JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Validating the Effectiveness of Dichroic Film in Color Blind using EEG

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Abstract: Color blindness is a congenital ocular condition that affects 8% of men and 0.5 percent of women around the world. It's a condition in which people can't tell the difference between different shades of color due to an excessive overlap of color confusion lines, making it difficult to tell the difference between red and green wavelengths. Currently there is no permanent cure for color vision deficiency as it is caused due to missing or defective photoreceptive cones in the retina. Colorblind people could benefit from wearables that improve color perception, such as filter glasses or lenses. Herein, a Dichroic film is designed and developed using red, green and blue filter films which is used to enhance the brightness of the color thereby helping the colorblind people to identify the colors more clearly. Traditional color blindness test (Ishihara test) was conducted to find out the colorblind people and classify them according to the type and extent of color blindness. After which necessary designed color filters were used to enhance the brightness of a particular color like red, green or blue hence making the previously unidentifiable color for the subject more differentiable and clearer by usage of appropriate filters. Simultaneously, Electroencephalogram (EEG) of the participants were recorded using a single channel neurosky brainwave sensor throughout the protocol and analyzed for further study. Evident enhancement in the color perception of the participants was seen after using the designed filter. Alpha and gamma waves had significant values while performing the task with and without the filter. The brain wave values increased after using the filter for color recognition and perception, indicating that it is beneficial as an assistive training aid for colorblind people. The findings show that using dichroic film causes a change in the normal perceived color. thereby enhancing the effectiveness of color identification in color blind people and eventually training them.

Keywords—Color Blind, Dichroic Film, EEG.

I. INTRODUCTION

Many people are unable to differentiate certain shades of colour in the normal way. This condition is usually known as colour deficiency which affects almost 0.8% of males and 0.5 % of females and people with these conditions are unable to distinguish the outline between red, green and blue shades [1]. Normal colour vision is trichromatic where the blue, green and red colours are perceived by a cluster of photo-receptive cones located in the retina, around the fovea. There are three photoreceptors, namely short cones (S), medium cones (M) and long cones (L) which are responsible for blue (short wavelength), green (medium wavelength) and red (long wavelength) respectively [2].

Defective or missing cones lead to colour vision deficiency where incorrect information is sent to the brain for processing. When one of the cones is defective, it causes protanomaly, in which the cone responsible for red colour shifts to the left; deuteranomaly, in which the cone responsible for green colour shifts to the right; or tritanomaly, in which the cone responsible for blue colour shifts to the right; or tritanomaly, in which the cone responsible for blue colour shifts to the left. [3]. In red green colour blindness, there is an excessive overlap of the M and L cones causing difficulty in distinguishing the colours properly eventually leading to 90% reduction in colour shade detection [4,5]. Globally there are about 300 million colour blind people and around 8% of males and 0.4% of females suffer from red green colour deficiency [6].

Colour blindness causes problems in everyday situations like driving, cooking, shopping, and other daily routines. Pilots and road transport drivers have difficulty in getting their license if they are colourblind, also colour-blind electricians are at a risk while doing their job [7,8]. Many colour blindness tests are available like Tritan, mosaic, mosaic tritan, colour matching, lantern, D15, PIP, etc, but traditionally the Ishihara test is performed to find the type and extent of the colour blindness [9]. According to the survey study performed by Blake porter, Enchroma technologies have developed lenses that increase contrast between red and green adding more difference to the confusion line hence alleviating the colour blindness symptoms [10]. Huei Yung lin et al., proposed and developed a method to assist colour-blind people to identify and distinguish the colours naturally through an image enhancement and recolouring algorithms [11]. Jinjiang Li et al., proposed and developed a saliency-based algorithm that adjusted colours in the image effectively enabling the colour-blind people to see the same salient areas as normal people [12].

Chuen-Lin Tien et al., designed and fabricated a multi-layer optical notch filter for enhancing the image quality with improved contrast thereby helping the colour-blind to visualize the colour more clearly [13].

