Garcia et al. (2013) Braz J Otorhinolaryngol [37]	n = 44 (18–60 years, mean 48 years) (i) n = 23 cases (ii) n = 21 controls	Unilateral or Bilateral Ménière's disease	Balance Rehabilitation Unit (BRU) with virtual reality glasses projecting visual stimuli	(i) DHI (ii) Analog dizziness scale (iii) ENT examination (iv) PTA audiometry, impedance (v) Functional vestibular examination (vi) Speech intelligibility testing (vii) Posturography

Bergeron, 2015

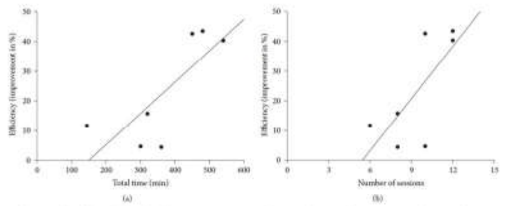


FIGURE 1: Impact of the duration of virtual reality exposure on treatment efficiency. (a) Average efficiency in terms of symptoms' improvement as a function of the total time spent in virtual reality-based therapy (linear regression, $r^2 = 0.5975$, $P < 0.05$). (b) Average efficiency in terms of symptoms' improvement as a function of the total number of sessions of virtual reality-based treatment ($r^2 = 0.5164$, $P = 0.07$).

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TABLE 2: Efficiency of rehabilitation regarding the type of device.

Study	Efficiency	Active versus passive	Average efficiency
dos Santos et al. (2009) [31] ACTA ORL	Low	Passive	15.75%
Rodrigues et al. (2009) [32] Equilíbrio Corporal e Saúde	High	Passive	43.50%
Viirre and Sitarz (2002) [33] Laryngoscope	Low	Passive	4.65%
Pavlou et al. (2012) [34] J Vestib Res	Low	Active	4.40%
Sparrer et al. (2013) [35] Acta Otolaryngol	High	Active	42.61%
Whitney et al. (2009) [36] Physical Therapy Reviews	Low	Active	11.67%
Garcia et al. (2013) [37] Braz J Otorhinolaryngol	High	Passive	40.35%

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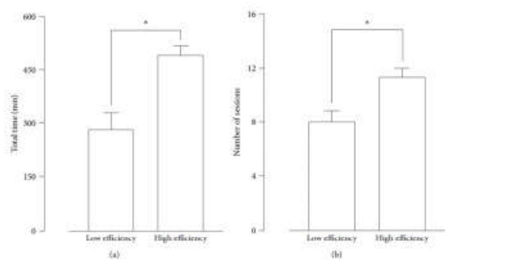
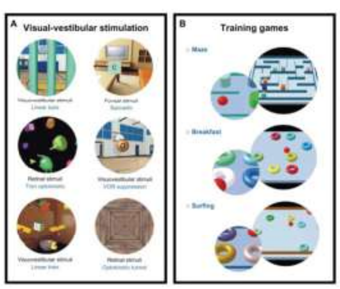


FIGURE 2: Differential characteristics of virtual reality protocols according to average efficiency. (a) Time spent in virtual reality-based treatment. (b) Number of sessions depending on the clinical impact of the treatment ("low efficiency" defining studies with less than 20% of improvement on average efficiency and "high efficiency" studies with more than 20% of improvement). * $p < 0.05$.

Bergeron, 2015

Pavlou et al. (2012)



Garcia et al. (2013)

frontiers in Neurology
ORIGINAL RESEARCH

Balance in Virtual Reality: Effect of Age and Bilateral Vestibular Loss

Elodie Chiarovano, Wei Wang, Stephen J. Rogers, Hamish G. MacDougall, Ian S. Curthoys and Catherine de Waele

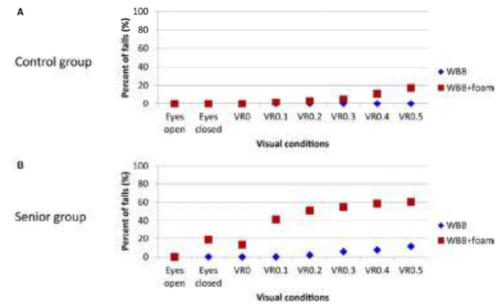
Background: Quantitative balance measurement is used in clinical practice to prevent falls. The conditions of the test were limited to eyes open, eyes closed, and sway-referenced vision. We developed a new visual perturbation to challenge balance using virtual reality (VR), measuring postural stability by a Wii Balance Board (WBB).

