COLORIMETRIC TRAINING BOOK

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ABSTRACT

The most important characteristics of human color vision are color identification and color discrimination. Subjects with color deficiency are impaired in both capacities when compared to subjects with normal color vision. Subjects with normal color vision can discriminate up to a few million hues whereas subjects with color deficiency cannot discriminate more than a few hundred of them. Our correction glasses help to substantially improve color discrimination in color deficiency. This improvement is also evident in respect of subjective color experience: our subjects reported that on starting to wear the glasses, the world became more colorful. However, subjects with corrected color deficiency need to memorize the new chromatic shades they are sensitive to and also to learn their names. In addition, the correction glasses modify those color experiences with which the subjects had been familiar before the correction started. In other words subjects with corrected color deficiency need to familiarize themselves with a “New World” of color. For people with normal color vision, color discrimination and naming are acquired in infancy and childhood, whereas only part of this learning process can take place in subjects with color deficiency. Our Colorimetric Training Book helps subjects with corrected color deficiency to improve their color identification and color naming.

KEYWORDS: Color vision, Defective color vision, Color identification, and Color discrimination

1. INTRODUCTION

The aim of our work is to help people with defective color vision to improve their color perception. The Colorimetric Training Book provides simple to use, inexpensive and entertaining assistance in color identification and naming.

2. NORMAL AND DEFECTIVE COLOR VISION

The most important characteristics of human color vision are color identification and color discrimination. Subjects with color deficiency are impaired in both capacities when compared to subjects with normal color vision [1, 2, and 3].

2.1. Color discrimination

Color discrimination is defined by the smallest change in color which can be detected by people under test conditions. Color discrimination can be characterized by ΔE. This change is about $\Delta E = 1$ by people with normal color vision. Subjects with normal color vision can discriminate between up to one million hues whereas subjects with color deficiency cannot discriminate between more than a few hundred of them.

Color discrimination is an inherited ability and depends on the characteristic of spectral sensitivity of the cone receptor [4].

2.2. Color identification

Color identification can be defined by correct the naming of colors. People with defective color vision confuse, for instance, brown with dark green, orange with red or turquoise with pink.

Color naming is a learned ability. A small child in the first two-three years has to learn the names of colors. But if the child has low color discrimination, he /she has difficulty in naming certain colors.

3. EFFECT OF SPECIAL COLOR FILTERS FOR COLOR VISION OF COLOR –DEFICIENT PEOPLE

We use special color filters in lenses in glasses to enhance color vision capacity of color-deficient people [5].

Our correction glasses help to improve substantially color discrimination in people with color deficient vision. This improvement is also evident in subjective color experience: our subjects reported that on starting to wear the glasses, the world became more colorful. However, subjects with corrected color deficiency need to memorize the new chromatic shades they are sensitive to and also to learn their names. In addition, the correction glasses modify those color experiences with which the subjects had been familiar before the correction started. In other words subjects with corrected color deficiency need to familiarize themselves with a “new world” of color. For people with normal color vision, color discrimination and naming are acquired in infancy and childhood, whereas only part of this learning process can take place in subjects with color deficiency. Our colorimetric training book helps subjects with corrected color deficiency to improve their color identification and color naming.

4. THE COLORIMETRIC TRAINING BOOK

The Colorimetric Training Book will have three parts. The first part has already been written.

The first part of the Colorimetric Training Book is the basic level Training Book. Its aim is to help subjects with color deficiency to recognize and name 25 colors that are of key importance in everyday life.

The basic level Training Book asks the reader questions about the colors presented. In our view, learning to perceive colors is like learning about more abstract subjects: it is focuses attention, encourages active thinking and gives the subject the opportunity to do exercises. The correct answers to the questions and exercises can be found at the end of the book.

4.1.The basic colors in the Colorimetric Training Book

We believe the 25 colors of highest practical importance are the three additive basic colors (red, green and blue), the three subtractive basic colors (cyan, magenta and yellow) and brown, orange, violet and grey. These colors are shown in the book at three levels of lightness: light, medium and dark.

4.2. Content of the Colorimetric Training Book

The first chapter presents each of the 25 colors along with their names.

Subsequently the same colors are shown again in random order, without descriptors, and the subject’s task is to name them. Each page contains a single color sample on a white background. In this first stage of learning our aim is to prevent simultaneous color comparisons from affecting recognition.

Following this we present pairs of colors that are often confused by subjects with color deficiency (for instance: lilac vs. cyan; dark brown vs. dark green). In this section the color samples appear in 10^0 viewing fields.

In the third section we present a number of different colors simultaneously, where individual color patches subtend 2^0. Our aim here is to familiarize subjects with different shades of the colors presented in viewing fields that are larger than in the first two sections.

