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The Effect of Colour Blindness on Seismic Interpretation

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SUMMARY

Colour is an integral part of how we interpret everything that we see, and it is also fundamental to how we communicate with each other, especially when trying to transfer information through reports, presentations and meetings. Colour blindness is caused by a reduction in the number of cones in the eye, the cells responsible for our detection of colour, and affects about 8% of the population. The principal question this study aimed to investigate was the impact that colour blindness might have on interpretation effectiveness. Four different interpretation tests were performed by the volunteers, each one aimed at investigating a different aspect of the decision making process that could be influenced by colour perception. Each test was a task that is commonly performed as part of a seismic interpretation workflow. What this study has shown is that there are differences in how individuals with a colour deficiency interpret seismic data when compared to individuals with full colour vision.

Introduction

Seismic interpretation involves visual identification of geological features and anomalies often with the aid of attributes that isolate certain characteristics within the seismic signal. The information within the reflectivity or attribute data is displayed by mapping data values to different colours. Different mappings can be used depending on whether the goal is to differentiate gross changes such as high from low, good from bad, or to show more subtle variations such as changes in reflector orientation or frequency content, or simply to create block coloured facies maps. In all cases colour perception impacts on how the information is communicated and the geological understanding that is gained. But what happens if an interpreter cannot differentiate red from green? Apart from the obvious confusion this can cause with well symbols (red for gas, green for oil), does it have an effect on their ability to interpret seismic data? The human brain is remarkably adaptive and will often compensate for a deficiency in one area with a heightened awareness in another area. So, whilst colour blind people are less reliant on colour discrimination do they have a heightened "awareness" to other factors, and what would those be? The principal question this study aimed to investigate was the impact that colour blindness might have on interpretation effectiveness.

Colour Blindness

Colour blindness, or more accurately colour deficiency, is caused by a reduction in the number of cones in the eye, the cells responsible for our detection of colour. Most of the population have 3 types of cones which are activated by different wavelengths of light, generally referred to as red, green and blue cones. A deficiency in any of the cone cells makes it harder to differentiate between certain colours. Most common is a deficiency in the green cones (deuteranopia), followed by red (protanopia), both of which are symptomatically similar due to the overlap of their absorption curves (fig 1b). Also possible is a deficiency in the blue cones (tritanopia), although this is very rare. Individuals who have a red or green deficiency will see red, orange, yellow and green as shades of muddy yellow, and will see pink, purple, blue and turquoise as shades of blue (Fig 1a). People who are blue deficient will see the world in shades of red and turquoise. There is general agreement that worldwide 8% of men and 0.5% of women have some form of colour deficiency.

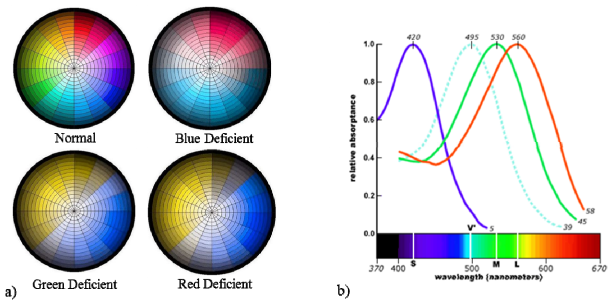

***Figure 1** a) The effect of colour deficiency on the colours perceived in a standard colour wheel (colour translation courtesy of vischeck.com), b) Normalised human photopigment absorption curves, wavelength of peak absorption in italics, number of photoreceptors measured at the end of the curve, solid line represents the response of cone cells, dotted line represents the response of rod cells (data from Dartnell, Bowman, & Mollon, 1983).*

Study Participants

In this study colour sensitivity was investigated using Ishihara plates which determine an individual's ability to identify numbers within a circle containing dots of mixed size, colour and tone. This is a standard diagnostic test for colour deficiency and was used to identify the members of each group in this study. Our volunteers included 19 individuals with normal colour vision, and 5 with a colour deficiency.

The effect of colour sensitivity on seismic interpretation

Four different interpretation tests were performed by the volunteers, each one aimed at investigating a different aspect of the decision making process that could be influenced by colour perception. Each test was a task that is commonly performed as part of a seismic interpretation workflow.

