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

Olivier A.J. Martin, Denis Faure-Vincent, Jean-Dominique Gascuel, Sébastien Schmerber, Alina Voda, Pascal Bellemain

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INTRODUCTION | VR-based balance rehab. relevance?

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

**CLINICAL TRIAL - PATIENTS**
- Unilateral vestibular patients (42-80 y.o.; 3 m. ± 4 f.)
- Visually-induced dizziness (areflexia, 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
- 5 Optic Flows STIM. : 3D scrolls (Up, Down) + 3D Rotations (Clockwise, Counterclockwise) + 3D Radial expansion.
- 6 Flows SPEED (speed ratio from s03 to s38 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)**
- Visual-spatial reference
- With GA: session 1-4; Without GA: session 5-8
- [With: session 9; Without: session 10]

**PROTOCOL**
- **1 Trial** = Visual stimulation
  - Trail + Rest = 2 min.
- **1 Series = 8 stim. (8 trials)**
  - 5 different 10/20 visual flows
- **1 Session = 6 Speed**
  - Trials x 6 speed = 48 trials
- **2 Gaze Ancehoring cond.**
  - Secs. 1-4 With GA
  - Secs. 5-8 Without GA
  - [35 trials = 48 trials sessions = 15 sessions]
  - [4 trials = 8 trials sessions = 15 sessions]

**DATA RECORDING and ANALYSIS**
- Balance control: Center-of-Pressure (COP) - CoP Trajectory length - Disequilibrium indicators (lost of balance control, falls)
- Gaze behaviour (Eye-Head-body) stability: BlueGain EOG, 100Hz: EOG trajectory (preliminary results)
- [Questions-Responses (subjective estimation of the “balance comfort” in every day life tasks)]

**RESULTS | VR immersion → Visual perturbation → Balance restoration**

**DISCUSSION – CONCLUSION | Rapid VR-based rehab. benefits**

**At a Clinical/Rehab. level:** Positive effects of the “large visual field” immersion on balance restoration

- METH. Patient-related sessions repetition + difficulty-dependent tunable scenarios + patient follow-up + methodical practice through short period (2 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 compensation.

- 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 (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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