



Naval Medical Research Unit Dayton

Assessment of Color Vision Screening Tests for U.S. Navy Special Duty Occupations

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Objectives



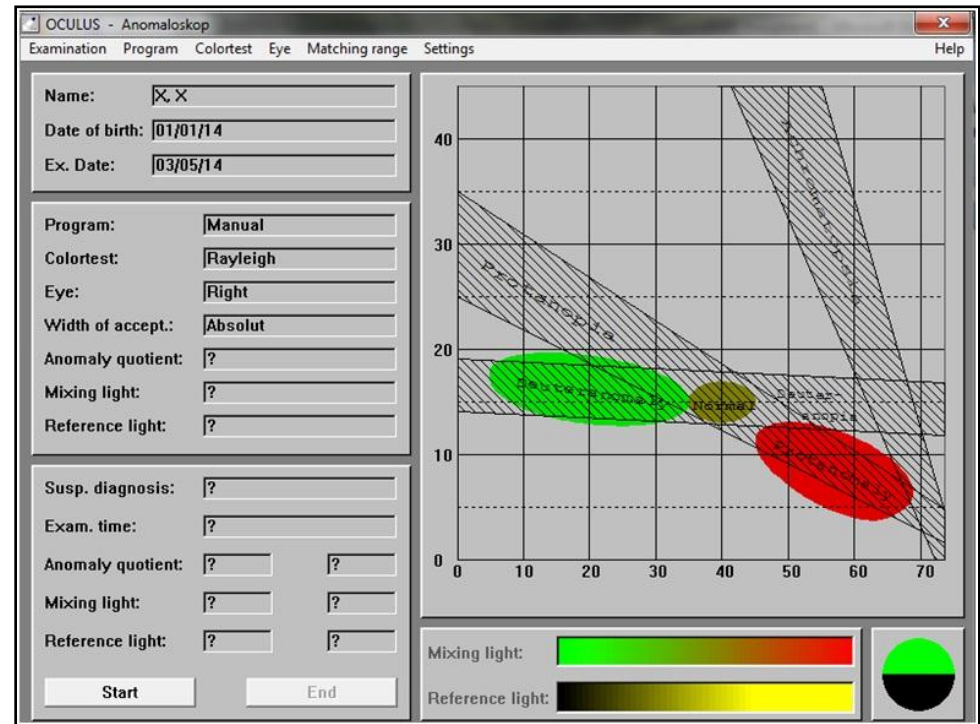
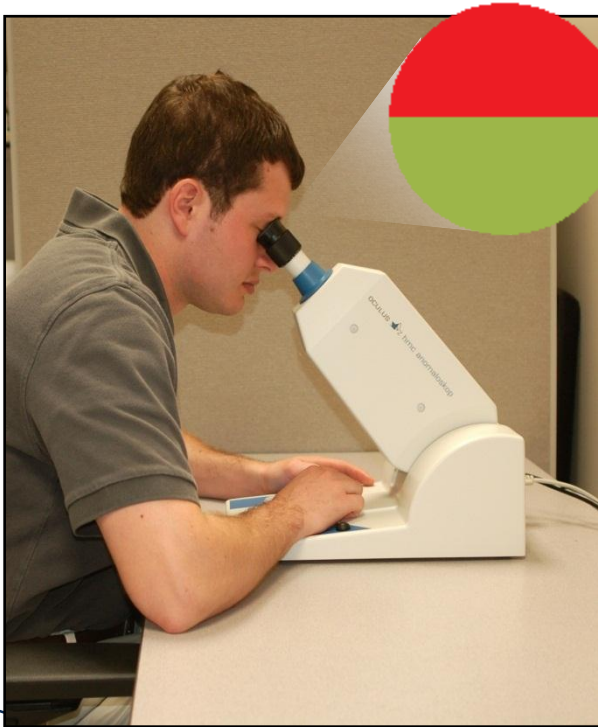
- Compare the diagnoses of two current and four proposed color vision tests (CVTs) to the HMC-RT anomaloscope
- Use a signal detection model to assess the sensitivity of each test
- Assess the degree to which the severity of a color-vision deficiency (CVD) affects human performance in aviation-related tasks



Method

Oculus HMC-RT anomaloscope

- The HMC-RT anomaloscope was used to determine color-normal and color-deficient (CVDs) participants, as well as to classify the type of color deficiency; monocular administration





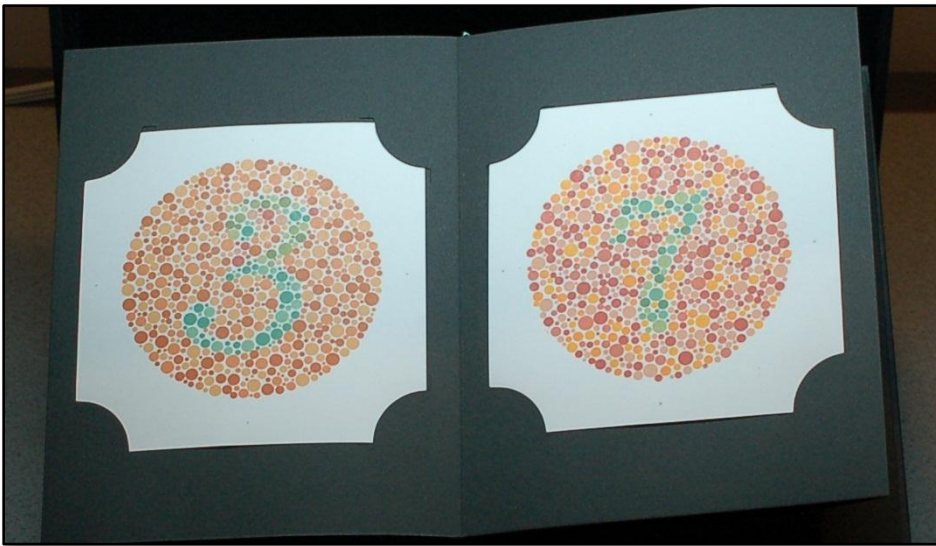
Method



Current USN aviation color-vision selection standards

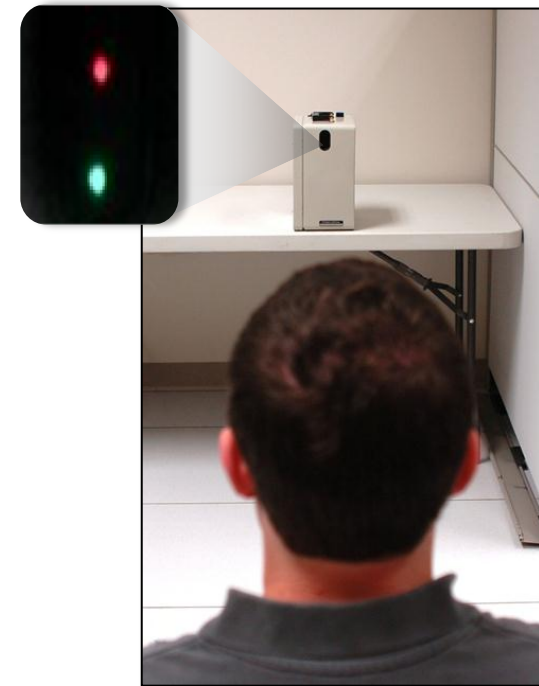
Ishihara Pseudo-isochromatic Plates (PIP)

