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The Influence of Color on Impulsiveness and Arousal: Part 2 – Chroma

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Abstract

In the preceding Part 1, the effect of hue on impulsiveness and arousal was studied. From those results, yellow, red and orange were selected for further investigation since participants' performance was consistent with a low arousal state (high error rate and long response time) for the yellow background and high arousal state (low error rate and short response time) for the red background, whereas orange tended to result in high impulsiveness. This paper will mainly investigate the fundamental theory of how chroma influences people's impulsiveness and arousal state. As in the previous paper, the two main factors used to measure impulsiveness and arousal are also response time and error rate for each colored background. In the psychophysical experiment, participants were looking separately at backgrounds consisting of three hues (red, yellow and orange) with different chroma levels on screen to complete a range of psychometric tests. During the experiment, participants gave their response to the psychometric test as quickly and accurately as possible. From the results it can be seen that chroma has a significant influence on participants' response time and error rate, and influences impulsiveness and arousal. Gender difference will also be discussed in this paper.

Key words: impulsiveness; arousal; chroma; color psychology.

Introduction

From part one, which dealt with the influence of hue on impulsiveness and arousal, it was seen that hue has a greater influence on arousal than impulsiveness, which indicates that particular hues can lead people to a high or low arousal state. The influence of hue on impulsiveness was very limited. It cannot be concluded that a particular hue highly influences impulsiveness. In this paper, the chroma influence on people's impulsiveness and arousal states will be discussed. In addition, the influence of the combination of hue and chroma, as two characteristics of color, will be discussed in this paper.

There are few examples which illustrate that some specific chroma environments can influence people's performance. For instance, research has shown that colors such as pink – a red color with lower chroma – have a moderating effect on calming people.[1] In Schauss's "pink prison study", pink was seen to physically relax people's muscles and reduce potential or actual aggression. This finding was examined in a prison in the US and received positive impact. AL-Ayash[2] found that people felt more relaxed, calm and pleasant under the light color conditions, and reading scores were significantly higher under the pure color conditions. Strong colors and patterns such as red put the brain into a more excited state, and sometimes cause a slowing of the heart rate.[3]

The present study is aimed at finding out how chroma can influence emotion (impulsiveness and arousal) and performance.

Methods

A psychophysical experiment was conducted to investigate chroma's influence on impulsiveness and arousal. In this experiment, the types of psychometric test were reduced to two groups (four types) based on the results from the previous hue experiment. Participants' performance on the Detail Ability (Odd One Out and Same Detail) tests was less influenced by color than the other four tests, therefore this group of tests has been removed from the chroma experiment. The psychometric tests used in the chroma experiment were: *Logical Ability* (Logical Rule and Mathematics Sequence) and *Spatial Imagination Ability* (Spatial Structure and Rotation). Table 1 provides an explanation of the four types of tests used in this study. In this experiment, participants needed to finish thirty examples of each type. In total, each needed to complete 120 psychometric tests.

(Table 1 is about here.)

Color Samples

Three hues (red, orange and yellow) were selected as three typical colors which exhibit different influences on impulsiveness. For each hue, four levels of chroma were selected – 100%, 75%, 50% and 25% – in the experiment together with a visual reference white (0% chroma). In total, thirteen colored backgrounds were used in the experiment. These had similar lightness, which varied in four chroma levels, and in red, orange and yellow hues. An equally-luminous visual reference white color was also used in this experiment. The CIELAB values of the thirteen colored backgrounds were determined from measurement by a CS-1000 spectroradiometer. The lightness of all the thirteen colored backgrounds was fixed at around 71 (± 2). The chromas of

each level were fixed at around 100%: 69 (± 2); 75%: 52 (± 2); 50%: 35 (± 2); 25%: 16 (± 2). Table 2 and Figure 1 show the characteristics of these colors and their position in the CIELAB color space. Figure 2 shows the actual screen in the experiment.

(Table 2 is about here.)

(Figure 1 is about here.)

(Figure 2 is about here.)

Participants

Similar to the previous hue experiment, a total of 28 participants including fourteen female and fourteen male Chinese subjects were selected to take part in the chroma experiment.

Experimental Procedure

The same procedure used in the hue experiment was carried out in the chroma experiment. The experimental environment was a dark room. Participants were tested individually in the room. The Ishihara Color Vision Test[4] was utilized to screen participants who had not participated in the first experiment. After passing this test, they were asked to read the instructions and familiarize themselves with each type of psychometric test. The total adaptation time before the real experiment was about five minutes. Again, each participant sat at a fixed distance of 75 cm from the display. The same LCD display was used in this experiment.

Results

The data collected from the experiments consisted of each participant's response time and the number of errors, which indicate their performance. These two sets of data will be analyzed by chroma and by gender in this section.

Participant Performance

In the chroma experiment there were 28 participants. In this section, participant repeatability will be discussed according to their consistency between the first and repeat experiments. Meanwhile, the agreement between individual results and those of the group will be also considered. As in the hue experiment, performance is divided into four groups: LI (low impulsiveness), HA (high arousal), LA (low arousal) and HI (high impulsiveness). In Figure 3 the Error-Speed space shows that for both first-time and repeat, performances may be clustered into four groups; more participants are plotted in the HI and LI quadrants than in the HA and LA quadrants.

(Figure 3 is about here.)

Repeatability has also been analyzed according to the four impulsiveness/arousal state categories, which are summarized in Table 3. LI and HI are the biggest among the four groups, followed by LA and HA. The response times for LI and LA are quite similar, around 37 and 36 seconds respectively; the response times for HI and HA are similar at nearly 25 seconds. Similar error rates for LI and HA can also be found, at around 39%; the rest of two groups, LA and HI, have the similar error rates: 19% and 21% respectively.

(Table 3 is about here.)

From the discussion above, data collected from the chroma experiment can be concluded to be repeatable and reliable. The four groups (LI, HI, LA and HA) are distinguishable. Data collected can therefore be confidently used in the next stage of analysis.

