Andrew Ilyas and Nikhil Patil - Optical Illusions - Does Colour affect the illusion?

1 Introduction

For years, optical illusions have been a source of entertainment for many. However, only recently have the applications, effects, and science behind optical illusions been discovered. In this paper, the eye and its parts and the attributes of an optical illusion will be studied.

2 The Eye

The eye is composed of mainly the iris, cornea, retina, and lens, which take in the image. The optic nerve, which plays the most important part in an optical illusion, carries signals from the eye to the brain. Along with blood vessels, it also creates the blind spot for your eye. Through many studies, optical illusions have been developed to near perfection. (Montgomery, 2012)

3 The attributes of an optical illusion

Optical illusions are meant to fool the mind. However, the way in which they do this differs with every illusion. Illusions can be classified based on their two main attributes of colour and geometry. One may think that the more attributes an illusion has, the better, but using all the attributes would upset the balance, making the illusion to confusing. We will study only the colour attribute.

3.1 Illusions depending on colour

The first attribute for an optical illusion is contrast. The theory behind this is that a colour appears to be different when in juxtaposition with two different colours. The type of contrast to be presented here is simultaneous contrast. Simultaneous contrast is used in after-images. In general, when being exposed to a colour for a while, and then looking at a white surface, it will look like the original colour's complimentary colour. Some illusion artists use contrast on top of other attributes, so that they leave you confused even after looking at the illusion. (Luckiesh, 1992)

The next colour attribute for an optical illusion that is presented here is sensor tiring, also known as growth and decay of sensation. An example of this is the spinning disc illusion. In this illusion, a disc with a spiral pattern on it is spun very fast. After staring at the centre of the disc for 30 seconds and then ceasing to look, one will see the world as if it were moving. How these illusions work is that the eye has two separate detectors for sensing motion in different directions. Usually, these two sensors are balanced. However, when looking at the spiral continuously, the motion detectors in your eyes get fatigued, and remain fatigued when the eye then focuses on a still object. The sensors fail to balance, giving the moving effect. There are many other illusions which use sensor tiring, such as the Benham disk, and the Waterfall effect. (4M, 2006)

4 Experiment

To test our hypothesis, we conducted an experiment to show whether the attributes were a key factor in how the illusion worked. In these experiments only the attribute of colour was tested, but it represents all attributes. This experiment utilized eleven original illusions and one or two more modified illusions. Overall there were 32 illusions in the slideshow used, and 21 subjects were tested. Experimentation is still in progress.

5 Method

5.1 Purpose

Our purpose is to identify the effect of the attribute of colour in optical illusions, and how the human eye is affected to make the brain perceive the image as an illusion.

5.2 Hypothesis

Vision level is not correlated with optical illusions, showing that anyone can be fooled by an optical illusion. Also, if and only if, an illusion is modified with the same relation on the colour wheel, then the illusion will maintain its effectiveness, because colour illusions depend on contrast more than separate colours.

5.3 Procedure

1. Create a slideshow and survey for the three sets of optical illusions with a set amount of time per slide.

2. Gather a group of subjects and request the below normal vision subjects to remove their glasses.

3. Present the slideshow and gather the results.

5.4 Analysis, Observation, and Results

The algorithm that was used for statistical analysis of the first part of our subject is the chi-squared algorithm, used to test the correlation between two attributes. This will be used to find the correlation of vision level with susceptibility to illusions (score on an illusions test, with $A => 50\%,\ B =< 50\%$).

5.4.1 Vision level to susceptibility (Chi-Squared)

The chi-squared algorithm compares two variables by creating an expected table of results based on the number of people in every category and compares the expected table to the actual results. To calculate the expected array, the formula in Equation 1 is used.

$$\frac{\sum_{k=1}^{c} O_{i,k} * \sum_{m=1}^{r} O_{m,j}}{N} \quad (1)$$

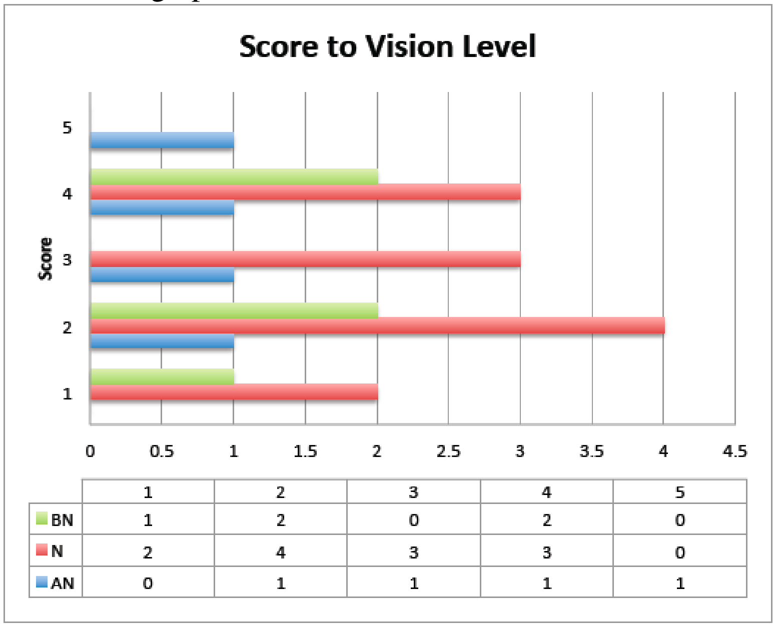
$$\chi^2 = \sum_{k=1}^{r}\sum_{m=1}^{c} \frac{(O_{i,j} - E_{i,j})^2}{E_{i,j}} \quad (2)$$

