Music Recommendation Based on Color

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***Abstract*—This study presents an alternative way in choosing songs based on a selection of colors through Color-to-Music application. There were three stages of this study: The first stage was the preparation music library of the association between color and emotion; and the association between music and emotion. Library data used for the Hue, Saturation, and Value (HSV) color model creation were: Hue to represent musical instruments, Saturation referred to tempo, and Value was key (pitch). Second stage was to create two types of graphical user interface (GUI) for color selection. The last stage was to collect data from 120 participants participating in the trials. This study focused on two questions. First was the accuracy rate of a recommended song that matched selected colors. Second was to find the most suitable GUI that provides the highest accuracy rate to the recommendation of songs. The tests were divided into two groups: test A and test B. As for test A, participants started a trial by choosing color from the application; while test B would start by selecting an initial emotion, and then choosing colors to match the chosen emotions. The results showed that the overall accuracy rate of test A is higher than test B and the slider GUI has the highest accuracy rate.**

Keywords—color-to-music, visualizing sound, cross-modal associations, synesthesia, psychology of music, music cognition, emotional indicators

I. Introduction

The study of the associations of color and music based on the emotional mediation hypothesis has found that colors associates with music based on shared emotional contents [1] – [5].

In earlier studies, the HSV color model is used for comparing colors associations with musical elements. Griscom [1] conducted the experiment of mapping timbre (of musical instruments) to colors. Whiteford [2] found that more saturated colors were selected for faster music. Collier & Hubbard [6] stated in the discussion that pitch height and contour influenced participants' rating of the brightness of ascending and descending major and minor mode scales.

In this study, the Color-to-Music application was investigated by providing choices for users to select songs according to a selection of colors. There are two questions that are examined in this study. Firstly, would the accuracy of the recommended songs matches the selected colors? Secondly, which type of GUI provides the highest accuracy rate to a recommendation song?

II. Methods

A. Task

The Color-to-Music application is created in two different types of GUI depending on the ease of color selection: First, GUI is designed as a color wheel and a second, GUI is designed as a slider.

The tests are accessible on a website and divided into two groups. Test A, participants started by choosing colors from the color wheel. After completing the choosing of colors, participants must then rate the selected colors and try to associate each one of them with a particular emotion; we call this as an initial emotion. By choosing colors from a color wheel, the Color-to-Music application will select an instrumental piece of music from its library and then display the result on screen. Then participants will be asked to use any type of headphone to listen to music for at least 30 seconds. Once the listening was completed, they must rate the recommended music that associated with their emotions once again; we call this as the final emotion. When participants complete the test, they would be required to repeat the test again in the same procedure but changing the way they choose colors from a color wheel to a slider.

Test B started differently. Instead of starting with the choosing of colors, this was done by asking participants to select an initial emotion first, then choose the colors that associated with that emotion. After choosing colors, participants listened to music provided by the Color-to-Music application and followed the same procedures of test A. At the end of the tests, participants in both groups were asked to rate the overall accuracy of each GUI.

The comparison between an initial and a final emotions will show the accuracy rate of the Color-to-Music application.

B. Stimulus

The associations of color and music based on shared emotions are listed in Table I. This is an idea we use for the preparation of the music library.

TABLE I. Color, Emotion, Music, and Physic

Color	Emotion	Music	Physic
Hue	Happy/Sad	Instrument	Waveform
Saturation	Intensity	Tempo	Time
Value	Brightness	Key	Frequency

i. There are three basic elements of music which we considered in the selection of songs. They are types of instrument, tempo (speed), and key (pitch). The four major types of musical instruments are Woodwinds, Brass, Percussion, and Strings. From [1] page 56, we decided to separate instruments into two groups according to happy and sad pair of emotions. Strings, percussion, and piano tend to relate more with

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happiness, while woodwinds and brass tend to relate with sadness. From [1] page 57, we group the instruments which relate to happy emotion with yellow color and put together the instruments related to sad emotion with blue color.

