Testability of a color vision screening test in a population with mental retardation

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Purpose: The purpose of this study was to determine the testability of the "Color Vision Testing Made Easy"™ color vision test, marketed as a screening test for young children, in a population of individuals with mental retardation. The test uses simple geometric figures that are easily identified. Previously, the test has demonstrated validity as a measure of color deficiency.

Methods: The test was presented to Special Olympic athletes, who are individuals with mental retardation or significant developmental delay, at four sites: the 1997 World Winter Games in Toronto, Canada; the Texas Summer Games in Houston, Texas; the Massachusetts Summer Games in Boston, Massachusetts; and Regional European Swim Competition in Seville, Spain. The criteria for passing was 8 correct responses on the first trial, or 9 of 9 on the second attempt.

Results: Testability in Toronto, Canada; Houston, Texas; and Seville, Spain was high—95.5%, 98.7%, and 95.7%, respectively. Testability, however, dropped to 78.8% during the Boston, Massachusetts screening. There was no apparent difference in the testing environment that would account for the difference. The overall rate of testability was 93.2% for the 1078 athletes screened. The frequency of males identified as color deficient was similar to that expected in the general population; only two females (in Spain) failed the color vision screening.

Conclusions: The "Color Vision Testing Made Easy"™ color vision test was successfully completed by a very high percentage of Special Olympics athletes. These results suggest that this test is useful in screening this population for color deficiencies, and that the prevalence of color vision deficiencies is approximately the same in individuals with mental retardation as in the general population.

Key Words: Color vision, mental retardation, Special Olympics, testability

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There are several compelling reasons to assess color vision. Identification of congenital and acquired color vision deficiencies provides necessary information for functional and vocational guidance.[1-6] Congenital color vision defects occur in approximately 8% of the male population and 0.5% of the female population, and incidence varies by race.[4,5,7] Acquired color vision defects signify an underlying pathological etiology that requires proper diagnosis and management; acquired defects may affect both eyes unequally and may change over time.[1,6,8-13] Changes in color vision may precede other signs of disease, and therefore serve as an early warning for differential diagnosis. Kollner's rule generalizes that disorders of the retina cause blue-yellow deficiencies and disorders of the optic nerve cause red-green deficiencies; however, there are some exceptions.[14] Color anomia and color dyschromatopsia or achromatopsia can occur in higher frequencies with populations having cortical insult.[15] Color vision testing can assist in the diagnosis of decreased visual acuity of uncertain etiology, the monitoring of degenerative retinal diseases, and the effect of retinotoxic medications.[16] Educationally, many activities use color discrimination or naming tasks that could create unnecessary confusion and difficulties for the color-deficient student.[17,18]

A color vision assessment usually begins with a screening test before administration of a test capable of determining the type and severity of a color vision defect. It is essential that a screening test have good reliability and validity, where the consistency and repeatability of results lead to high levels of sensitivity and a specificity for even mild color vision deficiencies.[19] Fundamental requirements of an effective screening test is that it is quick and simple to administer, leading to a high level of testability.

Most color vision screening tests use pseudoisochromatic plate designs, in which a symbol made of colored dots is embedded