- 24-plate version (plates 2-15)
- USN passing criteria:
 - Must correctly identify at least 12/14 plates



Optec-900

- FALANT equivalent
- USN passing criteria:
 - Must correctly identify 9/9 or 16/18 presentations





Method

Computer-based CVTs

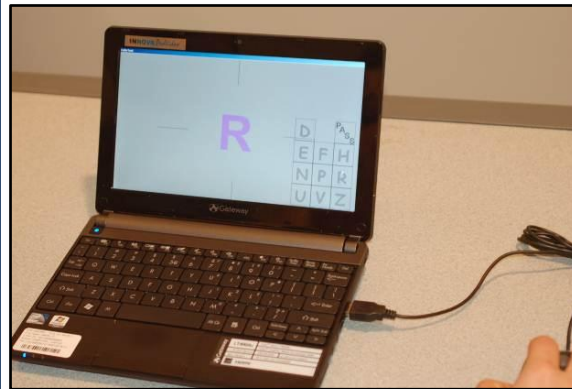
Colour Assessment and Diagnosis test (CAD)

- Manufacturer passing criteria:
 - Fast CAD: 100% correct
 - Full CAD:
 - Protan-like: Varies by age
 - Deutan-like: Varies by age



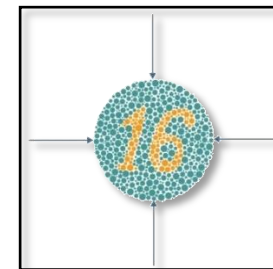
Cone Contrast Test (CCT)

- USAF passing criteria:
 - ≥ 75 for each section of the test (red, green, and blue)
 - Monocular administration



Waggoner Computerized Color Vision Test (WCCVT)

- Manufacturer passing criteria:
 - Screening section: $\geq 22/26$
 - Protan section: $\geq 28/32$
 - Deutan section: $\geq 28/32$
 - Tritan section: $\geq 10/12$



Nothing	
16	78
32	24
63	49
86	57

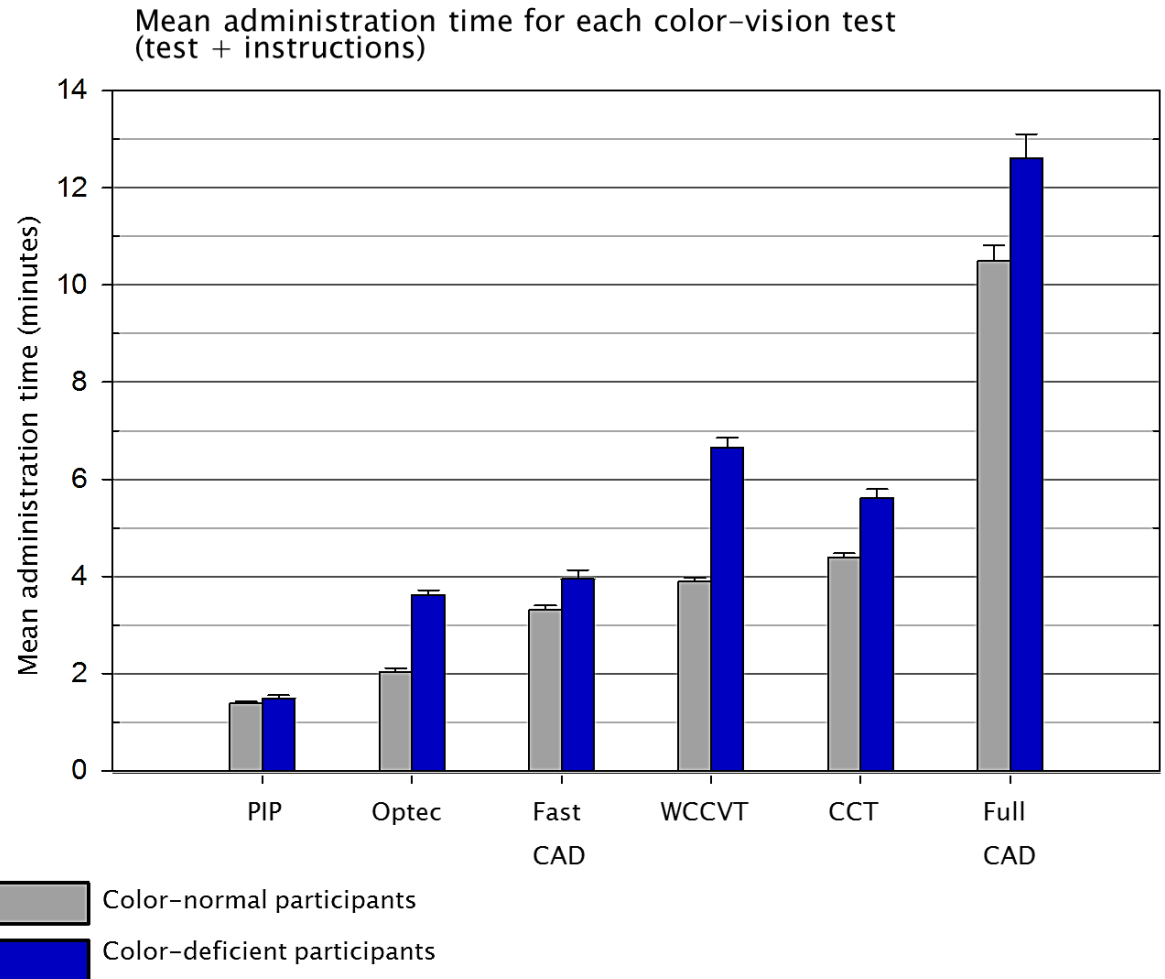


Method

Participants and procedures



- Participant population
 - 191 participants from USAFA, NAMI, NMOTC, and Naval Hospital Pensacola
 - Age range: 18–35
 - 17% female
- Procedures
 - All subjects completed anomaloscope first
 - Other CVTs were administered in counterbalanced order



