RED-GREEN COLOUR DEFICIENCIES AND THE STUDY OF SCIENCE, COMPUTER USAGE AND INTERNET BROWSING

G. Futagbi, E. D. Miensah and N.A. Eshun
Department of Zoology,
P. O. Box LG 67, University of Ghana,
Legon-Accra, Ghana

ABSTRACT

Colour blindness is the inability to perceive differences between some or all colours that other people can distinguish. It is most often of genetic nature but may also occur because of eye, nerve or brain damage or due to exposure to some chemicals. The most common type of colour vision deficiency is red-green colour blindness. Types of red-green colour blindness include protanopia, deuteranopia, protanomalia and deuteranomalia which denote lack of ability to distinguish between colours in the green-yellow-red section of the spectrum in addition to abnormal diming, lack of ability to distinguish between colours in the green-yellow-red section of the spectrum but without abnormal diming, less sensitivity to red and weakness in perception of green respectively. This study investigated the prevalence and impact of colour blindness on the study of science and on Information and Communication Technologies (ICTs) usage such as computer usage and internet browsing. The study participants were science students aged between fifteen and twenty-three whose courses such as Chemistry and Biology require identification, naming and matching of colours. The study was done using the Ishihara 24 plate edition which the participants examined and the numerals identified were recorded without more than three seconds delay. Questionnaires were administered to participants who tested positive for colour blindness. Out of 1194 male students sampled, 1.2% were colour blind. None of the 566 females included in the study was colour blind. Twelve (12) of the male participants were either deuteranopes, strong deuteranomalous, mild protanomalous, mild deuteranomalous, protanopes or strong protanomalous while 2 students had other forms of red-green colour blindness that could not be classified with the Ishihara plates. The deutan type was the most common red-green deficiency in this study accounting for 64% of all types. There was no significant difference between prevalence of red-green colour blindness at the secondary and tertiary levels (p>0.05). Colour blind students who experienced difficulties in their studies such as difficulties in performing practicals and internet browsing that require them to identify, name or discriminate colours, managed these difficulties by employing the help of their mates. The results suggest that red-green colour vision deficiency may influence but does not prevent study of science, computer usage or internet browsing and that some red-green colour blind science students may need help.

INTRODUCTION

Colour blindness or colour vision deficiency is the inability to perceive differences between some or all colours that other people can distinguish. It is also known as daltonism, named after the English chemist John Dalton who published the first major study of colour blindness in 1794 after the realization of his own colour blindness (Dalton, 1798). It is most often of genetic nature, but may also occur because of eye, nerve or brain damage or due to exposure to some chemicals. There are three types of colour vision deficiency. These are protan (red or long wave), deutan (green or middle wave) and tritan (blue or short wave), indicating first, second and third cones based on the wavelength or colour perception affected. The common types of colour blindness, however, result from malfunctioning of one or more cone systems and mostly from problems with either the middle or long wavelength sensitive cone systems (M-cone and L- cone respectively). These involve difficulties in discriminating reds, yellows and greens from one another. They are collectively referred to as 'red-green colour blindness' (Bowmaker and Dartnall, 1980; McIntyre, 2002).

Types of red-green colour blindness include protanopia (lack of L-cone), deuteranopia (lack of M-cone), protanomalia (red-weakness, defect in L-cone) and deuteranomalia (green-weakness; defect in M-cone). The first two are called dichromacy which comes about as a result of the complete lack of one of the three cone systems. The last two are termed as anomalous trichromacy where individuals have all the cone systems but there is a shift in the peak sensitivity of one of them due to variation in the cone pigments causing difficulty in colour discrimination. Anomalous trichromacy are by far the most common forms of red-green colour blindness and generally the least severe. They are known to reduce the ability to discriminate between colours but do not eliminate colour perception altogether (McIntyre, 2002; Wikipedia, 2009).

Red-green colour blindness accounts for about 99% of the colour blind. It affects significant number of people although the prevalence varies among groups with isolated communities with isolated gene pool sometimes having higher prevalent rates. The prevalence of red-green colour blindness in men is about 4% with 7 to 10% overall prevalence in men worldwide. Females have very low prevalent rates which is not more than 0.5% except in some few groups such as females of European origin where the rate is about 1%). Other forms of colour blindness are much rarer and include blue-yellow blindness (tritanopia) which involves the short-wavelength sensitive cone system (S-cone) and total colour blindness also known as monochromacy where affected individuals see only black and white (Bowmaker and Dartnall, 1980; Wikipedia, 2009).