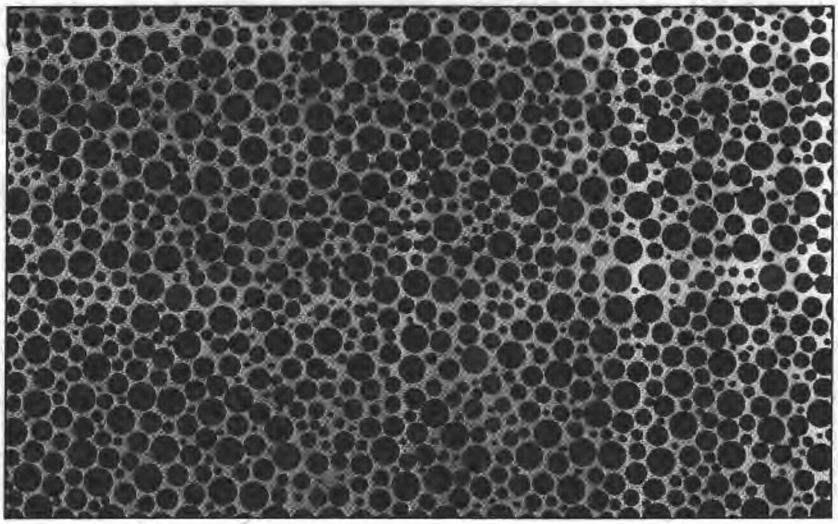

Figure Demonstration card for "Color Vision Testing Made Easy."™

in a background of different-colored dots.[20] The most common type is a vanishing plate design in which the color-deficient patient does not see any symbol embedded in the background because the colors correspond to the confusion line of their deficiency. Several tests are available that use this design, the common ones being the Ishihara Tests for Color Blindness,[21] the Dvorine Pseudoisochromatic Plates,[22] and the Richmond Pseudoisochromatic Plates (formerly known as the American Optical Hardy–Rand–Rittler Plates, or AO H–R–R[23]).

Patients with mental handicaps present clinical challenges during assessment and management of vision disorders that necessitate modification of standard procedures. In addition, the incidence of functional vision problems and ocular pathology tends to be higher in this patient population.[19,24-26] The incidence of color vision deficiencies, however, is considered to be the same among the mentally handicapped population as it occurs in the general population, although two studies have reported higher prevalence rates due primarily to poor test validity.[27,28] A premium is placed on examination techniques that have a high testability rate with mentally handicapped patients. It is common clinical practice to use pediatric examination procedures, based on the patient's developmental level.

Until recently, the commercially available color vision screening tests were not highly effective for screening in young children,[29-34] and therefore also presented problems for the mentally handicapped.[35] The reported problem is a high level of false-positive results using the D–15, AO H–R–R, Ishihara Test, Dvorine Plates, and anomaloscopic testing with mentally handicapped patients; abnormally high incidence of color vision problems were reported when these tests were used.[36-41] The primary difficulty reported for each of these color vision tests with mentally handicapped patients was trouble understanding the task required to assess color vision (e.g., understanding how to arrange the colored caps in the D-15 test). The "Color Vision Testing Made Easy"™ is a color vision screening test designed for young children that uses a vanishing pseudoisochromatic plate design.[42] This test uses common shapes or objects that are easily identified by young children. The main test uses shapes (square, circle, star) with a demonstration card, and there is a substitute test that uses objects (dog, balloon, boat, and car) with a demonstration card. This test has been shown to have validity as a screening instrument.[43] We wanted to determine if this test could be successfully administered to patients with mental handicaps.

Methods

The "Color Vision Testing Made Easy"™ color vision test was administered as part of the vision screening sponsored by the American Optometric Association Sports Vision Section or Special Olympics International at four separate sites at which Special Olympics competitions were taking place. The first site was Toronto, Canada (February 1–8, 1997), which was the location for the 1997 World Winter Games. Athletes from all over the world are invited to participate in these Olympic games. The other three sites were local, state, or regional games—specifically, Houston, Texas State Games (May 23 and 24, 1997); Boston, Massachusetts State Games (June 21 and 22, 1997); and the Regional European Swim Competition in Seville, Spain (October 31–November 2, 1997). To be eligible to participate in Special Olympics, the athlete must be at least 8 years old and identified by an agency or professional as having one of the following conditions: mental retardation, cognitive delays (as measured by formal assessment), or significant learning or vocational problems due

Table 1. Subject demographics for each vision screening site

Site	Total subjects	Male	Female	Age ranges
Toronto, Canada	421	362 (86%)	59 (14%)	8 to 53 years
Houston, Texas	149	87 (58.4%)	62 (41.6%)	12 to 55 years
Boston, Massachusetts	179	94 (52.5%)	85 (47.5%)	8 to 65 years
Seville, Spain	329	204 (62%)	125 (38%)	9 to 77 years
Totals	1,078	747 (69.3%)	331 (30.7%)	8 to 77 years

to cognitive delay that require (or have required) specially designed instruction.[44]

According to the new definition by the American Association on Mental Retardation (AAMR), an individual is considered to have mental retardation on the basis of the following three criteria: significant subaverage intellectual functioning level (IQ usually is below 70 to 75); related limitations exist in two or more adaptive skill areas; and the manifestation of the condition before the age of 18 years.[45] Adaptive skill areas are those daily living skills needed to live, work, and play in the community. The new definition includes ten adaptive skills: communication, self-care, home living, social skills, leisure, health and safety, self-direction, functional academics, community use, and work. Adaptive skills are assessed in the person's typical environment, across all aspects of an individual's life.[45] A person with limits in intellectual functioning who does not have limits in adaptive skill areas may not be diagnosed as having mental retardation.

