RELATIONSHIP BETWEEN OCULOMOTOR RESTING STATES AND SIMULATOR SICKNESS IN AN HEAD MOUNTED DISPLAY

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Simulator sickness is a potential side effect of head mounted display (HMD) use. Symptoms may include fatigue, headache, dizziness, visual discomfort, and nausea. Indirect effects of VE on the visual system (i.e., eyestrain, changes in binocular vision, and visual acuity), balance, motion detection, nausea, and motion sickness. Users experience differing symptoms to varying degrees.
Proposed Causes of Simulator Sickness

- Lag (DiZio & Lackner, 1997; Cobb, Nichols, Ramsey, & Wilson, 1999)
- Field of view (DiZio & Lackner, 1997)
- Image scale factor (Draper, Viirre, Furness, & Gawron, 2001)
- Occlusion of peripheral vision with eye cups (Moss & Muth, in press)
HMDs and the Visual System

- Visual fatigue due to a disruption of the natural relationship between accommodation and vergence
- Heterophoria caused by disruption of the link between accommodation and vergence
- Unlikely to cause nausea and disorientation, but are likely to increase symptoms like sore and aching eyes
Hypotheses

- Wearing an HMD would cause a change in dark vergence posture.
- Wearing an HMD would cause a change in dark focus.
- There would be a correlation between dark vergence posture and simulator sickness.
- There would be a correlation between dark focus and simulator sickness.
Participants

- 21 participants
- 10 males and 11 females
- 18 – 22 years of age
- Clemson University students
- Paid $10/hr for their time
Sickness Measures

- Motion sickness was measured using the Motion Sickness Assessment Questionnaire (MSAQ; Gianaros, Muth, Mordkoff, Levine, & Stern, 2001).

- Simulator sickness was measured using the Simulator Sickness Questionnaire (SSQ; Kennedy, Lane, Berbaum, & Lilienthal, 1993).
Resting Oculomotor Measurements

- Dark Vergence
  - Vergamatic II
  - Modified Binary Search (MOBS) algorithm (Tyrrell & Owens, 1988)

- Dark Focus
  - Grand Seiko WV–500 Auto–Refractometer
Head Mounted Display

- Kaiser Electro–Optics Inc. *ProView XL50 HMD*
- Bi–ocular HMD
- Eye cups were used to occlude peripheral vision
- Uniq *UC–610CL color digital camera*
- Camera lag program software was created using the programming library for image acquisition and control from Dalsa’s *Sapera LT*
- ~200 milliseconds of camera lag
HMD and Camera
Procedure

- Dark focus measurements and interpupillary distance (IPD) were acquired using the Auto Refractometer
- Dark vergence posture was measured using the Vergamatic II
- 2 practice object location trials
- 5 object location trials
- Post experiment measurements of dark focus and dark vergence posture
MSAQ and SSQ Administration

- **MSAQ**
  - Pre practice trials
  - Pre experimental trials
  - Post experimental trials

- **SSQ**
  - Pre practice trials
  - Pre experimental trials
  - Between each experimental trial
  - 2 post experimental trial SSQs
Object Location Task

- 5, 2 minute trials
- ~1 minute break between trials
- 8 objects
- Administered via tape recording
- 40 head movements
- 3 second intervals between objects
Objects

office door  clock  flag  fire extinguisher

front door  first aid  fan  curtain
Results

- Dark Vergence and Simulator Sickness
  - Simulator sickness scores among the sickest half of participants were positively correlated with dark vergence degrees before HMD exposure ($r = 0.670$, $p < 0.05$)

- Dark Focus and Simulator Sickness
  - Peak sweating reports were negatively correlated with dark focus in the left eye before HMD exposure ($r = -0.598$, $p < 0.01$)
  - Peak vertigo reports positively correlated with dark focus of the left eye after HMD exposure ($r = 0.593$, $p < 0.01$)
Conclusions

- Hypotheses only partially supported
- In most cases no relationship was found between oculomotor resting states and SSQ scores
- Small sample size
- Adjusting HMD displays to the IPD of the user
- The relationships that were observed warrant further investigation


