State of the Science Symposium

Virtual Reality and Physical Rehabilitation: A New Toy or a New Research and Rehabilitation Tool?

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Funded by the National Institutes of Aging and National Institutes of Deafness and Communication Disorders of the National Institutes of Health.
What questions do we ask about clinical treatment and research?

1. Are we influencing the actions of the brain?
2. Is there learning?
3. Does the amount, kind, frequency of practice matter?

These are the same questions that need to be asked about virtual reality when used for rehabilitation...
Traditional Outcomes Measures

- Increased frequency of participation
- Activity logs
- Subjective reports
- Sensory and Motor Clinical Tests
  - Manual muscle testing
  - Reflex latencies
  - Sensory identification
  - Timed Get Up and Go

A common weakness in all of these measures is the absence of multitasking
Is multitasking important for rehabilitation?
You don’t need to worry about where to focus attention when you are moving in an environment that does not distract from the goal of the movement.
BUT, in natural environments there are many things that may take your attention away from your actions...
Immersion in a virtual environment provides conflicting sensory demands like in a natural environment.
Incorporating other technologies can make demands of the Virtual World even more realistic.
How can we evaluate Virtual Reality as a Rehabilitation Tool?

1. Are we influencing the actions of the brain?

2. Is there learning?
3. Does the amount, kind, frequency of practice matter?
4. Can we use VR for rehabilitation and training?
Virtual Reality images generate whole body actions during realistic tasks

Laboratory for Innovations in Rehabilitation Technology, University of Haifa, Israel
(Director: Tamar Weiss, OT, PhD)
VR influences perception of environmental demands

Virtual Environment and Postural Orientation Laboratory
Temple University, USA, Emily Keshner PT EdD, Director
Visual Attention affects Spatial Orientation...
Motion of the Visual World Can Influence How we Plan our Movement

Keshner and Kenyon 2000
Evaluating the Value of Virtual Reality as a Rehabilitation Tool

1. Are we influencing actions of the brain?
   - Yes...Motor Planning and Perception

2. Is there learning?

3. Does the amount, kind, frequency of practice matter?

4. Can we use VR for rehabilitation and training?
Benefits of a virtual play rehabilitation environment for children with cerebral palsy

• Neural changes in the affected limb seen with fMRI after VR therapy.

• After VR therapy the child was able to spontaneously perform
  • Reaching
  • Self-feeding
  • Dressing

which were not possible before the intervention.

You et al. Developmental Medicine & Child Neurology 2005
Joyce Fung, PT, PhD Laboratory
Jewish Rehabilitation Hospital, Montreal, Canada

Level 1
Habituation to VE; no change in surface, no obstacles: time constraint

Level 2
Changes in surface: pitch (downward, upward slopes), roll: (left-right, right-left)

Level 3
Changes in surface and moving obstacles

Aim: to make appropriate anticipatory locomotor adjustments to avoid collisions while adapting to changes in surface with a time constraint
Habituation to Virtual Environments

Patient #2

Corridor Walking

Street Crossing

Control Subject

Corridor Walking

Fung et al. CyberPsych Behav, 2006
RESULTS of TRAINING in VR

• With practice, patients increased gait speed to match task demands and adapted their gait to fit with changes in physical terrain.

• However, they did not develop the ability to anticipate and avoid collision with obstacles.

• Patients learned to change their movement but did not develop new cognitive planning skills necessary for acting in new environments.
Evaluating the Value of Virtual Reality as a Rehabilitation Tool

1. Are we influencing the actions of the brain?
   • Perception and Motor Planning

2. Is there learning?
   • Yes, error feedback generates adaptive motor behavior

3. Does the amount, kind, and frequency of practice matter?

4. Can we use VR for rehabilitation and training?
Virtual grocery stores are being used for navigation and socialization skills.

The Multi-User Virtual Action Planning Supermarket
Weiss and Klinger, 2009

Trajectory while shopping for items by a user with no impairment.

A typical trajectory of the same shopping task by a client with Parkinson's Disease.
Combine virtual environments with a haptic master to provide practice for grasping, reaching, or both grasp and reach with assistance or resistance.
Stroke subjects after practicing approximately three hrs/day for 8 days demonstrated a more normalized trajectory even without haptic assistance.
Evaluating the Value of Virtual Reality as a Rehabilitation Tool

1. Are we influencing the actions of the brain?
   • Perception and Motor Planning

2. Is there learning?
   • We learn through error feedback generating adaptive behavior

3. Does the amount, kind, and frequency of practice matter?
   • To get functional carryover, learned movement must be incorporated into complex motor behaviors
   • The range of behaviors is still to be determined.

4. Can we use VR for rehabilitation and training?
A benefit of VR is standardized and individualized intervention within a purposeful context.
Elderly adults and patients with neurological deficit are visually dependent

Can we utilize this visual dependence to influence and evaluate motor relearning?
Participants

- 12 elderly (57-81 yrs)
- 17 patients with right hemiparesis (51-71 yrs)
- all community ambulators with intact sensation

Scene was moved in upward or downward pitch at 30° or 45°/sec
Healthy Young Adult’s COM is Sensitive to Velocity and Direction of Visual Motion

[Graph showing the movement of the center of mass (COM) for different visual motion conditions: Stable and Toes-Up.]
Responses reflecting direction and velocity of the virtual scene suggests that VR is a feasible training tool.
Balance Training on a Moving Platform in a VR CAVE

• Trained for a 2 week period

• In the dark

• Increased sensitivity of platform each day up to 2 times COM motion

• Patient instructed to focus on position of hips and knees.
Postural Sway Decreases with Practice

- 73 yo female who falls
- 10 years post-onset of bilateral vestibular deficit
- an active, community dweller
- no other significant health problems
Effect of Training on Individuals with Head Injury (e.g., concussion, stroke)

- Used visual motion and platform motion to produce instability
- Trained with plantar vibration in the dark to enhance stabilization

**Patient with Stroke Trunk Motion (COM)**

**Body Sway (COP)**
VR is a Research and Rehabilitation Tool

- Virtual reality is a motivating and safe tool for rehabilitation purposes
- Virtual reality can be used both as an intervention and an outcome measure of rehabilitation gains
- Dosages for applicability to motion in the physical world and accurate transfer of training need to be further verified
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