Color Vision Assessment in Normobaric Hypoxia

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  – The authors and presenter have no financial relationships to disclose.
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• **Purpose**
  • Assess the effects of normobaric hypoxia on the color vision of military aviators (met current color vision standards)

• **Subjects**
  • N = 26
    – 21 helo pilots, 5 flight crew
    – 24 males, 2 females
  • Age
    – Average = 35 (SD = 5.25) years
  • Flight hours
    – Average = 1580 (SD = 750) flight hours (N = 19) and
    – 5 student pilots with 200 < hours

• **Test order was always**
  – LD-15, CCT (L,M,S) and then the CAD
• **Design**
  – Repeated measures
    • All subjects, all measurements, 2 altitude conditions
  – Altitude Conditions
    • Mean Sea Level (MSL)
    • 14,000 ft above MSL normobaric equivalent
      – Half the Ss experienced MSL then 14k condition
      – Half the Ss experienced 14k then MSL condition
    » All Ss familiarized with all procedures at MSL before start of study
Reduced Oxygen Breathing Device (ROBD-2)

Parvo Medics TrueOne 2400 Metabolic Measurement System (CART)
Representative Physiological Data
(CAD Test)

<table>
<thead>
<tr>
<th></th>
<th>Sea Level</th>
<th>T-test probability</th>
<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Test Duration</td>
<td>20.44</td>
<td>1.71</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>% Oxygen in inspired air</td>
<td>21.09</td>
<td>0.11</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>SPO2</td>
<td>97.14</td>
<td>4.42</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Pulse Rate</td>
<td>66.99</td>
<td>9.92</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Respiration Rate</td>
<td>15.57</td>
<td>2.96</td>
<td>0.058</td>
</tr>
<tr>
<td>Fraction of Expired O2</td>
<td>17.33</td>
<td>0.34</td>
<td>0.131</td>
</tr>
<tr>
<td>Fraction of Expired CO2</td>
<td>3.18</td>
<td>0.32</td>
<td>0.035</td>
</tr>
</tbody>
</table>

A Couple of Notable Exceptions for the CCT and LD15
Subjects required the same amount of time to complete both tests at MSL and Altitude.
Subjects in CCT and Lanthony Trials had a lower fraction of Expired \( \text{O}_2 \) at MSL
The expired \( \text{CO}_2 \) was not different between MSL and altitude for the CCT and for the Lanthony Trial.
Color Assessment and Diagnosis (CAD) Test
(John Barbur)
CAD System 1 November 2008
Yellow-Blue axis

Red-Green axis

= Approximate normal color threshold
Slightly larger increase in B-Y thresholds based on JND units
Cone Contrast Test
(Jeff Rabin)
Innova Provideo1 Version 18 July 2011
CCT Test Results

<table>
<thead>
<tr>
<th>Number Correct</th>
<th>Sea Level</th>
<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>L-Cone</td>
<td>24.35</td>
<td>0.00</td>
</tr>
<tr>
<td>M-Cone</td>
<td>23.96</td>
<td>2.46</td>
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<tr>
<td>S-Cone</td>
<td>24.50</td>
<td>0.95</td>
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</table>

<table>
<thead>
<tr>
<th>Response Time (sec)</th>
<th>Sea Level</th>
<th>Altitude</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>L-Cone</td>
<td>1.90</td>
<td>0.26</td>
</tr>
<tr>
<td>M-Cone</td>
<td>2.00</td>
<td>0.24</td>
</tr>
<tr>
<td>S-Cone</td>
<td>1.91</td>
<td>0.22</td>
</tr>
</tbody>
</table>

CCT not sensitive to the effects of hypoxia
Lanthony Dichotomous-15 Test
LD-15
(Philippe Lanthony)
Lanthony Desat D15

Desaturated & Higher Value (Luminous Brightness) than Farnsworth D15
Results:

Color Difference Vector Analysis

<table>
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<tr>
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<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>F probability</td>
</tr>
<tr>
<td>S-Index</td>
<td>1.70</td>
<td>0.41</td>
<td>0.723</td>
</tr>
<tr>
<td>C-Index</td>
<td>1.34</td>
<td>0.42</td>
<td>0.174</td>
</tr>
<tr>
<td>Angle</td>
<td>49.41</td>
<td>42.81</td>
<td>0.662</td>
</tr>
</tbody>
</table>

- S-Index scores the scatter of the points
  - 1.42 corresponds to a perfect arrangement
- C-index scores deviation from ideal performance
  - 1.0 corresponds to a perfect score
- Angle is the primary axis of color confusion
  - 45 degrees corresponds to a perfect arrangement
- LD-15 not sensitive to the effects of hypoxia
Conclusions

Sensitive enough to pick up hypoxic effect under photopic adaptation?

Yes

No

No