Impression and Satisfaction of Color Perception of Painting Art Figures Utilizing Sound Pitches Through Touch-Screen Device for The Congenital Totally Blind

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Abstract

The congenital totally blind had no experiences or memories about pictures and colors. They have never had an opportunity to touch and perceive 2D paintings. Even if they were able to touch the paintings, they would only perceive the textures while the materials and colors will be damaged. This research proposes a new technique by utilizing touch-screen technology and developing computer software. It encodes color values, which are RGB, to HLS model colors and pair many colors in degree to MIDI sound pitches of musical notes. It can help the blind perceive colors and shapes of a painting. The software is divided 2 parts, i.e. touching program for color and shape perception of painting, and painting software. When the blind touches a painting master piece, they will be able to explain, describe and criticize the painting. This technique makes possible for an art to communicate to everyone.

The research is a qualitative study and serves as a case study and an applied research. It was carried out with congenital blind participants who were studying in high schools. Since the study was in an initial phase, we started out with 12 colors and 12 sound pitches for basic testing. The participants were assigned to touch the paintings using touch-screen and perceive the sound pitches corresponding to the positions on the picture. It was found that the device was able to help the blind perceive the colors

and shapes on the picture, which were represented by sound pitches of the musical notes. As a result, the participants were able to use their hearing to perceive vision. They could describe and criticize the composition, color and shape of the picture. Thus, these participants obtained the new experience, knowledge and imagination. In addition, they were also satisfied with this research activity since their color and shape perceptions of paintings were from good to excellent. Furthermore, they were able to draw and paint in color using this device.

The author has offered a useful computer-based technique for spatial and color information access for the blind. The 2D screen can give information about a 2D picture just by showing it in a simplified form. The colors are represented by pitches and triggered by touching the screen in, say, a green area of the picture. School-age blind participants in the study enjoyed learning and trying out the system.

Key Words: Color; Sound; Perception; Draw; Paint; Art; Blind; Computer

Introduction

Traditional art is not able to communicate and convey impression to everyone. Particularly, the congenital blind who are without vision cannot perceive pictures or paintings. They can only perceive things by hearing or touching. If they were to touch a painting, it would be damaged. Since the congenital blind never had any experience of vision before, how do they perceive colors on a painting if it was not to be touched? This research introduces the development of the technique to solve this problem for the congenital blind, which utilizes both device and software. It has been designed to aid them to be able to perceive the colors of a painting. In the same way, they also will be able to use this device to make their artworks by drawing and painting in colors.

"Art as expression, which is to be deeply moved or affected emotion be evident with media, such as sound, line, color, texture, form and others." (Royal Institute of Thailand, 2003: 1,101). The blind have the same right to perceive and express as sighted people, including the knowledge, information and experiences for themselves in the society. Art is an indicator of growth, civilization, taste, cognition and intelligence. Color is one of the important art elements. Thus, color perception is important for the blind. This research is intended to allow the blind to have new experiences in touching and perceiving the colors of the original paintings which are the master pieces in the world of art. They would be able to express their feelings about the drawings and paintings and acquire impression and satisfaction through making their 2D artworks via the device and software in this research. This purpose of the research was not to make the blind see the colors but to make them perceive the colorfulness and emotion of the pictures. The acquisition procedure was through hearing instead of seeing as they have a limited access. The technique was achieved by pairing colors with sound pitches.

The devices employed in the research include software especially developed for this work, computer, touch-screen monitor and keyboard. The technique to perceive colors and shapes from pictures makes use of paintings. It codes color values to match with sound pitches of musical

notes. The RGB that is used for color display on computers is converted to HLS which is double cone color model. Next, the HLS color model is compared with the helix of musical notes (Shepard, 1965, quoted in Deutsch, 1982: 353) by using degrees of color, and, finally, using MIDI, which is the musical instrument digital interface to play the sound pitches of musical notes corresponding to the colors. This research focuses on the color perception of the paintings which are the world master piece artwork and the expression of drawing and painting in colors of the participants. They will perceive the colors and shapes of the paintings. They will be able to draw and paint in colors from the sound pitches of musical notes. In this way, it would enable art to communicate and convey messages to everybody. This paper is an offshoot of the author's dissertation submitted as part of international Ph.D. program in Design Arts at Silpakorn University. A short version of the author's doctoral research was published under the title "Color Perception of Visual Art Painting Utilizing Sound for the Totally Blind" in *Burapha Arts Journal* Special Issue: November 2011. The published article describes color perception for the congenital blindness volunteers, which was based on the experiment and testing demo during the software development phase including raw data collection and improvement. This article is different from the earlier work in that it presents the final software development and data collection.

