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Comparison of Panel D-15 Tests in a Large Older Population

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Abstract

Purpose—To determine the frequency and type of color vision defects in a large group of randomly selected older people using two versions of the D-15, and to examine the agreement between the two tests.

Methods—The Adams desaturated D-15 test was administered under illuminant C (MacBeth lamp, ~100 lux) to a group of 865 individuals aged 58 to 102 years of age (mean 75.2 ± 9.1). No exclusion criteria, other than reported presence of a congenital color defect, were applied. Testing was binocular with habitual near correction. If any error was made on this test, the Farnsworth D-15 was administered under identical conditions. On both tests, a color confusion score of ≥30 was considered failing and for those failing the test, color defect type (blue-yellow, red-green, or non-selective) was determined using the method of Vingrys and King-Smith (1988).

Results—The majority (60.8%) of the people tested passed both tests. For the sample as a whole, the failure rates of the Adams desaturated D-15 and the Farnsworth D-15 were 36.2% and 20.76% respectively. As expected, for both tests, failure rate increased markedly with age. Among those who failed both tests, 17.5% of the population, the proportion of specific agreement for red- green and blue-yellow defects was high, 88%. The vast majority of those failing either or both tests had blue-yellow defects, in agreement with prior studies.

Conclusions—Blue-yellow defects were quite common among the aged, becoming increasingly prevalent with increasing age. More people failed the Adams' desaturated D-15 than the Farnsworth D-15, but among those that failed, the proportion of blue-yellow defects was similar for the two tests, approximately 75%. The agreement between the two tests in identifying acquired red-green and blue-yellow errors was high.

Keywords

color vision; aging; Farnsworth D-15; Adams desaturated D-15; color confusion score

Numerous studies have shown that color discrimination, as assessed using arrangement tests such as the D-15 tests or the FM 100-hue, deteriorates with age, typically resulting in tritan-like (blue-yellow) color vision defects. [1-6] Yet the frequency of blue-yellow defects on such tests among the general aged population remains unknown because previous studies have

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either used small samples at each age tested,[2,4,7] did not include individuals beyond about age 70,[2] selected the participants to be visually “normal”, i.e. free of frank disease or cataract,[2,4,5,6] and/or limited the sample to those with some criterion “good” visual acuity.[4, 6] Cataract, retinal diseases and glaucoma, among others, are prevalent in older populations and become more so with increasing age.[8] Therefore, measures from ‘selected’ cataract- and disease-free samples, while providing valuable age normative data, do not necessarily accurately represent color vision of the aged population.

We present results of color vision testing a large randomly selected population of older individuals, including over 250 individuals aged 80 years or more. Color vision was assessed using both the Farnsworth D-15[9] and the Adams desaturated D-15[10] tests. The latter test differs from the Farnsworth D-15 in that the Munsell chroma of each cap has been reduced by 2 units (from 5 to 3), making the cap colors less saturated. It differs from L’Anthony's desaturated D-15 test[11] in that the chroma of L'Anthony's test is further reduced to 2, making this test even less saturated than the Adams’ desaturated test. In addition, the value (lightness) for the L'Anthony test (8) is higher than the other 2 tests (which have values of 5). The Adams desaturated D-15 has been proposed to be sensitive to acquired color vision defects.[10,12]

Here we compare the frequency and types of color vision defects on the Farnsworth D-15 and Adams desaturated D-15 tests and examine the agreement between them in classification of color defect type. A brief description of the Farnsworth D-15 results on a nearly identical population has been published previously.[13]

METHODS

Subjects

The sample has been described in detail elsewhere.[13] Briefly, a random sample of community-dwelling individuals aged 58–102 (mean age 75.5 ± 9.3 years) years was tested with a large test battery. No exclusion criteria, aside from presence of a congenital color vision defect and age (must be >55 years) were applied. Thirteen men with congenital color vision defects (by self-report) were excluded. An additional 16 subjects were excluded due to incomplete data either due to experimenter error (e.g. cap orders recorded were incomplete; n=7) or, in 9 cases with poor acuity (near VA worse than 20/300) because only the saturated test was administered. Six additional participants were excluded because they refused to attempt one or both of the tests (near VA range from 20/138 to 20/20). The resulting data set includes 865 individuals aged 58 to 102 years (mean 75.2 ± 9.1). Approximately 15% of people tested had had cataract surgery in at least one eye prior to testing.

The research followed the tenets of the Declaration of Helsinki, and written informed consent was obtained from the subjects after explanation of the nature and possible consequences of the study. The study was approved by the California Pacific Medical Center IRB.

