Stereopsis, axis rotations, and visually induced motion sickness

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Stereopsis & body axis rotations

- **Visually induced motion sickness (MS)**
  - Motion sickness induced by visual motion in the absence of (or in conflict with) real motion
  - Typical symptoms: Nausea, cold sweat, pallor, dizziness...
- **Theories:**
  - Sensory conflict (Reason & Brand, 1975)
    - Mismatch between visual, vestibular, and/or proprioceptive systems
  - Postural Instability (Riccio & Stoffregen, 1991)
    - Loss of active body control and increased postural sway
Stereopsis & body axis rotations

- Our question: Which components affect the amount of sensory conflict and visually induced MS?

2 Experiments

- **Experiment 1**
  - Internal Factors: stimulus characteristics
    - Role of body axis rotation

- **Experiment 2**
  - External Factors: apparatus characteristics
    - Role of stereopsis
Experiment 1
Multiple axis rotations
Experiment 1 – body axis

- Question: Is motion along 3 axes more nauseating than single- or dual-axis rotations?
- N = 61 (no drop-outs)
- One-factorial, between-subjects design
- 3 groups, rotations along...
  - pitch axis
  - pitch and roll axis
  - pitch, roll, and yaw axis
Experiment 1 – body axis

Stimuli

- 3 simulated roller-coaster rides (each video appr. 15 min), including either (I) pitch (II) pitch and roll, or (III) pitch, roll, and yaw motion
- non-linear acceleration in the fore-and-aft direction

Presentation:

- large projection screen (164 x 123 cm), field of view 61° x 48°
- sitting participants with chinrest to fix the head
- no video sound
Experiment 1 – body axis

- Stimuli - Screenshots
Experiment 1 – body axis

- Motion sickness measurement:
  - Simulator sickness questionnaire (SSQ, Kennedy et al., 1993)
    - 16 Items, 3 subscores (nausea, disorientation, oculomotor)
    - Filled in before and after stimulus presentation
  - Fast motion sickness scale (FMS, Keshavarz & Hecht, 2011)
    - 20-point verbal rating scale (0 = no sickness, 20 = frank sickness)
    - Applied every minute to capture time course of MS
Experiment 1 – body axis

Results: SSQ-scores

SSQ-N: sign. effect of group, $F(2, 58) = 4.475$, $p = .016$, $\eta^2 = .134$

No differences for other SSQ-subscores
Experiment 1 – body axis

Results: FMS-scores

Sign. interaction Time*Group, \( F(30, 870) = 25.568, p = .012, \eta^2 = .090 \)

single axis < dual axes
single axis < triple axes
dual axes = triple axes
Experiment 1 – body axis

Discussion

Possible explanations:

- Difference in the role of each single body axis (yaw less important in the genesis of MS?) – evidence against this assumption (Lo & So, 2001)
- No linear relationship between the amount of sensory conflict and MS (plateau effect) – evidence that supports this assumption (Joseph & Griffin, 2008)
- Note: rather „weak“ stimuli, maybe not MS-provoking enough
Experiment 1 – body axis

Discussion

- Outlook on future research
  - Clear comparison of all three single axis
  - Exhaustive analysis of further axis-combinations (e.g., roll and yaw)
  - Optic flow and visually induced MS (linear relationship or plateau-effect?)
Experiment 2

Stereopsis
Experiment 2 – stereopsis

- Question: Does 3D produce more visually induced MS than 2D?
- N = 79 (5 drop-outs)
- 2 x 2 between-subjects design, including
  - View mode (3D vs. 2D)
  - Video type (real video vs. PC-simulation)
- MS measurement: SSQ & FMS
Experiment 2 – stereopsis

- **Stimuli:** video captured during a real rollercoaster ride and a computer simulation of the same ride
  - 3D condition: video recorded by 2 video cameras, 6 mm lens distance
  - 2D condition: video of the left camera

- **Laboratory settings:**
  - 3D projector, large projection screen (300 x 196 cm), field of view 60° x 43°
  - 3D Shutterglasses
Experiment 2 – stereopsis
Experiment 2 - stereopsis

Results - SSQ

2x2 MANOVA including SSQ and FMS-scores

Significant interaction View Mode*Video Type, $F(5, 71) = 2.345$, $p = .05$, $\eta_p^2 = .142$
Experiment 2 - stereopsis

- Results - FMS

Significant interaction
Time*Viewing mode, $F(15, 1050) = 2.984$, $p = .035$, $\eta_p^2 = .041$

Time *Video Type $F(15, 1050) = 3.928$, $p = .011$, $\eta_p^2 = .053$
Experiment 2 - stereopsis

- Discussion - Possible explanations:
  - 3D increases visually induced MS only in combination with realistic stimuli (due to level of detail?)
  - Stereopsis increases immersion, vection, and realism, and thus visually induced MS
    - Data do not support this idea!
  - Follow-up study: effect of stereopsis (real video of a bicycle ride) was confirmed
Summary

- **General Discussion**
  - Visually induced MS is influenced by internal (stimulus characteristics) and external (aparatus) factors
  - Stereopsis might include negative side-effects users of large-screen movies or simulators

- **Conclusion**
  - Is the level of the stimulus‘ realism highly related to the severity of visually induced MS?
  - Is the relationship between sensory conflict and visually induced MS not linear (as usually supposed)?
  - Can postural instability explain results (further data needed)?
References