Furthermore, this article contains more explanations and details of the research undertaken. It is also presented in a clear, concise and detailed manner. The participants who are congenital blind were able to express impression and satisfaction from touching the painting master pieces.

Goals of the Research

1) Making new technique using the software development for the congenital blind including touch and paint program. It converts colors to sound pitches through the devices that are touch-screen monitor and computer.

2) The congenital blind can perceive colors and shapes in paintings, and they can express them in the form of drawing and painting

utilizing the device and software based on their experiences, knowledge and imaginations.

3) The device of the research will help the congenital blind to perceive color of paintings by using their fingertip to touch, moving or dragging on the touch-screen and perceive the color positions on the picture from sound pitches. They will be able to explain, criticize and comment about the paintings that they have touched.

4) The congenital blind can perceive and remember the colors represented by sound pitches, and they can acquire the impression and satisfaction from the paintings.

Scope of the Research

1) The participants are congenital blind or they had lost their sights before 5 years old (Lowenfeld, 1981: 67), and they must have studied at secondary school in grade 10 or higher.

2) Sighting colors is not the aim of this research but it is the perception of various colors and the corresponding positions from the picture. The participants will perceive by hearing sound pitches of musical notes that represent colors by pairing and coding. The participants also can express themselves by drawing and painting on the device and using the software in the research.

3) This research is the development as a prototype and to be tested with the participants. They will be trained to remember the color codes represented by sound pitches. But, since the activity periods are limited, the testing was defined into 12 colors which are proper and necessary to do basic painting.

Framework of the Research

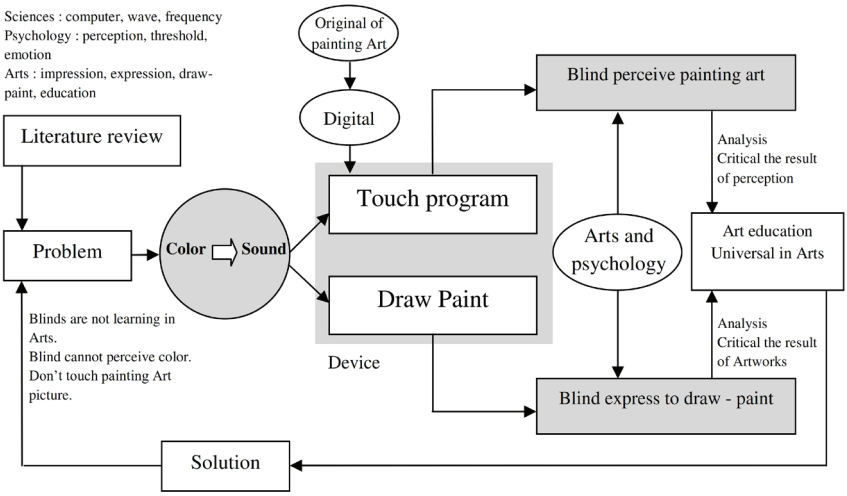


Figure 1 Framework of the research diagram

Literature Review

This study is related to 3 important fields, i.e. art, psychology and science. It is the integration of knowledge for the research. The participants or intended users are the congenital blind.

