USING CUSTOMIZED PSEUDOISOCHROMATIC PLATES FOR DETECTING CHOSEN FORMS OF DICHROMACY

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Abstract

Pseudoisochromatic plates have been used for detecting certain types of colourblindness (especially protanopia and deutanopia) for almost a century. Nowadays, due to its simplicity and relatively low examination cost, this method is widely used throughout the world. On the other hand, it is often criticized because of potential ambiguity and inaccessibility for certain groups of patients. This paper covers the analysis of different versions of currently used pseudoisochromatic plates. A tool for generating customized plates for detecting different types of dichromacy in certain user groups is also presented.

Colour vision disorder may prevent a person from engaging in certain occupations, especially when colour recognition is important either for safety or essential for the work itself. Being aware of having colour vision disorder is important not only for people with professions connected with colour-based signals.

Pseudoisochromatic plates – types and usage, pros and cons of the described method, proposal of the new diagnostic method – generating customized pseudoisochromatic plates, results of the preliminary research are presented in the paper.

Keywords: *pseudoisochromatic plates, colour vision, computer aided diagnosis, colourblindness*

1. Introduction

Having colour vision disorder may prevent a person from engaging in certain occupations, especially when colour recognition is important either for safety or essential for the work itself [4]. In many countries those limitations are introduced by law [3], although may differ in severity: in some cases the colourblind are not permitted to apply for driving or sailing license at all [4], while in other (e.g. in Poland [1]) the injunction applies only to professional qualifications.

Colourblindness affects mainly the ability of distinguishing the colours properly, but not the whole sense of sight - many people are not even aware of their impairment, as it can be detected usually only on few occasions: during pre-school medial tests or while applying for driving license [2]. But even then, due to the error of the examiner or the examining method [2], the colourblindness can be undetected. The result may be two-fold: either a colourblind person is allowed to apply for e.g. driving license (normally being not allowed to) or (more rarely) a person with normal colour vision is not permitted to do so. In both cases, this situation is not acceptable, especially concerning the countries with strict legal regulations regarding the colourblind.

Being aware of having colour vision disorder is important not only for people with professions connected with colour-based signals (e.g. drivers or sailors) – Fig. 1 presents an importance of the ability of distinguishing the colours in the cook's profession. Moreover, some types of colourblindness may affect everyday safety – people with protanopia may see red e.g. traffic light as blank (see Fig. 2).

There are several methods used for detecting colourblindness, varying in sensitivity, error rate or examination cost. Using pseudoisochromatic plates is one of the most commonly used methods, mainly due to its simplicity and relatively low examination cost [2].

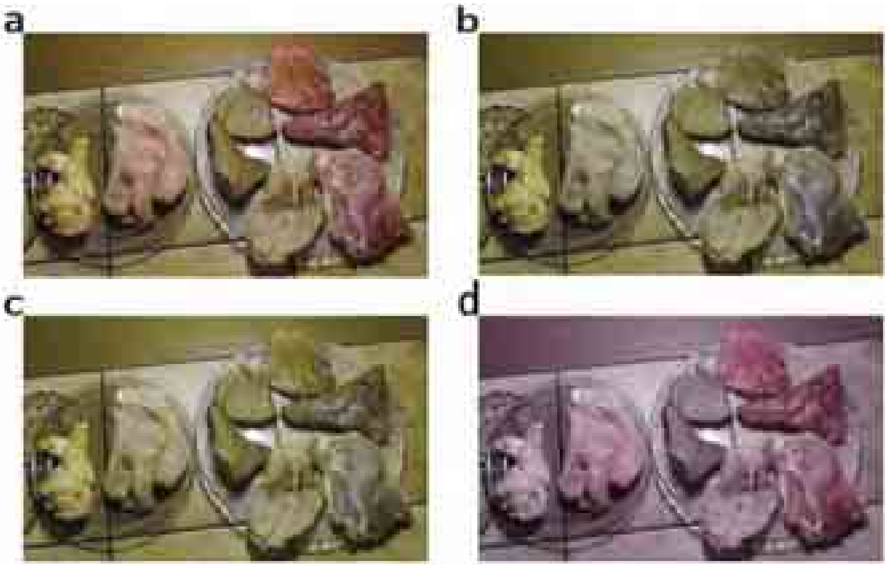


Fig. 1. A plate with both raw and fried meat as seen by person with a) normal colour vision, b) protanopia, c) deutanopia, d) tritanopia (source: own work, simulation engine: vischeck.com)