Electroencephalogram (EEG) is a method to record electrical activity of the brain on the scalp using electrodes. Yuting Wang et al., states that colour and structure plays a major role in determining the alpha and gamma waves respectively [14].

In this work, a colour blindness test was conducted to determine the colours the participants found difficult to identify. Then, a dichroic film was fabricated and the participant's viewed the patterns through the film. The EEG of the participants were recorded using the NeuroSky headset before and after the introduction of dichroic film.

II. METHODOLOGY

2.1 Filter Lens Preparation

The lens film was made from a red filter sheet. To install the filter sheet, a circular outer ring with a radius of 5 cm was employed, and a red filter lens was created. 5 such lenses were made and used for the color correction purpose of red-green colour-blind people. The outer ring frame, red filter film and the red filter lens are shown in Figures 1(a),1(b) and 1(c) respectively.

Fig 1(a) shows the outer ring frame, 1(b) shows red filter film, 1(c) shows the red filter lens

2.2 NeuroSky Brainwave Headset

This is a T-shaped headband with a forehead sensor that measures electrical impulses. This was utilized to investigate the patients' brain signal patterns while they were undergoing color blindness testing and training. The headset consists of eight parts namely a flexible ear arm, battery area, power switch, ear clip, an adjustable headband, sensor tip, sensor arm and inside a think gear chipset. The device measures the raw signal at a rate of 512 Hz, power spectrums of alpha, beta, delta, theta and gamma, attention level and meditation levels and blink detection. The Neurosky Mind wave sensor is shown in figure 2.

Fig 2. Neurosky Mind wave sensor

2.3 Colour Blindness test

A universally followed color blindness Test called the Ishihara Test was conducted for all of the participants. The test asks the participants to identify the number that was embedded inside the series of circular dots of different sizes and colours. Each plate displays mosaic dots of varied sizes and colours. The image features a one- or two-colour background with a number set in one or two colours that contrast to different degrees. The Ishihara plate test is also known as Ishihara 28 /14 plate test. This test helps in detecting congenital red green colour-blindness. Figure 3 shows the template of Ishihara test conducted for the participants. Furthermore, about 120 shades of monochromatic red and green hues were created as shown in Figure 4 using adobe colour and it was shown to the participants in order to classify the degree and extent of deficiency.