In certain situations the colour blind, for example, the deutanomalous have advantages over people with normal vision. They have the ability to discern subtle shades of khaki and can sometimes see through camouflage that fools everyone else (Barone, 2007; Wikipedia, 2009). However, there are many difficulties that the colour blind encounter in everyday life. These include problems in choosing and preparing food, whether a piece of meat is raw or well cooked; differentiating between green fruits and ripe ones, choosing clothes and decorations and discrimination of traffic lights. There are obvious problems in distinguishing weather maps and maps in general because of the colour coding on the legends (Cole and Steward, 1989; Tagarelli *et al.*, 2004).

The problems that the colour blind people encounter at school could be enormous. There are more difficulties with the study of science; in the fields of medicine, biology, chemistry, agriculture and horticulture, just to mention a few. A colour blind person is generally unable to: interpret some chemical reactions, for example, observe a litmus paper turns red or blue by an acid or a base respectively, indicating an end-point for a chemical reaction; identify a material by the colour of its flame such as lead blue or potassium purple; interpret test strips for hard water, soil or water pH tests and biochemical testing kits for biological samples - all of which rely on subtle colour differences and a band of similar colours to compare against (Pickford, 1969; Tocantins and Jones, 1993; Poole, 1997; Spalding, 1999a; 1999b; Cumberland, 2004).

In this study therefore, we were set out to investigate the types of red-green colour blindness and how colour blind science students cope with their studies.

MATERIALS AND METHODS

Study Population and Design

The participants were science students selected from the University of Ghana and some Senior High Schools in Accra. This research was focused on students who study at least Biology and Chemistry of the science programme. Students studying these subjects are involved in practical sessions and information search using the computer or the internet, all of which require colour identification, matching and discrimination.

In order to compare the impact of red-green colour blindness on the study of science, computer usage and internet browsing at the tertiary and secondary levels of education, first year students of the Biological Science programme of the University of Ghana (UG) and students offering the science option in the selected Senior High Schools (SHS) (PRESEC, West Africa Senior High and Amasaman Senior High) were involved in the study. Though colour blindness is rare in females, both sexes were included in the study. Participation in the study was voluntary and the results were treated as confidential.

Data Collection

Data were collected between February 2005 and October 2007. The Ishihara 24 plate edition was used to test the participants. During administration of Ishihara tests, normal observers see one series of numbers while colour deficient observers would either see no number at all or a different number than normals (Salvia and Ysseldyke, 2001). The plates provide a quick test and accurate assessment of red-green colour deficiency of congenital origin. It consists of a series of pictures of coloured spots with one or two Arabic digits embedded in the picture as a number made of similar spots of slightly different colour. These embedded figures can easily be seen by participants with normal colour vision but not with a particular colour defect. The full test plates covered a variety of figure/background colour combinations that enable diagnosis of types of red-green colour blindness.

Structured questionnaires were administered to participants who were observed to have red-green colour blindness.

Data Analysis

A z-test was used to compare the prevalence of red-green colour blindness among first year students of the Biological Science programme of the University of Ghana and their counterparts from selected Senior High Schools. It was used to determine whether red-green colour blindness hinders prospective Biological Science students from pursuing their dreams at the tertiary level or not. Prevalence was calculated for each category as: (Number of participants affected)/ (Number of total number of participants examined) x100.

RESULTS

Characteristics of Study participants

One thousand seven hundred and sixty (1760) students were tested comprising 1194 (67.8%) males and 566 (32.2%) females. Out of this number, 1278 (72.6%) were from the University of Ghana and 482 (27.4%) were from senior high schools (Legon PRESEC, West Africa Senior High School and Amasaman Senior High School) (Table 1).

Prevalence and types of colour blindness among science students

The prevalence of colour blindness was 1.2% among male science students of University of Ghana and 1.0% among male students from selected secondary schools. Put together, 1.2% (14) of the 1194 males from all the schools were colour blind. No female was found to be colour blind. The prevalence of red-green colour blindness was higher among participants at the tertiary level than the secondary level but it was not significant (z=0.013; p=0.9896) (Table 3).

Of the fourteen colour blind participants, 9 (64.3%) were deuteranopes or strong deuteranomalous 1 (7.1%) was mild protanomalous, 1 (7.1%) was mild deuteranomalous, 1 (7.1%) was protanope or strong protanomalous and the remaining 2 (14.3%) had other forms of colour vision deficiency which could not be classified with the Ishihara plates used in this study. There was no student with total colour blindness (Table 1).

