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BRIEF COMMUNICATION

Development and validation of the neuro-vision card

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Detection, diagnosis, and management of ocular disease requires testing beyond high contrast visual acuity (VA). Portability and affordability are equally important to make quantitative assessment available in remote settings, particularly during the COVID-19 pandemic wherein telemedicine and telehealth gained importance. Our purpose was to develop and validate the Neuro-Vision Card (NVC©), which allows diagnosis and monitoring of sensory and binocular vision dysfunction, which underlie various conditions and diseases. Importantly, the NVC© can be used for home self-monitoring and in austere settings: military deployments, vision screenings, law enforcement, sports events.

The NVC© is a two-sided 5″ × 7″ test card administered under normal room illumination (Fig. 1). It includes near VA, contrast sensitivity (CS), cone-specific color vision, blind spot size quantification, low contrast Amsler grid, fixation disparity (precise eye alignment) [1], and aniseikonia (interocular difference

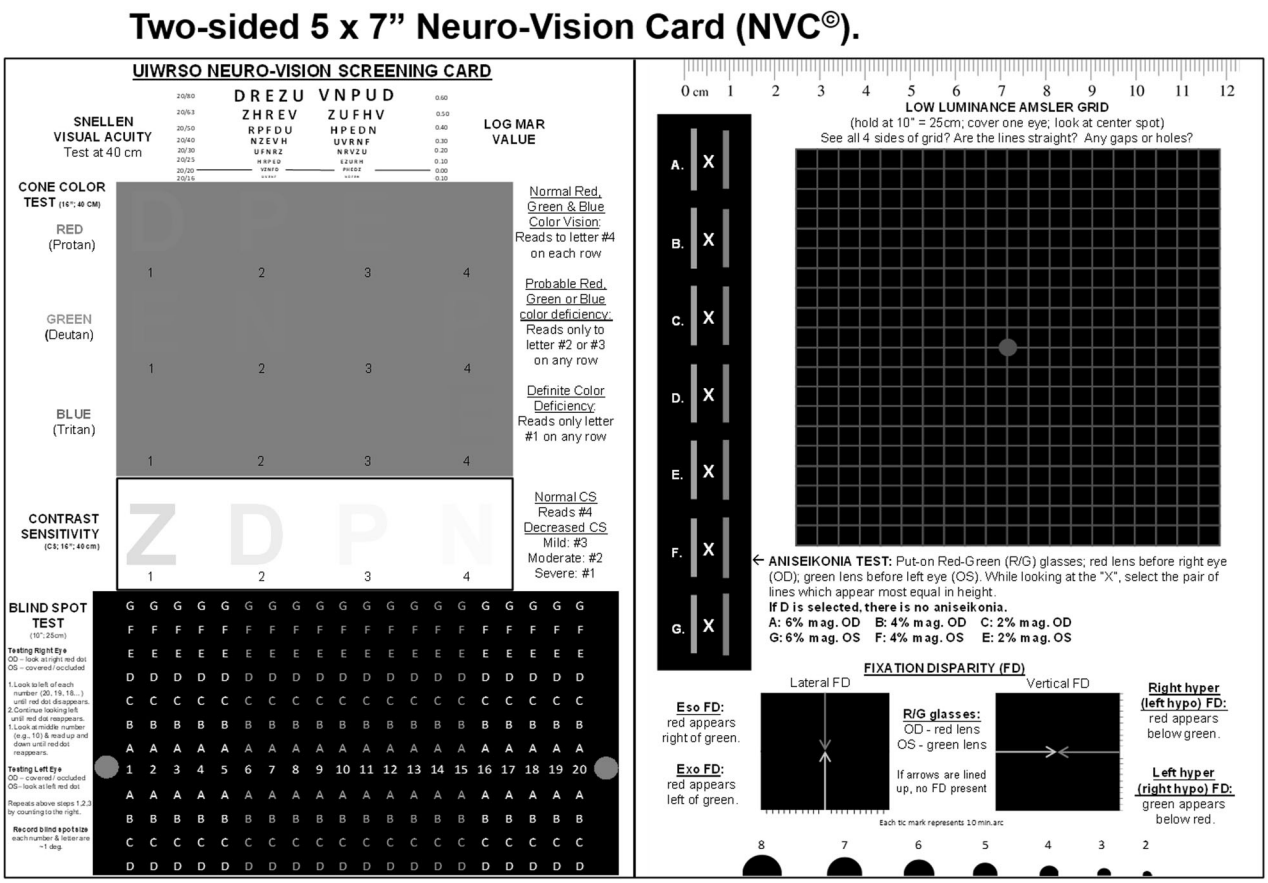

Fig. 1 Shows the 5″ × 7″ NVC© with front side on the left and backside on the right. Instructions for each test are included on the card and fixation disparity and aniseikonia require presenting separate images to each eye used (anaglyphic) red-green glasses (color figure online).

