International Baccalaureate Internal Assessment

To what extent is the ability to distinguish colors gender dependant?

Abstract
The experiment will test the possible difference in ability of color distinction between males and females. An online tool will be used to test the candidates, and 42 pieces of data are collected from them (21 males and 21 females). Each candidate will be tested using the online tool by putting colored boxes in order according to their hues. They will obtain a score that begins and 0 and increases every time a colored box is put in the wrong order. Therefore the lower the score the higher the ability of color distinction. The experiment has no set time limits to avoid unfinished results, and every candidate's sex and score will be recorded. In conclusion, females had an overall lower average score than males, but after conducting a T test I found that the sets of data are not significantly different, meaning that from this experiment the scores that males and females achieved were due to random variation.

Introduction
Males and females seemingly perceive colors differently. There are psychological and physiological differences between the two sexes that enable them to distinguish colors.
At a psychological level, it is believed that "there are a number of higher order cognitive differences between the two sexes" (Murray, Ian J., Neil R.A. Parry, Declan J. McKeefry, and Athanasios Panorgias, 2012). This could be due to the fact that evolutionarily speaking, women "were the gatherers in a hunter–gatherer society and needed better discrimination to detect reddish fruits against a green foliage" (Murray et al., 2012), therefore were better at color distinction.
There are also physiological differences in terms of chromosomes between the two sexes: "The genes for color vision are on the X chromosome. Females have two X chromosomes, so if one is deficient, the other chromosome can make up for it. On the other hand, males have one X chromosome and one Y chromosome. If the X chromosome is deficient, they will surely have color vision problems" (Lynn Langtree, and Ian Langtree, 2004). Therefore colorblindness or color deficiency is a sex linked trait. This means that in theory, more males should be color blind, or be able to distinguish colors less than females, due to evolutionary traits.
Being an IB Biology student, and finding a particular interest in the idea of sexual dimorphism, I decided to deepen my understanding of this.
I found online tools which allowed me to test this in a fast and efficient way, giving me a score. After trying a variety of tools, I came to the conclusion that the tool I used is the one that fits best with my experiment, in terms of simplicity time efficiency and ability to extract data. I believe that the amount of data I collected (21 male scores and 21 female scores) is adequate for a small scale experiment. The online tool tests the candidate's ability to distinguish color hues by putting them in order, going from one color to another. I believe that this test is appropriate for my experiment as it will allow me to determine which sex is able to distinguish colors better using a tool which gives me quantitative data to process.

Aim
The aim of this experiment is to actively test males and females using an online tool, in order to see if there is a significant difference between the online color test scores recorded from the two sexes. This would show whether females are able to distinguish colors better than males, due to the sex linked trait that they supposedly have, and due to evolution.

Prediction
I predict that females will obtain significantly lower scores on average (which means that they distinguish colors better) than males, because they are less affected by the sex linked trait, which causes color blindness, as they have two X chromosomes rather than one X and one Y chromosome, and because of the psychological differences due to evolution.

Research question

To what extent is the ability to distinguish colors gender dependant?

Material

-One computer with internet connection
-Access to the "Color Test Challenge" website
http://www.xrite.com/online-color-test-challenge
-42 people who are willing and able to take the test, having the same amount of males and females.
-Desk and chair.

Method

Using the online color tool I asked 42 people (21 male and 21 female) to take the test and then recorded their scores and gender.
I believe that for a small scale experiment 42 pieces of data are an adequate amount as it should allow me to draw a conclusion after carrying out a statistical test and processing my data.

Safety

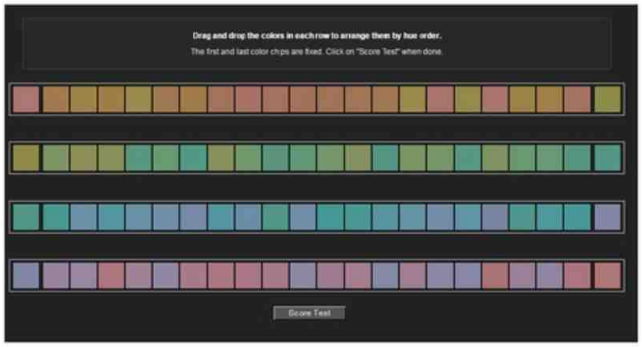
The experiment is safe as it is non-invasive, and also it does not affect the environment in any way. For ethical reasons all candidates must be aware that they are taking this experiment for an internal IB assessment and that they can stop at any given time.

Preliminary study

My preliminary study for this experiment was a self-assessment of the various tools that I could have used, in order to decide which one was best suited for my experiment.