This just means the number of recordings in row i of the actual table multiplied by the number of recordings in column j divided by the total number of recordings. Now the chi-squared value (noted as χ^2) is calculated with the formula in Equation 2, which simply means that the chi squared value is the difference between the observed and expected array values squared divided by the value in the expected array for all cells added up. For our experiment, the observed and expected arrays were as shown:

Observed	B	A
AN	1	3
N	6	6
BN	3	2

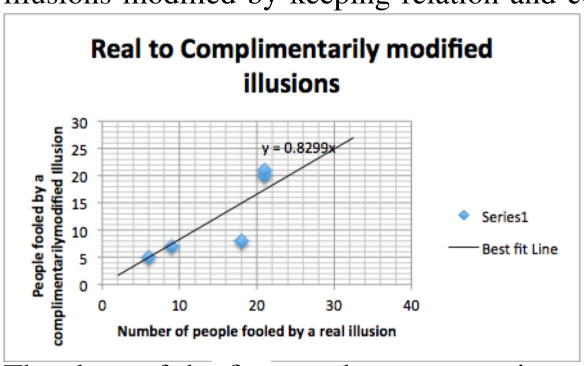
Expected	B	A
AN	1.904761905	2.095238095
N	5.714285714	6.285714286
BN	2.380952381	2.619047619

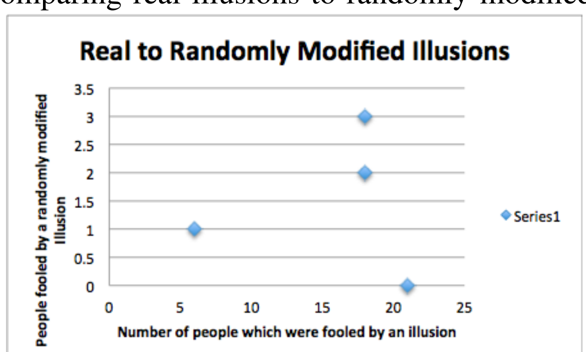
Giving a χ^2 value of about 0.56. In general if $\chi^2 > 0.05$, the variables are uncorrelated. Therefore, vision level does not affect reaction to optical illusions. Our results were also shown in a clustered bar graph.



5.4.2 Colour Modification

The next test was to determine whether colour relation has an important role in an illusion. For any colour-dependent illusion, there were three versions. There was one original illusion, one random colour replacement illusion, and one with colours in the same relationship as the original colours. Our results are shown with two scatter graphs comparing both real illusions to illusions modified by keeping relation and comparing real illusions to randomly modified ones.





The slope of the first graph was approximately one, and the data points held close to the line of best fit, indicating that that there was a strong, almost 1:1 correlation between the two axis. The second graph showed almost no correlation, and showed that the illusions that were randomly modified were much less effective.

Illusion number	Real Score	Random Modification score	Complimentary modification score	Dependant on
1	21	0	21	Colour
2	18	5	5	Geometry
3	9	N/A	7	Colour
4	21	N/A	21	Colour
5	17	16	16	Geometry
6	18	3	8	Colour
7	18	2	N/A	Colour
8	6	4	4	Geometry
9	6	1	5	Colour

Table 1: The scores of different illusions. Score is defined to be the number of people that were fooled by the illusion

Some of these illusions, as shown in the table, are dependant on geometry as well as colour. These illusions were omitted from the graphs and result analysis. They were included in the table only to show all illusions that were given to the subjects.

5.4.3 Next Steps

There were a few problems with this experiment. The first problem was that when the slideshow was presented on a projector, the colours may have changed slightly. The subject had a free choice of answer, sometimes leading to answers which were not useful to the experiment. Throughout this experiment many subjective decisions had to be made, which lowered accuracy slightly. Nevertheless, the results are still valid.

6 Conclusion

The analysis has shown that our hypothesis is correct. Vision level is not correlated with how effective the illusion is, and this shows why everyone can be fooled by an illusion, as the chi-squared algorithm proved this. Also, when modifications keep the same relation on the colour wheel, the illusion held its effectiveness. When modified with colour randomly, the illusion lost almost all of its effectiveness, which confirms the hypothesis.

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