Cone Contrast Test for Color Vision Deficiency Screening Among Trained Military Aircrew and Flying Related Vocations

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I have no financial relationships to disclose.

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

The views expressed are the sole opinion of the presenter and do not necessarily reflect the views and the opinions of the Republic of Singapore Armed Forces and Republic of Singapore Air Force.
Introduction

- RSAF reviewed and replaced its color vision testing modality in 2016
- Pre-July 2016: Concept of color safe
  - Primary - Ishihara Pseudo Isochromatic Plates
  - Secondary - Edridge Lantern Test
- Post-July 2016: Computerised Color Vision
  - Cone Contrast Test
    - Led to an increase of applicant attrition from 0.75% to 3%¹

¹ Isaac Chay, Shawn Lim, Benjamin Tan. Cone Contrast Test for Colour Vision Deficiency Screening Among a Cohort of Military Aircrew Applicants; 2017.
Cone Contrast Test

<table>
<thead>
<tr>
<th>Score</th>
<th>L Cone</th>
<th>M Cone</th>
<th>S Cone</th>
<th>Cone Contrast (%)</th>
<th>L, M</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>VZ</td>
<td>NF</td>
<td>EZ</td>
<td>27.5</td>
<td>173</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>FV</td>
<td>ZU</td>
<td>NR</td>
<td>19.1</td>
<td>120</td>
<td></td>
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<tr>
<td>30</td>
<td>RP</td>
<td>EP</td>
<td>FD</td>
<td>13.2</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>ZNP</td>
<td>ZV</td>
<td></td>
<td>9.1</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>HR</td>
<td>ED</td>
<td>RP</td>
<td>6.3</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>DR</td>
<td>HP</td>
<td>ZN</td>
<td>4.4</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>NZ</td>
<td>DU</td>
<td>ED</td>
<td>3.0</td>
<td>19</td>
<td></td>
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<tr>
<td>80</td>
<td>UV</td>
<td>FH</td>
<td>VR</td>
<td>2.1</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>ER</td>
<td>DN</td>
<td>FD</td>
<td>1.4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>DV</td>
<td>RE</td>
<td>NP</td>
<td>1.0</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

The scores correspond to the difficulty level of the test:
- **Mild** color deficiency for scores 70-100
- **Severe** color deficiency for scores 10-30
- **Normal color vision** for scores 40-60

The diagram on the right shows a letter R displayed with different colors, indicating the test's visualization.
Cone Contrast Test

- Score for each cone type (L,M,S)
- The CCT score for each eye is pegged to the cone type with the lowest score
- The lower score of both eyes will be used as the overall score
Methodology

• Retrospective cohort study from Nov 2016 to June 2018

• All trained military aircrew and controllers who underwent CCT as part of their annual medical screening
  
  • All had best corrected VA of 20/20 or better
  
  • All had no ocular pathology
Trained Aircrew and Controllers

CCT score $\geq 75$

Pass

CCT score $< 75$

OR

$\geq 15$ points difference between eyes

CCT score $\geq 75$

Pass FALANT

Color Safe

FALANT

Fail FALANT

Unfit for vocational duties

Medical Review; Workplace Functional Assessment
Workplace Functional Assessment
Results

• 143 trained military aircrew and ground based crew, including UAV operators and air-traffic controllers with abnormal CCT score

• Four personnel underwent ophthalmological review, workplace functional assessment with aviation medical officer and qualified instructor:
  – One unfit
  – Three returned to restricted vocational duties
Results

• All four who failed FALANT were controllers with PMhx of diminished colour vision
• Reviewed by Ophthalmologist: no ocular pathology
• Three out of Four who passed FALANT
  – Workplace Assessment: deemed functionally safe
  – Aeromedical Board: restricted control duties to specific platform and yearly FALANT
Discussion

- CCT is an effective colour vision test in identifying and quantifying colour vision deficiency
  - High sensitivity/specificity
  - Good repeatability and Fast administration
  - Impossible to memorise
- Majority of trained aircrew and controllers who previously passed colour vision testing continued to pass CCT
Discussion

• Decision matrix for trained aircrew and controllers with abnormal CCT score
  – Maintaining **flight safety**
  – **Retention** of trained personnel
• Waiver management is dependent on the etiology and severity of colour deficiency
  – Workplace functional assessment
  – Aeromedical board for case dependent restrictions