Procedures

The Adams desaturated D-15 was administered under Illuminant C (MacBeth Lamp, ~ 100 lux). If an individual made any errors on the Adams desaturated test, the Farnsworth D-15 test was administered under identical conditions. A color confusion score (CCS) was calculated for the cap order obtained for each test. CCS is an index of the severity of the color defect and represents the distance traveled in color space in excess of a perfect arrangement.[12] For both tests a criterion CCS of 30 or greater was considered failing.[13] For both tests, this criterion is equivalent to a 30% or more increase in distance traveled in color space over that of a perfect order (which yields a CCS of 0). Color defect type (red-green, blue-yellow, or nonselective) for those who failed was determined according to the vector analysis of Vingrys and King-Smith.[14] Confusion angles between −25 and 25 were considered red-green defects. Confusion angles between −70 and −100 and between 70 and 100 were considered blue-yellow defects. Defects with angles not falling within these zones were considered non-specific.

Testing was binocular with habitual near correction. Binocular habitual testing was used to better assess vision as people function in the world.

For analyses across ages, the participants were separated into ~ 5 year bins (58.00 – 64.99; 65.00 – 69.99; 70.00 – 74.99; 75.00 – 79.99; 80.00 – 84.99; 85.00 – 89.99; ≥90 years) and data are plotted at the mean age of each group in figures.

RESULTS

The majority (63.8%) of this aged sample passed the Adams desaturated D-15, having had a CCS <30. Approximately half of these (32% of the population) produced no errors on this test, i.e. had a CCS of 0. These individuals were not tested on the standard D-15, but are presumed to have perfect arrangements on that test. Of those with non-zero error scores on the desaturated D-15 who were thus tested on the Farnsworth D-15, an additional 246 individuals (28.4% of the sample) scored 0 on the Farnsworth D-15. Overall, 79.2% of this sample passed the Farnsworth D-15. Thus, the failure rates of the Adams desaturated D-15 and the Farnsworth D-15 were 36.2% and 20.8% respectively. The majority of people tested passed both tests (526 people, 60.8% of those tested). A large number of individuals (18.6%, 161 people) failed the desaturated test, but passed the standard D-15. On the other hand, only 3.1% (27 people) of those tested passed the Adams desaturated D-15 but failed the Farnsworth test. Only 17.5% of the sample (151 people) failed both tests. The mean age of those failing both tests was significantly older than the remainder of the sample (81.6 ± 8.2 years as compared to 73.7 ± 8.7 years) ($p<0.00001$).

Color Vision Across Ages

Figure 1 shows the change in median CCS across age for the Adams desaturated D-15 (panel a) and Farnsworth D-15 (panel b). Medians rather than means were used because CCS is not normally distributed. The error bars represent the 25th and 75th percentiles. Additional details about the distribution of CCS values for each age group, as well as the number of subjects in each age group are presented in Table 1. The 5th percentiles are not

included because they were 0 for all ages on both tests. For the Adams desaturated D-15 the median CCS was 0 for the youngest age group and then increased linearly over the entire age range tested. Twenty-five percent of those aged 65-69.99 and 70 – 74.99 had perfect arrangements on this test. The solid line represents the best fitting linear regression fitted to the median values for all age groups (r^2=0.99; slope = 1.62).

For the standard D-15, the 75th percentiles of the 2 youngest groups were zero, indicating that the large majority of people this age (below age 70) made no errors on this test. In fact, nearly 80% of those younger than 75 years of age made no errors. Over the four youngest age groups (up to and including 75-79.99 year olds) the median color confusion score (black squares) was 0 indicating a perfect arrangement with no errors in at least half of the people in each of these age groups. Beyond this point, median CCS of the standard D-15 increased linearly with age. The solid line represents the regression fitted to the medians of the four oldest groups (r^2 = 1.00; slope =1.81). Even among 80 – 89 year old age groups 30% of people produced perfect arrangements on the Farnsworth D-15.

Figure 2 shows the percent of people in each age group who failed the Farnsworth D-15 (gray bars) and the Adams desaturated D-15 (black bars). For both tests, the failure rate increased with age, more steeply for the desaturated D-15 than for the Farnsworth test. At all ages, more people failed the Adams desaturated D-15 than the Farnsworth D-15. Whereas only 7.7% of people in the youngest age group failed the Farnsworth D-15, nearly 50% of those aged 90 and above failed this test. In the youngest age group, 14.1% failed the Adams desaturated D-15, whereas 66.7% of the oldest age group (aged 90+) failed this test.