General Trend

In the chroma experiment, impulsiveness and arousal are also determined by response time and error rate. From Figure 4 it can be seen that participants performed best (and were most aroused) at the 100% chroma level, with the shortest response time and the lowest error rate at 26 seconds and 19% errors respectively. The 75% chroma level is where participants performed the worst (the least aroused), with the longest response time of 32 seconds and the highest error rate of 35%. The 0% chroma level showed the tendency for high impulsiveness, in which the response time is shorter than the average at 28 seconds and error rate is larger than the average at 32%. In the 50% chroma level, participants performed with low impulsiveness, with a response time of 32 seconds and an error rate of 25%. The 25% chroma level has a response time in line with the average line, but a lower error rate than average.

(Figure 4 is about here.)

For red, orange and yellow individually (shown in Figure 5), the 100% red and 100% orange are the chroma levels where participants performed with high arousal state (shortest response time and lowest error rate), whereas they

performed with high arousal for 50% yellow as well. The 50% red, 75% orange and 75% yellow chroma levels produced low arousal states for each color. (These chroma levels all have the longest response time and the highest error rate within the chroma group.) The 0% chroma (gray) was linked to high impulsiveness within each chroma group, as they have shorter response times than average (although red is similar to the average) but higher error rates than average.

(Figure 5 is about here.)

Experimental data collected from the chroma experiment are also dimensionless using the same statistical method (the extremum method) as before in order to posit the two factors as response time and error rate in a single coordinate to analyze impulsiveness and arousal. The extremum method uses the actual value divided by the maximum value of the whole data set of response times and error rates individually ($x_i' = \frac{x_i}{\max x_i}$). The Error-Speed space of dimensionless values is shown in Figure 6.

(Figure 6 is about here.)

From the figure it can be seen that the colors at the 25% chroma level are all plotted in the HA quadrant or on the boundary of HA and HI quadrants, which means participants responded quicker than average for this level. The 50% orange and 50% red are all in LA quadrant, while the 50% yellow is in the HA quadrant. The 50% orange and 50% red can influence people to be less aroused and perform slower with a high error rate, whilst the 50% yellow arouses people to perform quickly with a low error rate. Three hues at a 75%

chroma level are very far apart from each other in the Error-Speed space. The 75% yellow is an impulsive color that is plotted in the HI quadrant. The 75% red is plotted in the HA quadrant and can arouse people to respond quickly with fewer errors. The 75% orange is in the LA quadrant and influences participants to respond slowly with more errors. The colors at the 100% chroma level are roughly located in the HA and LI quadrants. The 100% yellow falls on the boundary of the HA and HI quadrants; 100% red is positioned on the boundary of the HA and LI quadrants. The 100% orange is in the LI quadrant. People generally made fewer errors for the 100% chroma level (for all three hues) than the average.

The order of chroma influence on impulsiveness has been calculated by the indicator E/R (where E is error rate, R is response time). The chroma influence on arousal has also been calculated by the indicator 1-ER (ER=E times R), which is the same as in the hue experiment. The E/R value and 1-ER (ER=E times R) values are summarized in Table 4. According to these, the regression between C* and impulsiveness values are summarized in Figure 7. The regression between C* for red, orange and yellow and impulsiveness values are summarized in Figure 8. The regression between C* and arousal are summarized in Figure 9, and the regression between C* for red, orange and yellow and arousal values are summarized in Figure 10.

(Table 4 is about here.)

(Figure 7 is about here.)

(Figure 8 is about here.)

(Figure 9 is about here.)

(Figure 10 is about here.)

From Figure 7 and Figure 8 it can be seen that, although there is no overall chroma change influence on impulsiveness as the R^2 value is too small (0.06), when comparing hues some trend can be found. For red, there is a strong influence of chroma change on impulsiveness. When chroma is increased, the impulsiveness state decreased. The R^2 value for red chroma-change and impulsiveness is 0.88. The chroma changes in orange are obvious, but not as significant as in red. There is also a decreasing impulsiveness in orange, and the R^2 value is 0.42. No trend can be found for chroma change on impulsiveness across yellow.

Chroma change has no significant influence on arousal, as from Figure 9 and Figure 10, the regression between chroma and arousal for the overall trend or for red, orange and yellow respectively are not significant. (For the overall trend, R^2=0.01; for red, R^2=0.28; for orange, R^2=0.01; for yellow, R^2=0.01.)

Color Influence on Impulsiveness and Arousal by Gender

Figure 11 summarizes the chroma influence on impulsiveness according to gender. At 100% chroma, male participants responded slower with a lower error rate than females. At 0 to 75% chroma, the male participants responded quicker with no higher error rate than females. Therefore, for females, 100% chroma is the level to influence them to be more impulsive. No chroma level was found that could influence males to be more impulsive. However, this trend is not significant as the error bars are mostly overlapping.

(Figure 11 is about here.)

The Influence of Color on Impulsiveness and Arousal

Error rate and response time are two indicators that can represent impulsiveness and arousal at the same time. Hue influence on impulsiveness and arousal will be discussed based on different combinations of these two indicators. From the hue and chroma experiments, some major findings are summarized as follows:

- According to the experimental results, hue has a significant influence on arousal. Hue's influence on impulsiveness is not significant.
- Purple and red are hues that led to participants performing with the highest arousal state. For blue, yellow and green they performed with the lowest arousal state among the six colors. Orange fell on the boundary of high impulsiveness quadrant, which is a relatively impulsive color among the six hues.
- There was a significant influence of red chroma changes on impulsiveness. When the chroma of red decreased, the impulsiveness state increased.
- An influence of orange chroma change on impulsiveness was also seen but this was not as significant as red. Similar to red, when the chroma of orange decreased, the impulsiveness state increased.
- The yellow 75% and 0% chroma levels are plotted in the HI quadrant. The 100% orange is plotted in the LI quadrant. Most of the middle chroma levels such as 75% orange, 50% red and 50% orange are to be found in the LA quadrant. Colors such as 75% red, 50% yellow, 25%

orange, 75% orange, 25% red and 100% red are located in the HA quadrant. The 100% yellow, 25% yellow and 100% red are positioned on the coordinate axis.