Fault Orientation

The aim of this test was to ascertain whether colour had an impact on the interpretation of fault orientation, and whether that differed between the two sample groups. The volunteers were shown a time slice of a Fault Detect attribute where the automatically detected faults were visible as black lines of a uniform thickness. The volunteers were asked how many fault orientations (fault strike) were present in the data. When the image was presented in black and white, both groups returned a wide range of orientations, from 2 to 8 in the normal group and 2 to 5 in the deficient group. When the question was repeated, this time with colour representing the different orientations the results were more focussed, in the range of 3 to 5 for both groups. There was very little difference between the number of orientations identified by the two groups, irrespective of whether the image was in black and white or in colour. The fact that in both groups the colour image resulted in a narrower range of values suggests that colour may help to standardise the interpretation between individuals, irrespective of whether they have a colour deficiency or not.

Reflector orientation

DipAzi combined volumes are often used to identify structural changes including major and minor faulting, anticlines, synclines and domes (Fig 2). The colour saturation represents reflector dip, and the colour hue represents the azimuth, or reflector orientation. Opposing colours indicate ridges, valleys and fault drag. In this part of the study the participants were asked to draw polygons around the zones of differing reflector orientations. Some of the orientation changes in the image are abrupt, others gradually change from one to the other and all have different shades and colours within one zone (a bit like the Ishihara plates). When the polygons from the two groups are displayed, distinct similarities and differences are visible (Fig 2), suggesting that some boundaries are equally visible to the two groups whereas others are harder for the colour deficient group to discern.

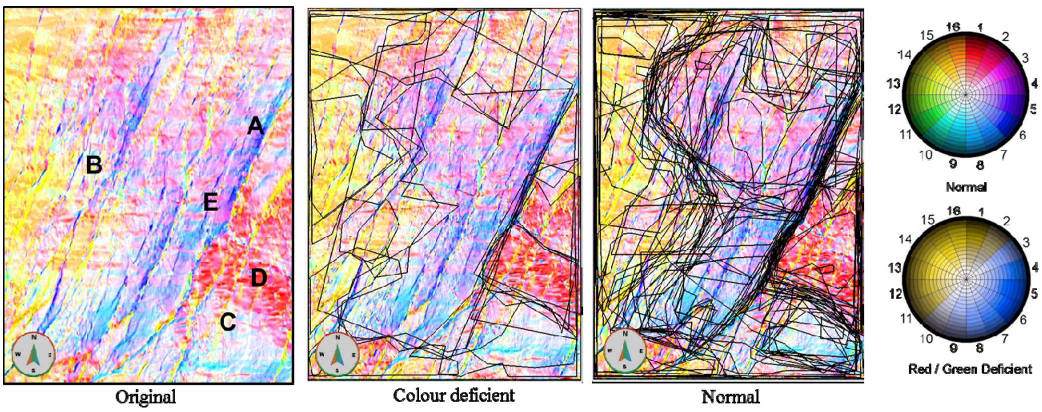

Figure 2 *Interpretation of reflector orientation. Polygons drawn by individuals in each group are displayed on the test image, along with the colour bar and a representation of how the colour bar may be perceived by red or green deficient individuals. Letters indicate particular boundaries of interest.*

Stratigraphic features of interest

Identification of features of interest is a fundamental component of seismic interpretation. In this part of the study we were investigating the influence of colour on identification and interpretation of stratigraphic features, by showing the participants an Envelope volume mapped onto a horizon. In that display colour represents amplitude with greens and reds indicating the highest amplitude areas. The participants were simply asked to draw a polygon around "any stratigraphic feature of interest".

They were told what the volume was and what it represented (seismic amplitude) and were shown the colour bar.

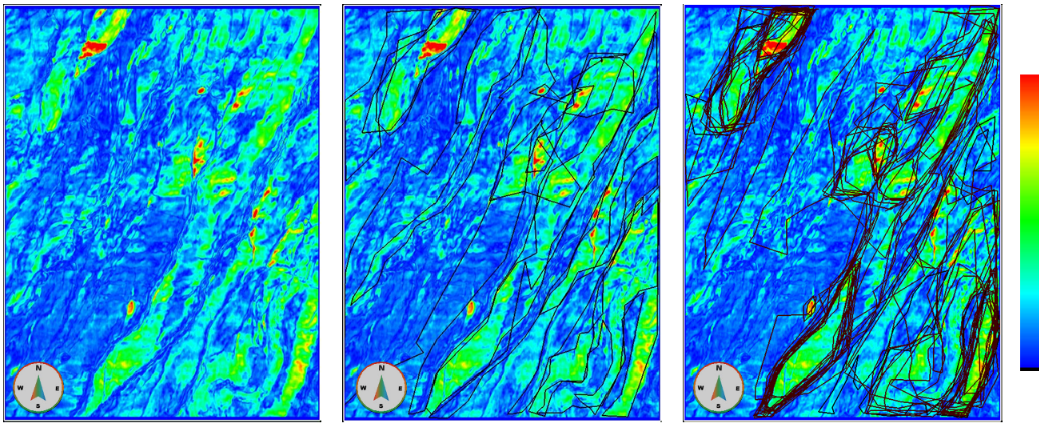

Figure 3 *Interpretation of "stratigraphic features of interest". Polygons drawn by individuals in each group are displayed on the test image.*

