



# *Naval Medical Research Unit Dayton*

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

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# Objectives



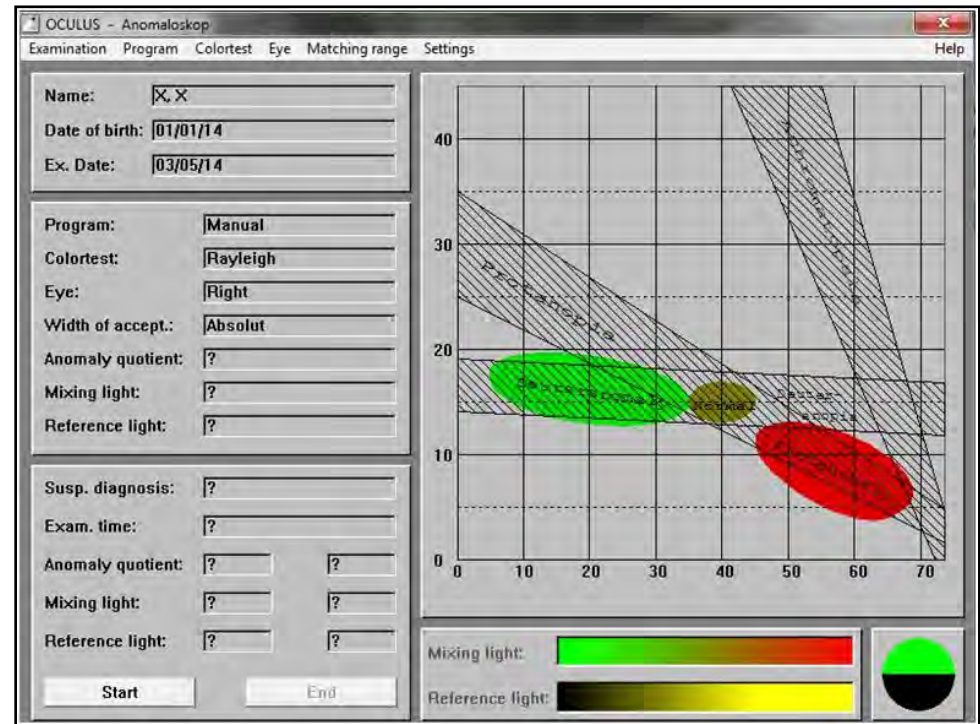
- Compare the diagnoses of two current and four proposed color vision tests (CVTs) to the HMC-RT anomaloscope
- Use a signal detection model to assess the sensitivity of each test
- Assess the degree to which the severity of a color-vision deficiency (CVD) affects human performance in aviation-related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





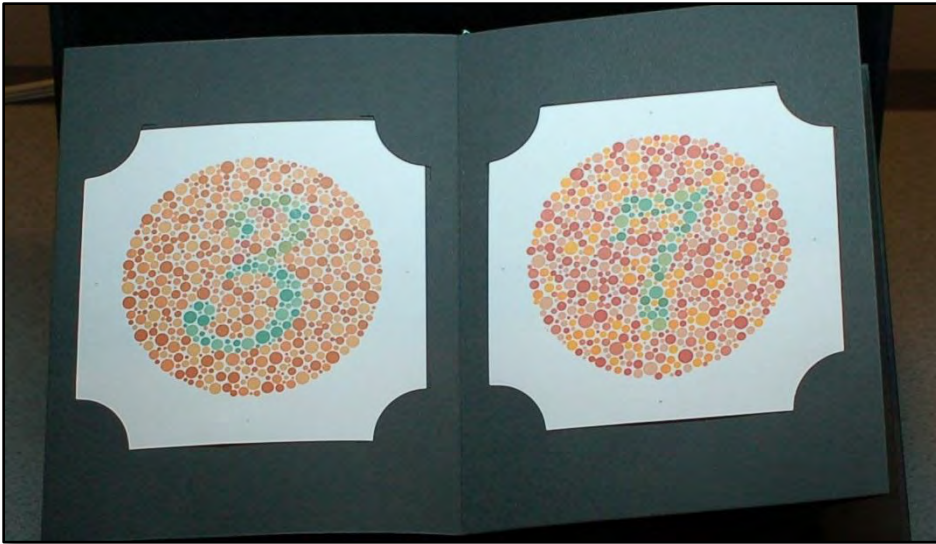
# Method



## 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

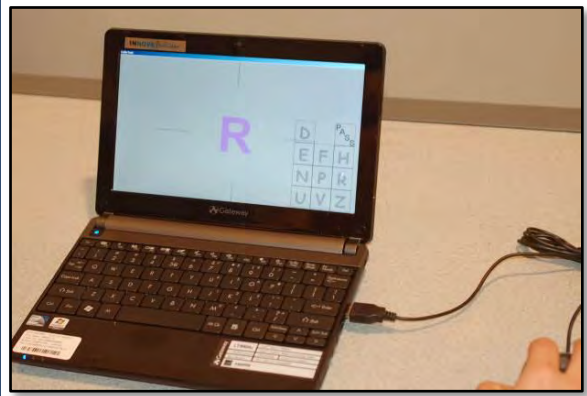
### Colour Assessment and Diagnosis test (CAD)

