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assessment report

Color Blindness

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Color Blindness

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Color Vision

Color vision is determined by the discrimination of three qualities of color: *hue* (such as red vs. green), *saturation* (that is, pure vs. blended colors), and *brightness* (that is, vibrant vs. dull reflection of light) (Arditi, 1999a). The essential difference between the color blind and most people is that hues that appear different to most people look the same to a color blind person. In other words, having a color vision deficit means that the ability to discriminate hue, saturation, and brightness is reduced. To accommodate test users with these deficits, Pearson has developed assessments with more dramatic color contrast to address each of these three qualities of color.

Research on Color Blindness

In order to understand color blindness, the national researchers acknowledged at the beginning of this report, advised us to begin our literature review with the normal perception of color. Therefore, we looked first at the research conducted in the area of the psychophysics of reading. Legge, Pelli, Rubin, & Schleske (1985) studied how those with normal vision read. Legge, Rubin & Luebker (1987) documented the importance of color contrast in normal vision. Other research conducted by Lighthouse International (Arditi, 1999a, 1999b) and the American Printing House for the Blind (Willis, 1996; Henderson, 2001, 2002) was also used to shape the use of effective color contrast for Stanford 10 as well as our own reviews of the material.

Types of Color Blindness

Color blindness may be partial (affecting vision of only some colors) or complete. Complete color blindness is very rare. Those with complete color blindness often have other serious eye problems.

Photosensitive cells in the eye called cones allow us to perceive color. Cones are located in the very center of the retina and contain three types of photosensitive pigments able to detect red, green, and blue. Those with color blindness have a deficiency or absence in one or more of these pigments. The table that follows summarizes some of the medical terms used to describe the major types of color vision problems, percentages affected, and implication.

Term	Percentage of Population Affected	Definition & Implication
Trichromats	92%	People with normal vision—responded well to colors used in Stanford 10 materials.
Anomalous trichromats	1% red-insensitive (red-sensitive cones shifted toward green) 4.9% green-insensitive (green-sensitive cones shifted toward red)	Deficiency in one of the photosensitive pigments. The most common type of color vision problem. Three-quarters of color blind people are anomalous trichromats—usually red or green.
Dichromat	1% red-blind 1.1% green-blind	Complete absence of a cone pigment. This is usually red or green, very rarely blue. One-quarter of color blind people are dichromats.

According to Rigden (1999),

> "Eight percent of Caucasian men are colour blind. This is made up of 1% red-blind (***protanope***) and 1.1% green-blind (***deuteranope***) dichromats; 1% red-insensitive (***protanomolous***) trichromats, and 4.9% green-insensitive (***deuteranomolous***) trichromats. Only 0.002% of men are blue-blind (***tritanopia***—tritanomalous conditions are not known) and 0.003% of men are totally colour blind" (p. 3).
>
> "Only 0.4% of women have any sort of colour vision deficiency, most of them being the red or green forms" (p. 3).

Published algorithms enabled us to calculate how colors appear to people with various types of color blindness. We also used the VisiBone Web Designer's Color Card,* for Stanford 10 online applications.

Pearson's Review

Pearson engaged six nationally known experts in the field of visual impairment. All were provided with the background articles referenced in this report, a copy of the VisiBone Web Designer's Color Card, a rating instrument, and directions. Each expert was asked to review every item at every level of Stanford 10 for items that would impact students with color vision deficiencies. The reviewers were asked to identify issues by item number and to offer suggestions for correcting any potential color problems.

The responses were returned to Pearson and then summarized and analyzed. Content specialists reviewed the items for which changes were recommended to evaluate how the change might impact content. The most significant color issues identified were the item-number icons for the SESAT, Primary 2, and Advanced 1 level test booklets. These were quickly corrected.

Reviewers had different perceptions on some items in the Reading, Mathematics, and Science domains. Using the Delphi Method (Linstone and Turoff, 1975), the reviewers were asked to look at the items again and rank ways to correct the items. Three rounds were utilized.

Finally, four of the reviewers together examined the items (some having been revised) one more time and considered their impact on students with color blindness.

As a result of this entire review process, Pearson is confident that the use of color in Stanford 10 meets the needs of the vast majority of students with color deficiencies. For students with visual impairments and color deficiencies, the large print version is available on non-glare paper in black and white.

* VisiBone Web Designer's Color Card: http://www.visibone.com/color/card_800.gif

Implications for the Future

Pearson will study the effects of color and color blindness on Stanford 10 online applications in the future. Research conducted by others (Rigden, 1999; Legge and Rubin, 1986) has shown that the potential for assisting students—with regular vision and vision problems alike—is great. The research done by Arditi (1999a, 1999b) on effective color contrast and making text legible, as well as that done by Legge *et al.* (1990, 1989, 1987), will set the parameters for the future studies.

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