Effects of Red-Green colour blindness on Learning, computer and internet Usage

Out of the 14 colour blind participants, 9 expressed some difficulties when using computer to browse the internet especially inability to distinguish pop-up menu instructions highlighted in colour, while 4 reported that they had difficulties in discerning colour-coded words and buttons that are used to differentiate functions or similar items. Eight of them reported having difficulties during practical sessions. Some of these difficulties are; discerning the end points of certain titration experiments as well as identification and naming of certain colour combinations during qualitative analysis practical sessions in chemistry. Three colour blind participants out of the 10 from University of Ghana reported difficulties with making out notes or instructions written with green-coloured markers during lectures. Two deuteranope or strong deuteranomalous persons and the only participant with protanopia or strong protanomalia had difficulty with all the activities listed. Three reported that the defect does not affect their academic performance in any way while 8 reported coping with the difficulties through the help of their mates. In addition, 6 of the colour blind participants were unaware

Table1: Prevalence of Red-Green Colour blindness

Sample size	UG	SHS	Overall Number (Percentage)
	1278	482	1760
Male	808	386	1194 (67.8%)
Female	470	96	566 (32.2%)
Number (Percentage) in males	10 (1.24)	4 (1.03)	14 (1.17)
Deuteranope or strong deuteranomalous	6	3	9 (64.4)
Mild deuteranomalous	0	1	1 (7.1)
Protanope or strong protanomalous	1	0	1 (7.1)
Mild protanomalous	1	0	(7.1)
Not classified	2	0	2 (14.3)

Table 2: Difficulties in Learning and Computer/ Internet Usage

Activity	No Difficulty	Difficulty
Internet browsing	5	9
Computer use	8	4
Qualitative analysis in chemistry	6	8
Instructions written in red or green colour	7	3

Table 3: Prevalence of Red-green Deficiency Compared between UG and SHS

Institution	No deficiency	Deficiency	Total	Proportion with deficiency	z-test (p-value)
UG	798	10	808	1.24	
SHS	382	4	386	1.03	0.013 (0.9896)
Total	1180	14	1194	1.17	

of their deficiency and were distributed among the deuteranope or strong deuteranomalous (4), mild deuteranomalous (1) and the not classified (1) groups (Table 2).

DISCUSSION

Although there is no data to show whether the prevalence of red- green colour vision deficiency is the same as in the general population, the data shows that red-green colour blindness does not prevent the study of science. There is, also, no difference between the prevalent rates at the tertiary and secondary levels indicating that attainment of higher education in the Biological sciences is not hindered by colour blindness. These results corroborate other studies that have shown no hindrance by even severe forms colour blindness to pursuance of higher education, even in the field of medicine (Pickford, 1969; Tocantins and Jones, 1993; Poole, 1997; Spalding, 1999a; 1999b; Cumberland, 2004). But this does not mean they do not have challenges. At both levels, deutan type was the most common. This is not surprising as deutan type specifically; deuteranomlous trichromacy is the most common type of red-green colour blindness in many populations and student groups (Cameron, 1966; Pickford, 1969; Spalding, 1999a; 1999b). Therefore, although the Ishihara test does not assess severity of colour blindness, many of the colour blind participants may be deuteranomalous trichromats (or 'above-average observers', according to Spalding (1999a), especially, those who did not know about their vision deficiency until tested in this study. Generally, anomalous trichromats; both the deuteranomalous and protanomalous are known to go through daily activities without much difficulty. Even those with severe deficiency consider it to be minor inconvenience, since a moment's help from a colleague with normal colour vision solved any difficulty (Goudie, 1998, Spalding, 1999a).

The problems encountered by these students, such as difficulties in qualitative analysis in chemistry, computer usage, internet browsing and inability to read instructions presented in colour, are not unique and their approach in getting around them by seeking help from colleagues are also similar to those employed by others in previous studies (Goudie, 1998; Spalding, 1999a)

Though the prevalence rates are low, it will not be out of place if such individuals are identified and counselled on how to use adaptive strategies effectively in educational institutions. The fact that only three of the colour blind participants could confidently say the vision deficiency does not affect their academic performance implies that the majority may appreciate any help that can be offered them.

CONCLUSION

There was no difference between prevalence of red-green colour blindness at the secondary and tertiary levels indicating that the types of red-green colour blindness encountered in this study do not prevent those affected from pursuing careers in Biological sciences at the tertiary level. In addition, colour blind students who experienced difficulties in their studies got around these difficulties by employing the help of their mates. This suggests that red-green colour blind Biological science students need help.

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