- The 100% red is the color having the lowest impulsiveness state whilst 75% yellow has the highest impulsiveness state among the test colors used in this experiment. The 75% orange is the least arousing color whereas 50% yellow is the most aroused color among all test colors.
- There is a tendency for females to be more impulsive than males across all six hues. However, as the error bars are mostly overlapping, this trend is not significant. No gender difference can be found in the arousal influence. The 100% chroma level could influence female participants to perform with a higher impulsiveness state than males.

Gorn and colleagues found that when designing web pages, chroma is an important factor for relaxation.[5] Lower levels of chroma associated with a higher level of relaxation. In Gorn's experiment,[6] he found that when people feel more relaxed they will perceive web downloads as being quicker. In this study, 0% is the chroma where participants performed the quickest among the five chroma levels, which agreed with the findings from Gorn et al.[6] The 25% chroma is also relatively quick for participants to respond. However, in this study participants responded slower for middle chroma levels (50% and 75%).

Ayash et al.[2] found that whiteness has a significant influence on reading comprehension. Colors like pale blue and pale yellow have a more positive impact on intellectual activity and spatial properties. Schauss found that pink, a red color with low chroma, has the effect of calming people.[1] From the chroma experiment, some findings were seen to agree with Ayash's research. The 0%

chroma level is where participants made the fewest errors for the general trend. Therefore, it can be concluded that the low to middle chroma levels can influence people to be calmer and have a positive impact on their physical expression.

One significant finding from this experiment is that the colors in the middle chroma levels influence people to think more carefully and improve their answers for almost all types of psychometric tests. This partly agrees with the major findings from literatures.[1-2, 5-6] However, in this study, the chroma influence on impulsiveness and arousal is more complex than that found in previous research. Some vivid colors can also make a positive impact on human performance. For example, the general trend shows that people perform with low impulsiveness for the 100% chroma level for the 100% orange and 100% red in particular. When chroma decreases, this does not mean that performance keeps improving. For colors like red and orange, chroma decrease can raise the level of impulsiveness.

In the chroma and hue experiment, as participants roughly spent 15 minutes on each color, the influence of color on them is more short- to mid- term. Figure 12 and Figure 13 indicate the degree of impulsiveness and arousal in the Hue-Chroma polar contour space.

(Figure 12 is about here.)

From Figure 12, it can be seen that high impulsiveness is located at ***middle to high chroma yellow and orange*** (hues around 75° to 125°, with chroma levels of 75% – 100%). The low impulsiveness plots at ***high chroma red*** (hue

of nearly 45° and 100% chroma level), ***middle chroma yellowish green*** (hue of around 100° and 50% chroma level), and ***high chroma greenish blue*** (hue of around 180° – 240°, and 100% chroma level).

(Figure 13 is about here.)

From Figure 13, the high arousal colors are located at ***high chroma reddish colors*** (hue of 330° – 45°, and 100% chroma level), and ***middle chroma yellowish green*** (hue of 100°, and 25% – 50% chroma levels). The low arousal colors are located at ***middle chroma orange*** (hue of 50° to 75°, and 50% – 75% chroma levels), and ***high chroma yellow*** (hue of 90° to 100°, and 75% chroma levels).

Summary and Suggested Applications

This study investigated the influence of hue and chroma on impulsiveness and arousal. Some novel findings from this experiment are summarized as follows:

- The effect of chroma on impulsiveness and arousal is complex. Chroma influences impulsiveness more than arousal, as a clear decreasing trend of impulsiveness can be seen along with the increase of chroma for red and yellow. There was no clear effect of chroma on arousal.
- Generally, middle chroma levels (50% and 75%) result in slower response times than low and high chroma levels. Colors at 100% chroma result in the fewest errors. Although people think for longer with middle chroma levels, this does not mean that they will make fewer mistakes. On the contrary, they normally make more errors for middle chroma levels than with 100% chroma.

- Chroma influences on response time, error rate and impulsiveness are significantly different across the four types of psychometric tests.
- Gender difference was not significant, however there was a trend for females to respond slower than males and with more errors.

The hue and chroma experiments have some limitations. Participants in this experiment were all Chinese, aged between 20 and 38. The results in this experiment are limited in that it did not cover a broad culture and age group. It is difficult to use these selected colors to predict the trend of hue and chroma influence across the whole color space; this would need to be studied more comprehensively in the future.

From the findings in this study, some suggestions can be proposed to guide designers in their use of color. A more explicit commentary of how the findings can be used to specific design practices are summarized in four parts as Fashion and Textile Design, Environment Design and Graphic Design.

Fashion and Textile Design

From previous research, a red uniform can arouse people to perform better.[7] According to the findings from this study, apart from red, all chromatic reddish colors (e.g. red, orange and purple) can improve people's performance. These are all preferred colors for sportswear or functional uniform design, which aims to affect people's bodily behavior. High chroma yellow is the least arousing color and influences people to perform slower with more mistakes, which seems to be the color that designers should avoid in sportswear design. If yellow is really needed, medium chroma yellowish-green colors are more effective improving.

Environment Design

McKean reported that in Tokyo, blue lights in train stations are claimed to influence people to become less impulsive and to reduce the suicide rate in that location.[8] However, to the author's knowledge, there is no theoretical basis can support this. From the results in this study, the hue influence on impulsivity is not obvious. All colors having a high chroma level (75% - 100%) can influence people to be less impulsive. From the results in this study, green and blue are relatively "safe" colors that have little influence on arousal and impulsivity. They can be used in interior design, such as offices or hospitals, where people need to stay calm. For example the "green room" in the theatre (in which walls were originally painted green) was first designed for actors to reduce anxiety and nerves.

Graphic Design

In graphic design, colors have various functions that can influence people differently. For example, the color of warning or remaining signs need to be obvious, and people need to respond quick when they see the sign; therefore from the findings in this study, high chromatic red and yellow are colors that are more suitable when designing such signs. Another example is located in web design. Apart from aesthetics, when designing website elements, the mission of color can be attracting attention. High chroma yellow can influence people to have a high level of impulsivity compared with other hues. Reddish colors (such as orange, red and purple) can arouse people's performance. They are all recommended colors in web design for gaining attention.

References

[1] Schauss AG. Tranquilizing effect of color reduces aggressive behavior and potential violence. Orthomolecular Psychiatry. 1979; 8 (4): 218-221.