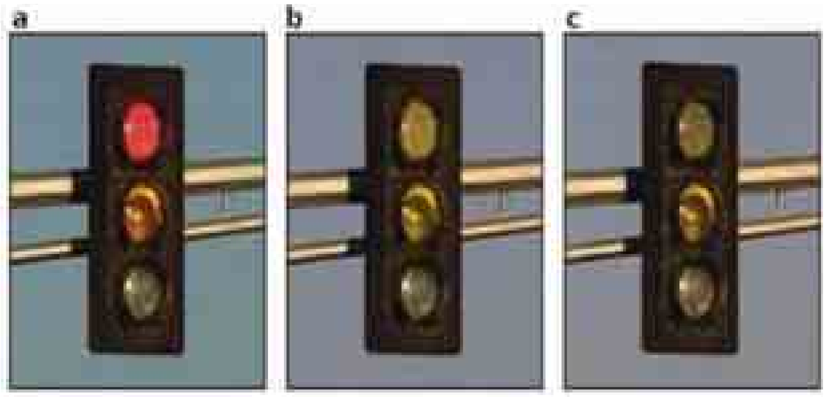


Fig. 2. Traffic lights as seen by person with a) normal colour vision, b) protanopia, c) deutanopia (source: own work based on [5], simulation engine: vischeck.com)

2. Pseudoisochromatic plates – types and usage

The first medically used pseudoisochromatic plates were introduced in 1917 by Japanese ophthalmologist Shinobu Ishihara [6] and contain a circle of dots seeming random in both colour and size, forming a number, which is visible for people with normal colour vision but invisible (or hard to see) for colourblind [6].

The original Ishihara set consisted of 38 plates designed mainly for red-green colour deficiencies (both protanopia and deutanopia), but some of the plates can also be used for testing blue-yellow colour deficiencies. Typically, the test is performed using printed sets, but web-based applications using predefined plates are also used [2].

Each set should consist of five types of plates [7]:

– introductory – which is used for explaining the testing process, with pattern visible to everyone,
– vanishing figure - with pattern easily read by people with normal colour vision but unreadable for people with colour vision impairment,
– hidden digit (also called reverse plate) – with pattern readable only to colour defectives,
– transformation plate – with combination of two patterns – one readable to people with normal colour vision (e.g. number 74), while the other being readable only to colourblind (e.g. number 71),
– qualitatively diagnostic - vanishing plate that also permits differentiation between protans and deutans.

There are many different sets of pseudoisochromatic plates developed based on Ishihara's work, although they are not as widespread as the original [7].

3. Pros and cons of the described method

Pseudoisochromatic plates (both Ishihara plates and its variations) are a widespread method due to the simplicity and relatively low examination cost - one set of plates can be used for several years [7]. Despite those advantages this method is often criticized because of its ambiguity (e.g. in the original set different answers to selected plates are accepted as correct, like reading whether 23 and 73 [7]) and inaccessibility for certain patient groups (children or foreigners) [6]. In the original sets of Ishihara plates there are several plates especially dedicated for illiterates with numbers replaced by different patterns (usually a trail form point A to B), but their effectiveness is often based on development level or linguistic abilities of the examinee [7].

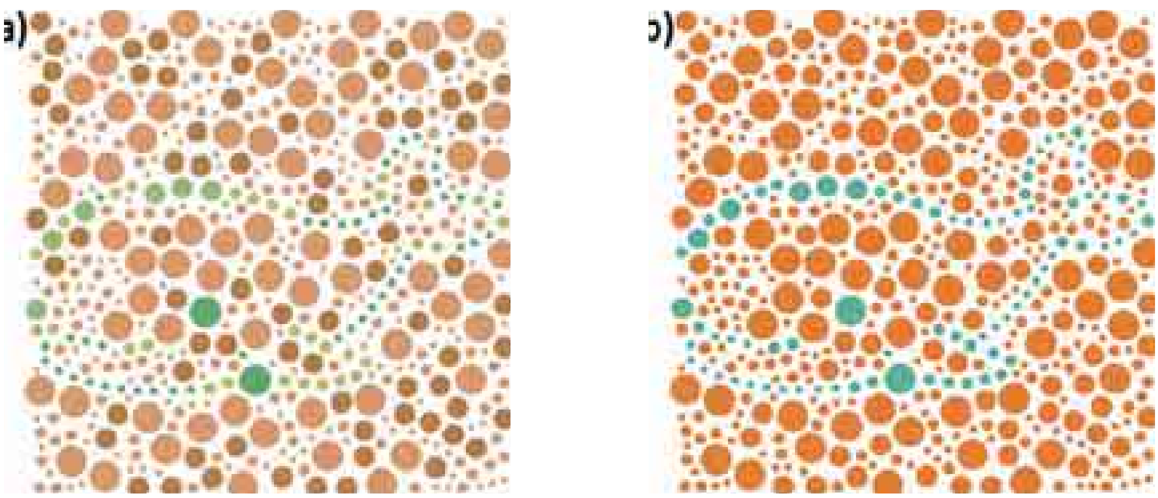
4. Proposal of the new diagnostic method – generating customized pseudoisochromatic plates