How the online tool works

After searching for a tool to use in my experiment I decided on the "Online color test challenge" as it was the simplest and least time consuming tool that gave me a score to base my findings on. These scores did not have a unit, therefore this could lead to some imprecision as I cannot state explicitly what the score bases itself on. I found four other color tests online, but they were either too complicated or didn't give me a score to record my findings. In terms of reliability I cannot be completely sure that this tool gives me reliable results, also in terms of scoring, but after exploring their website and reading about their corporation which was founded in 1958 and is "The global leader for color based technology"("Color Vision Tests." *Munsell Color System Color Matching from Munsell Color Company*. N.p., n.d. Web. 19 Nov. 2015), I decided that it was the most respectable tool to obtain my results from.



- The first and the last colored boxes at each row are fixed.
- Drag the remaining boxes in each row in color hue order.
- This is not measured in time. When you are finished click score.
- The lower your score is, the better you distinguish colors

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Procedure

1) Explain how the tool works to the person who is being tested. He/she must know that the results obtained will be used for an IB internal assessment. and his/her gender will be recorded. Names are not required.
2) The person who is being tested must be placed in an environment that lacks distractions. He/she must sit on a chair and have a computer placed in front in order to carry the test out. The environment must be kept the same. Keep the light intensity of the computer the same.
3) Do not impose a time limit as it may cause an unfinished score to be recorded, patiently wai for the candidate to finish the test.
4) When they complete the test record their score and gender.
5) Repeat these steps until you get a sufficient amount of data (21 males and 21 females). The scores must all be taken in the same environment and with the same computer.

Dependent variable: The score of the color test is the dependent variable, as it will show how well the candidate distinguishes color hues, going from a score of 0 upwards. It does not specify a unit on the online test.

Independent variable: The gender of the person being tested is the independent variable, as the ability of distinguishing colors according to gender is being evaluated.

Control variable:
-Light intensity of the screen, as it may affect the way colors look to the human eye.
-The website used, as there are various websites available and they may work slightly differently.
-Keep the environment in which the candidate is being tested the same, as different positionings may alter results, and also light intensity must be kept the same as these could alter the perception of the colors on the computer screen.

Uncontrolled variable:
The computer screen may be tilted slightly accidentally and a person's height determines how he/she perceives the brightness of the screen. This may cause human error and alteration of results. Also, some **confounding variables** may be present. I did not record vision impairment and did not set a time limit. Vision impairment would have been difficult to be considered, as various degrees and types must be taken into account, but this may have caused some uncertainty. Also, time was not recorded to avoid any unfinished results which would lead to great uncertainty, but at the same time candidates who took more time than others may have been at an advantage, therefore still creating room for uncertainties to occur.

Raw data

Table 1: showing the scores collected from 21 males and 21 females

Female score	Male score
46	70
135	82
78	246
35	102
178	167
68	154
61	212
55	178
92	159
109	106
46	132
26	84
129	131
77	52
56	12
116	169
88	139
98	146
121	164
51	132
116	196

This is the raw data I collected from the participants. It consists of the scores of the online color test. 21 pieces of data for each sex were collected.
I cannot determine any uncertainties in the results as they can all depend on the person's ability to distinguish color.

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Processed data

Male and female average scores
I worked out the average scores for males and females using this formula.

$$\overline{X} = \frac{\sum X}{N}$$

Female

(46+135+78+35+178+68+61+55+92+109+46+26+129+77+56+116+88+98+121+51+116)/21=
84.81

Male

(70+82+246+102+167+154+212+178+159+106+132+84+131+52+12+169+139+146+164+132+196)/21=**134.90**

The female average score is lower than the male average score. This could signify that females are able to distinguish colors better than males.

Standard deviation

To calculate the standard deviation this formula may be applied.

$$\sigma = \sqrt{\frac{\sum(x-\overline{x})^2}{N}}$$

where:

$\sigma = the\ standard\ deviation$
$x = each\ value\ in\ the\ population$
$\overline{x} = the\ mean\ of\ the\ values$
$N = the\ number\ of\ values\ (the\ population)$
("Standard Deviation." *Simple Example of Calculating*. N.p., n.d. Web. 19 Nov. 2015.)

Due to the fact that doing this calculation by hand would be very time consuming, I decided to use my GDC TI-84 Plus calculator. This also limited the chance of human error that could occur during the calculation, as it is complex.

