Euro: A new color vision test in the pockets of three hundred million Europeans

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Abstract: As of 1 January 2002, twelve European Union countries have a new common currency - the euro. Amongst the many advantages that the use of this single currency may bring, there is one that is serendipitous from the viewpoint of studying anomalies in color vision: the eurocent coins serve as a ready-made test to detect anomalous chromatic vision.

OCIS codes: (330.0330) Vision and Color; (330.1720) Color vision

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1. Introduction

The increasingly important role of color in our society makes the capacity to discriminate colors necessary for the development of certain professional activities: advertisers, designers, etc., use color to enhance the appeal and acceptance of their products in the marketplace; chemical laboratory analysts and personnel use color codes to label certain properties of chemical compounds. Furthermore, the early detection of anomalous color vision in children, especially at the infant school stage, may be vital for color-vision impaired pupils to be able to fulfill their cognitive and educational development [1].

Anomalies in color vision may be congenital or symptomatic of some other more serious disorder such as multiple sclerosis or of the treatment of another disease with a drug such as chloroquine in Lupus erythematosus. The population which is affected by some type of congenital red-green anomaly has been estimated by several authors as 8% of men and 0.4% of women in Europe and North-America [2].

For these reasons, tests to detect deficiency in color vision are now widely used by health care and human resources professionals. The most common evaluation procedure in the examination of the visual system is testing for red-green color deficiencies. Two accepted approaches to detecting color anomalies are the Ishihara plates and American Optical Pseudoisochromatic plates [3]. Other methods, such as the Nagel anomaloscope or the Farnsworth-Munsell 100-Hue test require skilled examiners and precisely calibrated devices [4]. There also are other kinds of cathode-ray tube (CRT) based devices using computer applications which obviate the need for a skilled examiner, but which also require the system to be calibrated before it can be used properly [5].

Most of these methods of detecting chromatic vision anomalies are expensive, and in many cases they are difficult to evaluate or calibrate. We here present a new test for color vision deficiencies which is easy to use, very cheap, and ready to hand for 300 million European citizens.

2. A new color vision test

Since the negative consequences of anomalous color vision can be minimized by an early as possible diagnosis, so that both the persons affected and their families are made aware of the deficiency [1], it is fundamental that the tests used to detect these anomalies should have a broad diffusion. The simpler, cheaper, and easier to obtain the test is, the wider its diffusion will be. The ideal situation would be to have a test using everyday objects, or ones that are very easily obtained, and which also are exactly the same everywhere so that the test will be homogeneous.

In a research project that we have been carrying out over the last three years, we have been analysing such everyday, or at least easily accessible, materials in the school environment that may involve unforeseen difficulties for a defective observer. As of 1 January 2002, twelve of the European Union countries have been using a single currency, the euro. The euro and eurocent coins have thus become the most everyday possible of the objects handled by 300 million Europeans. Within the variety of banknotes and coins issued and now in circulation, there are two classes of eurocent coins: those of least value, made of copper-covered steel with a reddish tone (1, 2, and 5 eurocents), and those of higher value made of Nordic gold, *Cu89Al5Zn5Sn1*, which is yellowish in tone (10, 20, and 50 eurocents. A colorimetric analysis of these coins, using a GretagMacbeth Spectrolino spectrophotometer with the C illuminant, gave the CIE (x, y) coordinates shown on the CIE 1931 chromaticity diagram of Fig. 1.

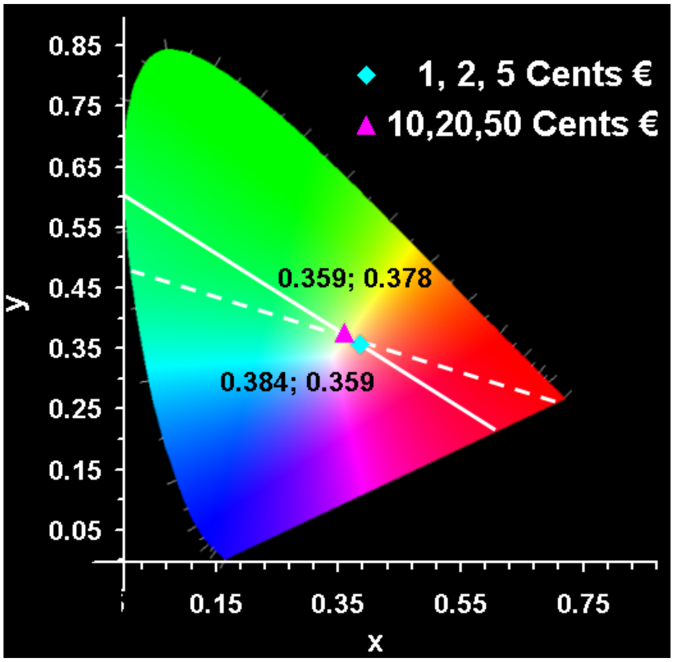

Figure 1. Plot of the chromaticity coordinates of eurocent coins on the CIE 1931 diagram, together with the confusion lines of protanopes (dashed line) and deuteranopes (solid line).

One sees that the two chromatic values coincide on what is known as the confusion line. Confusion lines are lines joining points on the chromaticity diagram that appear the same in color for dichromats [6]. In the case represented in Fig. 1, the two colors lie on a deuteranope confusion line (solid line), as well as presenting an acceptable fit to a protanope type of line (dashed line).

This indicates that the two coins would be perceived as having the same tone by deuteranope observers, and that the differences that protanope type dichromats would observe will be minimal. This therefore opens up the possibility of using these coins as a new type of test for red-green color deficiency. To study how equally anomalous observers would perceive the two classes of coin, we applied a simulation algorithm of the two types of deficiency, deuteranope and protanope [7], on a picture of two coins of different color. The variability in the luminosity from the different zones of the coins due to the irregularities in their surfaces made it difficult to obtain this picture. The best image was obtained using a digital camera and avoiding reflections in so far as possible. The result is shown in Fig. 2.

Figure 2. (Left) photograph of 20 and 5 eurocent coins; (centre) simulation of how a deuteranope observer would see these two coins; (right) simulation of how a protanope observer would see them.

To check the validity of this medium as a quick test to detect anomalous color vision, one group of 10 dichromat observers and another of 10 normal observers performed a trial based on separating by color fifteen coins of 5, 10, and 20 eurocents. The test was performed with mint coins, supplied directly by the European Central Bank. They were placed on a table lit with diffuse midday natural light. To avoid the possibility of the coins being classified by value, they were all presented obverse up. Also, so that the designs of these obverses should not serve as a classification criterion, we used coins from three different countries of the eurozone with distinct obverse designs unknown to the observers. We verified that the luminosity of the coins could not be used as a classification criterion given its similarity and variability due to irregularities in their surfaces. The dichromat observers were found to be incapable of performing the separation, while the normal observers completed it successfully in a matter of seconds. Of course, it has to be borne in mind that there exist other lesser degrees of anomalous color vision, such as the anomalous trichromats. We found that these subjects did manage to complete the eurocent coin separating task according to the color, but they took a far longer time to do so than did the normal observers.

4. Conclusions

With the entry of the euro into circulation, more than 300 million Europeans now have the opportunity to check straightforwardly and quickly whether or not they suffer from some anomaly in color vision. The repercussion could be both in minimizing the problems that go with this type of anomaly since it will be detected early, and, from a researcher's point of view, in advancing a better knowledge of these conditions due to the sudden widescale enlargement of the study population.

Acknowledgments

We are grateful to the Department of Optics of the Universidad de Granada, and in particular to Prof. Hita Villaverde for invaluable help and constant support.