- 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:
  - $\geq 75$  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:  $\geq 10/12$



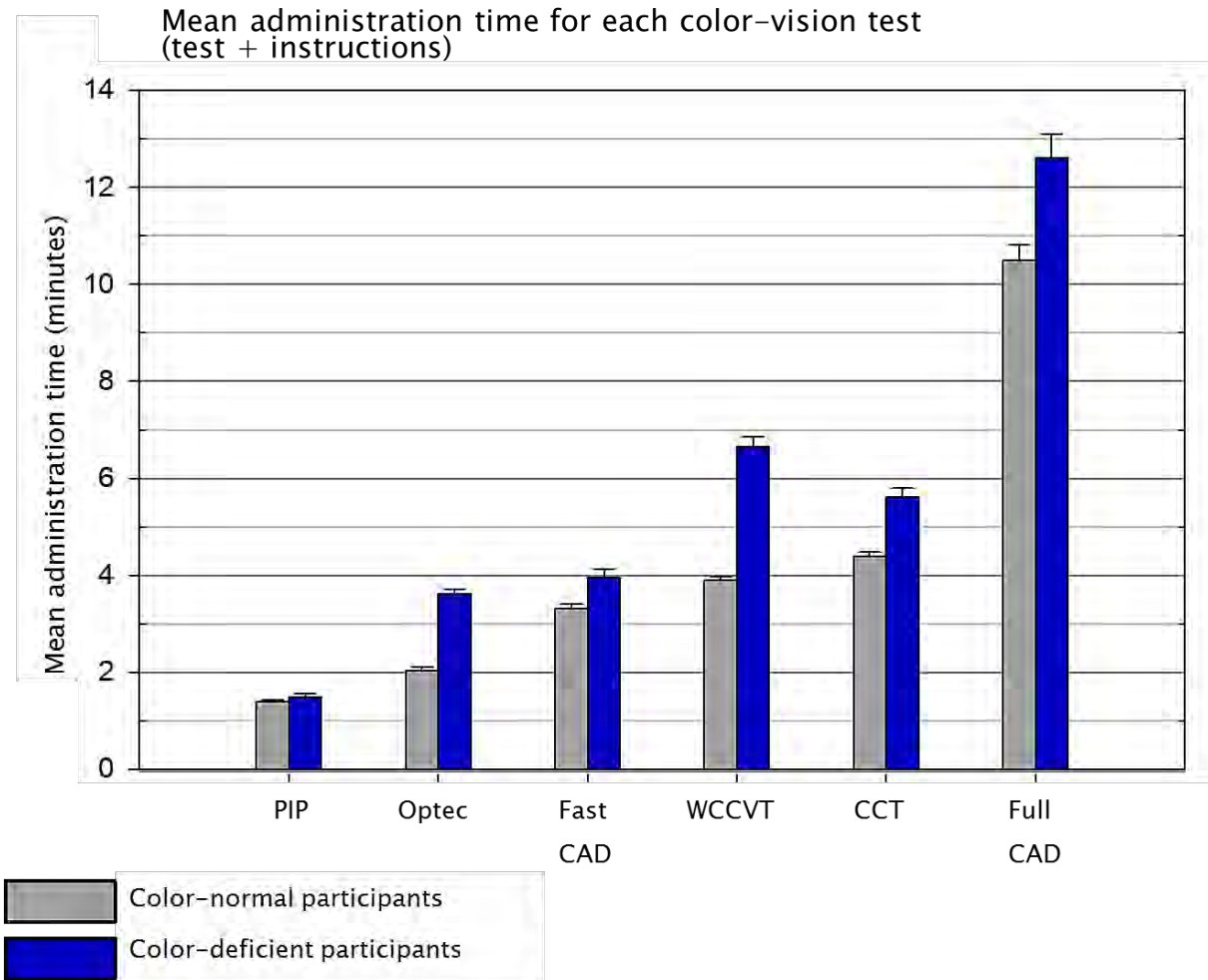
Nothing		
16		78
32		24
63		49
86		57