Figure 3 shows (Adams desaturated D-15: panel a; Farnsworth's D-15: panel b), for each age group, the percent of those failing the test who had blue-yellow (black bars), red-green (white bars) or nonselective (grey bars) color defect types. At all ages, for both tests, the majority of those failing the test produced blue-yellow error patterns. There was little change across age in the percentage of blue-yellow defect types among people failing a test. On average 78.3 % of failures on the Adams desaturated D-15 were blue-yellow; a very similar rate (75.6%) of blue-yellow defects among those who failed was seen for the Farnsworth D-15.

Though the percentage of people with blue-yellow defects among those who failed was fairly consistent across age, the percent of people who failed each test increased with age, as discussed above. Thus, the percent of this color defect type seen in the sample as a whole increased considerably with age. This is illustrated in Figure 4 which shows the percent of people in each age group with each of the three types of color defect on the Adams desaturated D-15 (panel a) and Farnsworth D-15 (panel b). In the population as a whole, the frequency of blue-yellow defects (black bars) increased with age, with nearly 60% of the oldest age group having had blue-yellow defects as measured by the Adams desaturated D-15 and nearly 40% as measured by the Farnsworth D-15. Overall, 33% of this whole population had blue-yellow defects on the Adams desaturated D-15 and 18.2% on the Farnsworth D-15.

Only 1.3 % and 1.2% of individuals had red-green defects on the Adams desaturated and Farnsworth D-15, respectively. On the desaturated D-15, red-green defect frequency varied unsystematically with age, ranging from 0% to 2.6%. On both tests, the frequency of nonselective color defects was also low, at 5.9% on the Adams test and 4.6% on the Farnsworth D-15. For the desaturated test, nonselective defects varied non-monotonically with age, ranging from 2.6 to 12.5%. On Farnsworth's test nonselective defects increased with age from 1.6 to 10%.

Comparison of Performance on the Adams Desaturated D-15 and Farnsworth D-15 Tests

A total of 151 individuals (17.5% of the population) failed both the Adams desaturated D-15 and the Farnsworth D-15. We examined the frequency with which the two color vision tests produced the same defect type. There was agreement in 122 of 151 cases, a rate of overall agreement of 80.8%. Cohen's kappa of agreement was 0.38, which was highly statistically significant ($z=6.25$, $p<0.0001$). In only one instance was an individual's performance classified as blue-yellow on the desaturated test and red-green on the Farnsworth test. The converse did not occur; no one classified as having a blue-yellow on the Farnsworth test was classified as having a red-green defect on the Adams desaturated test. However, 17 people classified as having blue-yellow defects on the Adams desaturated D-15 were classified as having nonselective defects on the Farnsworth D-15. Conversely, 10 people with defects classified as blue-yellow on the Farnsworth D-15 were classified as having a nonselective defect on the Adams desaturated D-1 (Table 2) The proportion of specific agreement between the two tests for each of the 3 categories of defects was quite high at 88% for both red-green and blue-yellow defects and quite low at 26% for non-specific defects.

DISCUSSION

We find that color discrimination declines with age and that the majority of color defects among the older population (about 80%) are of the blue-yellow type, in agreement with previous studies. We have expanded upon existing knowledge by testing a large group of older individuals from a population-based random sample, with a mean age of 75 years, and including 274 people aged 80 and above, an under-studied group. This study enabled us to determine the frequency with which these acquired defects are observed in elders in a general population.

At all ages, as expected, more people failed the Adams desaturated D-15 test than the Farnsworth D-15indicating the desaturated test's greater sensitivity to age-related acquired color deficiencies. This is to be expected given that the color differences in the Adams test are approximately half that of the Farnsworth D-15. Farnsworth's D-15 was designed to only detect defects sufficiently severe to affect performance in daily life.[15] In contrast, Adams' desaturated test was designed to detect more subtle acquired defects. For the Adams desaturated test about 15% of the youngest age group fail compared to approximately 60% in the oldest age groups. Among those in their 60s, less than 8% fail the Farnsworth D-15, compared to 40-50% among those aged 85 and older, and these individuals would have problems carrying out tasks that rely on color vision.

Though the Adams desaturated test was administered prior to the Farnsworth D-15, the better performance on the latter test is unlikely due to a learning or practice effect. Repeatability of the Adams test is very high when using failure criteria comparable to that used here[15] indicating an absence of significant learning effects. Therefore, the experience of having performed the Adams test is unlikely to have resulted in an advantage for the saturated test that followed it. Further, using the L'Anthony test, Roy et al[6] reported that the eye tested first had lower error scores than the eye tested second, again arguing against a learning effect on panel D-15 tests. Among those that failed both tests, 17.5% of the population, we find the agreement of defect types to be high, suggesting that the tests classify individuals as having the same defect type. There has been no previous study of the agreement between these two tests on a large sample of people without congenital color defects. The results also showed highly significant overall agreement between the two tests and particularly the proportion of specific agreement for red-green and blue-yellow defects (88%).