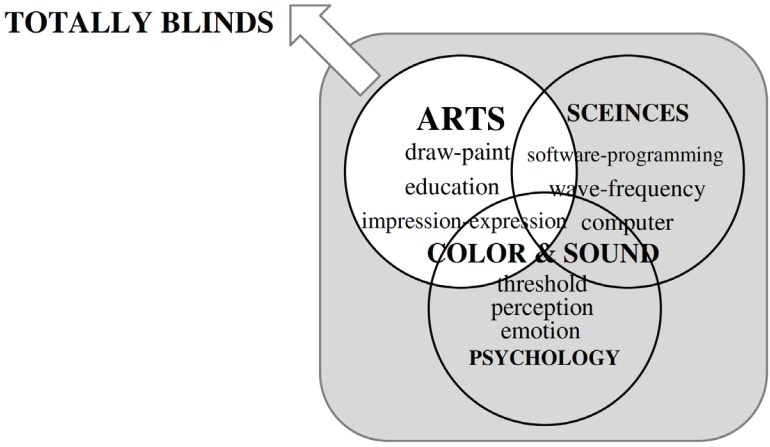


Figure 2 A conceptual study in the integration of the research objectives

Methodology of the Research

This is a qualitative research. The research types are a case studied and applied research based on case studies. The method and tools for data collections include memos, interviews, observations, voice records of conversations, photographs, videos, and test methods of painting. It is a study and development of a device to help the blind perceive colors of painting and express them with drawing and painting. It also involves making a training course for the participants on how to utilize the device. In addition, it will help them understand and obtain knowledge and skills in art and design. They will be able to adjust their skills, creativities, imaginations and integrate the other fields. The results of the research are analysis of perception, satisfaction and artwork of the participants who are congenital blind.

1) Area selection of the research: this research is aimed at designing and developing a device to help the congenital blind. The author selected the research area in Thailand because it is convenient to travel and perform fieldwork. The author obtained assistance and kindness from Khon Kaen School for The Blind of The Christian Foundation for the blind in Thailand under The Royal Patronage of His Majesty the King.

2) Fieldworks are divided into 2 sections. The first part or experimental fieldwork involves studying with the participants for data collection by testing software demo, interviews and observations for the device, and software improvement (Pre-Test). The final fieldwork uses the device and final software version to evaluate the participants for the analysis of the results (Post-Test).

3) Design and develop the software and device including computer (desktop or laptop), keyboard and touch-screen monitor.

4) Prepare the interview questionnaires, for instance, before, during and after touching pictures to evaluate their feelings. Since the participants had not studied art before or they had limited knowledge of art, interview guidelines should also be prepared. It will help them answer and respond to this activity more effectively.

5) For the experiment and improvement of the final software for data collection, the author will be testing and using the device and art lesson with the participants. During the experiment, the author will observe, inquire, interview, note the advantages or disadvantages and perform preliminary analysis and summary of the results. The author personally collects the data because the author would contact data and seeing along the activities all the time.

When the data was collected and classified, it would be analyzed by comparison, relationship and coherence of data from the participants, such as their attention, motivation and learning, and surrounding factors of sensation including thought, attitude, knowledge, experience, belief, perception, satisfaction and emotion of the participants. The results will be analyzed for each participant as part of the case studies. The analysis uses the art theories and will refer to the related theories, such as imitationalism, formalism, emotionalism (Mittler, 1994: 91-92), imaginationalism, and others. Conclusion, discussion and suggestion of the research are presented after the analysis of results.

Technique of Software and Device Development

This article is a part of research and thesis on color perception and expression with drawing and painting of the congenital blind. The technique involves software to code colors into sound pitches.

However, this article presents the participants' impression and satisfaction from the activity in touching the pictures and utilizing touch-screen and software.

From the literature review and related studies about the color theory and the sound theory, the author analyzed and synthesized the principles and criterions of design and software development in order to represent color codes into sound pitches of musical notes. This is referred to as the principle of universal music for making the software in this research. It can be explained as follows:

1) Software and device are selected for this research: The author selected the touch-screen monitor. It could input data by touching or pointing