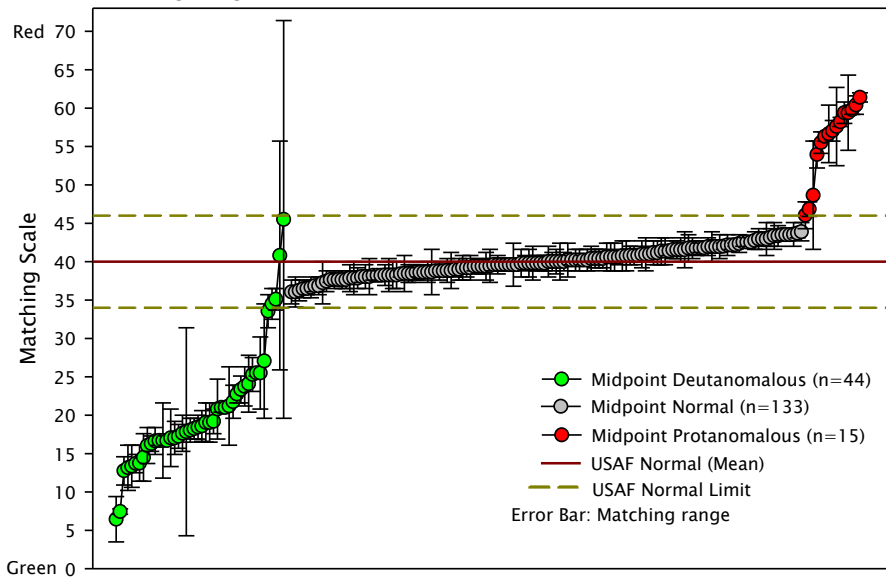


Results

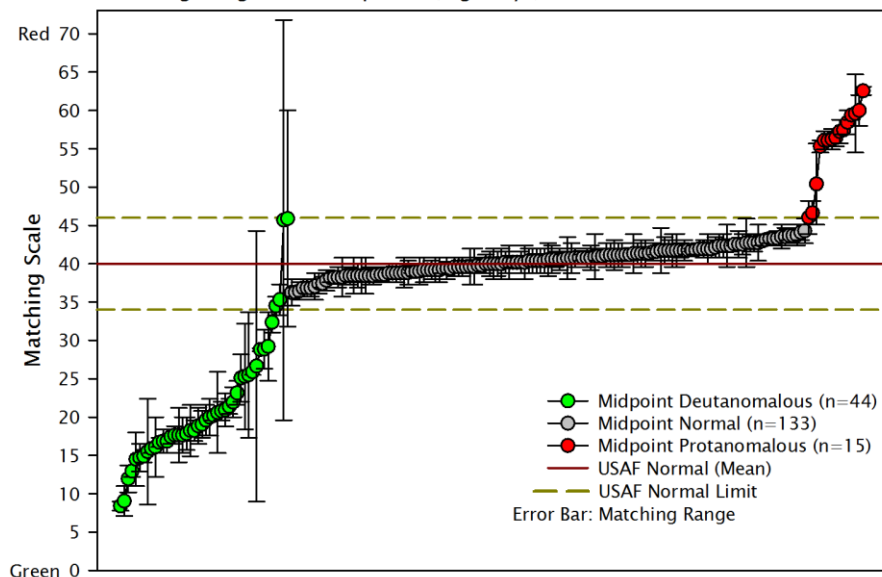


Color-vision classification by HMC-RT anomaloscope

Matching Ranges and Midpoints (Left Eye)



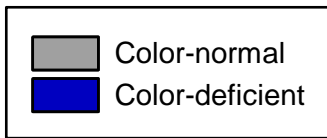
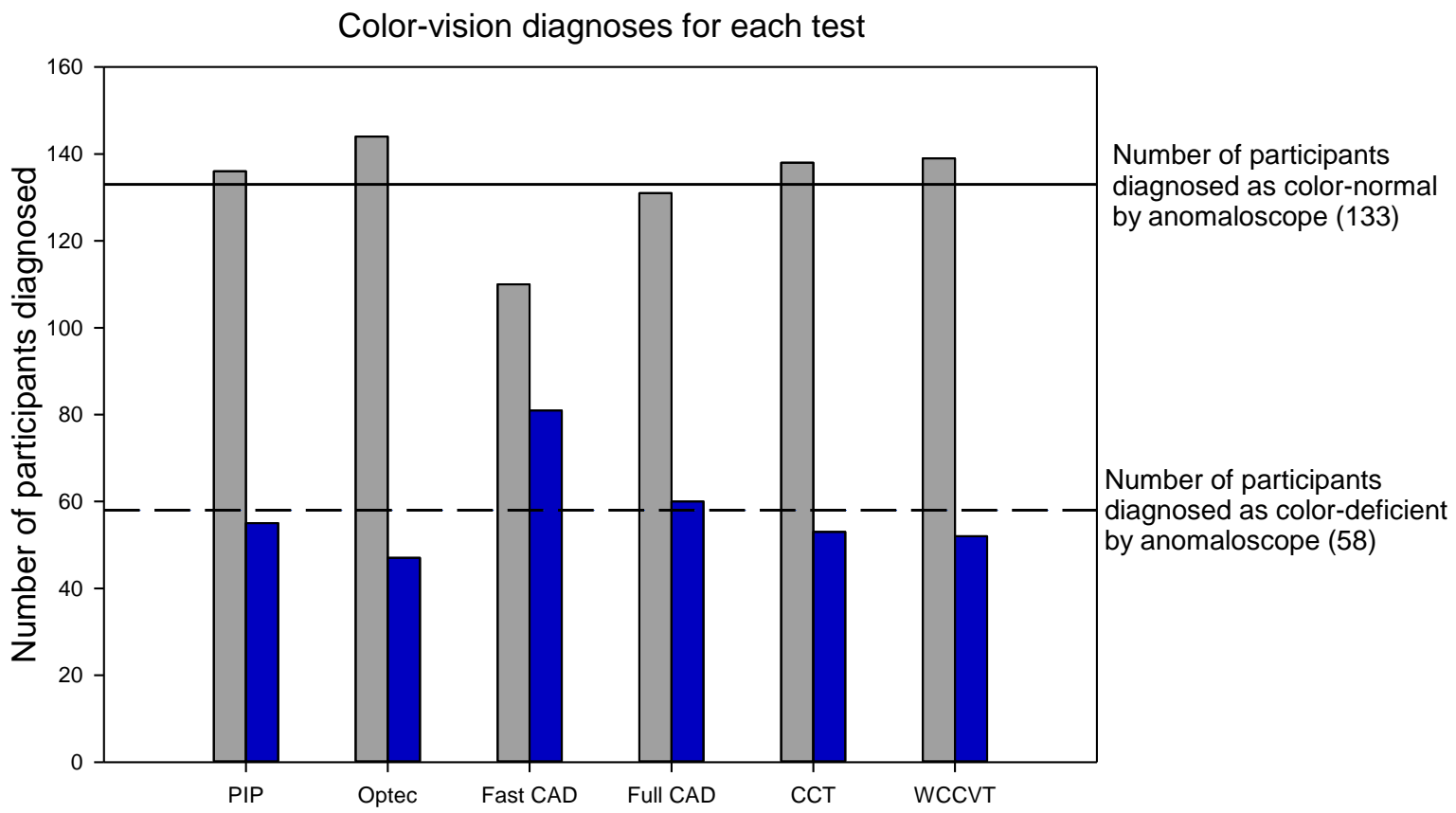
Matching Ranges and Midpoints (Right Eye)





