


Visually induced and modulated, but vestibularly caused motion sickness

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Point(s) to make

VIMS is caused by a visual-vestibular conflict

- Only visual motion cues, no (or inadequate) vestibular motion cues

VIMS (inversely) modulated by visual-visual conflicts

- The more natural the visual, the larger the effect of the visual-vestibular conflict, the sicker the subject



Visual-vestibular conflict

LD-patients do not suffer from VIMS¹

- Organs of balance essential re VIMS


The more visual motion, the more sickness

- Within certain limits
- E.g., curved city trajectories vs. rural roads in driving simulation

Bad simulator motion is worse than no motion

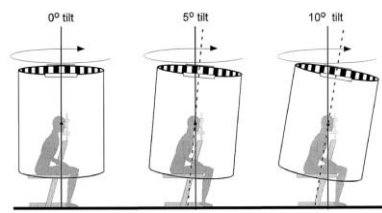
- False cues are detrimental

1 Cheung BSK, Howard IP, Money KE. (1991) Visually-induced sickness in normal and bilaterally labyrinthine-defective subjects. Aviation Space and Environmental Medicine 62:527-531.




Visual-vestibular conflict

VIMS increases with tilt of OKN-bars²



2 Bubka A, Bonato F. (2003) Optokinetic drum tilt hastens the onset of vection-induced motion sickness. Aviation Space and Environmental Medicine 74:315-319.




Visual-vestibular conflict

VIMS increases with tilt of OKN-bars²

- Earth-vertical axis rotation = natural (no conflict)
 - gravity does not change re head
 - canals insensitive for constant angular velocity
- Off-vertical axis rotation = visual-vestibular conflict
 - BBQ-spit rotation vs. Earth vertical axis rotation

Hence
VIMS *caused* by visual-vestibular conflict

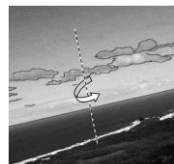

2 Bubka A, Bonato F. (2003) Optokinetic drum tilt hastens the onset of vection-induced motion sickness. Aviation Space and Environmental Medicine 74:315-319.




Visual-visual conflicts

However, VIMS only increases with tilt of OKN-pattern < 45°³

- visual impact set apart when the motion appears unnatural
- termed "quarantining"

3 Golding JF, Arun A, Wortley E, Watton-Hamirou K, Cousins S, Gresty MA. (2009) Off-vertical axis rotation of the visual field and nausea. Aviation, Space and Environmental Medicine 80:516-521.



Visual-visual conflicts

Moreover, VIMS ↑ when $\Delta(\text{iFOV}, \text{eFOV}) \downarrow$ ^{4,5}

- A "natural" view can be obtained with $\text{iFOV} = \text{eFOV}$
- Natural view assumed to give least sickness⁶

4 Bos JE, Vries SC de, Emmenik ML van, Groen EL. (2010) The effect of internal and external fields of view on visually induced motion sickness. Applied Ergonomics 41:516-521.
5 Van Emmenik ML, De Vries SC, Bos JE. (2011) Internal and external fields of view affect cybersickness. Displays 32:169-174.
6 Kobasinski G. (1995) Simulator sickness in virtual environments, United States Army Research Institute for the Behavioral and Social Sciences, Orlando, Technical Report 1027.

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Visual-visual conflicts

Observed, however, VIMS ↑ when $\Delta(\text{iFOV}, \text{eFOV}) \downarrow$

- 50 min VE-exposure
- 30-100° FOV
- 8 combinations
- N = 60
- 3 combinations / S
- 24 Ss / condition
- VIMS ≈ $0.06 * \text{eFOV} + 0.01 * \text{iFOV} - 0.02 * |\text{eFOV} - \text{iFOV}|$

- Here too: larger $\Delta(\text{iFOV}, \text{eFOV})$ makes imagery unnatural

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Visual-visual conflicts

Furthermore, 3D gives more VIMS than 2D⁷

- 3D more realistic than 2D
 - depth perception
 - vergence eye movements

Hence

- Visual-vestibular conflict can be modulated (= attenuated), by discrepancies between the imagery and the reality it suggests.
- These discrepancies may also be referred to as visual-visual conflicts

7 Keshavarz B, Hecht H. (2012) Stereoscopic viewing enhances visually induced motion sickness but sound does not. Presence 21:213-228.

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Point(s) made

VIMS is caused by a visual-vestibular conflict

and

VIMS (inversely) modulated by visual-visual conflicts

or

The more natural the imagery, the more VIMS due to a visual vestibular conflict

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Consequences

Displays

- Applied more frequently
- Getting big, bigger, biggest (FOV)
- Getting better
 - spatial, temporal and colour resolution
- 2D → 3D

Images

- approaching photo-realism

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Consequences

Artificial imagery is getting more natural hence VIMS likely to become a major societal issue soon

@Work

- Health & safety

@Home

- Health & safety & comfort (= selling point)
- Home cinema-sets + gaming !!! (>8h / day, >20h / wk ≠ exceptional)

Simulators

- Motion cueing will become more critical ⇒ better cueing hence a challenge!

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