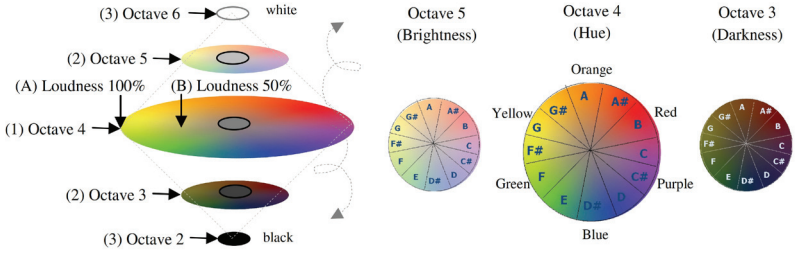
on screen and output data on a display. Keyboard is used to input data and commands. The device would interact with the users by using a fingertip to touch on a screen and the sound pitches would be played corresponding to the colors that they represent in real-time. The software is developed with Microsoft Visual Basic 6.0, which can be installed and run on Microsoft Windows 7 operating system. The system supports touch-screen technology. (These applications are permitted to use for study and research from Silpakorn University, the formal memo at no. 0520.207/1499 on 26 September, 2012., that *"It can use to develop computer applications that is Microsoft Visual Basic Version 6.0 for reference of the research but not the commercial."*. These applications are used only for the study and research.) 2) Method of comparison and pairing colors and sound pitches of musical notes: There were several authors that have mentioned about comparison between colors and sound. There was referred to 7 colors in spectrum and 7 sound pitches of musical notes on diatonic scale by Newton (Newton, 1721: 134-136). The spectrum could be divided into 12 color ranges and compared with 12 sound pitches of musical notes on chromatic scale by Castel (Peacock, 1988: 400), Rimington (Rimington, 1912: 177) and Bishop (Bishop, 1983: 5). Scriabin used the circle of fifth of musical notes to pair with colors and also the several others that the author did not refer to. They used the pairing between colors and sound pitches to create the music instrument called "Clavesin oculaire" or "Color organ". In the past, it was the ancient piano which flicks lines and sticks it on pin that was called "The ocular harpsichord". Kandinsky mentioned to compare about color to sound with narration. As mentioned above, it showed that these authors referred and paired colors and sounds differently depending on the focus or objective of each person.

Consequently, the comparison of colors and sound pitches in this research is defined specifically for the device and software used in this research only. The aims are to help the congenital blind to perceive colors and shapes of painting, and help them express the painting by drawing and painting using their fingertips by touching, pointing, moving or dragging on a touch-screen. It refers to the 3D of HLS color model that starts from

X-axis and Y-axis which are on the circular plane of hue and compared with the helix of sound model (Shepard, 1965, quoted in Deutsch, 1982: 353). The color spectrums was arranged from purple to red by color wheel and divided by degree into 12 color ranges. The participants could use them to learn about color theory and color mixing. Colors, hue and saturation were on X-axis and Y-axis, and lightness was upward and darkness was downward on Z-axis.

In the theory of universal music, the principle of sound and music can separate the sound system into 4 scales, i.e. diatonic, pentatonic, chromatic and mode scale (Samrej Kommong, 2009: 22-25). The chromatic scale has 12 musical notes, which are "C", "C#", "D", "D#", "E", "F", "F#", "G", "G#", "A", "A#" and "B". The 12 sound pitches are increased in each half of tone and complete to an octave. They can be made in the circular plane and divided into 12 ranges of musical notes. These can match to 12 ranges of color as layer. When it was paired between colors and sound pitches, the 4th octave will be hue of 12 colors on color wheel, the 5th octave is 12 colors of brightness and the 3rd octave is colors of darkness, the 6th octave is white that is the highest, and the 2nd octave is black that is the lowest. The sound pitches are lower than the 2nd octave that cannot be heard or is hard to hear because they are undertone and sotto voce.

From the above, there were 3 steps from hue circle or the 4th octave (4th, 5th, 6th were upward and 4th, 3rd, 2nd were downward that each 3 steps). When they were paired, they had 77 sound pitches and colors.



(1) HLS color model in 3 steps (2) Light, hue, dark Color wheel

Figure 3 Comparison and pairing colors and sound pitches with the HLS model

The software is developed specifically for this task. There method of programming involves converting colors from RGB to HLS double cone model and pairing of the colors from HLS to MIDI which is the sound pitches of musical notes.