# 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



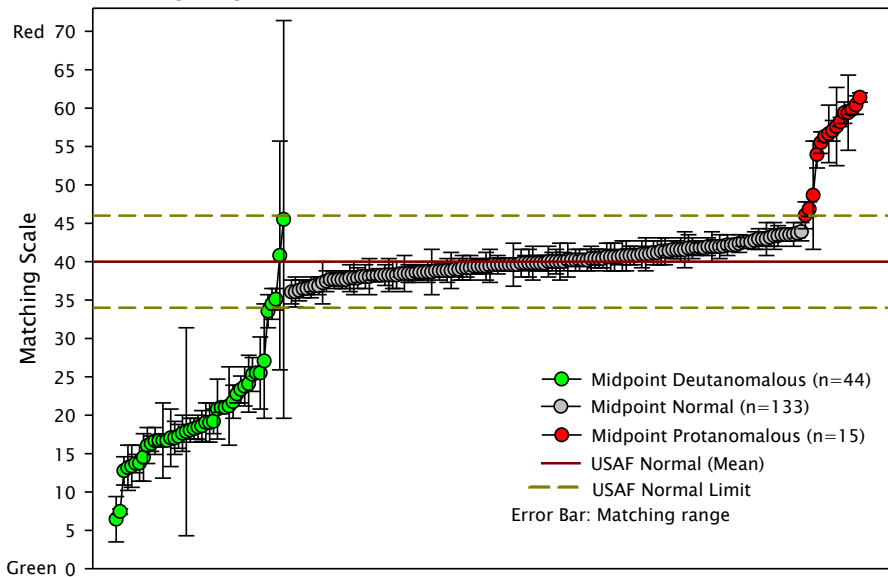


# Results

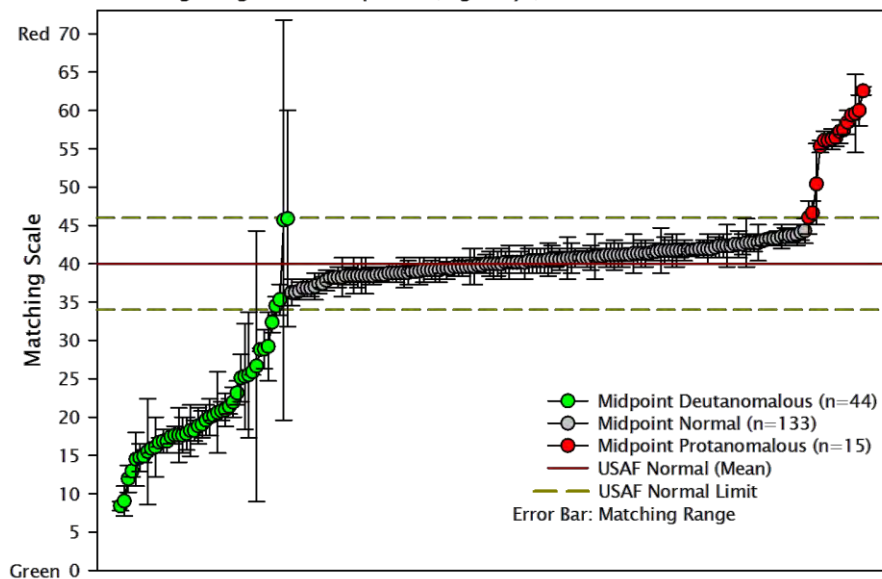
## Color-vision classification by HMC-RT anomaloscope



Matching Ranges and Midpoints (Left Eye)



Matching Ranges and Midpoints (Right Eye)