The results showed that both groups identified the main high amplitude features (Fig 3), but the colour deficient group interpreted more "channel like" features in the lower amplitude areas. In the normal group only 4% of polygons were drawn around low amplitude features (3 polygons from 2 interpreters), whereas in the deficient group 21% were low amplitude features (6 polygons from 2 interpreters). This could suggests that the deficient group were less influenced by the bright red colours and therefore more aware of subtleties in the data, or it could simply be that those 4 individuals work in areas where low amplitude is important and they are therefore more tuned to low amplitude features.

Interpretation Confidence

Reducing ambiguity improves confidence in the accuracy of an interpretation. Colour bars can be used to both reveal information and also to hide it. Monochromatic colour bars are more effective at highlighting edges and linear features due to the avoidance of false contours (Froner *et al*., 2013, Paton and Henderson 2015) whereas polychromatic colour bars are more effective at highlighting zones of continuity or stability of response. As colour deficient individuals generally have problems differentiating between red and green (as well as other colours), and these are two of the key colours in one of the principal colour bars used for attribute interpretation (the Rainbow or Spectrum colour bar), we wanted to investigate whether other colour bars would give individuals a greater understanding of the data. In addition, three dimensional colour bars such as RGB blends have become a standard method of displaying seismic attribute data, and are generally considered to be more intuitive to look at despite being more complex and conveying more information than a single volume displayed with a linear colour bar. We were interested in investigating whether a colour deficiency had an impact on the effectiveness of RGB blends. Participants were shown an Envelope volume with 4 different colour bars and an RGB blend of three frequency bandpass magnitude volumes. All the images showed the strength of the seismic response along a horizon which contained a channel. The participants were asked which image would give them the greatest confidence in their interpretation of the channel.

In the normal group the vast majority of the participants felt the RGB blend would give them the greatest confidence in their interpretation, whereas in the deficient group the results were more uniformly spread across 3 colour bars (Fig 4). It appears that within the deficient group there is no strong colour bar preference. Again this was backed up in conversations with the group where they indicated they regularly rotated the colour bars used for seismic interpretation in order to see the information most effectively.

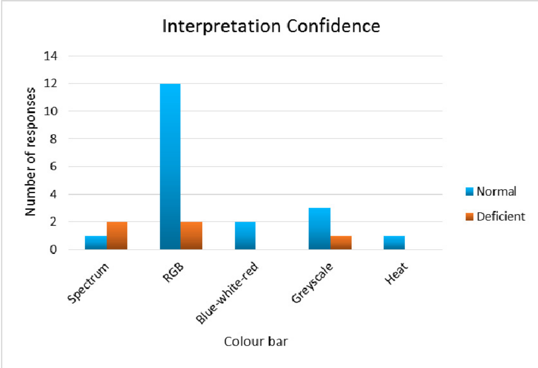

Figure 4 *Interpretation confidence in relation to the colour bar used to display the information.*

Discussion

Colour is an integral part of how we interpret everything that we see, and it is also fundamental to how we communicate with each other, especially when trying to transfer information through reports, presentations and meetings. It is very easy to forget that not everyone in the audience will perceive colour in the same way as we do, and therefore what appears obvious to us in an image, may be ambiguous to the person we are talking to. What this study has shown is that there are differences in how individuals with a colour deficiency interpret seismic data when compared to individuals with full colour vision. What was also apparent during the study, which is hard to capture in anything other than an anecdotal form, is how the interpreters from both groups tried to "work out" what was going on in the image. It wasn't simply a case of seeing a colour and drawing around it, many were trying to figure out the context of the colour they were seeing, and how it related to the other colours (and features) around it. And it was this assumed understanding of the bigger picture that influenced their decisions on the answers they gave. So one of the conclusions from this study, which is supported by both the fault orientation and the polygon experiments, is that an awareness of the context of the image that is being interpreted is as important as how the image is displayed. All interpretations are a matter of opinion, using an understanding of the available data, mixed with prior knowledge and experience. Colour deficient individuals have a different way of seeing an image and this results in an alternative interpretation based on a different weighting of the available information. Perhaps more important is the consideration during meetings and presentations that what jumps out to normal sighted people is not necessarily the most obvious feature to someone with a colour deficiency.

Acknowledgements

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