The athletes were all screened binocularly under standard illumination while seated or standing at a test distance of 75 cm. The athletes were asked to find the circle (or ball) on the demonstration card as an orientation to the test and to ascertain if the task was understood by the athlete (*see* Figure). Translators were used (when available) when the athlete did not speak or understand English—or the language of the examiner was used (i.e., Spanish was the language used at the games in Spain). Gestures were also used to explain the testing process. If the athlete could identify the demonstration card correctly, it was assumed that visual acuity was adequate for testing. The athlete was provided cotton swabs to aid in pointing to the test plates without touching them. The nine test plates were presented sequentially, and at least 3 seconds were allowed per plate for the athlete to "find the circle." The number of correct responses was recorded on the first trial. To pass the screening, the athlete had to correctly locate the circle on eight of the nine plates on the first trial. If fewer than eight correct responses were given, a second trial was conducted. To pass on the second attempt, the athlete was required to localize the circle on all nine test plates.

Results

The total number of athletes who were screened at all four sites was 1,078; 747 (69.3%) were male and 331 (30.7%) were female (*see* Table 1). The athletes ranged in age from 8 to 77 years. There were 1,005 (93.2%) athletes who were able to successfully complete the color vision screening, yielding testability rates of 92.6% for the males and 94.6% for the females (*see* Table 2). The overall pass rate on the screening was 94.6%, with 7.5% of the males and 0.6% of the females failing the test (*see* Table 3).

There were 421 athletes, ranging in age from 8 to 53 years, who completed the testing at the games in Toronto (*see* Table 1). Color vision testing was completed on 402 (95.5%) athletes, 21 (5.2%) of whom failed (*see* Table 3). All of the athletes who failed the screening test were male, with only one female who was unable to complete the test.

At the Houston, Texas games, 149 athletes were evaluated. The age range was 12 to 55 years, and there were 87 males and 62 females who participated (*see* Table 1). Only two athletes (1.3%) were unable to complete the color vision test, one male and one female (*see* Table 2). Of the 147 athletes who completed the screening, five males (5.8%) and no females failed (*see* Table 3).

There were 179 athletes tested at the Boston, Massachusetts games, ranging in age from 8 to 65

Table 2. Testability of the color vision screening test by site and gender

Site	All subjects	Males	Females
Toronto, Canada	402/421 (95.5%)	344 (95%)	58 (98.3%)
Houston, Texas	147/149 (98.7%)	86 (98.9%)	61 (98.4%)
Boston, Massachusetts	141/179 (78.8%)	67 (71.3%)	74 (87.1%)
Seville, Spain	315/329 (95.7%)	195 (95.6%)	120 (96%)
Totals	1,005/1,078 (93.2%)	692/747 (92.6%)	313/331 (94.6%)

years (*see* Table 1). The athletes were comprised of 94 (52.5%) males and 85 (47.5%) females, 141 (78.8%) of whom were able to complete the test (*see* Table 2). Of the total number of athletes who completed testing, seven males (10.4%) and no females failed (*see* Table 3).

At the Regional European Swim Competition in Seville, Spain, 329 athletes were evaluated. There were 204 male athletes (62%) and 125 female athletes (38%), ranging in age from 9 to 77 years, who participated in the screening (*see* Table 1). The total number of athletes unable to complete the test was 14 (4.3%), nine of whom were males and five were females (*see* Table 2). Of the 315 athletes able to complete the test, 21 (6.7%) failed; there were 19 male athletes (9.7%) and two female athletes (1.7%) who did not pass the screening.