Results

CVT performance



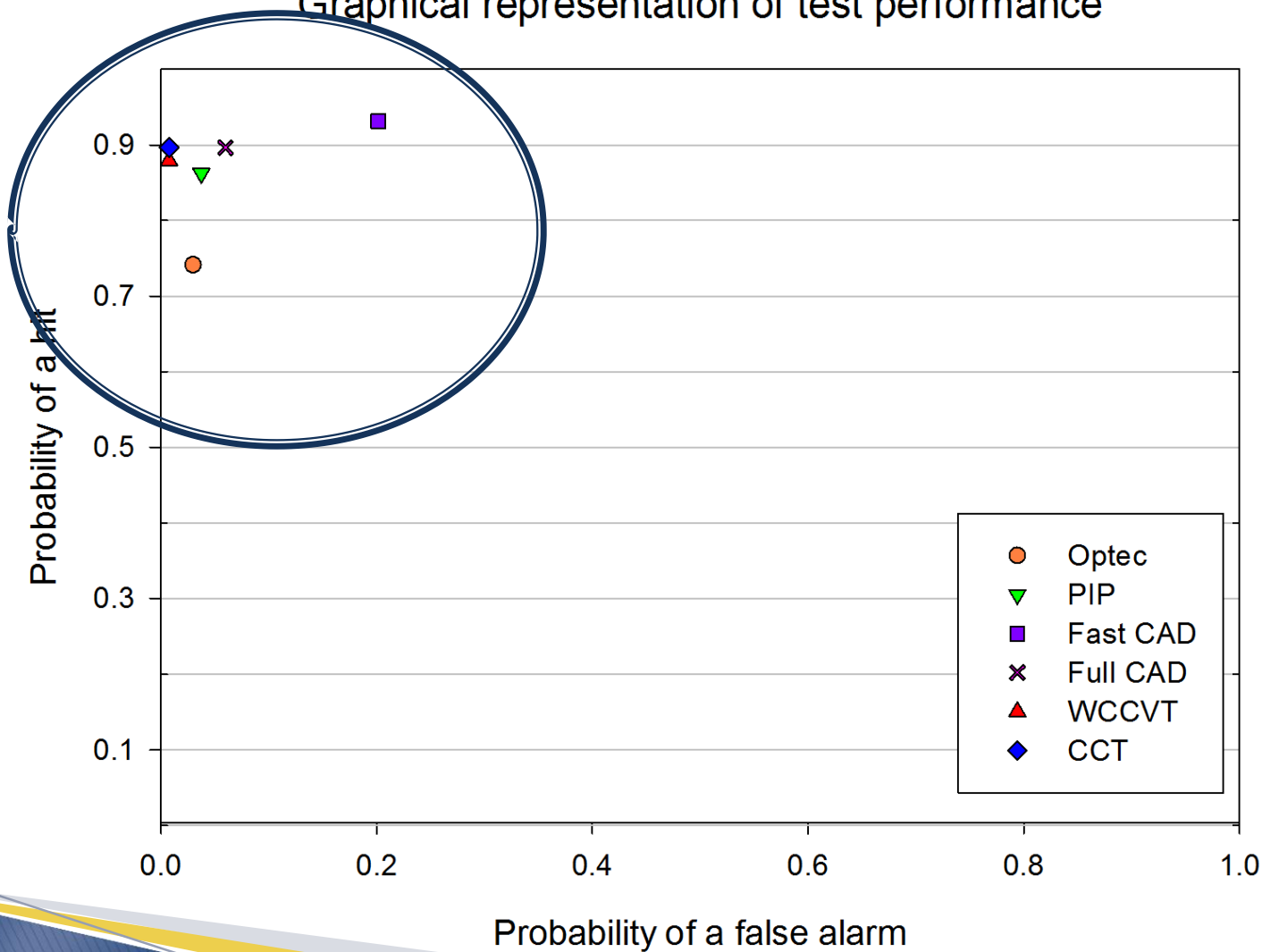


Results

CVT performance



Graphical representation of test performance



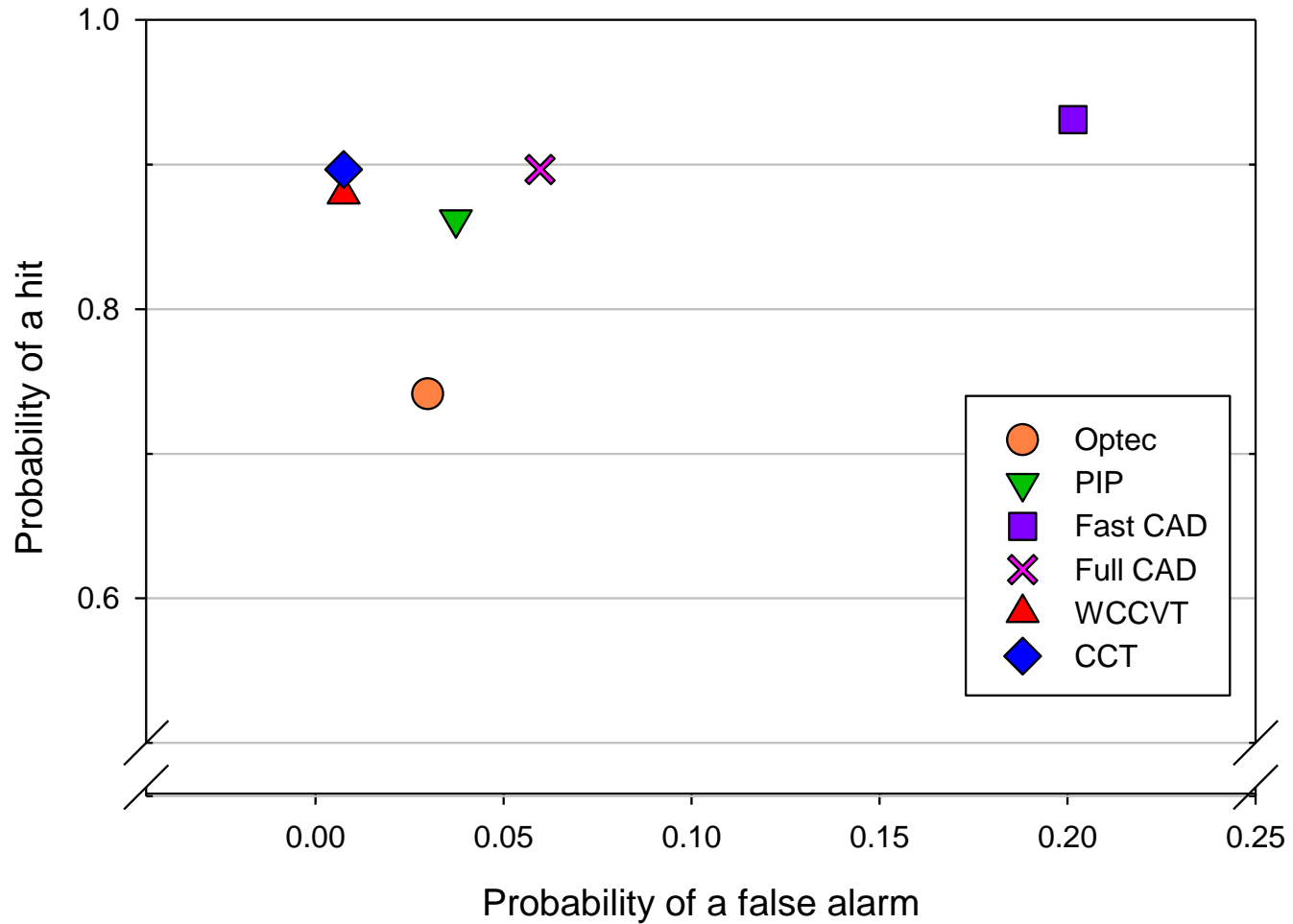


Results

CVT performance



Graphical representation of test performance





Method

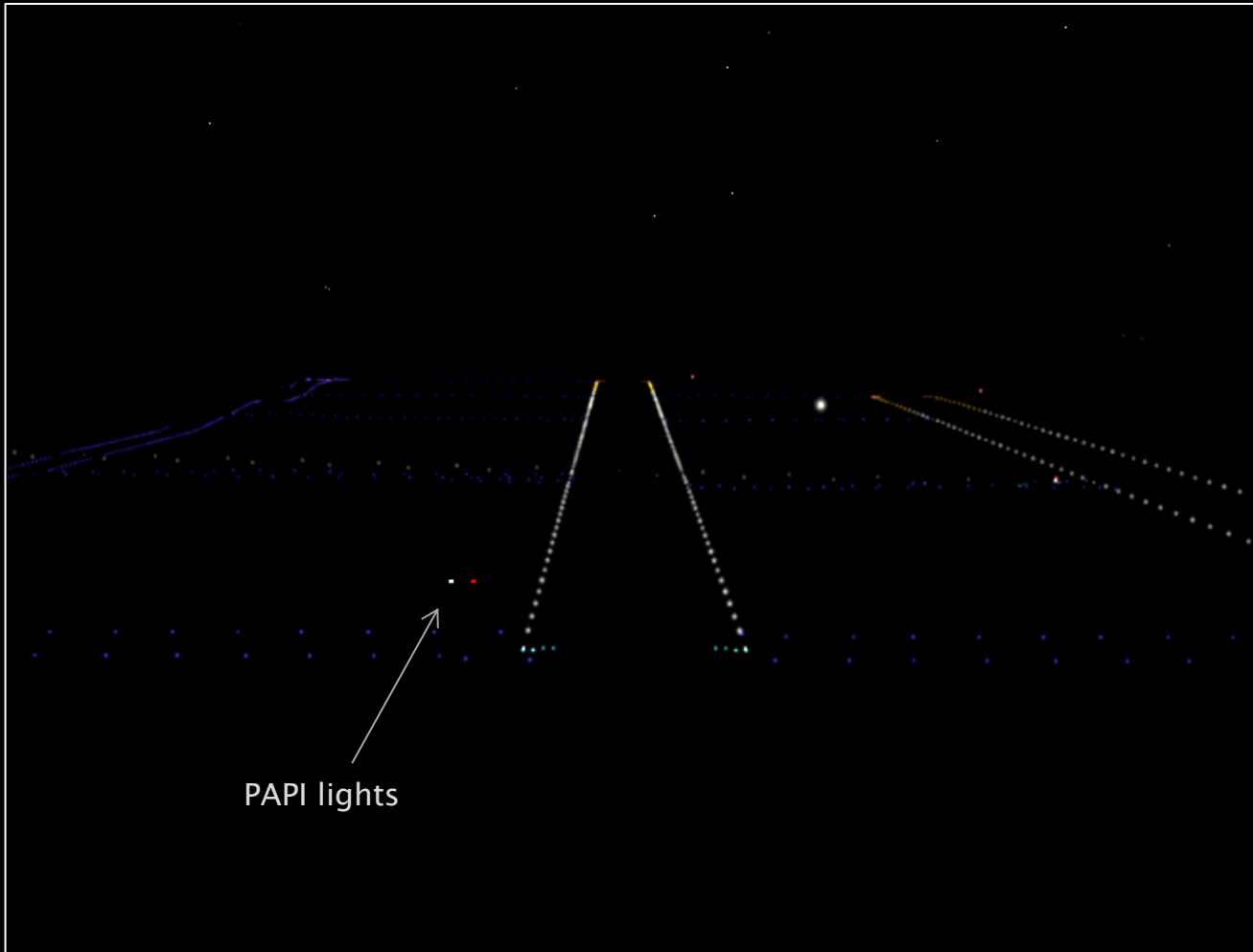


Development of aviation-related reaction time tasks

- Relate CVD type and severity to human performance
 - Out-of-cockpit color discrimination reaction time task
 - Precision Approach Path Indicator (PAPI)
 - FAA aviation red and white
 - In-cockpit display icon discrimination reaction time task
 - F/A-18E/F AMPCD glass cockpit colors (red, yellow, and green)
 - Tests were administered in counterbalanced order