Nearly one third of this elder population made no errors on the Adams Desaturated D-15. These individuals were not tested on Farnsworth's D-15 and the assumption was made that these individuals would have also had a CCS of 0 on this test. Is this a reasonable assumption? Many individuals (18.6%) fail the desaturated test, but pass the standard D-15. On the other hand, only 3.1% of those tested passed the Adams desaturated D-15 but failed the Farnsworth test. This indicates that in the vast majority of cases, individuals tend to perform better on the Farnsworth test, supporting our assumption.

Using the FM 100-Hue, Knoblauch et al.[5] demonstrated that as the illumination on the arrangement test decreased, performance fell off, with blue-yellow errors predominating, mimicking the changes seen with age. The authors also demonstrated an age-illuminance trade off. In the present context, this has two implications. First, the prevalence of color defects, assessed at 100 lux here, would likely decrease if tested at higher illuminances and would increase at lower illuminances. Second, pupillary miosis that occurs with aging reduces the entrance aperture, reducing the effective retinal illuminance and undoubtedly contributes to the increase in color defects, and blue-yellow color defects in particular, seen among the aged. Pupillary miosis also constrains the entry path to the thickest part of the lens, further reducing transmittance due to Bouguer's law[15], which states that transmittance through a material declines as its thickness increases. The lens-related reduction of intensity is not equal for all wavelengths, but is particularly evident for the short-wavelengths, further contributing to blue-yellow defects.[16-18]

Though the contribution of the ocular media to age-related blue-yellow defects is considerable[18], there is evidence that declines in the function of the short-wavelength sensitive pathway remain after the pre-retinal media transmission loss is taken into account. [19] Thus, changes in function of receptoral and/or post-receptoral elements of the short-wavelength-sensitive pathway of the visual system also likely contribute to age-related acquired blue-yellow defects. [20]

The most common age-related eye diseases (glaucoma, age-related macular degeneration, and diabetic eye disease) all produce blue-yellow color vision anomalies, at least in the pre-

clinical or early stages. [21,22,23] As this sample was not selected to be disease free, it is likely that some of the blue-yellow defects are attributable to the presence one or more of these conditions.

Though individuals identified as congenital color defectives by self-report were excluded, a small percentage of red-green color defects were seen. In total, 10 participants, all but one male, demonstrated red-green defects on the Farnsworth D-15. The female was the only individual who showed a red-green defect on the Farnsworth D-15, but a blue-yellow defect on the Adams desaturated test. Medical records, though non-contemporaneous, were available for 8 of the 9 men, and only two had any diagnosed eye disease (diabetic retinopathy OU; retinal tear), though 6 had cataracts in at least one eye (which one might expect to produce a blue-yellow defect) and 2 of those had had cataract surgery in at least one eye. It is quite possible that the 9 men had congenital defects that they did not report or were unaware of.

In summary, in agreement with previous reports, blue-yellow defects are quite common among the aged, becoming increasingly prevalent with increasing age within this group. The Adams desaturated D-15 identifies more color vision defects than the Farnsworth D-15, but among those with a color defect, the frequency of blue-yellow defects is similar for the two tests. The agreement between the two tests in identifying red-green and blue-yellow defects is high.

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REFERENCES

1. Helve J, Krause U. The influence of age on performance in the panel D-15 colour vision test. Acta Ophthalmol (Copenh). 1972; 50:896–900. [PubMed: 4678877]
2. Pinckers A. Color vision and age. Ophthalmologica. 1980; 181:23–30. [PubMed: 6970910]
3. Verriest G, Van Laethem J, Uvijls A. A new assessment of the normal ranges of the Farnsworth-Munsell 100-hue test scores. Am J Ophthalmol. 1982; 93:635–42. [PubMed: 6979252]
4. Bowman, KJ.; Collins, MJ.; Henry, CJ. The effect of age on performance on the Panel D-15 and Desaturated D-15: a quantitative evaluation.. In: Verriest, G., editor. Colour Vision Deficiencies VII : Proceedings of the Seventh Symposium of the International Research Group on Colour Vision Deficiencies Held at Centre Médical Universitaire; Geneva, Switzerland. 23-35 June, 1983; The Hague: W. Junk Publishers; 1984. p. 227-31.
5. Knoblauch K, Saunders F, Kusuda M, Hynes R, Podgor M, Higgins KE, de Monasterio FM. Age and illuminance effects in the Farnsworth-Munsell 100-hue test. Appl Opt. 1987; 26:1441–8. [PubMed: 20454340]
6. Roy MS, Podgor MJ, Collier B, Gunkel RD. Color vision and age in a normal North American population. Graefes Arch Clin Exp Ophthalmol. 1991; 229:139–44. [PubMed: 2044973]
7. Kinnear PR, Sahraie A. New Farnsworth-Munsell 100 hue test norms of normal observers for each year of age 5-22 and for age decades 30-70. Br J Ophthalmol. 2002; 86:1408–11. [PubMed: 12446376]
8. Congdon N, O'Colmain B, Klaver CC, Klein R, Munoz B, Friedman DS, Kempen J, Taylor HR, Mitchell P. Causes and prevalence of visual impairment among adults in the United States. Arch Ophthalmol. 2004; 122:477–85. [PubMed: 15078664]