Methods: In this study, we recorded balance performance of 116 healthy subjects and of 10 bilateral vestibular loss patients using VR to assess the effect of age and the effect of total loss of vestibular function. We used several conditions: eyes open (normal visual inputs), eyes closed (no visual inputs), stable visual world (vision referenced), and perturbed visual world (visual perturbation) at different amplitudes of perturbation. Balance under these visual conditions was assessed on the WBB (stable support surface) and on the WBB plus foam rubber (unstable support surface).

Results: In healthy subjects, we found that the percentage of falls increased with age and with the amplitude of perturbation for both conditions: WBB or WBB + foam. Moreover, we can define a threshold for falls in each age group as the amplitude of perturbation which induced falls. For bilateral vestibular loss patients, on the WBB + foam, all of them failed with eyes closed and with perturbed visual world even at the minimal amplitude of perturbation. Finally, we observed that stable visual world induced fewer falls than eyes closed whatever the subject's group (healthy or bilateral vestibular loss) and whatever the age decade.

Conclusion: VR allowed us to develop a useful new tool with a wide range of visual perturbations. Rather than only two levels of visual condition (eyes open and eyes closed), the VR stimulus can be continuously adjusted to produce a visual perturbation powerful enough to induce falls even in young healthy subjects and which has allowed us to determine a threshold for falls.

FIGURE 7 | New portable and mobile configuration of the material used in this study: (A) foam rubber; (B) Samsung virtual reality (VR) headset; (C) iPhone running BalanceRite App; (D) switch on/off foot button for the Wii Balance Board (WBB); (E) remote controller to launch the visual perturbation; (F) Samsung Galaxy S6 phone running TuscanVilla App (visual perturbation); (G) WBB.



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Full length article

Virtual reality balance training for elderly: Similar skiing games elicit different challenges in balance training

Aijse W. de Vries[a], Gert Faber[b], Ilse Jonkers[c], Jaap H. Van Dieen[b], Sabine M.P. Verschueren[a,*]

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ABSTRACT

Background: Virtual Reality (VR) balance training may have advantages over regular exercise training in older adults. However, results so far are conflicting potentially due to the lack of challenge imposed by the movements in those games. Therefore, the aim of this study was to assess to which extent two similar skiing games challenge balance, as reflected in center of mass (COM) movements relative to their Functional Limits of Stability (FLOS).
Methods: Thirty young and elderly participants performed two skiing games, one on the Wii Balance board (Wiiski), which uses a force plate, and one with the Kinect sensor (Kinski), which performs motion tracking. During gameplay, kinematics were captured using seven opto-electronical cameras. FLOS were obtained for eight directions. The influence of games and trials on COM displacement in each of the eight directions, and maximal COM speed, were tested with Generalized Estimated Equations.
Results: In all directions with anterior and medio-lateral, but not with a posterior component, subjects showed significantly larger maximal %FLOS displacements during the Kinski game than during the Wiiski game. Furthermore, maximal COM displacement, and COM speed in Kinski remained similar or increased over trials, whereas for Wiiski it decreased.
Conclusions: Our results show the importance of assessing the movement challenge in games used for balance training. Similar games impose different challenges, with the control sensors and their gain settings playing an important role. Furthermore, adaptations led to a decrease in challenge in Wiiski, which might limit the effectiveness of the game as a balance-training tool.

https://www.youtube.com/watch?v=mmYQI1xiKHw

https://www.youtube.com/watch?v=S3x3iI-w_NU

https://www.youtube.com/watch?v=9Z8IolvhE0E

Thank you for your attention!