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Description
Inherited color vision deficiency affects approximately 8% of the male Caucasian population, 5% of non-Caucasian males, and 0.4% of all women. In addition, significant numbers of patients of both genders acquire color vision loss due to ocular disease or pharmaceutical medications.

Yet in many clinical settings color vision testing presents a challenge because plate tests, like those designed by Ishihara, do not easily differentiate green (deutan) from red (protan) defects. Tests that do differentiate, like the Farnsworth D-15, show false positive results with mild to moderate anomalous trichromacy, and are time-consuming. In addition, both require proper lighting to administer.

To screen for color vision deficiencies, and accurately diagnose them when they are found, a reliable automated test would be desirable, as it could be run by technicians and aid the optometrist in interpretation.

Disciplines
Optometry

Comments
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Comparison of Farnsworth and Lanthony D-15 Color Vision Tests to an Automated Color Vision Cap Rearrangement Test

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INTRODUCTION
Inherited color vision deficiency affects approximately 8% of the male Caucasian population, 5% of non-Caucasian males, and 0.4% of all women. In addition, significant numbers of patients of both genders acquire color vision loss due to ocular disease or pharmaceutical medications. Yet in many clinical settings color vision testing presents a challenge because pie-chart tests, like those designed by Ishihara, do not easily differentiate green (deutan) from red (protan) defects. Tests that do differentiate, like the Farnsworth D-15, show false positive results with mild to moderate anomalous trichromacy, and are time-consuming. In addition, both require proper lighting to administer. To screen for color vision deficiencies, and accurately diagnose them when they are found, a reliable automated test would be desirable, as it could be run by technicians and aid the optometrist in interpretation.

METHODS
152 eyes of 76 healthy young adults (44 male, 32 female; overall average age 24.6 years, range 21-38 years) were administered both the conventional cap versions of the Farnsworth (saturated color) and Lanthony (desaturated color) D-15 color vision tests. The tests were administered in accordance with the software manufacturer's instructions. Lighting was provided by an illuminant C filtered Macbeth Easel lamp, and the results recorded. One week later, a second investigator, masked to the results on the first session, repeated an automated, computerized version of both color vision tests. The software used for the comparison was the Color Vision Recorder (version 3) from Optical Diagnostics (http://www.opticaldiagnostics.com). The tests were administered using a Dell desktop CRT monitor that was calibrated according to the standard backwards C-shaped graph by hand, a time-consuming process. The cap test showed 141 eyes (93%) with normal trichromacy, and 11 eyes (7%) with defective color vision (severe anomalous trichromacy or dichromacy). The computerized version of the Farnsworth D-15 test completes the graphing and analysis automatically. This test showed 146 eyes (96%) with normal trichromacy, 4 eyes (3%) with unclassified anomalous trichromacy, and 2 eyes (1%) with dichromacy (protopanopia). All of the eyes that failed the conventional Farnsworth D-15 cap test, classification of a color deficiency depends on recording the subject's responses on the standard backwards C-shaped graph by hand, a time-consuming process. The cap test showed 141 eyes (93%) with normal trichromacy, and 11 eyes (7%) with defective color vision (severe anomalous trichromacy or dichromacy). All of the eyes with defective color vision were also detected by the software Lanthony test, only 20 eyes tested as color defective with the conventional Lanthony (desaturated) D-15 cap test, identifying 8 (24%) false positives. However, there were 5/11 (45%) false negatives. Nonetheless, chi-square analysis shows that there is no significant difference in the results of the two tests, $\chi^2(1) = 1.56, p = 0.212$.

RESULTS
For the conventional Farnsworth D-15 cap test, classification of a color deficiency depends on recording the subject's responses on the standard backwards C-shaped graph by hand, a time-consuming process. The cap test showed 141 eyes (93%) with normal trichromacy, and 11 eyes (7%) with defective color vision (severe anomalous trichromacy or dichromacy). As with the Farnsworth D-15 cap test, the Lanthony D-15 cap test requires graphing by hand to classify color deficiencies. This cap test showed 118 eyes (78%) with normal trichromacy and 34 eyes (22%) with defective color vision (mild, moderate or severe anomalous trichromacy or dichromacy). The computerized Lanthony D-15 testing showed 124 eyes (82%) with normal trichromacy, 26 eyes (17%) with unclassified anomalous trichromacy, and 2 eyes (1%) with dichromacy (protopanopia). All of the eyes that failed the Farnsworth (saturated color) also failed the Lanthony (desaturated) test. However, of the 28 color-defective eyes identified by the software Lanthony test, only 20 eyes tested as color defective with the conventional Lanthony cap version, resulting in zero false positives. However, there were 5/11 (45%) false negatives. Nonetheless, chi-square analysis shows that there is no significant difference in the results of the two tests, $\chi^2(1) = 0.73, p = 0.393$.

CONCLUSION
When testing normal trichromats, the Color Vision Recorder software demonstrated accuracy in assessing color vision deficiency within 3% of the traditional Farnsworth (saturated) D-15 cap test, and within 5% of the traditional Lanthony (desaturated) D-15 cap test. When testing color-deficient subjects, there were no false positives, with the automated Farnsworth and 41% with the automated Lanthony. In addition, the automated Lanthony test had 24% false positives. There were no differences in this project.

FINANCIAL DISCLAIMER
The authors have no financial interest in Optical Diagnostics or this software.

REFERENCES