9. Farnsworth, D. The Farnsworth Dichotomous Test for Color Blindness Panel D-15. Psychological Corp; New York: 1947.
10. Adams, AJ.; Rodic, R. Use of desaturated and saturated versions of the D-15 test in glaucoma and glaucoma suspect patients.. In: Verriest, G., editor. Colour Vision Deficiencies VI: Proceedings of the Sixth Symposium of the International Research Group on Colour Vision Deficiencies Held at the Klinikum der Freien Universität; (West) Berlin-Steglitz. 17-19 September 1981; The Hague: W. Junk Publishers; 1982. p. 419-24.
11. Lanthony P. The desaturated panel D-15. Doc Ophthalmol. 1978; 46:185–9. [PubMed: 310382]
12. Adams, AJ.; Haegerstrom-Portnoy, G. Color deficiency.. In: Amos, JF., editor. Diagnosis and Management in Vision Care. Butterworths; Boston: 1987. p. 671-713.
13. Haegerstrom-Portnoy G, Schneck ME, Brabyn JA. Seeing into old age: vision function beyond acuity. Optom Vis Sci. 1999; 76:141–58. [PubMed: 10213444]
14. Vingrys AJ, King-Smith PE. A quantitative scoring technique for panel tests of color vision. Invest Ophthalmol Vis Sci. 1988; 29:50–63. [PubMed: 3257208]
15. Hovis JK, Ramaswamy S, Anderson M. Repeatability indices for the Adams D-15 test for colour-normal and colour-defective adults. Clin Exp Optom. 2004; 87:326–33. [PubMed: 15312035]
16. Weale RA. Age and the transmittance of the human crystalline lens. J Physiol (Lond). 1988; 395:577–87. [PubMed: 3411488]
17. Savage GL, Haegerstrom-Portnoy G, Adams AJ, Hewlett SE. Age changes in the optical density of the human ocular media. Clin Vis Sci. 1993; 8:97–108.
18. Nguyen-Tri D, Overbury O, Faubert J. The role of lenticular senescence in age-related color vision changes. Invest Ophthalmol Vis Sci. 2003; 44:3698–704. [PubMed: 12882826]
19. Johnson CA, Adams AJ, Twelker JD, Quigg JM. Age-related changes in the central visual field for short-wavelength-sensitive pathways. J Opt Soc Am (A). 1988; 5:2131–9. [PubMed: 3230482]
20. Schefrin BE, Werner JS, Plach M, Utlaut N, Switkes E. Sites of age-related sensitivity loss in a short-wave cone pathway. J Opt Soc Am (A). 1992; 9:355–63. [PubMed: 1548554]
21. Adams AJ, Rodic R, Husted R, Stamper R. Spectral sensitivity and color discrimination changes in glaucoma and glaucoma-suspect patients. Invest Ophthalmol Vis Sci. 1982; 23:516–24. [PubMed: 7118508]
22. Lovie-Kitchin J, Feigl B. Assessment of age-related maculopathy using subjective vision tests. Clin Exp Optom. 2005; 88:292–303. [PubMed: 16255688]
23. Feitosa-Santana C, Paramei GV, Nishi M, Gualtieri M, Costa MF, Ventura DF. Color vision impairment in type 2 diabetes assessed by the D-15d test and the Cambridge Colour Test. Ophthalmic Physiol Opt. 2010; 30:717–23. [PubMed: 20883359]

