Evaluation of the Waggoner Computerized Color Vision Test

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INTRODUCTION

•People with normal color vision are called normal trichromats and they have three types of cones in their retina (L-cones, M-cones, & S-cones). People with congenital color vision defects either have anomalous cones or lack one or more types of cones.
•Anomalous trichromat has 3 types of cones, but one is anomalous
  Protanomal has anomalous L-cones
  Deutanomal has anomalous M-cones
•Dichromat lacks 1 type of cones
  Protanope lacks L-cones
  Deuteranope lacks M-cones
  Tritanope lacks S-cones
•Protan and deutan defects are collectively called red-green color vision deficiencies because they have difficulty distinguishing these middle- to long-wavelength regions. Up to 8% of population can be affected by protan and deutan defects. Thus, color vision screening is a very important public health issue.
•Traditional color vision tests are expensive, require a highly skilled examiner, and/or require a specific lighting condition. The recently developed Waggoner Computerized Color Vision Test (WCCVT) overcomes these difficulties because it is administered through the Internet. The WCCVT can also screen for less common tritan defects, whereas many traditional tests only screen for red-green color vision defects.

PURPOSE

- To evaluate whether the recently developed WCCVT can accurately screen color vision deficiencies.
- In order to do so, we will compare the sensitivity and the specificity of the WCCVT to those of well established color vision tests: Ishihara Pseudoisochromatic Plates Test (24-plate edition), 4th edition Hardy Rand and Rittler (HRR) test, and the Farnsworth D-15 test.

METHODS

Participants

The sample consisted of 305 participants, 101 of which were male (33%) and 204 were female (67%). The mean age was 21 (*SD*=6.6). Approximately 35% were Hispanic, 25% Asian, 25% White, 2% Black/African-American, 1% Native Hawaiian or Pacific Islander, and 10% Mixed/Other.

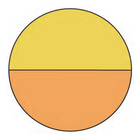
METHODS (cont.)

Procedures

•Tests were administered in a dark room (for the anomaloscope and the WCCVT) or under a standard daylight light box (for visual acuity, the Ishihara test, the HRR test, and the D-15 test).
•Visual acuity was determined binocularly with a 40cm Traditional SLOAN Runge Pocket Near Vision Card.
• A visual acuity of at least 20/40 was required, which all participants satisfied.

Neitz OT-II Anomaloscope

View through the eye piece



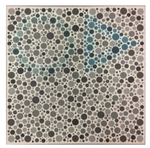
545 nm + 670 nm: variable color

589 nm: variable luminance

•A participant looked through the eye piece that shows a bipartite field as above.
•Upper knob varied the ratio of 545 nm (green) light and 670 nm (red) light. This will change the color of the upper field.
•Lower knob varied the luminance of the lower field.
•After finding the approximate luminance for the participant, the experimenter presented various combinations of the color mixture in a pseudorandom manner.
•The goal was to find the exact matching range of the color mixture that a participant perceives the upper field and the lower filed to be identical.
•A normal trichromat shows a small matching range with a stable luminance setting.
•The results from the anomaloscope was used to establish the formal diagnosis of color vision of participants.
•This is the most definite method to diagnose one's red-green color vision. However, the anomaloscope is unable to diagnose tritan defects.

METHODS (cont.)

HRR Test

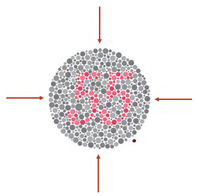


•Each plate includes 0, 1, or 2 shapes (circle, triangle, or cross) that are visible only by differences in the colors of dots.
•A participant reported the number, the identity, and the location of shapes.
•4 practice plates followed by 6 screening plates.
•A normal trichromat should not miss any of the 6 screening plates. If a participant failed 1 or more screening plates, diagnostic plates followed.

Ishihara Test

•Each plate includes 0, 1, or 2 numbers that are visible only by differences in the colors of dots.
•Participants read the numbers from 17 plates.
•A normal trichromat may miss up to 2 plates.

WCCVT



•A pseudoisochromatic plate similar to the Ishihara plates is presented for 2 sec on a computer screen.
•When the plate disappears, 9 possible choices (including "nothing") are presented. When a participant clicked on the number he/she saw, the next plate was presented.
•Screening test consisted of 29 plates.
•A normal trichromat may miss up to 3 plates.
•If the participant failed the screening test, three diagnostic tests (protan, deutan, and tritan) followed in order to determine the type and severity of color vision deficiency.

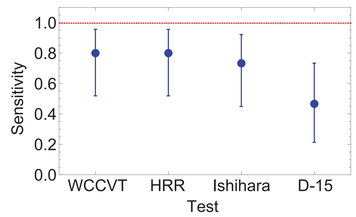
D-15 Test

•16 colored chips are sealed in a clear plastic case.
•One is the anchor chip and the rest are testing chips.
•A participant used a magnetized pointer to arrange 15 chips so that the color of the chips changed gradually from the anchor chip to the other end continuously.
•A normal trichromat may make up to 1 major crossover of the color arrangement (skipping 4 or more color chip numbers).

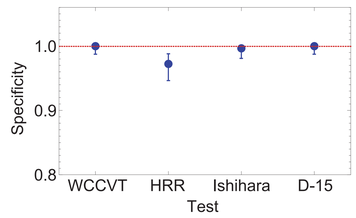
RESULTS

- Out of 305 participants, 290 were normal trichromats and 15 were color vision defectives based on the anomaloscope results.
- All of the normal trichromats were classified as normal by the WCCVT and D-15 test, whereas 1 and 8 normal trichromats were classified as color vision defective by the Ishihara test and HRR test, respectively.
- All the 4 tests classified 3 "very mild" color vision defectives as normal trichromats, who were detected only by the anomaloscope. The WCCVT and the HRR test correctly identified the remaining 12 color vision defectives, whereas the Ishihara test missed 1 more and the D-15 test missed 5 more.

Sensitivity of the Four Color Vision Tests



Specificity of the Four Color Vision Tests



Error bars indicate 95% exact binomial confidence intervals

CONCLUSIONS

- Among the four color vision tests evaluated, the D-15 test is inferior in sensitivity and the HRR test is inferior in specificity. The WCCVT and the Ishihara test perform well in both of these measures. Considering the ease of administration, the WCCVT seems very promising as a color vision screening test.
- The limitation of the current study is the scarcity of color vision defective participants. In order to assess performance of color vision tests, it is critical to have more color vision defective people, ideally we should have a similar number of normal trichromats and of color vision defectives.