Colour blindness in central Tanzania

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ABSTRACT

A seemingly reckless driver causes a fatal accident and pleads that the traffic lights had been green. It turned out that he was colour blind. Colour blindness or colour vision deficiency is a problem to which the affected persons may not be aware of. It is the inability to perceive differences in colour. Colour blindness is a sex-linked trait. The gene for colour blindness is found on the X-chromosome. 2862 ophthalmic patients were tested for colour blindness using Ishihara colour plates. Of 1520 male patients tested, 5.9% were found to be colour blind while 1432 female patients were tested and 0.6% found to be colour blind. These results agree with others obtained elsewhere.

Key words: Colour blindness, sex-linked, X-chromosome, Ishihara colour plates

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INTRODUCTION
A car speeding to the airport along Nyerere Road in Dar-Es-Salaam caused a fatal accident. The driver miraculously survived, even though both his legs had to be amputated. On giving evidence, he claimed that the saw “green, in the process of changing to yellow…….” when in fact the traffic lights were on red. Visible light is only a narrow band of 400 to 700nm wavelength; these correspond to the colours of the rainbow, going from red (the longest) to violet (the shortest).

**Fig.1** Visible light wavelengths

The ability to distinguish and differentiate the colours of the visible spectrum is made possible by photoreceptors of the eye called cones. Other photoreceptors which respond to dim light or night vision are called rods.

If we are to “see” a red shirt, a wave of light of 700 nm travels from the shirt and falls on a cone, which then transmits a neural impulse to the brain through the optic nerve. Colour vision deficiency (CVD) is the inability to distinguish the different colours in the spectrum. Colour vision deficiency is caused by lack of or non-functioning cones.

There are three types of retinal cones: red, green and blue cones. Red cones are sensitive to light of long wavelength from about 640 nm onwards; green cones are sensitive at medium wavelength (about 490 – 560 nm) while blue cones are sensitive at short wave lengths of about 450 – 490nm.

When one or more types of cones are missing or not functioning properly, a colour blindness or colour vision deficiency results. There are several kinds of colour vision deficiencies: Monochromacy or total colour blindness is caused by lack of or non-functioning cones. Dichromacy is when one of the three cones is missing or not functioning.

In turn there are three different kinds of dichromacy: Protanopia is when the red cones are missing or non-functioning Deuteranopia is when the green cones are missing or not functioning. Tritanopia is when the blue cones are missing or not functioning.

Colour blindness or CVD is a sex-linked genetic or inherited characteristic affecting more males than females. Literature has it that between 5-8% of all males are colour blind while only about 0.5% of the females are. The gene for colour blindness is recessive and carried on the X-chromosome. Males stand more risk of inheriting such a defective X-chromosome than their female siblings because the latter need to inherit both defective X-chromosomes for them to show full – blown colour blindness. The Punnett square diagrams in **table 1** illustrate this inheritance of colour blindness.
### Table 1 Colour vision deficiency inheritance

| (a) If a normal male XY marries a carrier female XX', they will produce | (b) If a normal male XY marries a colour blind female X'X, they will produce | (c) If a colour blind male X'Y marries a normal female XX, they will produce | (d) If a colour blind male X'Y marries a normal carrier female X'X, they will produce | (e) If a colour blind male X''Y marries a colour blind female X'X', they will produce:
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
<td><strong>Female</strong></td>
<td><strong>Male</strong></td>
<td><strong>Female</strong></td>
<td><strong>Female</strong></td>
</tr>
<tr>
<td>X</td>
<td>X'</td>
<td>X</td>
<td>X'</td>
<td>X'</td>
</tr>
<tr>
<td>Y</td>
<td>X'</td>
<td>X</td>
<td>Y'</td>
<td>X'</td>
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<tr>
<td>X X' X</td>
<td>X X' X</td>
<td>X' X</td>
<td>X X'</td>
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<td>Y Y</td>
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<td>Y Y</td>
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</tbody>
</table>

#### Offspring Genotype:
- 1 XY normal male
- 1 X'Y color blind male
- 1 XX normal female
- 1 X'X normal carrier female

#### Genotype Ratio:
2:1:1 (normal: carrier: colour blind)

#### Phenotype Ratio:
3:1 (normal: colour blind)
Some colour blind victims may not be aware that they have a problem. Colour blindness may be diagnosed by the renowned Ishihara colour test. This is a set of pictures consisting of coloured dots, in the centre of which is an Arabic numeral or figure (e.g., circle or square) of different colours. If one is colour blind, one cannot see the “number or figure” in the test chart clearly.

MATERIALS AND METHODS
5 eye clinics in Central Tanzania, Singida Region, were visited. The doctors were requested to include in their standard acuity test for patients who visit them to also show them Ishihara test plates and record their responses.

A total of 2862 patients were tested and the results recorded. These results shown below

RESULTS AND DISCUSSION
The following responses were recorded from the patients. They are summarized in a table showing the name of the hospital/clinic from which the patients were tested divided into males/females, normal/colour vision deficient.

Table 2: Normal/colour vision deficiency respondents

<table>
<thead>
<tr>
<th>Name of Hospital</th>
<th>Normal Males</th>
<th>CVD Males</th>
<th>Total Males</th>
<th>%CVD Males</th>
<th>Normal Females</th>
<th>CVD Females</th>
<th>Total Females</th>
<th>%CVD Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilimatinde</td>
<td>271</td>
<td>17</td>
<td>288</td>
<td>5.9</td>
<td>259</td>
<td>2</td>
<td>261</td>
<td>0.7</td>
</tr>
<tr>
<td>Sanjaranda</td>
<td>285</td>
<td>18</td>
<td>303</td>
<td>6.0</td>
<td>254</td>
<td>1</td>
<td>255</td>
<td>0.4</td>
</tr>
<tr>
<td>Makiungu</td>
<td>292</td>
<td>18</td>
<td>310</td>
<td>5.9</td>
<td>199</td>
<td>1</td>
<td>200</td>
<td>0.5</td>
</tr>
<tr>
<td>Kina-mpanda</td>
<td>293</td>
<td>19</td>
<td>312</td>
<td>6.1</td>
<td>311</td>
<td>2</td>
<td>313</td>
<td>0.6</td>
</tr>
<tr>
<td>Iambi</td>
<td>290</td>
<td>17</td>
<td>307</td>
<td>5.5</td>
<td>311</td>
<td>2</td>
<td>313</td>
<td>0.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1431</td>
<td>89</td>
<td>1520</td>
<td>5.85</td>
<td>1334</td>
<td>8</td>
<td>1342</td>
<td>0.6</td>
</tr>
</tbody>
</table>

1520 male patients were tested for colour blindness and 89 were found to be colour blind. This represents 5.85%. On the other hand, 1342 female patients were tested; of these, 8 were found to be colour vision deficient or 0.6%
The fateful driver who caused the accident did not even know he had a colour vision deficiency. He was probably suffering from protanopia, that is, a condition where the red retinal photoreceptors are missing. This is an incurable hereditary problem.

When diagnosed, such victims should be helped to cope with the situation. For example, traffic lights might be mounted on a black board with a white margin, whereby colour blind people could identify the position of the light as “top”, “middle” or “bottom” for “green”, “yellow” and “red” respectively. The lights could also be shaped differently, such as square for green, triangular for yellow and circular for red.

Another way to help known colour blind people to live with their situation is not to offer them jobs that require normal colour vision, such as colour mixing in paint factories etc.

**CONCLUSION**

Our findings on colour blindness in Central Tanzania generally agree with those obtained by others who have carried out research in Africa and the Middle East.

**REFERENCES**