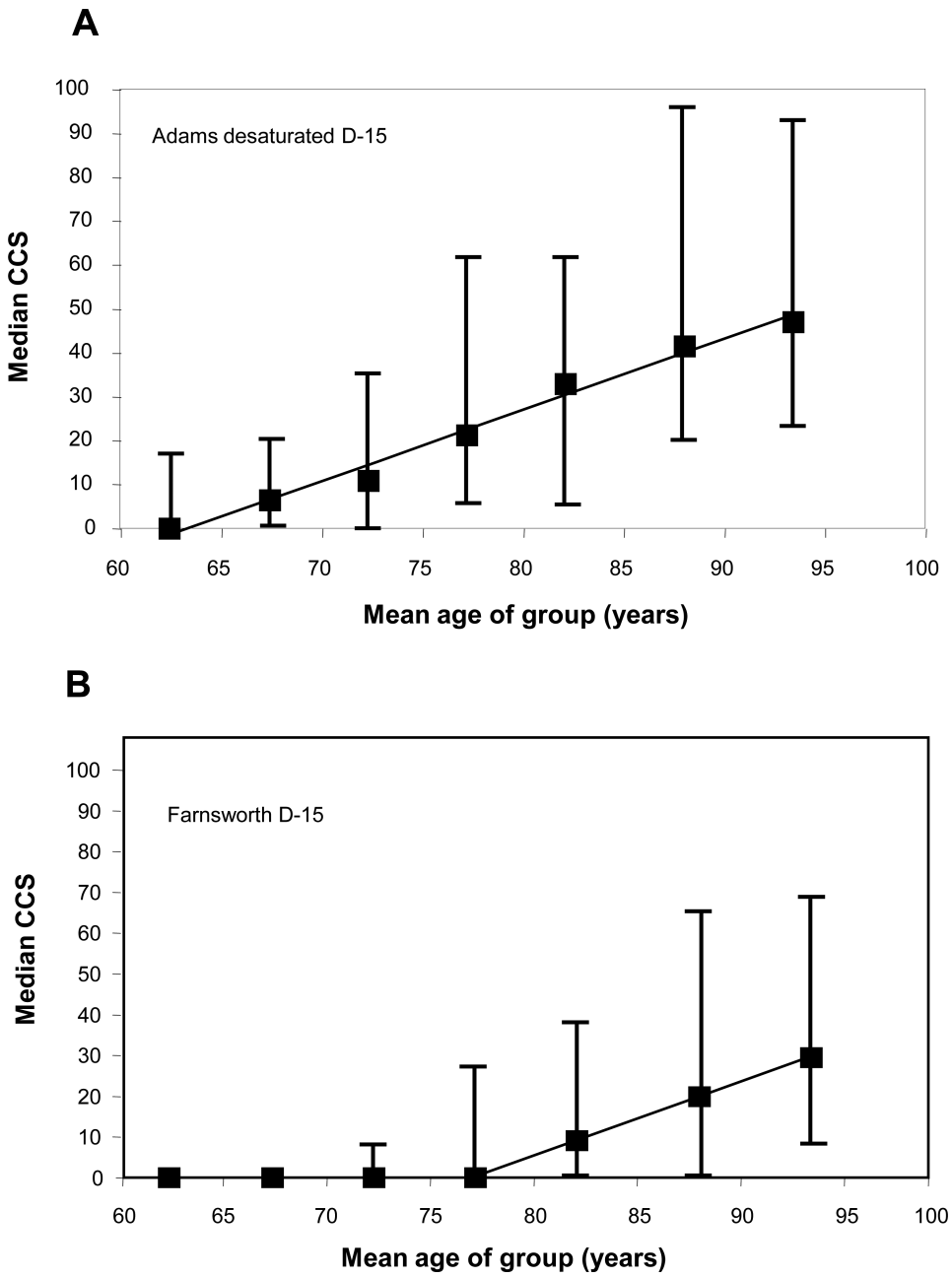

Figure 1.

Median color confusion score (CCS) across age for the Adams desaturated **(A)** and Farnsworth **(B)** D-15 tests (squares). Bars indicate 25th and 75th percentiles. Values on the abscissa are the mean ages for the groups.