To separate the strings and the percussion, we use the differences in attacking time, meaning the first part of the sound envelope would describe the time taken during an initial run-up from nil to peak level of sound pressure: Shorter attack time would describe more transient or sharp sound. From [2] page 11, we interpreted a fast attacking time (of the percussion) with punchy characteristics, this related to redder hue. A slow attacking time from the strings would be on the other side of hue value.

Next, to separate the woodwinds and the brass by the frequency range. Piccolo has the highest frequency at approximately 5 kHz and Tuba has the lowest frequency at 45 Hz. From [7] page 16, higher frequency associated with color at hue value was closer to 0 degrees while lower frequency associated at hue value were closer to 360 degrees. Therefore, we can associate the woodwinds which have highest frequency to hue value from 90 to 180 degrees; and associate brass which has lowest frequency to hue value from 180 to 270 degrees.

Second element of color is saturation, we associate saturation with tempo (musical speed or pacing) [3]. Faster tempo represented more saturated colors and slower tempo belonged to less saturated colors; thus, we assign musical pieces with three different tempo periods: First period is any tempo below 76 beats per minute (BPM) or below *andante*. This associated with color of 34 percent saturation or less. Second period is a tempo between 76 to 120 BPM, or *andante* to *allegro*, this associated with color with 35 to 67 present saturation. The last period is a tempo above 120 BPM or above *allegro* that fell into the color range greater than 67 present saturation.

The last element of color is value. We associate a value with musical scales (key), [6] page 165. Major key associated with more than 50 percent value and minor key associated with 50 percent value or less.

From all the interpretations, we have come to the conclusion of three elements of music associations with HSV model, as shown in Figure 1.

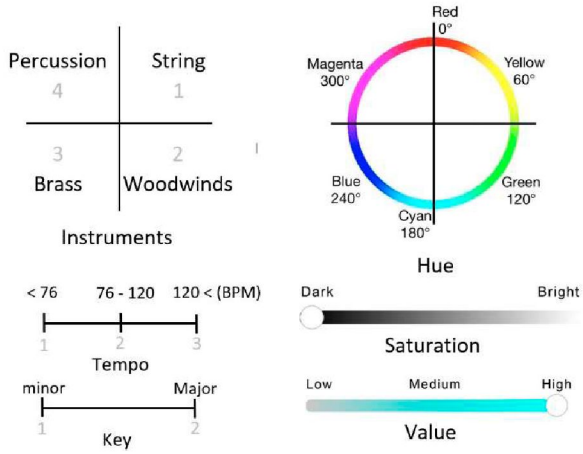
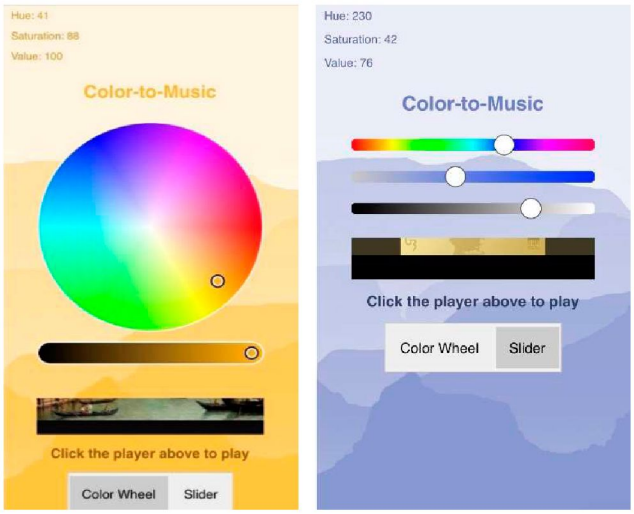


Fig. 1. Three musical elements associations with HSV model

ii. A set of 72 instrumental pieces of music are prepared as a standing library. These 72 pieces came from 24 possibilities: 4 types of instruments, 3 periods of tempo, and 2 keys, as shown in Figure 1. We also prepared 3 pieces for each possibility in case the participants selected the same color. All pieces are selected from concerto works (an instrumental work that maintains contrast between an orchestral ensemble and a smaller group or a solo instrument) from an open-source YouTube downloader.

iii. The two types of GUI are created by using HTML editors which both are available on the web page. First GUI is in the form of a color wheel and the second is in the form of a slider. Both GUIs have different advantages; a color wheel can easily select hue and saturation at the same time; and a slider provides three separated selections of hue, saturation, and value, as shown in Figure 2.