Considering the problem of detecting colourblindness using pseudoisochromatic plates, question arises: is it possible to eliminate the aforementioned problems by customizing the set of plates to a certain patient? For example, it may be troublesome for a child to name the numbers or geometric figure seen on a plate properly, but it should be relatively easy to name a characteristic shape (e.g. a fruit or animal). Analogically, the patterns on the plates should be adjusted to the limited linguistic abilities of the examined person, e.g. foreigners.

eyeConv is an application developed by computer science students at Lublin University of Technology under the supervision of the author, which allows user to convert almost any monochromatic bitmap into a pseudoisochromatic plate. The bitmap image should not be complicated, as the shape may be obfuscated during the conversion. Canny edge detection is used for detecting the edges in the transformed image.

The sample sets generated by eyeConv from Fig. 3 are presented in Fig. 4 a-f, while Fig. 6 a-b present plates generated from an image with a complicated shape.

Fig. 3. Simple monochromatic image used for generating pseudoisochromatic plates (source: own work)



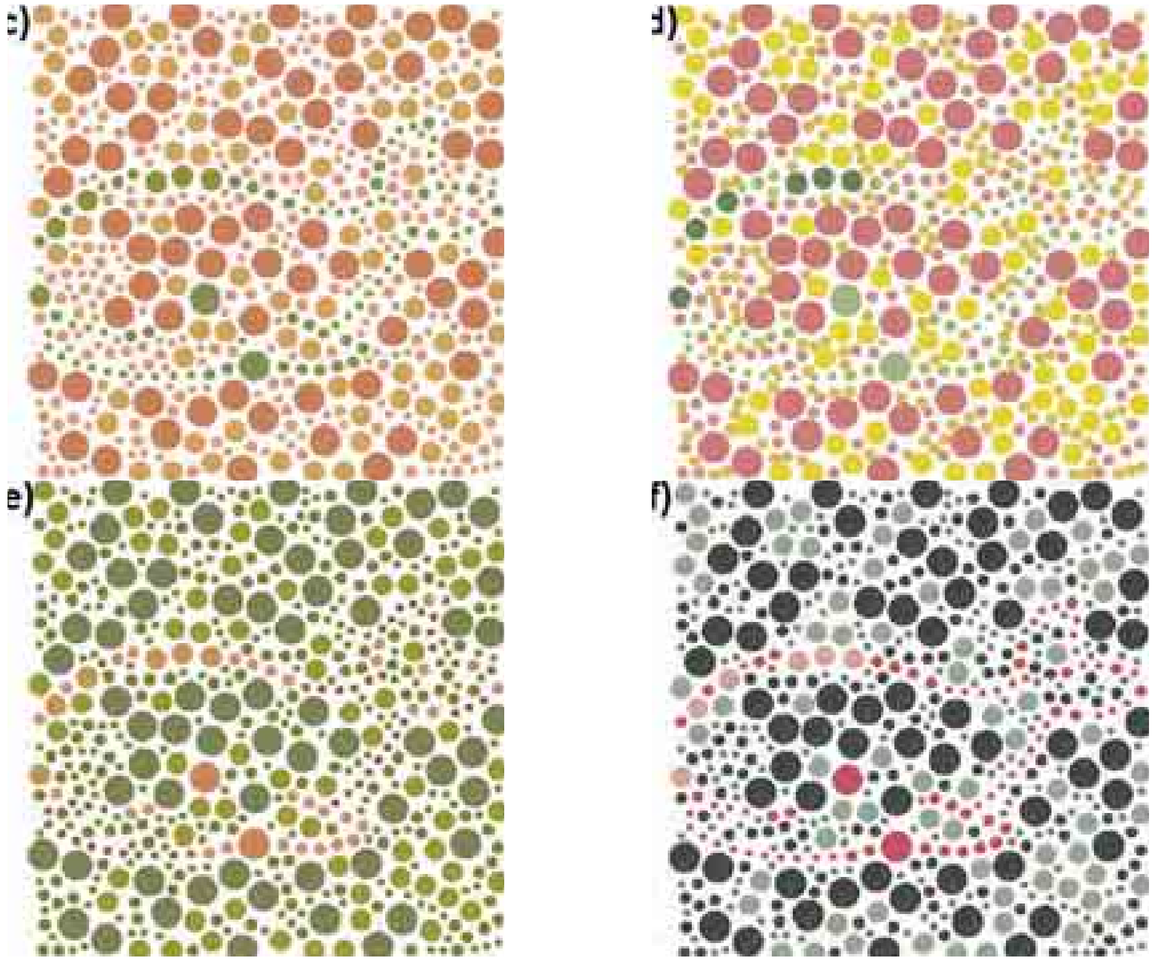


Fig. 4. a-f. Samples of plates generated by eyeConv application (source: own work)