[2] AL-Ayash A, Kane RT, Smith D, Green-Armytage P. The influence of color on student emotion, heart rate, and performance in learning environments. Color Research and Application. 2015; 41 (2): 196-205.

[3] Küller R, Mikellides B, Janssens J. Color, arousal, and performance - A comparison of three experiments. Color Research and Application. 2009; 34 (2): 141-152.

[4] Ishihara, S. 1993. *Ishihara's Tests for Color-Blindness*. Tokyo: Plate Edition.

[5] Gorn GJ, Chattopadhyay A, Yi T, and Darren WD. Effects of color as an executional cue in advertising: they're in the shade. Management Science, 1997; 43 (October): 1387-1400.

[6] Gorn GJ, Chattopadhyay A, Sengupta J, and Tripathi S. Waiting for the web: how screen color affects time perception. Journal of Marketing Research, 2004; XLI (May): 215-225.

[7] Hagemann, N., Strauss, B. and Jan, L., 2008. When the referee sees red. Psychological Science, 19, pp. 769-771.

[8] McKean, C. A., 2014. How Blue Lights on Train Platforms Combat Tokyo's Suicide Epidemic. [Online]. [Accessed 26, Jan, 2017]. Available from: https://nextcity.org/daily/entry/how-blue-lights-on-train-platforms-combat-tokyos-suicide-epidemic.

Biographies

Dr Yiting Duan is a textile design lecturer in Faculty of Material and Textile, Silk Institute, Zhejiang Sci-Tech University. Her research areas are related to color psychology, color design, textile and fashion product design. She was awarded a PhD from University of Leeds for her thesis "The Impact of Colour on Impulsivity, Arousal and Emotion", which proposed a possible beginning of

research between color and two emotional and bodily response: impulsivity and arousal. She was awarded the Palmer Award from The Colour Group Great Britain (CGGB) in 2013 for her research in color and textile design.

Dr Peter A. Rhodes is a lecturer in color imaging at the School of Design, University of Leeds. He was awarded a PhD for his thesis “Computer Mediated Color Fidelity and Communication” from Loughborough University of Technology which led to the development of the first what-you-see-is-what-you-get system for color specification and communication within the textile industry. He has produced over 50 academic publications, including book chapters on color management and color notation systems, and contributed towards the development of the ISO 10617 standard for colorimetric communication. In addition to his role as Director of Student Education, he is actively engaged in a number of commercially-oriented research and development projects.

Dr Vien Cheung currently holds an academic post as Associate Professor in Color and Imaging Science at the University of Leeds. Her research interests are color vision, spectral imaging, color reproduction and color, all as applied to the art and design disciplines. Dr Cheung is active in several professional bodies including The Colour Group Great Britain (CGGB), the International Colour Association (AIC), and the Society for Imaging Science and Technology (IS&T). She was awarded the Selwyn Award from The Royal Photographic Society in 2008 for her research in color imaging and imaging technology, a Silver Medal from the Society of Dyers and Colourists in 2011 in recognition of her contributions to education, the Society and in the interests of the allied industries, and the 2016 Service Award from the IS&T for her contributions in organizing IS&T color conferences.

Figures:

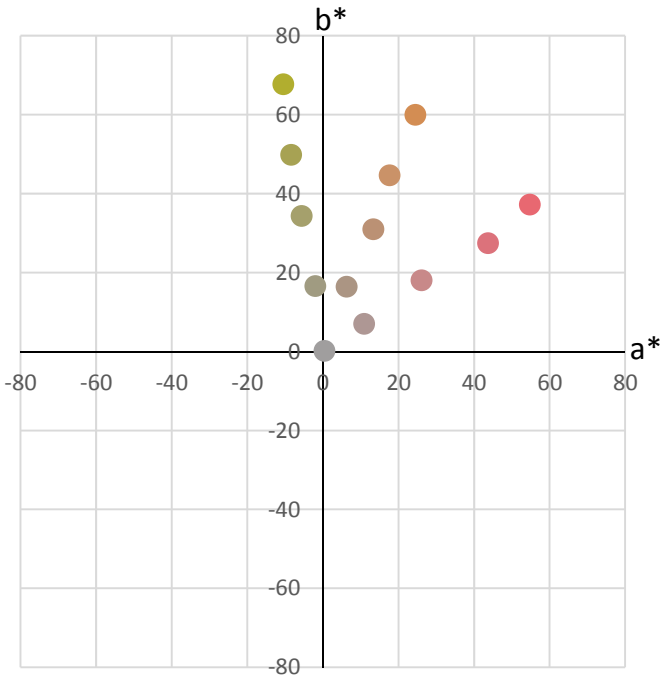


Figure 1 The thirteen colors in CIELAB space.

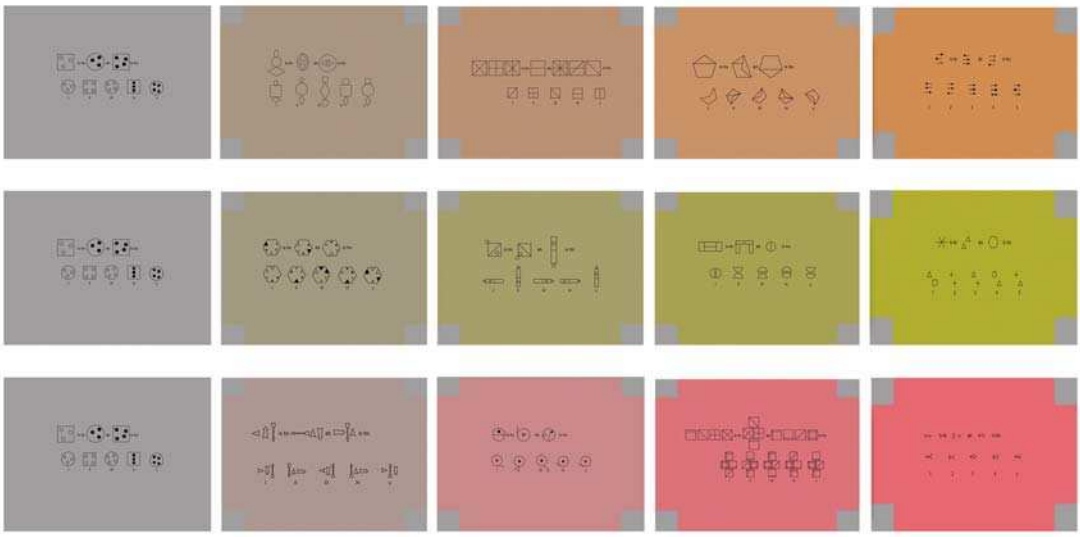


Figure 2 The actual screens shown in the experiment.

