Blink Rate And Pupil Size Changes As Biomarkers For Hypoxic Incapacitation

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Disclosure Information

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I have the following financial relationship to disclose:

• Grant/Research support from: Swiss Defense Procurement Agency (Armasuisse)

I will not discuss off-label use and/or investigational use in my presentation

I am employed in Mayo Clinic, Scottsdale, Arizona.
Learning Objective

• The effect of hypoxia on blink rate and pupil size during cognitive and scanning tasks.
**Introduction**

- Effects of **cerebral hypoxia**
  - Cognitive impairment
  - Adverse influence on judgment and decision-making capacity.

- **FOCUS:** Noninvasive and neurophysiological biomarkers to detect early signs of hypoxia

- **Visual performance** measures
  - Direct physiological signs of cognitive activity
Oculometrics in Hypoxia

- Decreased pupil diameter, constrictor amplitude and latency, and an increase in saccadic velocity (Cymerman 2005).

- Fluctuation in pupil diameter (Thompson 1981, Wilson 2008)

- No effect on saccadic performance (Merz 2013)
Eye Movements and Cognitive Performance

• Eye movement metrics could discriminate
  • Problem Solving - relaxed vs. engaged cognitive states,
  • Visual Search - fatigue vs. alertness, and
  • Driving Simulation - distracted vs. focused driving. *(Marshall 2007).*

• Fixational eye movements as relevant indicators of attention and cognitive engagement *(Martinez-Conde 2008)*

• Blink metrics has been linked to cognitive activity *(Wong 2002)*
Open Problems

• Oculometric changes were not studied in the early phase of the hypoxic exposure.

• Quantitative measurements of eye movement metrics can be problematic due to varying levels of mental workload.

• Need more studies to report changes due to acute, severe exposure (>6,096m or 20,000ft) to altitude.
Objective

• Evaluate the effect of hypoxia on **blink rate** and pupil size

  • during cognitive and scanning tasks
  • during an acute hypoxic exposure to a simulated altitude of 22000 ft (6705 m).
Methods

A non-invasive eye-tracking device during a validated cognitive challenge task (the King-Devick (K-D) test)

• 25 subjects (M:F=14:11)

**Step 1:** K-D learning process

**Step 2:** K-D baseline test in Normoxia

**Step 3:** 3 min Hypoxia

(8% O₂ = 22000 ft or 6705 m)

**Step 4:** K-D Hypoxic test

**Step 5:** 3 min Normoxia

**Step 6:** K-D Post-baseline
Results

**Blink Rate**

- Baseline
- Hypoxic Hypoxia
- Post-Baseline

**Fluctuation in Pupil Size**

- Baseline
- Hypoxic Hypoxia
- Post-Baseline

- $P = 0.025$
- $P = 0.05$
Conclusions

• The significant increase in blink rate and fluctuation of the pupil size while performing cognitive and scanning tasks are associated with hypoxia.

• The detection of these changes in safety critical operators (pilots, mountaineers etc) could be useful as an early sign of impending hypoxic incapacitation.
Questions & Discussion