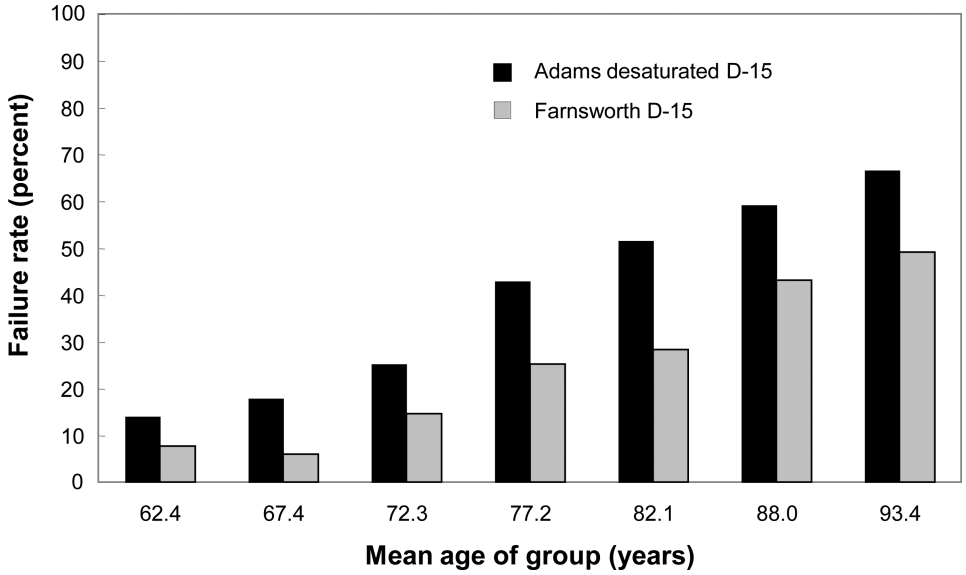

Figure 2.

Percent of people failing (CCS≥30) the Adams desaturated (black bars) and Farnsworth (gray bars) for each age group. Values on the abscissa are the mean ages for the groups.

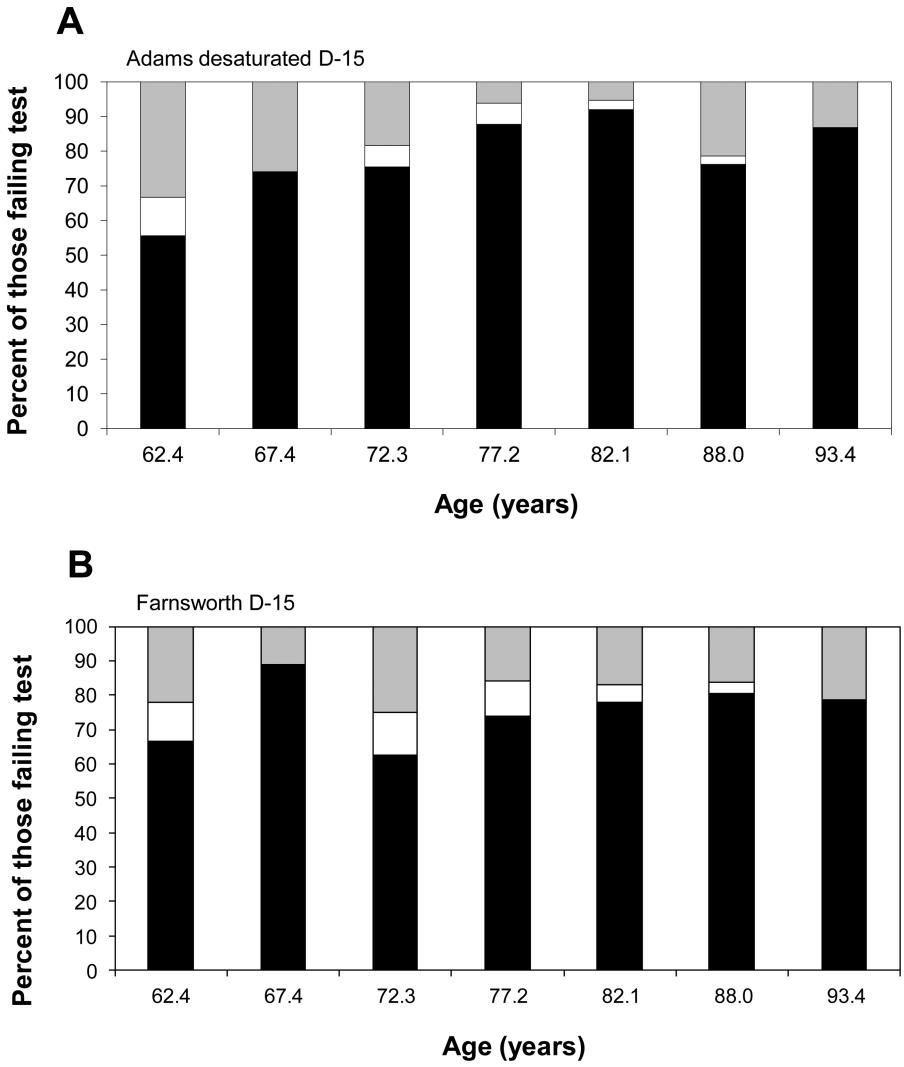

Figure 3.