(a) (b)

Fig. 2. Two types of GUI (a) Color Wheel (b) Slider

C. *Test design*

As for the test, we selected participants between the ages of 18 and 24; 25 males, 93 females, and 2 LGBTs. Most of them are the students of King Mongkut's Institute of Technology Ladkrabang. As mentioned earlier, the tests were divided into two groups. There were 60 participants in each group. To avoid the possibility of bias, each participant will be allowed to do only one trial, not both. All participants gave consent and acknowledgement for the purpose of the study, and the Committee for the Protection of Human Subjects at the King Mongkut's Institute of Technology Ladkrabang, had approved the experimental protocol.

Figure 3 shows the procedure of the tests. This can be described as the differences of test A and test B which occurred during the initial emotion. Test A, participants starts directly by choosing colors from the application. Then they were instructed to rate the association of an initial emotion with the selected color; while test B, they started by selecting an initial emotion, then associating colors with it.

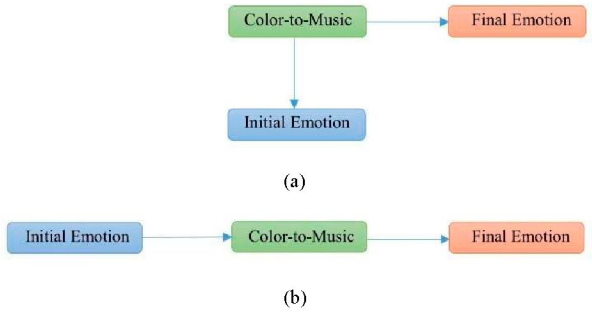


Fig. 3. Test Procedure (a) Test A (b) Test B

D. Analysis

The analysis will be conducted according to two research questions, as described in the introduction. First, the accuracy rate of the recommended song matches selected colors; from Fig. 3 the final emotion will be compared with the initial emotion and will show the results of the accuracy rate in percentage. Second, the most suitable GUI of the application will be analyzed by the overall rating given by participants from 1 to 5 (0 to 100%). Lastly, we do a cross-checking between the accuracy results of the first and the second research question; to see the results whether they go in the same direction or otherwise.

III. RESULTS

The results are displayed in two formats: with numeric distributions and graphs.

A. Color-to-Music Library

Table II – VII shows an overview of the test results of slider 1 from test A and the test results of slider 2 from test B.

TABLE II. ACCURACY RATE OF COLOR-TO-MUSIC LIBRARY: SLIDER 1 – H

Slider 1	Hue		
	Count	*Correct*	*Accuracy (%)*
Happy	22	15	68.18
Sad	38	15	39.47
Overall	60	30	**50.00**

TABLE III. ACCURACY RATE OF COLOR-TO-MUSIC LIBRARY: SLIDER 1 - S

Slider 1	Saturation		
	Count	*Correct*	*Accuracy (%)*
Low	9	7	77.78
Medium	20	8	40.00
High	31	7	22.58
Overall	60	22	**36.67**

TABLE IV. ACCURACY RATE OF COLOR-TO-MUSIC LIBRARY: SLIDER 1 - V

Slider 1	Value		
	Count	*Correct*	*Accuracy (%)*
Dark	20	9	45.00
Bright	40	31	77.50
Overall	60	40	**66.67**

From Table II, 22 participants chose happy as an initial emotion; after comparing with a final emotion, there are 15 correct matching cases which were equivalent to 68.18 percent accuracy. Only 15 cases of sad emotion are correct equivalent to 39.47 percent accuracy. The overall accuracy of hue of slider 1 from test A is 50 percent.

The accuracy rate of saturation in Table III shows most participants tend to choose a high level of saturation (31 counts) but there are only 7 cases matching which equal to 22.58 percent accuracy. On the other hand, there are only 9 participants who chose low levels of saturation but have the highest accuracy rate at 77.78 percent. These two cases provides the overall result of accuracy rate equivalent to 36.67 percent.