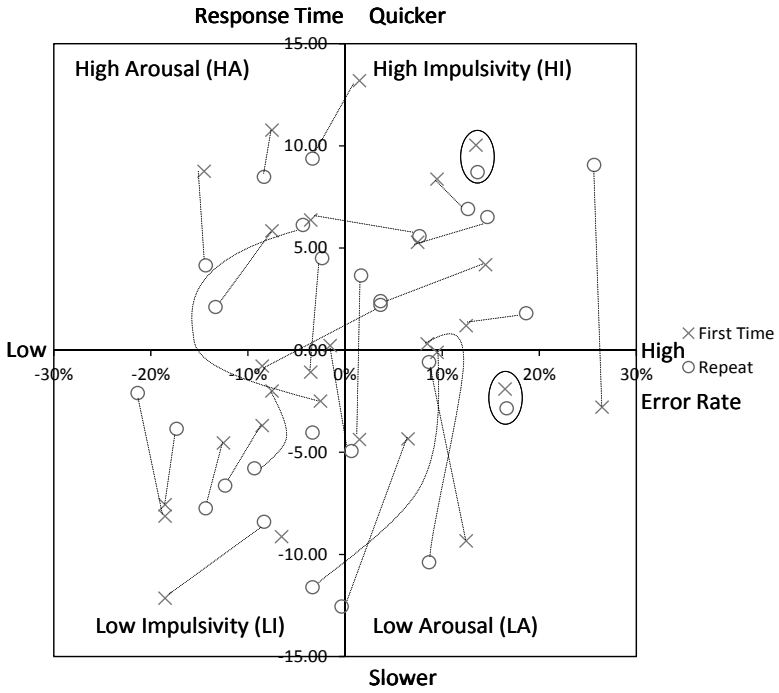


Figure 3 The Error-Speed space and participants' performance in the chroma experiment.

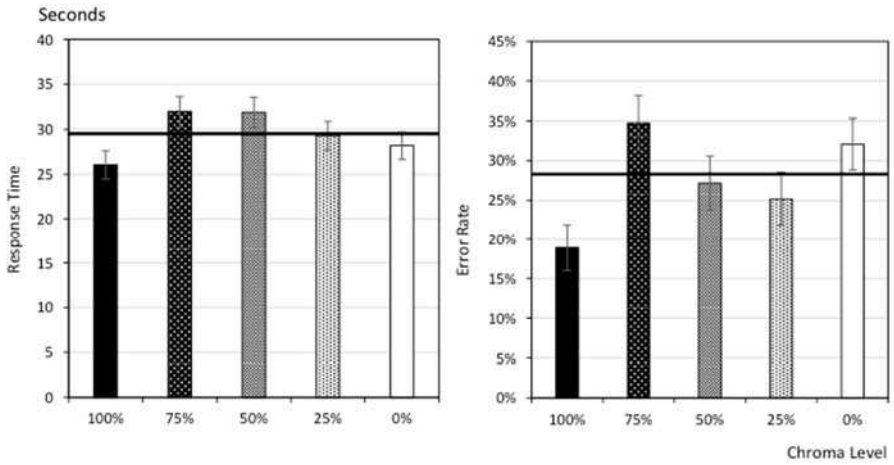


Figure 4 Response time and error rate by chroma level. The lines in figure represent the mean.