Percent of those failing the D-15 test (CCS ≥ 30) that have blue-yellow (black bars), red-green (white bars) and nonselective error patterns (gray bars) for the Adams desaturated D-15 **(A)** and Farnsworth D-15 **(B)** for each age group. Values on the abscissa are the mean ages for the groups.

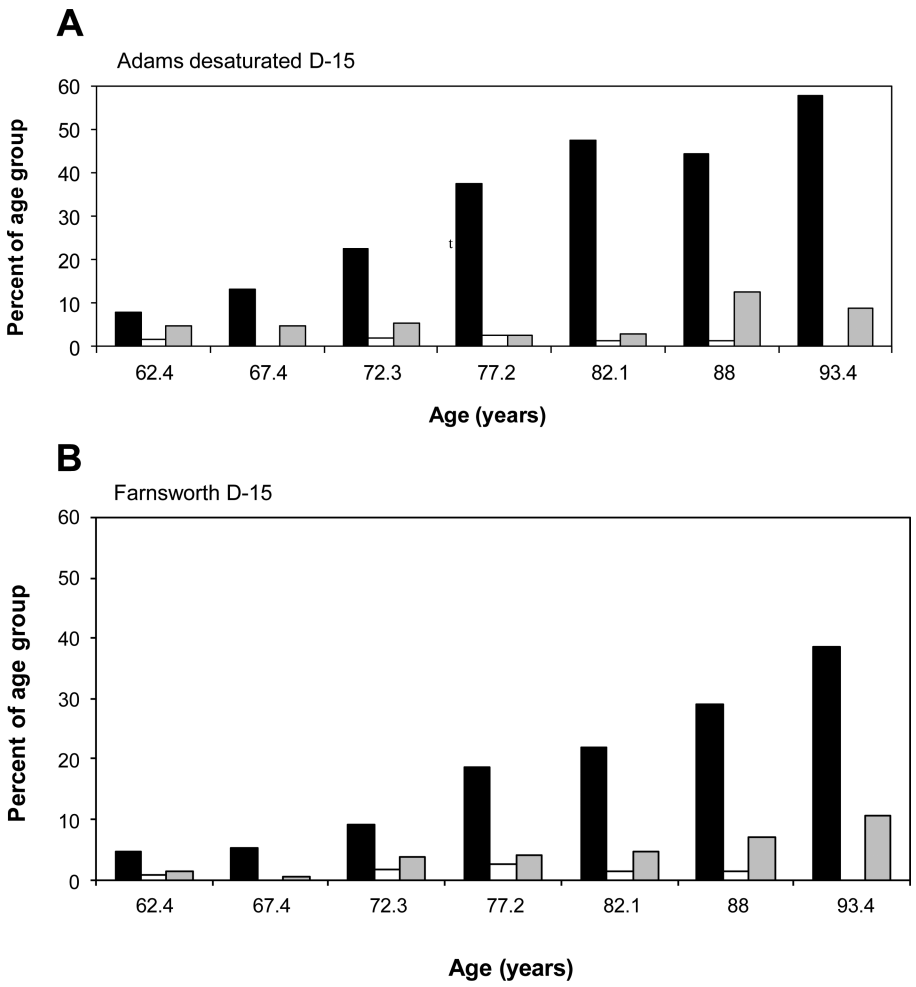

Figure 4.

Percent of each age group with blue-yellow (black bars), red-green (white bars) and nonselective (gray bars) color defects measured using the Adams desaturated D-15 **(A)** and Farnsworth D-15 **(B)** for each age group. Values on the abscissa are the mean ages for the groups.

Table 1

Distribution of color confusion scores and number of individuals (N) in each age group.

		Adams Desaturated D-15				Farnsworth D-15			
Age	**N**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**
58 – 64.99	128	0	0	17.0	52.1	0	0	0	38.9
65 – 69.99	150	0	6.5	20.4	53.9	0	0	0	33.6
70 – 74.99	162	0	10.9	35.1	89.9	0	0	8.4	63.4
75 – 79.99	151	6.5	21.3	61.3	113.9	0	0	27.6	114.5
80 – 84.99	145	6.5	32.9	61.4	124.6	0	9.1	37.4	87.7
85 – 89.99	72	19.4	41.5	95.8	148.2	0	19.8	65.1	139.4
90 +	57	23.2	47.0	93.0	122.3	8.3	29.4	68.7	119.4

Table 2

Agreement between the two color tests for color defect type. Values are number of subjects.

		Farnsworth D-15			
		Blue-yellow	**Red-green**	**Non-selective**	**Totals**
Adams Desaturated D-15	Blue-yellow	109	1	17	127
	Red-green	0	8	1	9
	Non-selective	10	0	5	15
	Totals	119	9	23	151

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