Method

PAPI color-discrimination reaction time test

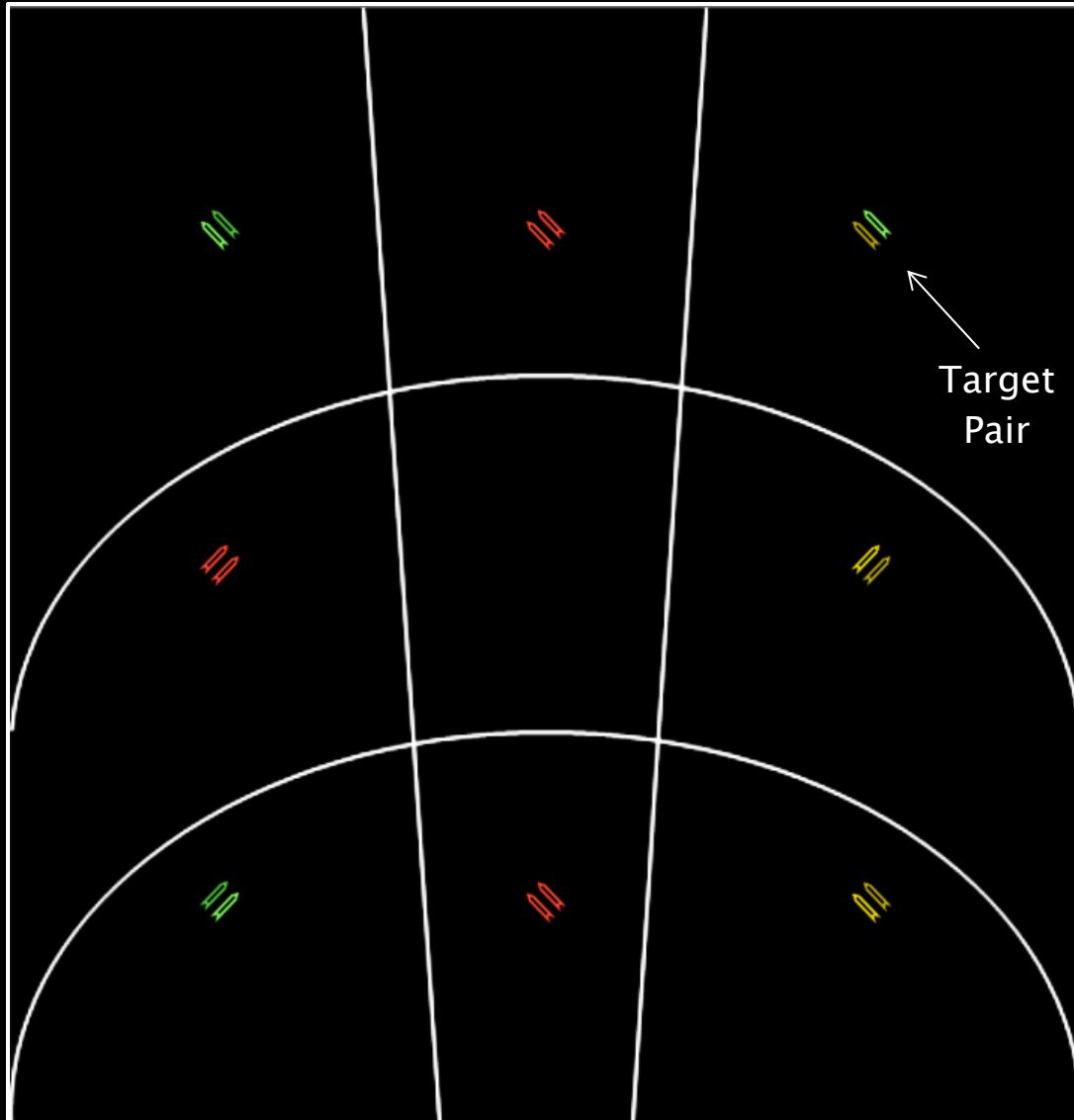


Low	● ●
On	● ●
High	● ●

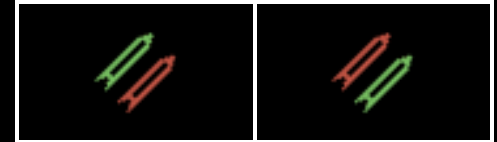
Simulated 1 NM view

Method

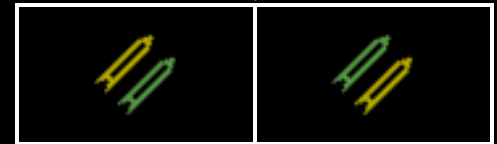
Display icon color-discrimination reaction time test