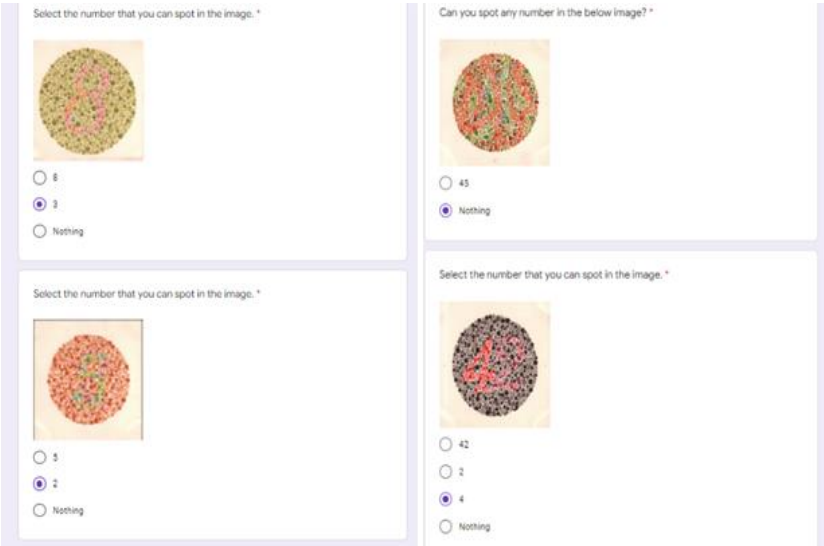

Fig 3. shows the Ishihara color blindness test

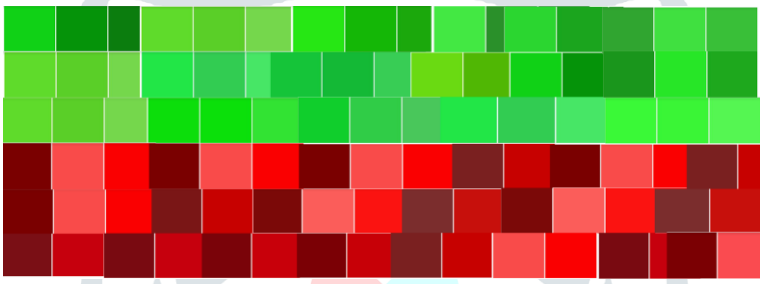

Fig 4. Different shades of color that was displayed to the participants

2.4 Experiment Protocol

Ten people took part in the study, two of them were colourblind and the rest were not. The study methods were explained to the participants. Firstly, the participants were asked to sit in a relaxed position. Then, they were asked to open their eyes and view the patterns and colours that were shown. Each participant was asked whether the numbers were visible. EEG of the participants was recorded during this process using the NeuroSky headset. The block diagram is shown in Figure 5.

Now, in order to make the colours clear and visible, dichroic filters were introduced to enhance the brightness of the color that was unidentifiable for the subject previously. The EEG of the participant was recorded during the entire process when the participant viewed the pattern through a dichroic film. The recorded signal is used for further analysis. The block diagram of the process is shown in Figure 6.

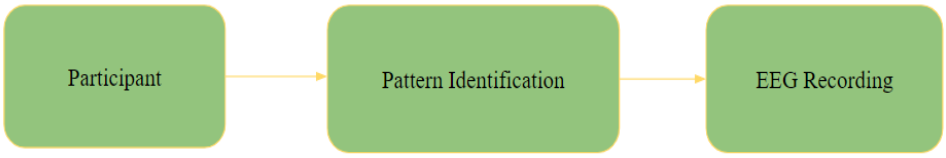

Figure 5. Block diagram of EEG recording during the former stage.

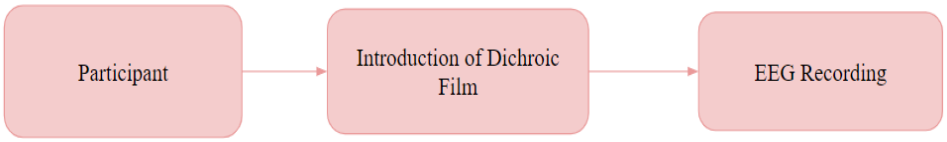

Figure 6. Block diagram of EEG recording during the latter stage.

III. RESULTS AND DISCUSSION

The individual was found to be unable to recognize the pattern that was displayed at first. Following the introduction of the dichroic film, the participants were able to discern not only between various hues, but also the number embedded in the mixed shade of colors. This shows that the film filters the wavelengths of lights perceived by the participants and makes it easier to view and visualize the colors. During the study, the participants' EEGs were also recorded and plotted as shown in Figure 7. The numerical values of the various bands of EEG such as theta, delta, low alpha, high alpha, low beta, high beta, low gamma and high gamma were determined from the software. The values of EEG observed before the introduction of dichroic film is given in Table 1 and the values of EEG that was observed after the introduction of dichroic film is given in Table 2. The attention and meditation values were also calculated. It can be seen that there is a significant difference in terms of the various parameters associated with EEG before and after the introduction of dichroic film. Also, the attention and meditation values of the participants is high when viewed through a dichroic film. This shows that color blind people are able to perceive and visualize the colors that are displayed to them when dichroic film is used. The film not only eliminates the color confusion lines but also enhances the various shades of color. This film can further be integrated into a spectacle which is more advantageous and useful when it comes to real time applications.