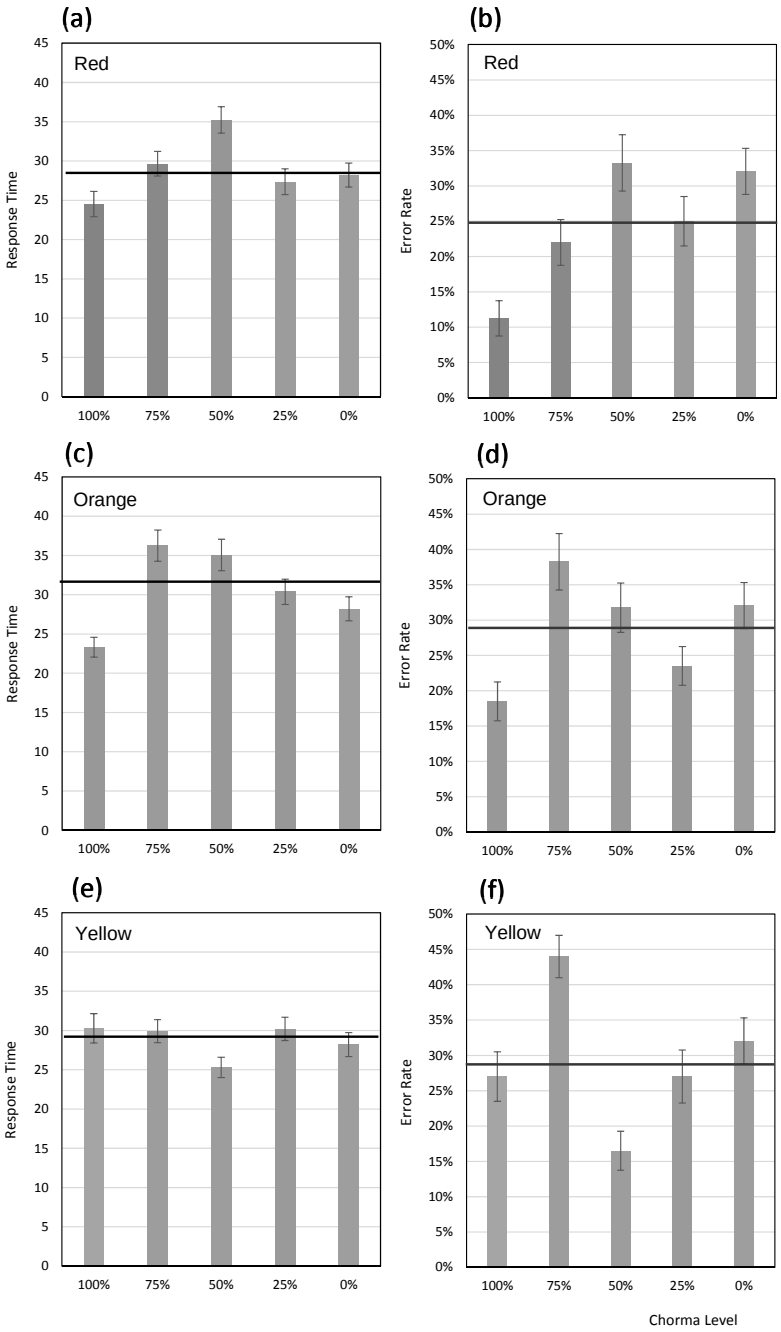


Figure 5 (a)-(f) represent the response times and error rates by chroma level for red, orange and yellow. The lines in (a) - (f) represent the mean.

Figure 6 Thirteen colors (with reference white) plotted in Error-Speed space.

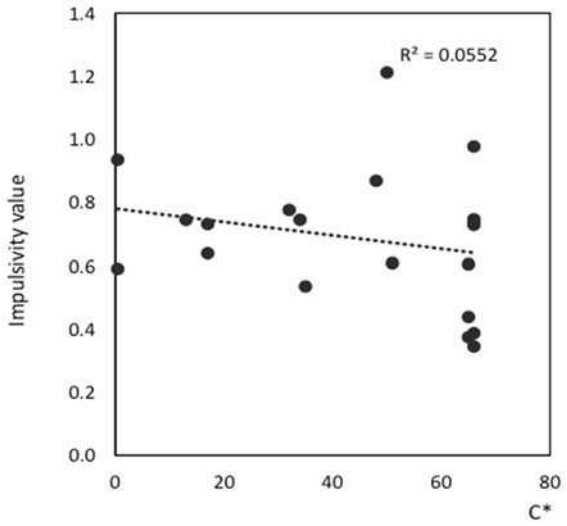


Figure 7 The regression fit between C* values and impulsiveness values.

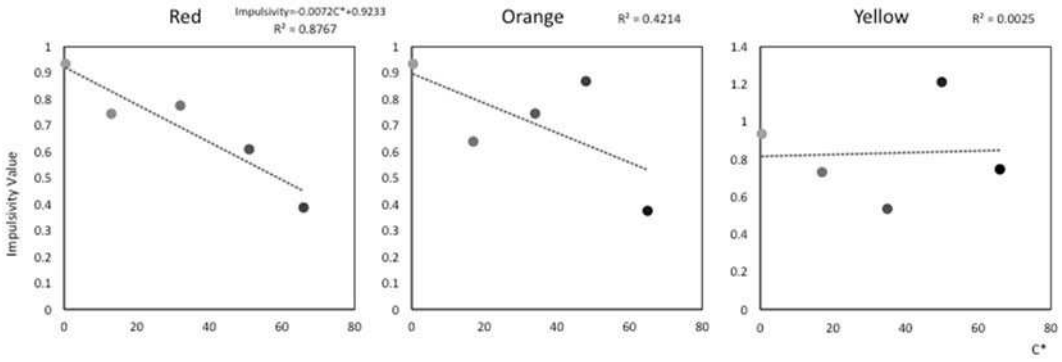


Figure 8 The regression fit between C* value for red, orange and yellow and impulsiveness values.

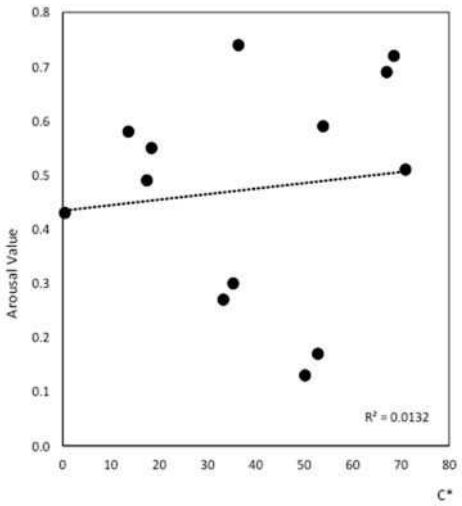


Figure 9 The regression fit between C* values and arousal values.

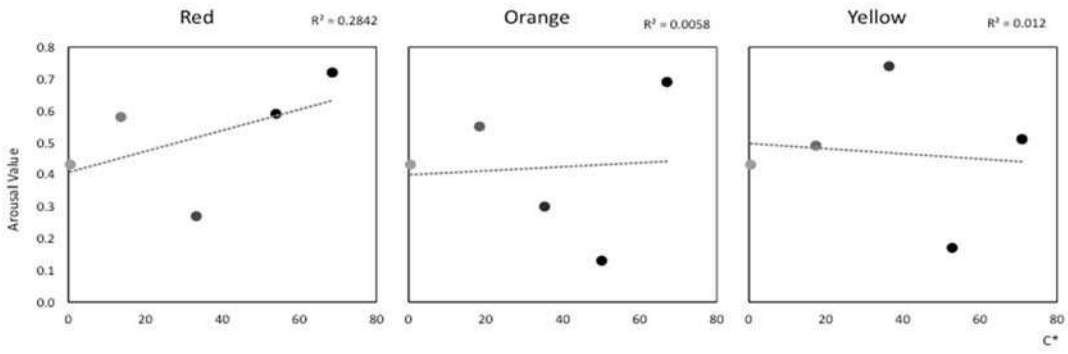


Figure 10 The regression fit between C* value for red, orange and yellow and arousal values.

