Color Vision and Color Deficiencies

Jane Philipps and Nallely Garcia
Overview

• How Do We Perceive Color?
• Color Deficiencies
• Tests for Color Deficiencies
• Our Test Results
• How Do Color Deficiencies Limit People?
How Do We Detect and See Light?

- Light enters eye
- Focused by cornea and lens onto back of retina
- Photoreceptors absorb light
- Light is transformed into electrical signals
- Signals sent to brain via optic nerve
Two types of Photoreceptors in Retina

**Rods**
- For Night Vision
- > 90 % of Photoreceptors
- None in Fovea

**Cones**
- For Day Vision
- < 10 % of Photoreceptors
- Concentrated in Fovea
Cones are Responsible for Color Vision

Three Types:
- Long (L, Red) 62%
- Medium (M, Green) 31%
- Short (S, Blue) 7%
Images of Cones in the Fovea

*A. Roorda & D.R. Williams, Nature 1999
H. Hofer, J. Carroll, D.R. Williams

1:3

5 arcmin

16:1
How Do People Get Color Deficiencies?

Genetic

- Color Deficiencies are recessive traits carried on X chromosome
- Females have XX, Males have XY – Males have a greater chance
- 8% of Caucasian males have a Red/Green Color Vision Deficiency
- 15% of Caucasian females carry Color Vision Deficiency genes

Acquired

- Eye Disease, Drug Use, Overexposure to Lead or Mercury, Injury to eye or brain
- Equal Chances for Males and Females
Types of Color Deficiencies

**Normal Color Vision**
Trichromacy - Three Cone Types (L, M and S)

**Color Deficiencies**
Anomalous Trichromacy
  Three Cone Types - One Has Altered Sensitivity
Dichromacy
  Two Cone Types
Blue Cone Monochromacy
  One Cone Type (S only)
Rod Monochromacy
  No Cone Types, Only Rods
Dichromacy and Anomalous Trichromacy

Red/Green Color Deficiencies

Protan – L Cone Deficiency
• Protanomalous – altered sensitivity
• Protanope – missing

Deutan – M Cone Deficiency
• Deuteranomalous – altered sensitivity
• Deuteranope – missing

Blue/Yellow Color Deficiency

Tritan – S Cone Deficiency
• Tritanope – missing
Normal (S,M,L)  
Protan or Red/Green (S,M)  
Deutan or Red/Green (S,L)  
Tritan or Blue/Yellow (M,L)  

http://webexhibits.org/causesofcolor/2.html
Screening Tests for Color Deficiencies

C100

AO-HRR

ISHIHARA

D15
AO-HRR – Pseudoisochromatic Plates

• Tests for Protan, Deutan, Tritan

• Subject must identify and trace shapes on plates
AO-HRR Results

- 20 subjects tested
  - 10 males
  - 10 females

- 1 protan (male)
- 1 deutan (male)
- 18 normal
  - 8 males
  - 10 females
Ishihara – Pseudoisochromatic Plates

- Tests for Protan, Deutan
- Subject must read numbers they see

Normal Color Vision
Ishihara – Pseudoisochromatic Plates

- Tests for Protan, Deutan
- Subject must read numbers they see

Protan Color Vision
Ishihara Results

- 22 subjects tested
  - 10 males
  - 12 females
- 1 Protan (male)
- 1 Deutan (male)
- 20 normal
  - 8 males
  - 12 females

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• Tests for Protan, Deutan, Tritan
• Subject must arrange colored disks by hue
D-15 Results

- 21 Subjects tested
  - 10 males
  - 11 females
- 1 Protan (male)
- 20 normal
  - 9 males
  - 11 females
C100

- Tests for Protan, Deutan
- Subject must find spot with least amount of flicker
C100 Results

- 22 Subjects
  - 11 males
  - 11 females
- 1 Protan (male)
- 21 Normal
  - 10 males
  - 11 females

C100 Test Results

C100 Average Score

# of Subjects

Protan
Normal
Deutan
How Can Color Deficiencies Limit Humans?

Careers

Bus Driver, Firefighters, Police Officers, Paint Makers, Doctors, Chemists, Decorators, Computer Programmers

School

Affects Reading and Math Skills

Which Flask Contains the Pink Solution?
Conclusions

• Cone Photoreceptors are Used to Perceive Color
  
  **Long** (L), **Medium** (M), and **Short** (S) Wavelength Sensitive

• Three Main Color Deficiencies
  
  **Protan** (Missing or Altered L Cone)
  
  **Deutan** (Missing or Altered M Cone)
  
  **Tritan** (Missing or Altered S Cone)

• Color Deficiency Screening Tests and Results
  
  1 Protan (AO-HRR, Ishihara, D-15, C-100)
  
  1 Deutan (AO-HRR, Ishihara)

• Need to Conduct Several Tests for Accurate Diagnosis
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