The last chapter focuses on psychological and esthetic color assessment. For instance, subjects are asked to choose colors that they find beautiful or unaesthetic, calming or stimulating. Our aim with these questions is to keep the subject's attention focused on the colors and to see if the esthetic and psychological assessment of a subject with corrected color vision differs from that of subjects with normal color vision.

5. EXPERIMENTS

5.1. Observers

Using the Training Book we did experiments with 20 uncorrected and 20 corrected color deficient subjects, and color-normal control group with 20 individuals was also examined. Our subjects were university students between 20-24 years of age.

15 individuals with anomalous color vision and 5 individuals with protanopy or deuteranopy were examined in the color deficient block.

Each people under test were examined with Ishihara test, Oculus anomaloscope, D15 test and F-M 100 hue test.

We will show the results of exercises without correction glasses because we wanted to show the effect of exercises using the colorimetric training book

5.2. Experimental results using the D 15 test

The Farnsworth-Munsell D 15 test is a sorting test [5]. It consists of 15 caps with Munsell colors. The observer has to sort them by color. The color arrangement made by the observer is drawn on a circular diagram representing the hues. Isochromatic errors give rise to lines which cross the diagram and show that colors from opposite sides of the hue circle have been placed next to each other in the arrangement. Typical results are obtained in congenital protan, deutan and tritan color deficiency.

A standard illuminant (source C) has to be applied for the test.

5.2.1 Administration the results of the D15 test

A simple method was applied for calculating a numerical score of the results evaluating the D 15 test. Every missed point in the diagram of D15 test means 1 Error Score (Fig. 1). The Total Error Score is the sum of the error scores.

5.2.2 An example of the examinations

As an example, we take the test results of R.R., a person with severe color deficiency. He failed in 17 plates out of 20 in the Ishihara test. He seems to be protanope according to the anomaloscope test. His D 15 test showed typical protanopy in the initial examination.

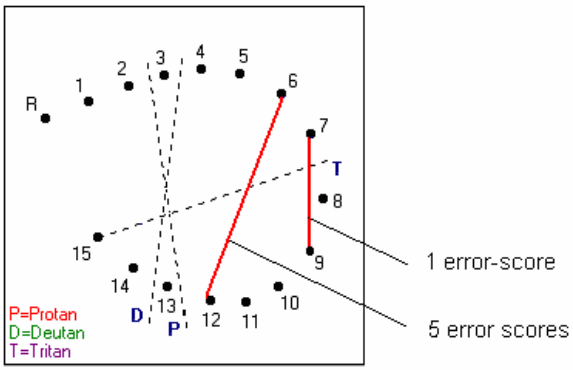

Fig. 1 Calculation of Error Score evaluating the results of D 15 Panel test

Exercises from the Colorimetric Training Book were conducted over a period of 6 months, once in every one or two weeks. After 6 months the D 15 polar diagram was nearly identical to the normal diagram (Fig. 2).