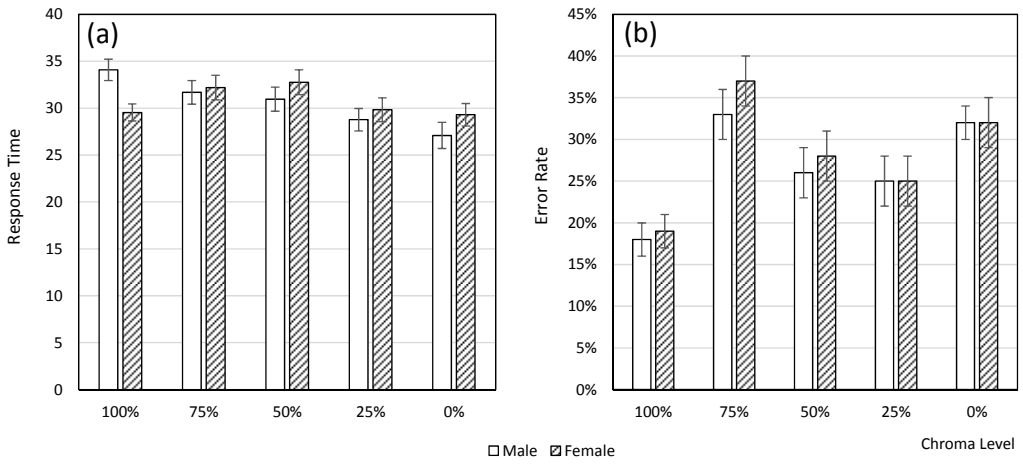


Figure 11 (a) Response time by gender; (b) error rate by gender.

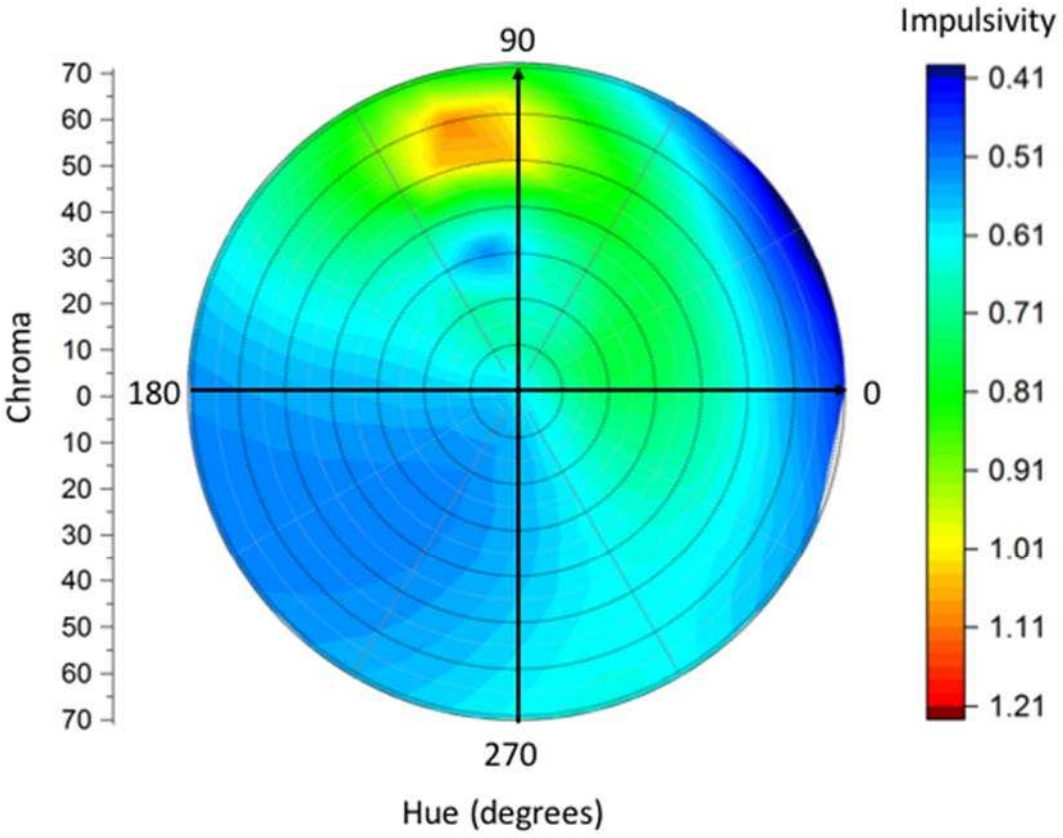


Figure 12 Impulsiveness contour map.