Green/Red



Yellow/Green



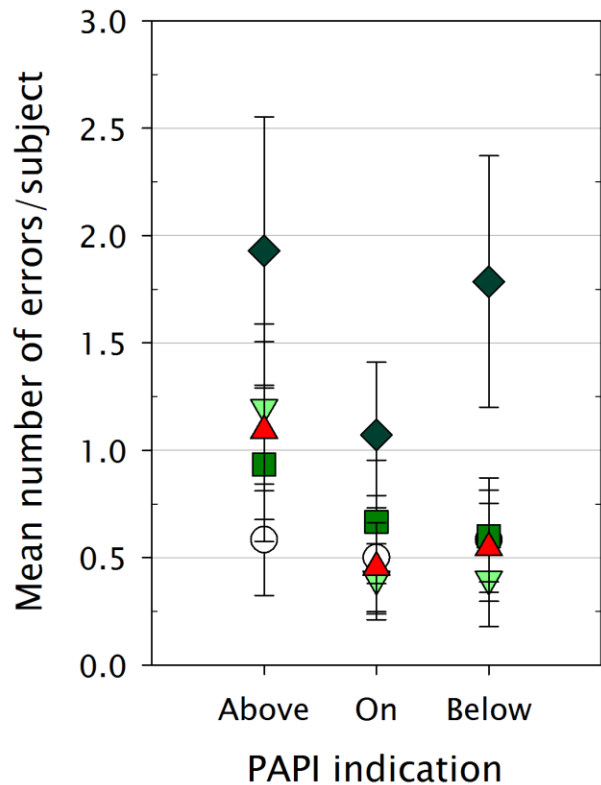


Results

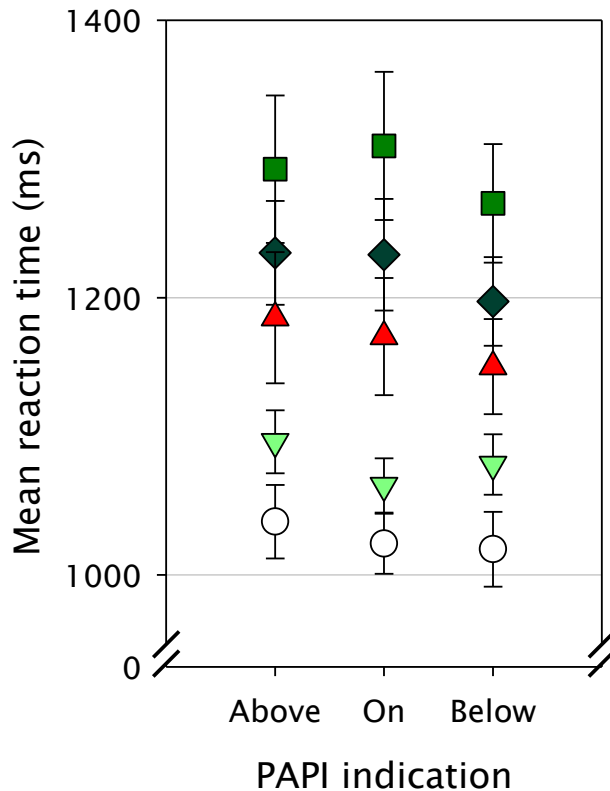
PAPI task



Mean number of errors per subject



Mean reaction time



- Color-normal (n=12)
- ▽ Mild Deutan (n=10)
- Moderate Deutan (n=15)
- ◆ Severe Deutan (n=14)
- ▲ Severe Protan (n=11)

Main effect of color-vision deficiency severity on accuracy (*p*-values)

	Color-normal	Mild Deutan	Moderate Deutan
Mild Deutan	0.995		
Moderate Deutan	0.973	0.999	
Severe Deutan	0.079	0.170	0.148

Main effect of color-vision deficiency severity on reaction time (*p*-values)

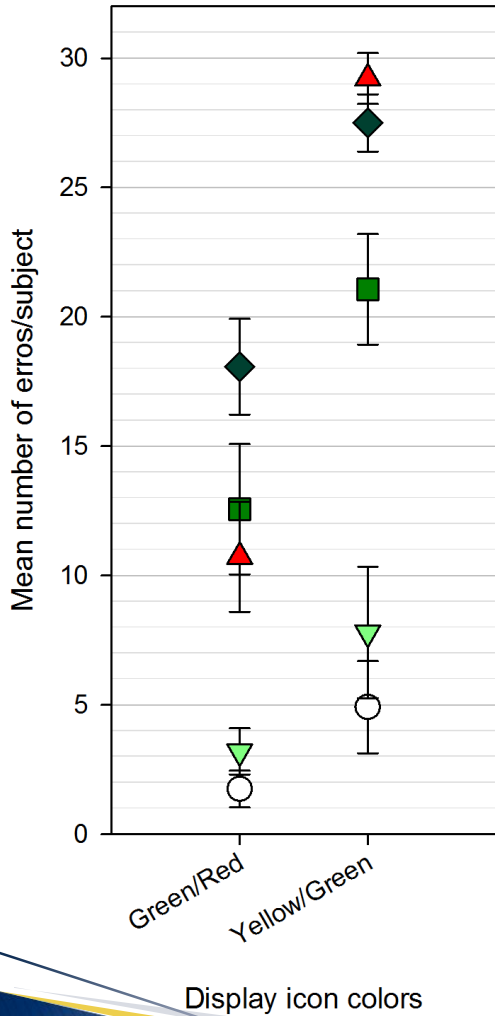
	Color-normal	Mild Deutan	Moderate Deutan
Mild Deutan	0.760		
Moderate Deutan	0.000	0.001	
Severe Deutan	0.002	0.051	0.460



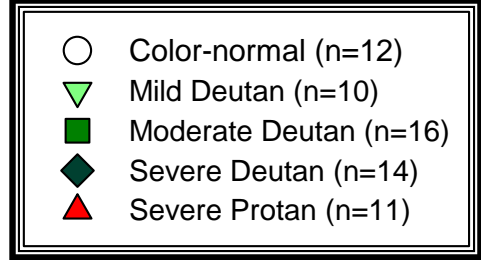
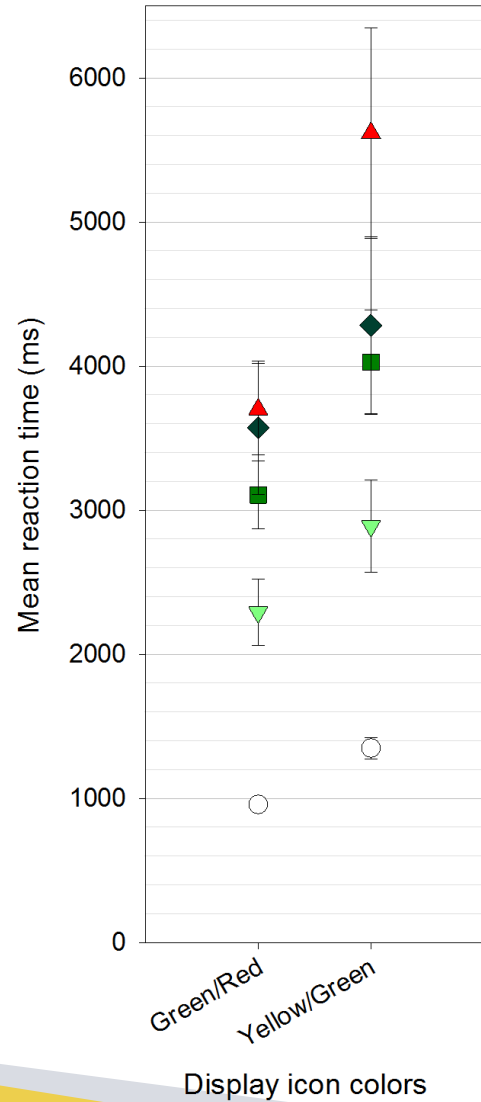
Results

