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

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INTRODUCTION | VR-based balance rehab. relevance ?

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

CLINICAL TRIAL - PATIENTS
• Unilateral vestibular patients (42-80 y.a ; 3 m., 4 f.)
• Visually-induced dizziness (aparexia, 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) + 3D Rotations (Clockwise, Counter-clockwise) + 3D Radial expansion.
• 6 flows SPEED (speed ratio from 0.3 to 2B A.U.)
• Scenario optimized for efficiency 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

PROTOCOL
> 1 Trial = Visual stimulation
  • Next - Rest - Next = 23 sec. 
> 1 Série = 8 stim. (8 trials) 
  • 5 different 10/20-D0 visual flows 
> 1 Session = 6 Speed 
  • 4 Trials + 6 Speed = 48 trials 
> 2 Gaze Anchorage cond. 
  • Sess. 1-4 With GA 
  • Sess. 5-8 Without GA 
  • 4 trials S1 - 8 trials S2 (in 15sec.)
> 2 Phases = Compuls/Fixed 
  • A VR-based ass. (PIVVIT)
  • [Proof of concept]+++
  • A standard O2G ass. 
  • [Proof of non-inferiority]+++

DISCUSSION – CONCLUSION | Rapid VR-based rehab. benefits

At a Clinical/Rehab. level : Positive effects of the “large visual field” increase on balance restoration
• METH. Patient-related sessions repetition + difficulty-dependent tunable 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 plasticity in balance 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 (undetermined 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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