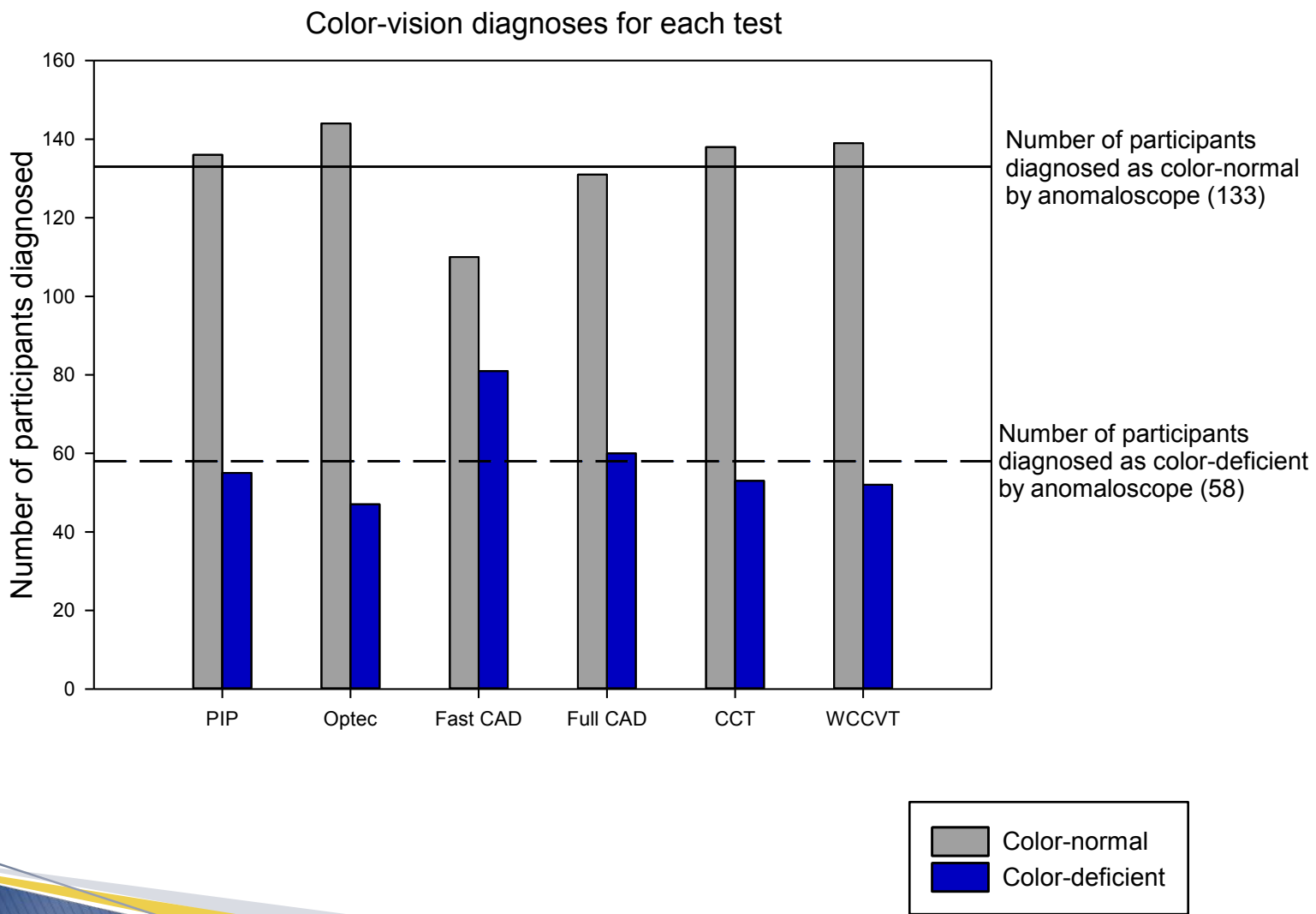






# Results

## CVT performance



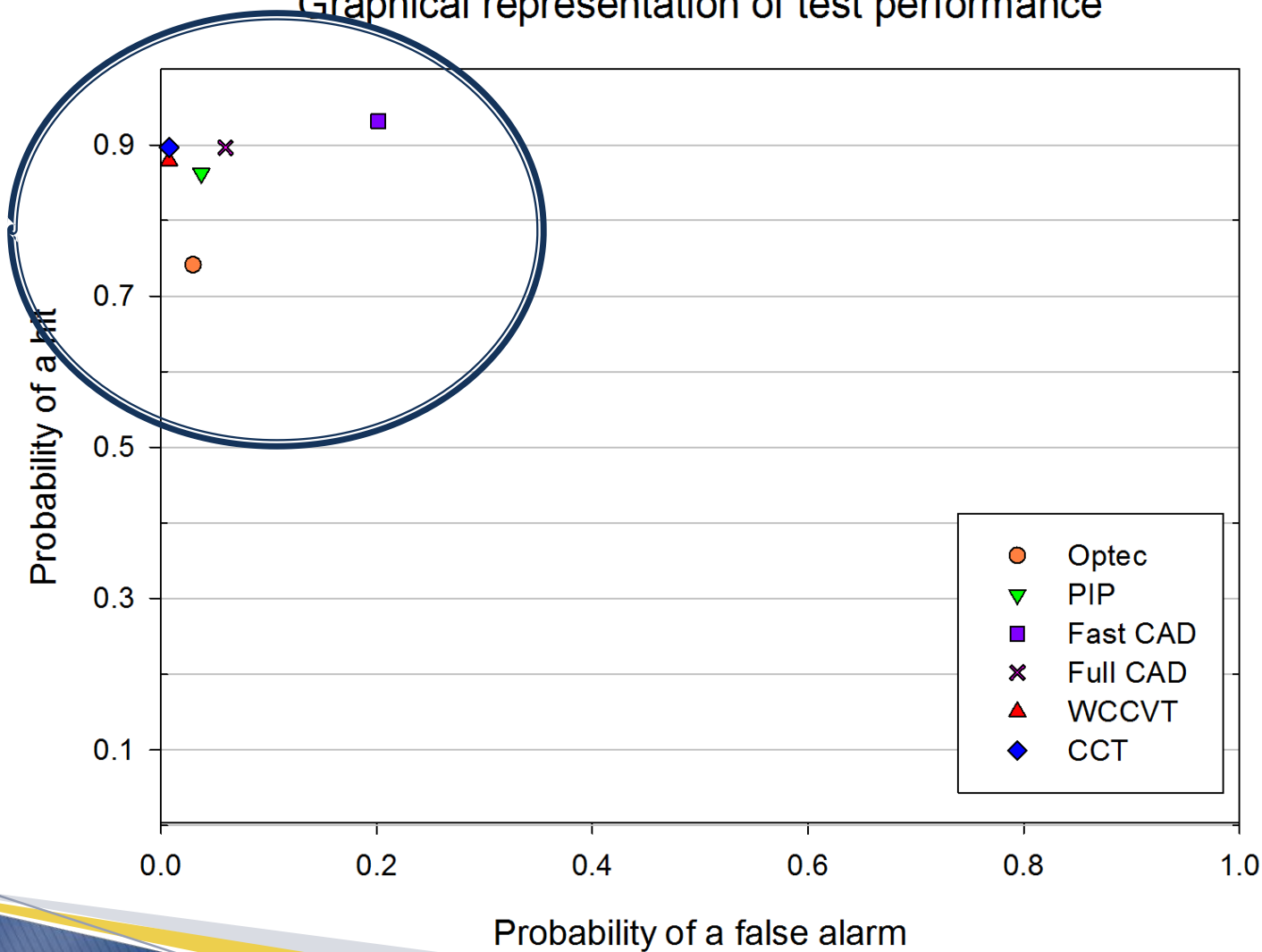


# Results

## CVT performance



Graphical representation of test performance