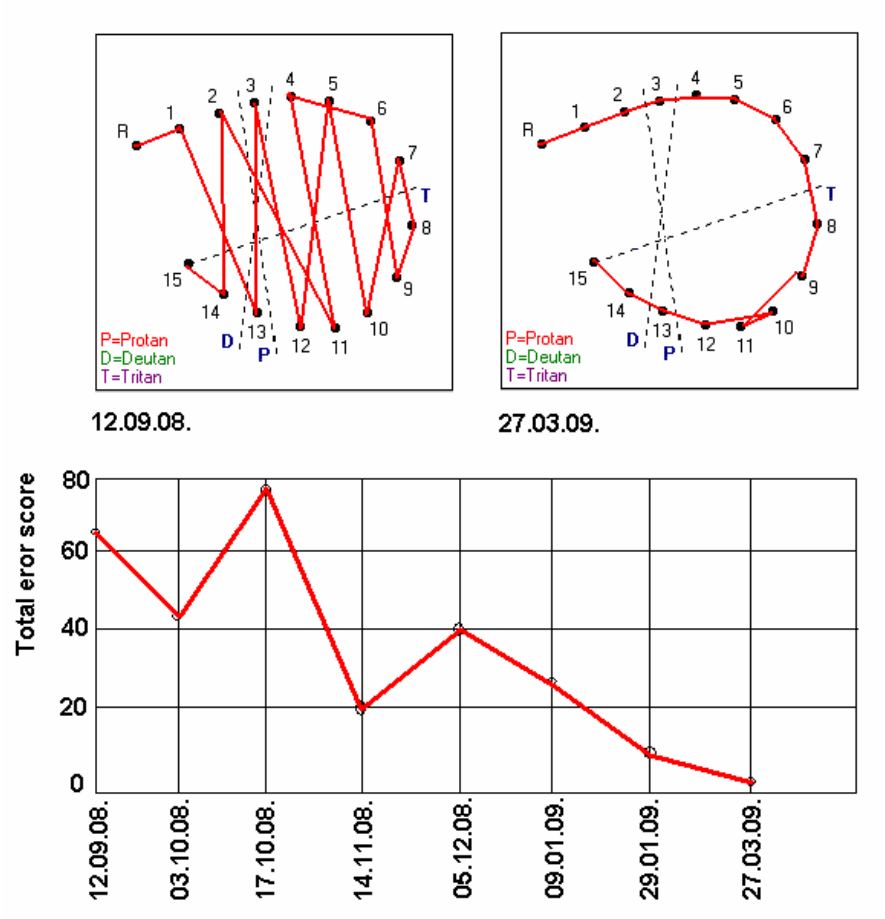

Fig. 2 D 15 test results of R.R., a protanop people before and after 6 months execirses with the Colorimetric Training Book

5.2.3 Experimental results using the F-M 100 hue test

The F-M 100-hue test examines hue discrimination ability [5]. Hue discrimination ability is estimated from the total error score. The type of color deficiency is determined from a graphic representation of the results. Characteristics F-M 100 hue plots for people with congenital protan, deutan and tritan defects show concentrations of errors in two well-defined positions which are nearly opposite in the polar diagram representing the circle of hues (Fig. 3)

The case of R.R., the subject with protanopy, produced a significant result on the Farnsworth-Munsell 100 Hue test too. In the initial stage of the exercises his Total Error Score was 124 (that means moderate color deficiency). After 6 months of exercises with the Coloristic Training Book, the Total Error Score was 40 (that means slight color deficiency) (fig. 3).

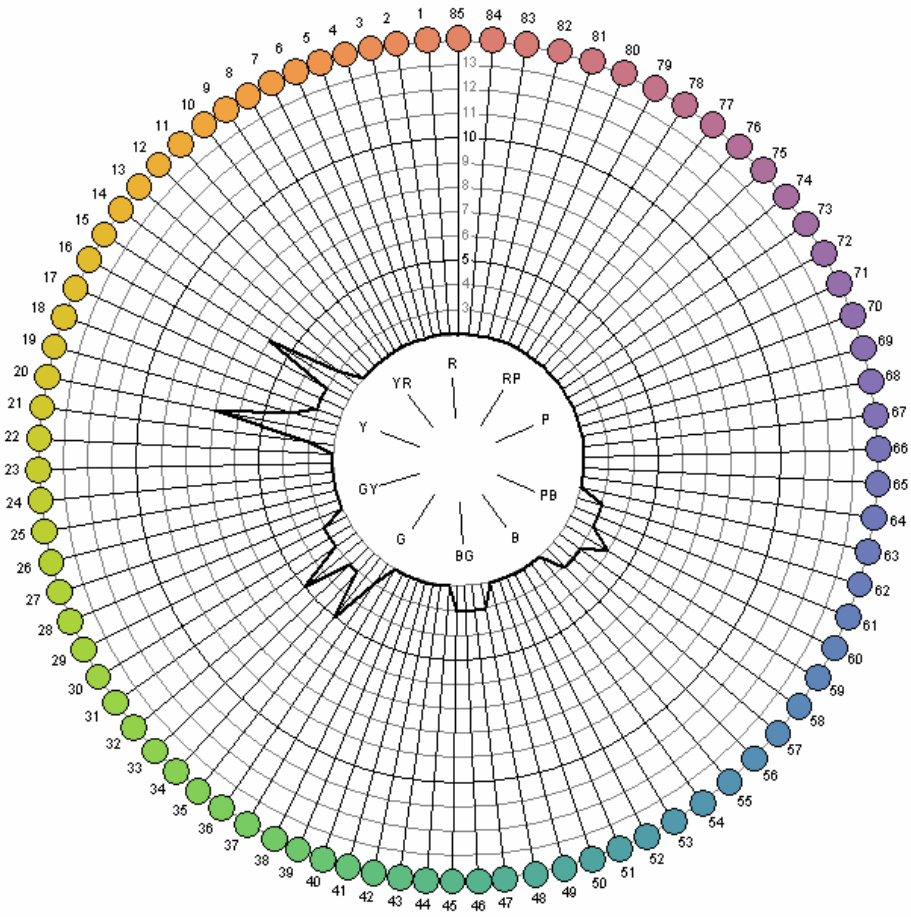

Fig. 3 The F-M 100 Hue result of R.R. after 6 Months exercises with the Colorimetric Training Book.

SUMMARY

Subjects with both corrected and uncorrected color deficiency showed gradual improvement after repeating the exercises a few times. Subjects with corrected color deficiency solved the tasks with significantly fewer errors than uncorrected subjects.

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