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Therapeutic effects of large-field visual virtual immersion on balance control in unilateral vestibular patients

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INTRODUCTION | VR-based balance rehab. relevance?

CLINICAL TRIAL - PATIENTS
• Unilateral vestibular patients (42-80 yrs; 3 m., 4 f.)
• Visually-induced dizziness (aesthetic, chronic recurrent dizziness, vestibular neuritis)
• 8 weeks rehab. period = 1 or 2 rehab. session per week included in the patients care process
• Ethics validation (CPP - voluntary informed patients)

VISUAL STIMULI
• Large-field (panoramic) visual virtual flows
• Standardized optokinetic stimulus
• 8 Optic flows STIM.: 3D scrolls (Up, Down) + 2D Rotations (Clockwise, Counterclockwise) + 3D Radial expansion.
• 6 flows SPEED (speed ratio from 0.3 to 2.8 A.U.)
• Scenario optimized for efficacy on patient: visual-flows constraints increase throughout the therapeutic session: flows pattern (scroll, radial, and rotation), stimulation speed increased, gaze anchoring on the visual reference (with/without).

GAZE ANCHORAGE (GA)
• Visuo-spatial reference
• With GA: session 1-4; Without GA: session 5-8
• [With: session 9; Without: session 10]

METHODS | The PIVVIT project (Plateforme d’Immersion Visuelle Virtuelle Thérapeutique)

PROTOCOL
1. Trial = Visual stimulation
   - Nest = Rest - Nest = 23 sec
2. Series of 8 stim. (8 trials)
   - 5 different 10/20 visual flows
3. Session = 6 Speed
   - Stims 1-6 speed = 6 trials
4. Gaze Anchorage cond.
   - Sans 1-4 With GA
   - Sans 5-8 Without GA
   - 10 trials = 4 trials
5. Total stim. duration = 6 min.

RESULTS | VR immersion → Visual perturbation → Balance restoration

At a Clinical/Rehab. level: Positive effects of the “large visual field” immersion on balance restoration
  • METH. Patient-related sessions repetition + difficulty-dependent tuneable scenarios + patient follow-up + methodical practice through short period (two months)
  • BENEFITS. Rapid functional restoration of efficient synergistic control between balance and gaze process.
  • PSYCHOL. Patients’ motivation and self-confidence!

At a Neuro-functional level: “visual-vestibular-motor” adaptation occurs despite the vestibular deficits
  • PROCESS. Reweighting of the visual-vestibular sensory inputs → reciprocal inhibition restoration
  • ADAPTATION. Reduction of the visual dependence by visual-vestibular reverse compensations
  • Questions about the neural basis of the “visual-vestibular plasticity”
  • Sensory adaptive threshold/gain of the VOR and/or OKN?
  • Dual sensorimotor balance in plastic restoration: Interaction MT visual area - vestibular nuclei → visual-vestibular integration for motor command tuning/adjustment.

CONCLUSION
• Optimized rehabilitation strategies based on simple virtual visual immersions Vs. standardized rehabilitation protocols (uncontrolled OKS) for unilateral vestibular patient
• Limit: No long-term effects (reported by patients after a six months period) requiring periodic booster sessions.
  • Our study corroborate the proof of concept of interactive VR-rehabilitation based on a large visual field stimulation device (experimental and clinical validation).


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