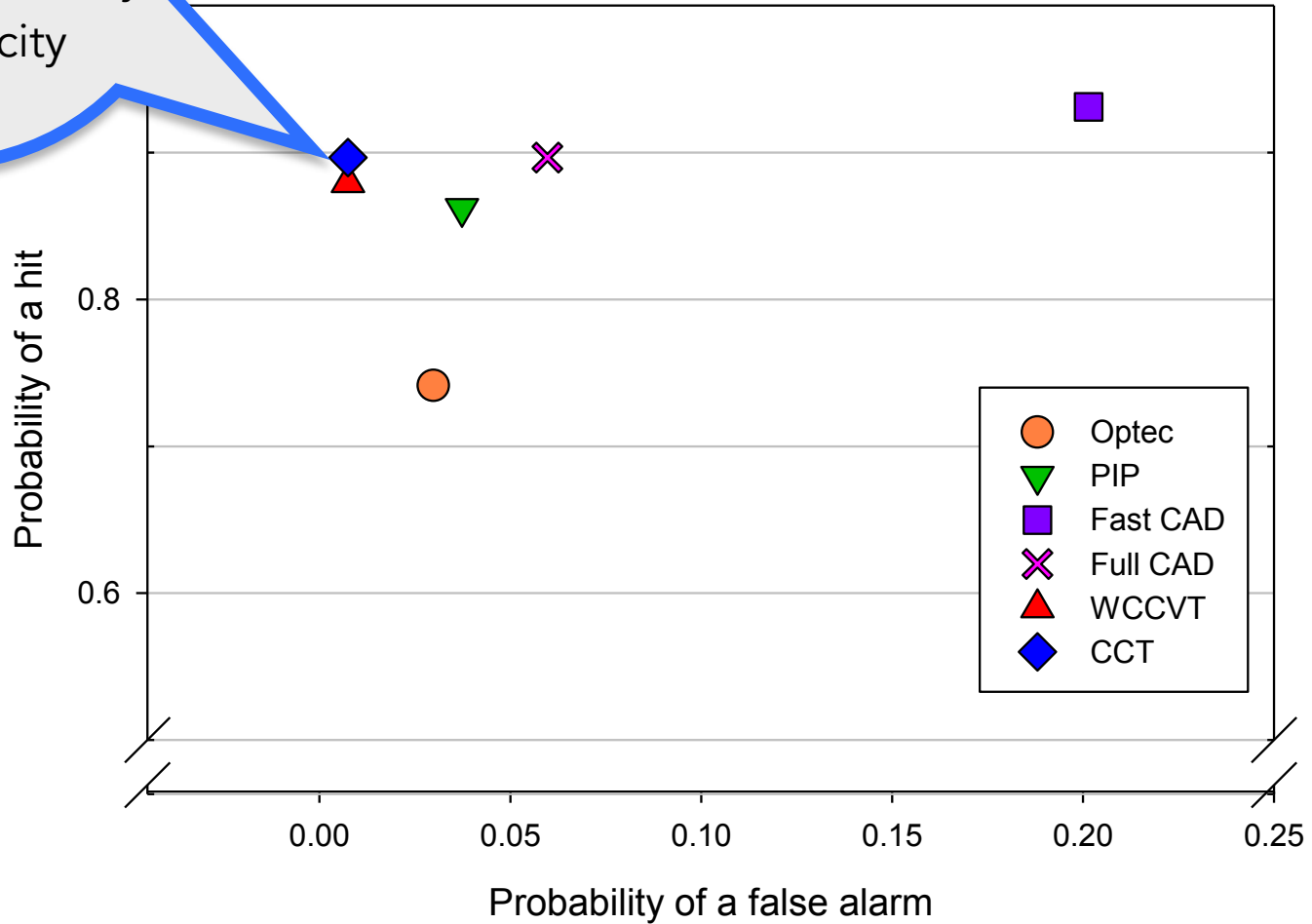


# Results

## CVT performance

Konan notes:  
WCCVT =  
ColorDx Application  
Excellent Sensitivity  
& Specificity