Display icon task

Mean number of errors per subject



Mean reaction time



Main effect of color-vision deficiency severity on accuracy (p-values)

	Color-normal	Mild Deutan	Moderate Deutan
Mild Deutan	0.905		
Moderate Deutan	0.000	0.003	
Severe Deutan	0.000	0.000	0.065

Main effect of color-vision deficiency severity on reaction time (p-values)

	Color-normal	Mild Deutan	Moderate Deutan
Mild Deutan	0.039		
Moderate Deutan	0.000	0.169	
Severe Deutan	0.000	0.042	0.862



Optec performance



Color diagnoses of subjects failing PIP/passing Optec

- From the US Navy perspective is the Optec/FALANT still valid?
 - Official US Navy color vision test in 1954 to: “salvage those persons with a mild color vision defect who are not considered dangerous to Naval service”
 - 14 subjects failed the PIP, but passed the Optec

		Subjects (n)	Percentage
Normal*		5	36%
	Mild*	6	43%
Deutan*	Moderate*	2	14%
	Severe*	1	7%
Protan*		0	0
Total Subjects		14	
*Classification based on USAF standard (CCT). Score ranges: normal 75-100; mild 55-70; moderate 35-50; severe 0-30			

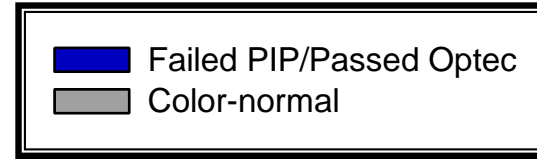
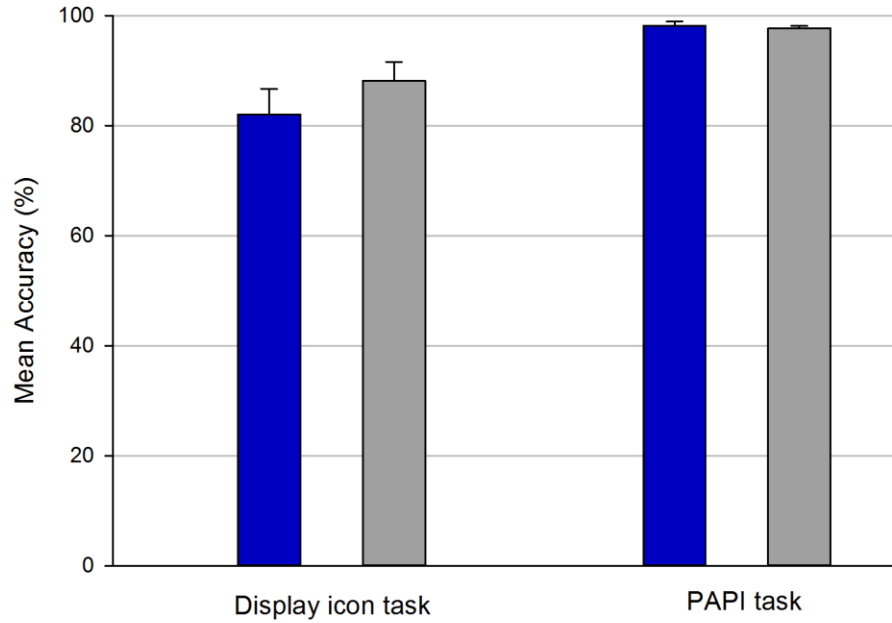


Optec performance

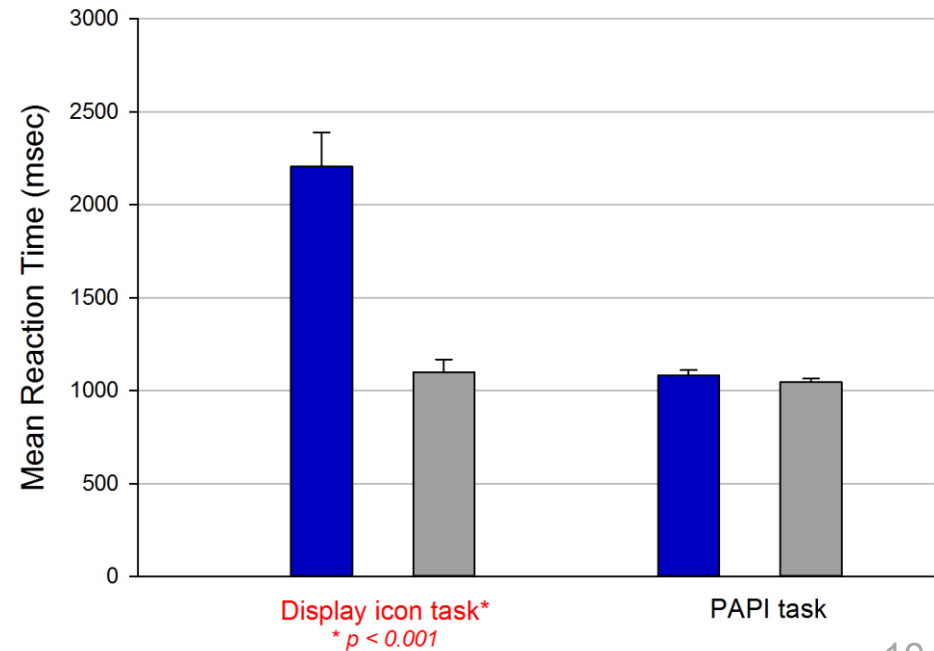
Reaction time task performance



Accuracy



Reaction Time





Summary



- Computerized color-vision tests (CAD, CCT, WCCVT) have near equal sensitivity (d').
- Glass cockpit color palette is likely to produce decrements in human performance for mild CVDs.
 - PIP + Optec screening criterion may be too liberal.
- Should selection standards development be tied to human performance metrics? If so, ideal test would have:
 - Valid sensitivity & specificity across a wide area of CIE color space
 - Severity scales that predictably relate to human performance
 - Severity scales offer greater flexibility for setting selection standards suitable for specific special duty occupations.

Questions?

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