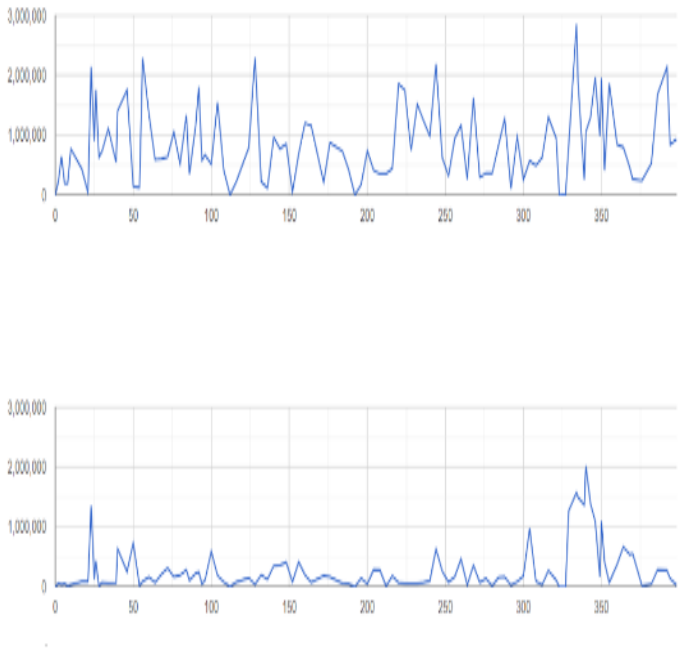

Fig 7. EEG plot that was observed during the study.

Table 1. EEG values obtained from Neurosky before introduction of Dichroic Film

Before Introduction of Dichroic Film	Before Introduction of Dichroic Film
eSense: {attention: 0, meditation: 0} *eegPower:* delta: 1358120, theta: 1491633, lowAlpha: 318386, highAlpha: 221100, lowBeta: 61566, highBeta: 179643, lowGamma: 7843, highGamma: 1729021	*eSense:* {attention: 0, meditation: 0} *eegPower:* delta: 812127, theta: 279276, lowAlpha: 233942, highAlpha: 40961, lowBeta: 22783, highBeta: 134433, lowGamma: 10800, highGamma: 1169906

Table 2. EEG values obtained from Neurosky after introduction of Dichroic Film

After Introduction of Dichroic Film	After Introduction of Dichroic Film
eSense: {attention: 53, meditation: 37} *eegPower:* delta: 3098644, theta: 455655, lowAlpha: 184183, highAlpha: 53668, lowBeta: 26782, highBeta: 168791, lowGamma: 3964, highGamma: 1098919	*eSense:* {attention: 50, meditation: 17} *eegPower:* delta: 1166422, theta: 924664, lowAlpha: 72763, highAlpha: 164807, lowBeta: 37942, highBeta: 86820, lowGamma: 8274, highGamma: 985723
eSense: {attention: 56, meditation: 1} *eegPower:* delta: 301969, theta: 166031, lowAlpha: 26872, highAlpha: 2822, lowBeta: 2009, highBeta: 29705, lowGamma: 1538, highGamma: 233240	*eSense:* {attention: 64, meditation: 1} *eegPower:* delta: 193689, theta: 771205, lowAlpha: 83299, highAlpha: 22150, lowBeta: 5705, highBeta: 135184, lowGamma: 6293, highGamma: 841752
eSense: {attention: 63, meditation: 1} *eegPower:* delta: 1344976, theta: 338254, lowAlpha: 130991, highAlpha: 36600, lowBeta: 13862, highBeta: 116924, lowGamma: 2828, highGamma: 754807	*eSense:* {attention: 0, meditation: 0} *eegPower:* delta: 812127, theta: 279276, lowAlpha: 233942, highAlpha: 40961, lowBeta: 22783, highBeta: 134433, lowGamma: 10800, highGamma: 1169906

IV. CONCLUSION

Color-blind people found it challenging to see and distinguish the diverse patterns embedded in various combinations of red, green, blue, purple, and other colours in this study. The dichroic film was effective and useful in removing the confusion lines and, as a result, making the patterns more visible and distinguishable. During both tasks, EEG was recorded, and there was a substantial change in the various bands of EEG before and after using dichroic film. Also, it was found that those waves were responsible for the color and structure related information in the brain. This could be used as a method to train the colour-blind people.

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