The overall accuracy rate of value in Table IV is the highest compared with the overall accuracy rate of hue and saturation.

TABLE V. ACCURACY RATE OF COLOR-TO-MUSIC LIBRARY: SLIDER 2 - H

Slider 2	Hue		
	Count	*Correct*	*Accuracy (%)*
Happy	22	17	77.27
Sad	38	14	36.84
Overall	60	31	**51.67**

TABLE VI. ACCURACY RATE OF COLOR-TO-MUSIC LIBRARY: SLIDER 2 - S

Slider 2	Saturation		
	Count	*Correct*	*Accuracy (%)*
Low	18	1	5.56
Medium	25	6	24.00
High	17	12	70.59
Overall	60	19	**31.67**

TABLE VII. ACCURACY RATE OF COLOR-TO-MUSIC LIBRARY: SLIDER 2 - V

Slider 2	Value		
	Count	*Correct*	*Accuracy (%)*
Dark	32	10	31.25
Bright	28	26	92.86
Overall	60	36	**60.00**

The accuracy rate of hue from slider 2 (from test B) is similar with the results from slider 1. There is only 1.67 percent difference in the overall rating. This also happened with the overall rating of the saturation from slider 2 in Table IV, showing only 5 percent lower than the results of slider 1; but the interesting thing is that the accuracy of participants who chose low saturation has only 1 case matching. Therefore, we would say that this is the lowest accuracy rate of all results. We also found that the accuracy rate of the participants who chose bright saturation in Table VII is the highest accuracy rate compared with all results; nonetheless, overall rating of saturation is still lower than slider 1 at 6.67 percent.

B. GUI

The overall ratings of each GUI are shown in Figure 4.

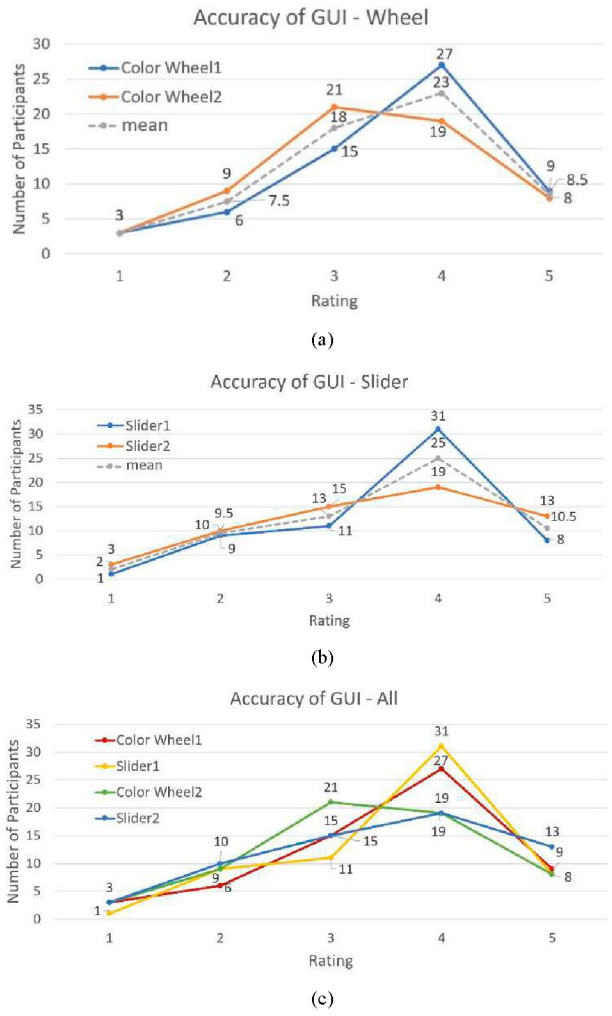


Fig. 4. Accuracy of GUI (a) Wheel (b) Slider (c) All

As the graphs showed, these three figures are the results of the overall rating of the accuracy from each GUI (wheel and slider) which answered the second research question as written in the introduction. Figure 4 (a) shows a number of participants who rated color wheel 1 from test A and color wheel 2 from test B. There are 36 participants rated 4 and 5 (75 and 100 percent) for color wheel 1 which accounted to 60 percent of total participants; while 27 participants rated 4 and 5 for color wheel 2 which accounted to 45 percent.