Fig. 5. Example of an image with too complicated shape (source: own work)

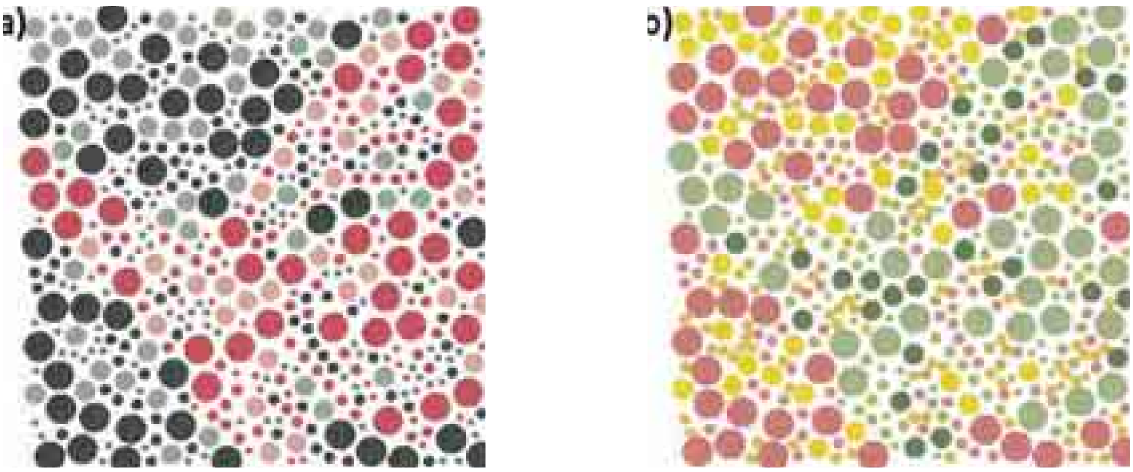


Fig. 6. a-b. Sample plates generated from an image with a complicated shape (source: own work)

Each plate is generated in six different colour versions, allowing testing not only all types of dichromacy but also anomalous trichromacy, thus differing from e.g. original Ishihara plates limited mainly to testing two types of dichromacy.
eyeConv allows its user to create their own sets of pseudoisochromatic plates, varying in detail level or difficulty, although at this level of application development it allows only creating vanishing design plates. This allows the colour vision test to be flexible and adjustable to the needs of the patient, without using predefined and inflexible sets of plates, often developed decades ago.

5. Results of the preliminary research

The preliminary research was conducted on a group of 16 high school students, four of whom were refugees living in Poland for about a year. The participants were divided into four equal groups. All the foreigners were placed in group no. 3.

Each of the participant was given a three sets of four random pseudoisochromatic plates: 'classic' Ishihara plates (set no. 1), Handy-Rand-Ritter plates (similar to Ishihara, with simple geometric patterns) (set no. 2) and plates generated with eyeConv application (set no. 3).

The examinees were asked to read the pattern from each plate and to mark the reading difficulty (from 1 – the easiest to 10 – the hardest). In case the reading suggested colourblindness, the diagnosis was confirmed by a set of four reverse Ishihara plates, adjusted to certain type of colour vision deficiency. Reading time was also a measured factor.

During the test, two potential cases of colourblindness were detected – one in group 3 and one in group 4. Both cases were confirmed with the reverse Ishihara plates test.

The average reading times of plate sets for each group are presented in Tab. 1, while mean difficulty level for each set is presented in Tab. 2.

Tab. 1. Average reading time

group no.	*Set no.1*	*Set no.2*	*Set no.3*
1	98	91	94
2	91	89	89
3	122	110	117
4	87	93	91

Tab. 2. Mean difficulty level

group no.	*Set no.1*	*Set no.2*	*Set no.3*
1	2.25	2	2
2	2.75	2.5	2.5
3	4	3.5	4.5
4	3.75	3	3.25

6. Conclusions

The following conclusions can be drawn from the results presented above:

1) the pseudoisochromatic plates generated using eyeConv application seem to have the same level of detecting colourblindness as currently-used sets of plates,
2) the test using generated plates was easier (in the subjective perception) and quicker that the test using 'standard' set of plates in case of people with Polish not being a mother's tongue, thus confirming the assumptions – minimizing the influence of external factors (e.g. linguistic abilities) on test results,

3) the effectiveness of generated plates on detecting anomalous trichromacy is to be checked, although is requires using more precise methods (e.g. Farnswoth D-15 or D-100 Test) to confirm the potential diagnosis.

Despite promising preliminary results, the author would like to emphasize that at the current level of application development all of the plates generated by eyeConv should be used only to detect potential colourblindness, as each diagnosis should be confirmed by further medical examination using methods more precise than pseudoisochromatic plates, such as anomaloscope or lamp method.

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