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

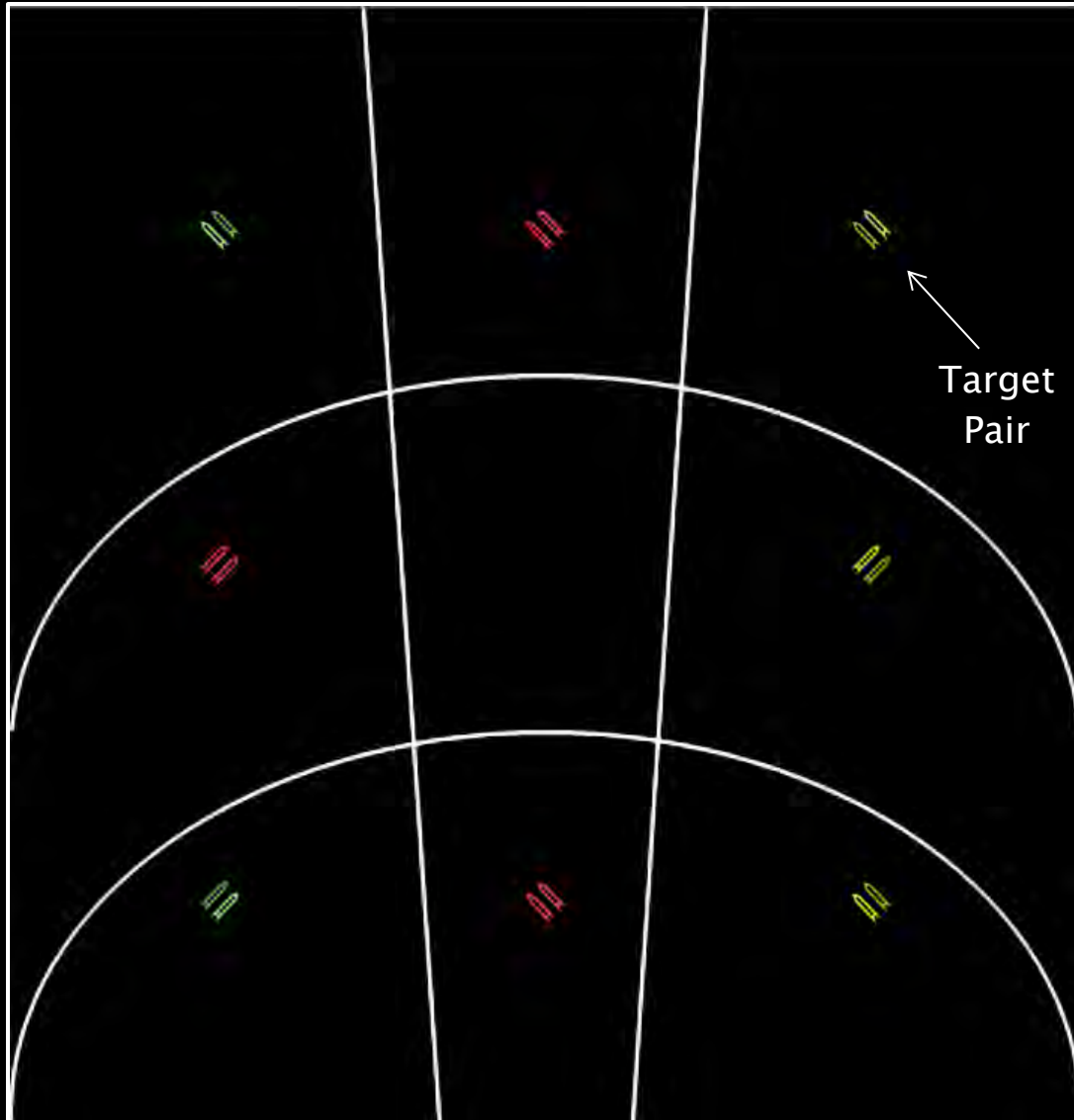


Low	● ●
On	● ●
High	● ●

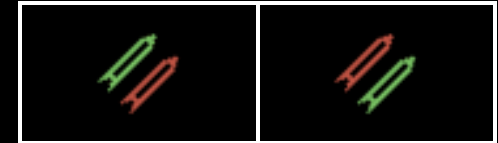
Simulated 1 NM view

# Method

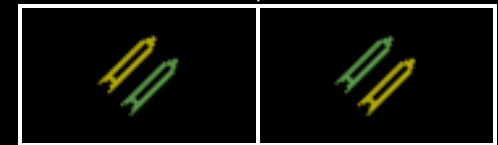
Display icon color-discrimination reaction time test