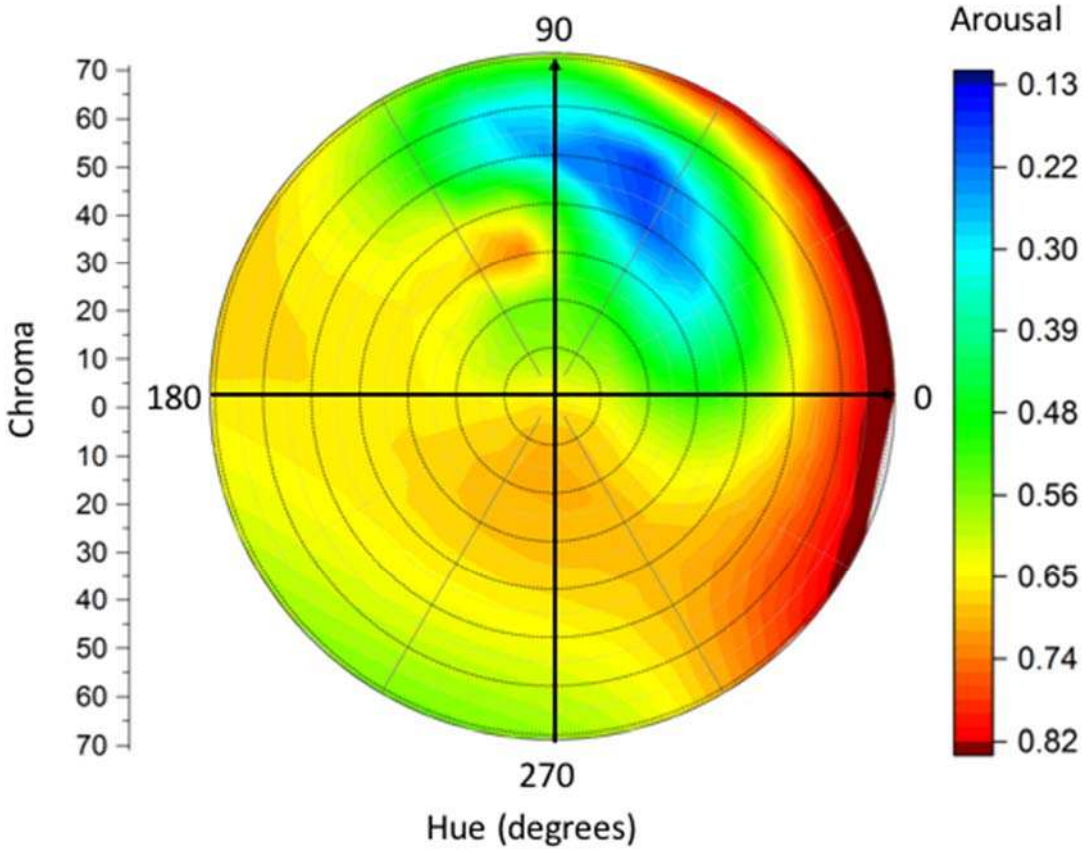
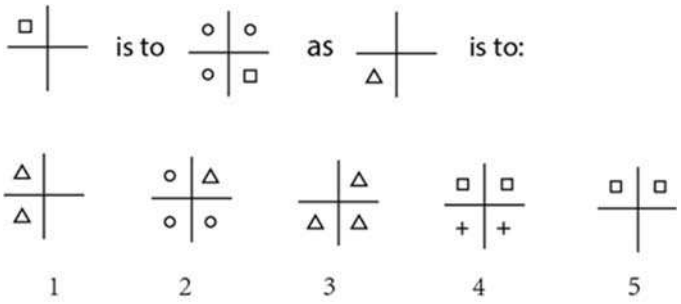
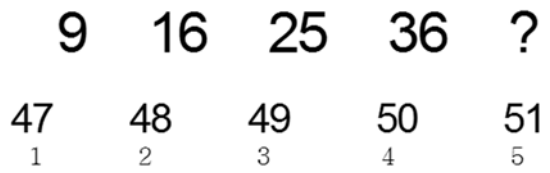
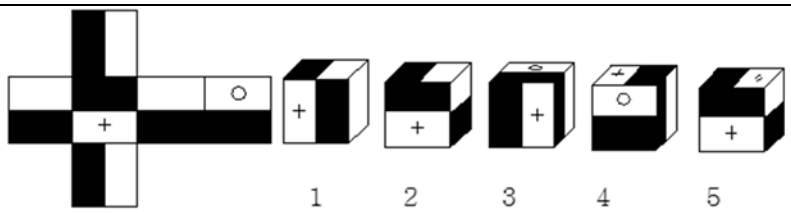


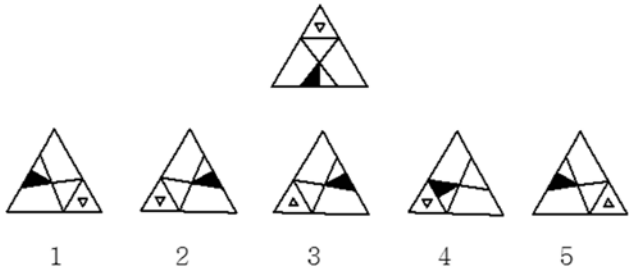
Figure 13 Arousal Contour Map.

Tables:

Table 1

(a) Logical Ability Test

Logical Rule: In this type of test, you are required to choose from a set of alternatives which diagram will complete a similar analogy to the first example.

Mathematics Sequence: In this type of test, you are given a string of numbers. You have to work out the number that is missing from the string (marked "?").

(b) Spatial Imagination Ability Tests

Spatial Structure: In this type of test, you need to look at the unfolded shape and then choose which of the objects below would best represent the first object if it were folded.



Rotation: In this type of test, you are shown a shape in the middle of the page. Below there are five other shapes. You have to decide which of the alternatives is identical to the original shape. It will still be identical to the original if it has been rotated. It will not be the same as the original if it has been reflected, or if the proportions or parts have been changed.

Table 2

Colors	L*	h (°)	C*	a*	b*
Visual Reference White	69.71	29.10	0.48	0.42	0.23
Red 100%	69.63	34.24	68.58	56.69	38.59
Red 75%	71.30	32.12	53.92	45.67	28.67
Red 50%	72.49	34.73	33.25	27.32	18.94
Red 25%	71.67	32.59	13.64	11.49	7.35
Orange 100%	71.17	67.83	67.07	25.31	62.11
Orange 75%	72.69	68.43	50.16	18.44	46.64
Orange 50%	70.20	66.74	35.31	13.94	32.44
Orange 25%	69.16	68.91	18.40	6.62	17.17
Yellow 100%	70.71	98.78	70.97	-10.83	70.14
Yellow 75%	68.56	99.49	52.83	-8.71	52.11
Yellow 50%	69.13	99.21	36.40	-5.83	35.93
Yellow 25%	68.60	96.83	17.44	-2.07	17.32

The white point in this experiment was customized. The XYZ values for the white point are:

X=112.7; Y=113.9; Z=186.7.

Table 3

Variables	Impulsiveness Status	N	Mean± STD error
Response time (sec)	LI	18	37±1
	LA	11	36±1
	HI	17	25±1
	HA	10	24±1
Error rate (%)	LI	18	19±2
	LA	11	39±3
	HI	17	39±2
	HA	10	21±2

LI, Low Impulsiveness; HI, High Impulsiveness; LA, low arousal; HA, high arousal.

Table 4

Color	E/R	1-ER	Color	E/R	1-ER
100% yellow	0.75	0.51	25% orange	0.64	0.55
75% yellow	1.21	0.17	100% red	0.39	0.72
50% yellow	0.54	0.74	75% red	0.61	0.59
25% yellow	0.73	0.49	50% red	0.78	0.27
100% orange	0.37	0.69	25% red	0.74	0.58
75% orange	0.87	0.13	reference white	0.93	0.43
50% orange	0.75	0.30			