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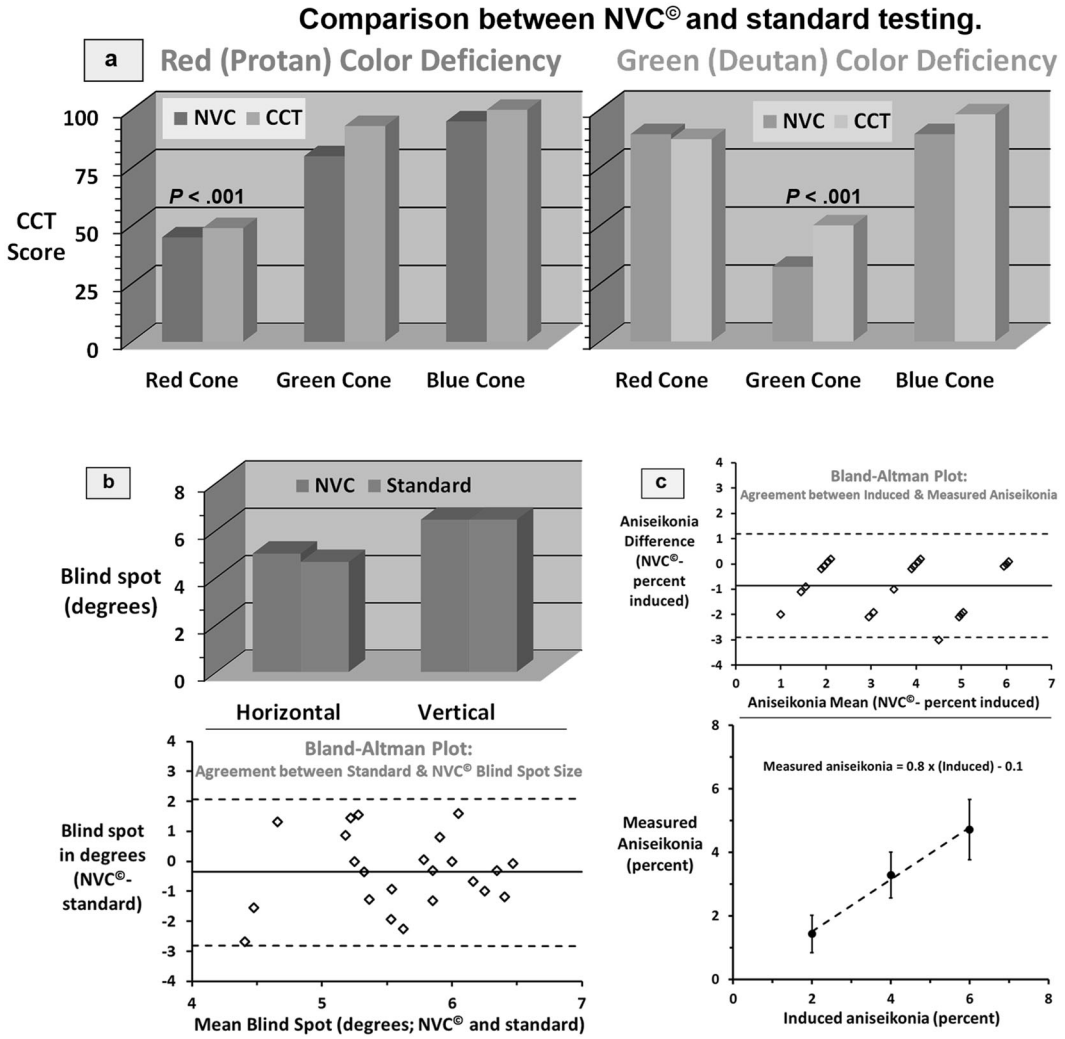

Fig. 2 Validation of the Neuro-Vision Card. a NVC shows good agreement with the Cone Contrast Test for detecting color deficiency. **b** NVC provides an accurate measure of blind spot size. **c** NVC provides an accurate measure of aniseikonia (color figure online).

in perceived size from anisometropia or retinal distortion) [2, 3]. Fixation disparity and aniseikonia testing are not widely available. A mm ruler and pupil size meter are included. The NVC© was evaluated in 37 observers (mean age 25, range 21–52; 12 had hereditary color vision deficiency: CVD). Results were compared to standard tests using repeated measures ANOVA and Bland–Altman analyses after subject written informed consent in accord with our IRB-approved protocol.

There was no difference between NVC© VA and ETDRS near VA ($P > 0.16$). All subjects achieved the NVC© screening log CS score (1.60) consistent with normal Pelli Robson letter CS [4]. No defects occurred with NVC© low contrast Amsler grids or the standard grid. NVC© red, green, and blue cone CS did not differ from Cone Contrast Test [5] scores in normals (Innova Systems, Inc., $F = 1.88$, $P > 0.17$) while both protan and deutan CVDs were significantly decreased on both red and green CCT and NVC© tests, respectively ($P < 0.001$, Fig. 2a), without difference between sensitivity of each test for CVD detection ($F = 1.82$, $P > 0.18$). NVC© blind spot size was not different from computer mapping of blind spot size ($F = 0.69$, $P > 0.41$) with vertical larger than horizontal ($P < 0.001$, Fig. 2b) and data fell within Bland–Altman 95% confidence limits. NVC© fixation disparity results were not different from the validated Wesson Card© ($F = 0.21$, $P > 0.64$). NVC© aniseikonia was evaluated on seven subjects by inducing aniseikonia with afocal size lenses producing 2, 4, and 6% magnification in the left eye. Figure 2c shows that all points fell within the Bland–Altman 95% confidence limits. Induced aniseikonia was highly predictive of measured aniseikonia ($F = 37.66$, $P < 0.001$, $r^2 = 0.66$, Fig. 2c). The linear equation indicates that NVC© underestimates aniseikonia by 20%. Hence multiplying NVC© measured aniseikonia by 1.25× improves accuracy.

The NVC© can detect visual dysfunction signifying ocular, systemic, and/or neurologic disease and provides a sensitive metric of binocular vision with tests not widely available. The NVC© can be used in virtually any setting and will be available commercially at minimal cost. Additional validation of the NVC© in eye disease and binocular vision disorders is planned.

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COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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