Green/Red



Yellow/Green



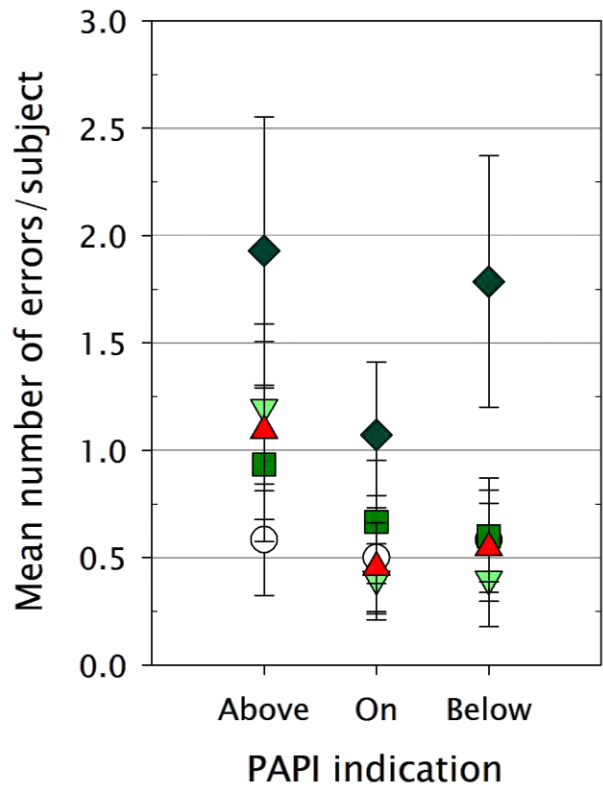


# Results

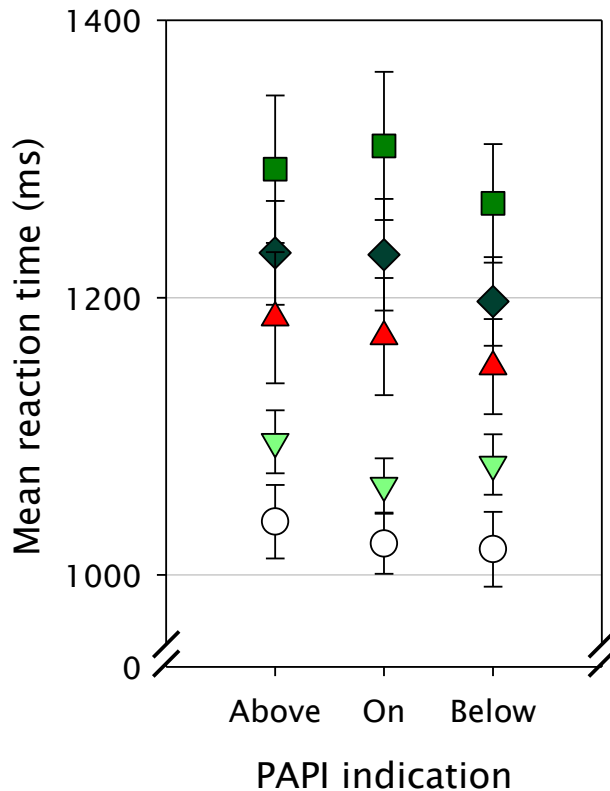
## PAPI task



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

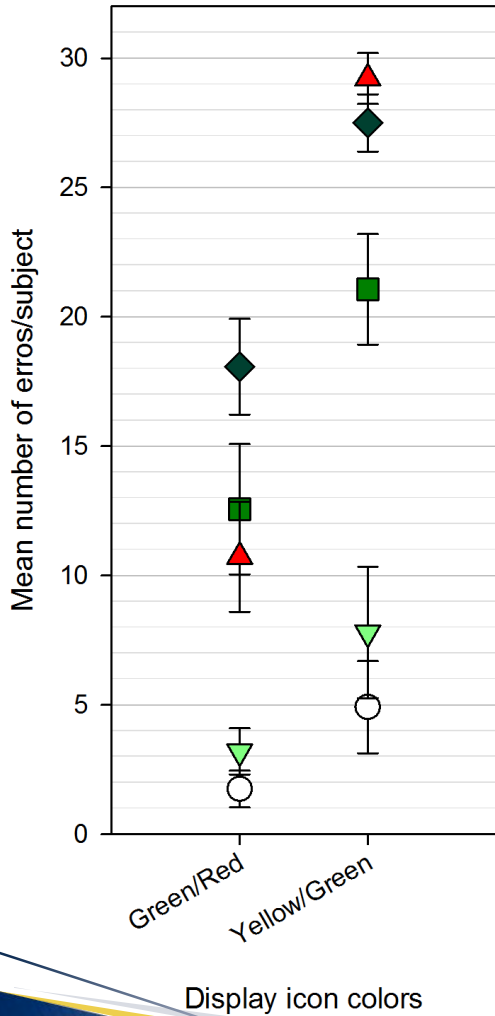


# Results

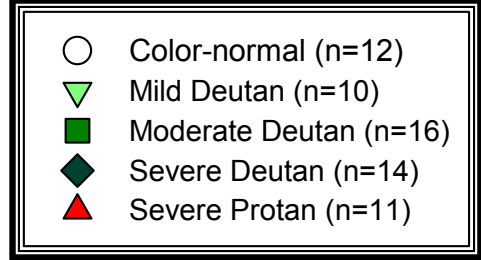
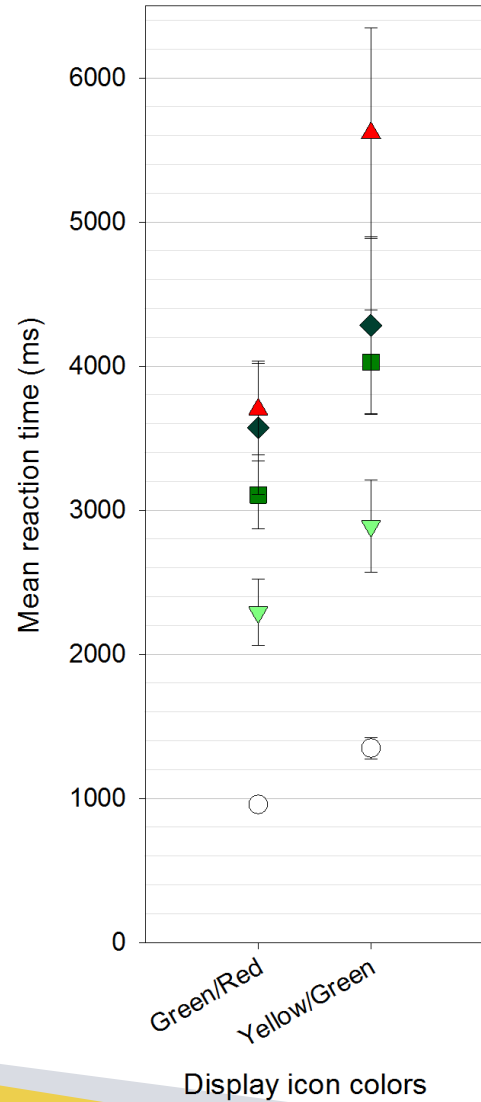
## Display icon task