Discussion

Reliable color vision testing in individuals with mental handicaps and preschool children with previously available techniques has been difficult. The "Color Vision Testing Made Easy"™ test has been shown by previous researchers to be a reliable screening device; however, an evaluation of testability in a population with mental retardation was necessary. The subjects who participated in this study included individuals who have been diagnosed with mental retardation or significant developmental delay. The athletes tested during the World games in Toronto represented many countries in which the primary language is not English. More than 95% of the athletes, however, were able to sufficiently understand the task required to complete the test. The testability was the same at the Regional European Swim Competition in Spain (95.7%), and even higher at the Houston, Texas games (98.7%).

The Massachusetts games, however, did not reflect the same high success rate. Only 78.8% of the athletes were able to complete the test. The most significant variable that may have caused this difference in our results was interexaminer variability. At each site, volunteers were trained to administer the test based on the protocol described in the methods. The volunteers were primarily optometry students, although some practicing optometrists manned this station of the vision screening. We attempted to control interexaminer variability through training and standardization of testing procedure; however, individual variation in administration and recording may have impacted our results. In addition, the temperature in the testing environment could not be controlled—in some cases reaching temperatures greater than ninety degrees. In spite of the precautions taken, the conditions may have had the impact of the athletes demonstrating a lower testability level.

Another variable not controlled for at any of the locations was the level of mental retardation. The athletes are not classified by impairment for the Special Olympics, and significant differences in mental retardation may have existed with any of our subject populations. Some subclassifications of mental retardation include *mild* (educable), *moderate* (trainable), *severe* (trainable-dependent), and *profound* (custodial-life support).[20,46,47] Therefore, the possibility exists that the subjects at the Massachusetts games were more severely involved than the subjects at the other three locations, and had more significant difficulty with communications. Our overall results may not generalize to a population with severe and profound levels of mental retardation.

The results of the screening show a prevalence rate of color deficiency among the athletes that matches the prevalence expected in the general population. This agrees with previous reports on the incidence of color deficiency in a mentally

Table 3. Passing and failing rates* on the color vision screening test by site and gender

Site	Total subjects	Males	Females
Toronto, Canada			
Pass (8/9 to 9/9)	381 (94.8%)	323 (93.9%)	58 (100%)
Fail (0/9 to 7/9)	21 (5.2%)	21 (6.1%)	0 (0%)
Houston, Texas			
Pass (8/9 to 9/9)	142 (96.6%)	81 (94.2%)	61 (100%)
Fail (0/9 to 7/9)	5 (3.4%)	5 (5.8%)	0 (0%)
Boston, Massachusetts			
Pass (8/9 to 9/9)	134 (95.0%)	60 (89.6%)	74 (100%)
Fail (0/9 to 7/9)	7 (5.0%)	7 (10.4%)	0 (0%)
Seville, Spain			
Pass (8/9 to 9/9)	294 (93.3%)	176 (90.3%)	118 (98.3%)
Fail (0/9 to 7/9)	21 (6.7%)	19 (9.7%)	2 (1.7%)
Total of all four sites			
Pass (8/9 to 9/9)	951 (94.6%)	640 (92.5%)	311 (99.4%)
Fail (0/9 to 7/9)	54 (5.4%)	52 (7.5%)	2 (0.6%)

* Passing criteria was 8 or 9 correctly identified plates of the 9 plates presented (8/9 to 9/9); fewer than 8 correctly identified plates (0/9 to 7/9) resulted in a failing score.

handicapped population.[38,47] The sensitivity and specificity of this test in this population has not been investigated; therefore, information concerning expected rates of false-positive and false-negative results cannot be factored into our results.

"Color Vision Testing Made Easy"™ demonstrated the fundamental requirements of an effective screening test for individuals with mental handicaps. It is quick and simple to administer, and has a high level of testability. The reliability and validity of this test—although established in previous studies—needs to be investigated with this population. In addition, comparison of testability rates in populations with different levels of severity of mental retardation could provide useful information for the clinician.

Summary

The "Color Vision Testing Made Easy"™ color vision test was successfully completed by a very high percentage of Special Olympics athletes. The lower rate of successful completion in Boston may be related to examiner differences and the possible variability in the cognitive and communication levels of the athletes. The results of our study suggest that this test is useful in screening this population for color deficiencies, and that the prevalence of color vision deficiencies is similar to the prevalence found in the general population.

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