Figure 4 (b) shows rating results from participants who used slider GUI from test A and B. The percentage of participants who rated 4 and 5 on slider 1 and 2 are 65 and 53 percent in order which are greater than the results of wheel GUI in Fig. 4 (a). In this case, we would say that slider 1 has the highest accuracy rate compared with the rest of the results.

Figure 4 (c) shows the distribution of the results which can be seen that the mean of participants who rate 1 - 3 and 5 are quite similar; but participants who rated 4 are obviously different. Therefore, if we take this information to cross-check with the accuracy rate of the Color-to-Music library in the results (A), then we can conclude that the slider GUI in the test A (slide 1) has the highest accuracy rate.

IV. Discussions

As expected from the test design phase, different test procedures creates the difference in accuracy rate. The results of test A have higher accuracy than test B; to explain this statement we need to analyze carefully the difference of test A and B which occurs at the initial emotion (see Fig. 3). Choosing color directly from the Color-to-Music application and listening to a recommended piece of music created less error than test B; which asked to select an initial emotion first then choosing colors associated with that emotion.

V. Summary

From the results, the Color-to-Music Library has low accuracy rate; which has overall accuracy only 51.11 percent. The associations of HSV model and three basic elements of music in Methods (B) should be improved. On the other hand, two types of GUI have high accuracy rates; there are 65 percent of all participants rated 4 and 5 (75 percent and above). This means that these GUIs are ready available to be used for further studies.

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References

[1] W. Grisom, "Visualizing Sound: Cross-Modal Mapping Between Music and Color," Doctoral diss., University of California, Berkeley, CA, 2014. [Online]. Available: https://www.semanticscholar.org/. [Accessed: Jun 1, 2020].

[2] K. L. Whiteford, K. B. Schloss, N. E. Helwig, and S. E. Palmer, "Color, Music, and Emotion: Bach to the Blues," *i-Perception: SAGE Journals*, vol.9, no.6, pp.1-27, October 2018. [Online serial]. Available: https://journals.sagepub.com/doi/pdf/10.1177/2041669518808535. [Accessed: Jun 1, 2020].

[3] S. E. Palmer, K. B. Schloss, Z. Xu, and L. R. Prado-Leon, "Music–color associations are mediated by emotion," *Proceedings of the National Academy of Sciences of the United States of America*, vol.110, no.22, pp.8836-8841, May 2013. [Online serial]. Available: https://www.pnas.org/content/110/22/8836. [Accessed: Jun 3, 2020].

[4] S. E. Palmer, T. A. Langlois, and K. B. Schloss, "Music-to-Color Associations of Single-Line Piano Melodies in Non-synesthetes," *Multisensory Research*, vol.29, issue 1-3, pp.127-193, Jan 2016. [Online]. Available: https://brill.com/view/journals/msr/29/1-3/article-p157_8.xml. [Accessed: Jun 3, 2020].

[5] E. S. Isbilen, and C. L. Krumhansl: "The Color of Music: Emotion-Mediated Associations to Bach's Well-Tempered Clavier," *Psychomusicology: Music, Mind, and Brain*, vol.26, no.2, pp.149-161, 2016. [Online]. Available: https://psycnet.apa.org/record/2016-23674-001. [Accessed: Jun 7, 2020].

[6] W. G. Collier, and T. L. Hubbard, "Musical Scales and Brightness Evaluations: Effects of Pitch, Direction, and Scale Mode," *Musicae Scientiae: SAGE Journals*, vol.8, no.2, pp.151-173, September 2004. [Online].Available:https://journals.sagepub.com/doi/10.1177/102986490400800203. [Accessed: Jun 1, 2020].

[7] G. Hamilton-Fletcher, C. Witzel, D. Reby, and J. Ward, "Sound Properties Associated With Equiluminant Colours," *Multisensory Research*, Vol.30, Issue 3-5, pp.337-362, May 2017. [Online], Available:https://brill.com/view/journals/msr/30/3-5/article-p337_10.xml. [Accessed: Jun 3, 2020].