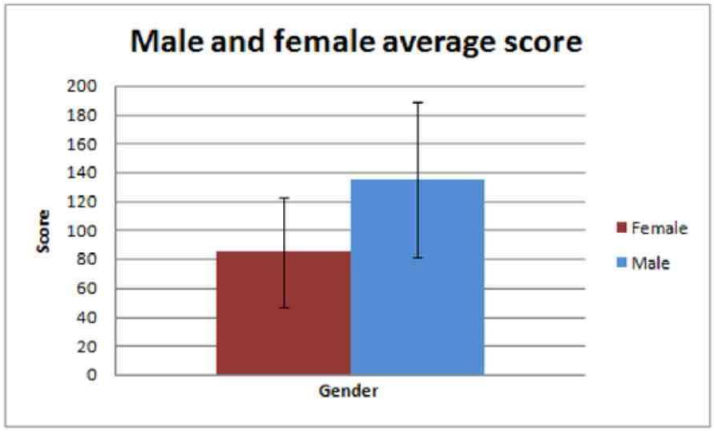
Female
37,79

Male
54,1

The standard deviation for females is lower than the standard deviation for males. This means that females have less spread out scores from the mean compared to males. This greater variation of scores in males could signify the fact that some males that were tested had the sex linked trait for color blindness. Being colorblind would result in having a very high score compared to normal color vision scores, therefore a set of very different scores would be obtained.

Graph 1: showing male and female average scores and standard deviation

This graph shows the average scores for males and females. I decided to use a bar graph in order to be able to compare the scores visually. As we can see, females have a lower average score than males, meaning that they could distinguish colors better. The standard deviation error bars overlap, so this could mean that the difference between the two means are not statistically significant.



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T test

Assuming that my data has a normal distribution, I decided to perform a T test in order to see if the male and female scores are significantly different or not to gain a more concrete conclusion, as a visual graph and processed data is not enough. I used excel to perform the T test. This test is appropriate because the two populations are males and females, and this is a small scale experiment.

Null hypothesis: The scores that males and females got are due to random variation.
Alternative hypothesis: Male and female scores are significantly different.

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1 (F)	**Variable 2 (M)**
Mean	84,80952381	134,9047619
Variance	1500,161905	3076,590476
Observations	21	21
Hypothesized Mean Difference	0	
df	36	
t Stat	-3,393340061	
P(T<=t) one-tail		
t Critical one-tail		
P(T<=t) two-tail	0,001692612	
t Critical two-tail	2,028093987	

If *t Stat* is greater than *t Critical two-tail* we reject the null hypothesis. In this case *t Stat* is smaller than *t Critical two-tail*, so the null hypothesis is accepted. Therefore the scores that males and females got are due to random variation.

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Conclusion and evaluation
To what extent is the ability to distinguish colors gender dependant?

The data obtained from my experiment shows that females are able to distinguish colors better than males, as they had a lower average score. But, after performing a T test to see whether the data obtained was significantly different or not, I came to the conclusion that the null hypothesis is accepted, therefore the results I gathered are due to random variation. From my experiment I can deduce that the ability to distinguish color is not gender dependant.

Graph 1 illustrates male and female average test scores. We can see that the female average score of 84,81 is lower than the average score of males which is 134,90. This should mean that on average, females were able to distinguish colors better than males as they obtained lower scores.

The standard deviation for males and females overlaps, which could mean that the two sets of scores are not significantly different. Therefore, a T test was performed. The T test allowed me to conclude that the sets of data are not significantly different, as the null hypothesis that states that the scores are due to random variation is accepted.
My conclusion does not conform to scientific consensus found in my research, as it states that "Females are better at discriminating among colors" (James Owen, 2012). This could be due to the fact that I did not have enough data to reach this conclusion, or my online test did not test the ability to distinguish colors well.

Reliability
The data gathered from this experiment should be reliable as it was collected under my supervision in order to ensure that the control variables, such as using the same website and the same screen brightness were kept. Also, the experiment was performed in the same environment, so lighting of the room wasn't altered and distractions were limited. Human error may have been possible though, for example through accidental tilting of the screen which could alter screen brightness, and the height of the person would cause their perception of brightness to alter. Even though the website seemed reliable to me by reading their resources that stated "The Farnsworth color blindness test has been used to evaluate color vision for more than 50 years. It evaluates the extent to which your color vision can discern between specific colors and slight hue variations within a given color."("Color Vision Tests." *Munsell Color System Color Matching from Munsell Color Company*. N.p., n.d. Web. 19 Nov. 2015.), I cannot be completely sure that the scores fully test the ability to distinguish colors, also because they don't have a measuring unit.

Modification of the experiment
The experiment would benefit from an increased number of participants in order to get further results which could have lead to a more accurate conclusions that possibly did not occur due to random variation. To avoid using a computer, I would have used the real "X-Rite (Macbeth) Farnsworth Munsell 100 Hue Test Kit" which can be bought online. This would have remove human error due to screen tilting and brightness. Also the lack of a time limit and possible vis... impairment may have created some uncertainties, therefore setting a minimum and maximum time could have decreased this, and taking into consideration for the experiment only candidates that have perfect vision to avoid impairments could have removed this issue.

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