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			

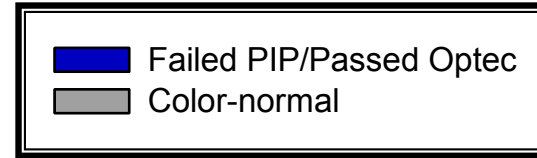
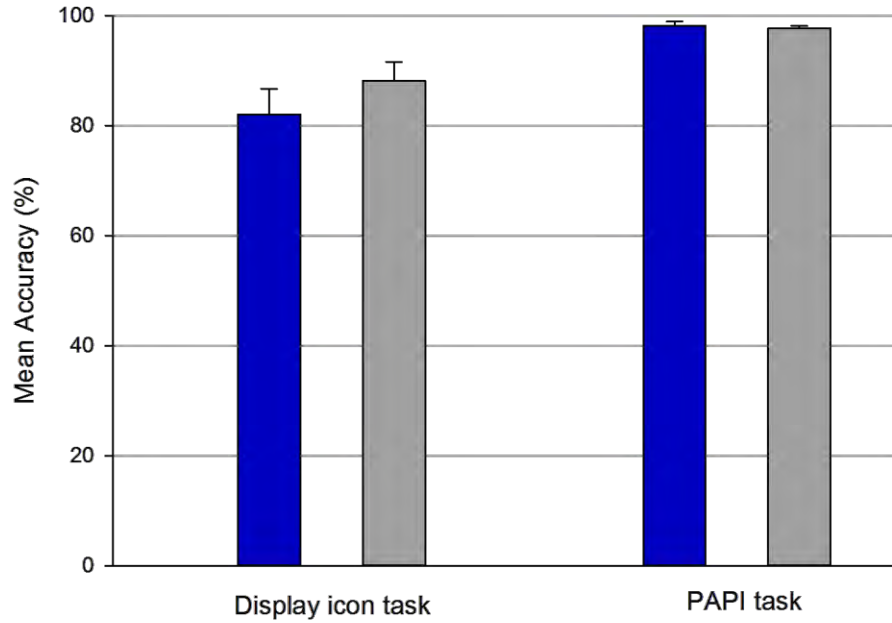


# Optec performance

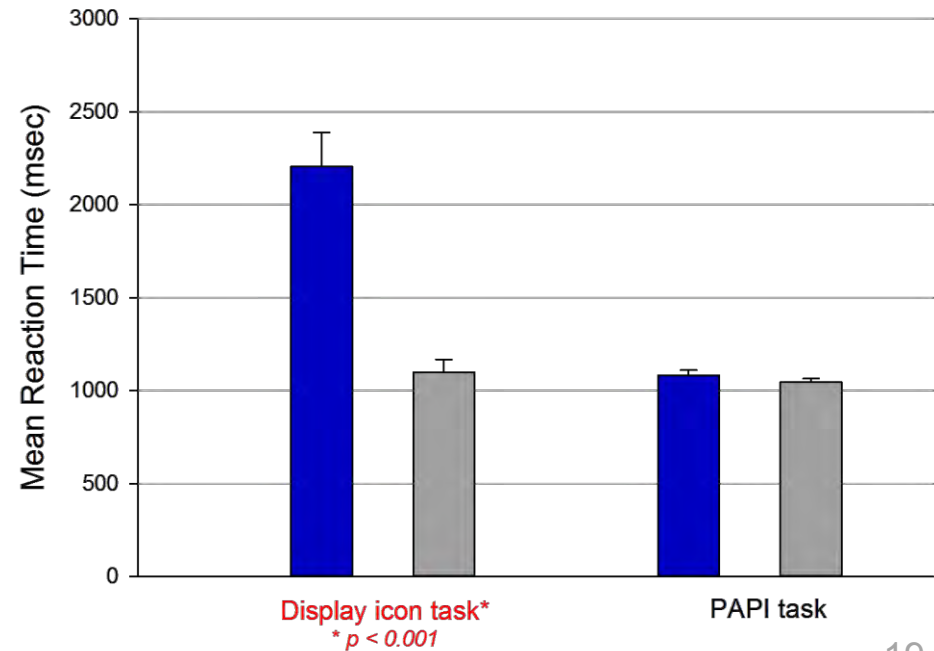
## Reaction time task performance



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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