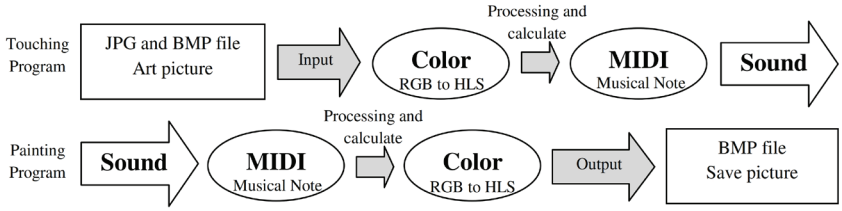


Figure 4 Diagram of software input and output processing

The developed software prototype is used primarily for testing the participants. Therefore, the colors are reduced for ease of implementation and small memory usage. The author selected 6 colors from hue, such as purple, blue, green, yellow, orange and red. These 6 colors can be used and explained about the color wheel and secondary color mixing. Next, selected 6 colors need for using and painting in preliminary, such as light blue, pink (light red), brown (dark orange), white, grey and black. There are total of 12 colors.

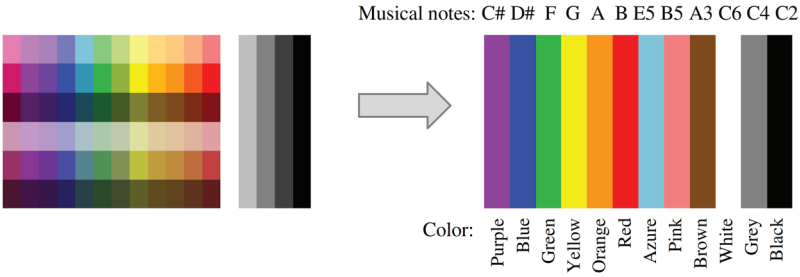


Figure 5 The palette of 77 colors and reduce to select 12 need colors

3) Design of user interface: The software was separated 2 programs including, touching program and painting program. There is the device including, touch-screen monitor, keyboard and computer.

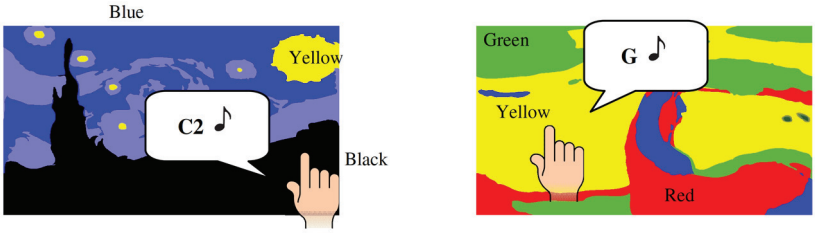


Figure 6 The fingertip is pointing and touching on touch-screen monitor with the artistic painting of Vincent van Gogh's "The Starry Night", and Franz Marc's "Horse in a Landscape", which were simplified in details and colors

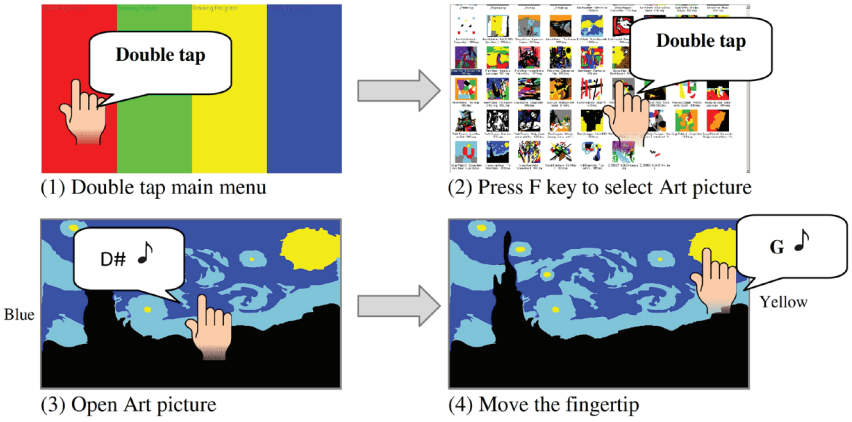


Figure 7 Using the touching program

Touching program, when users pointed their fingertip to the picture that opened on a touch-screen, the color that was touched would play the sound pitch of musical notes. For example, blue is "D#" note, black is "C2" note ("C" in the second octave). The picture used was simplified in some details and colors by having no more than 12 colors.

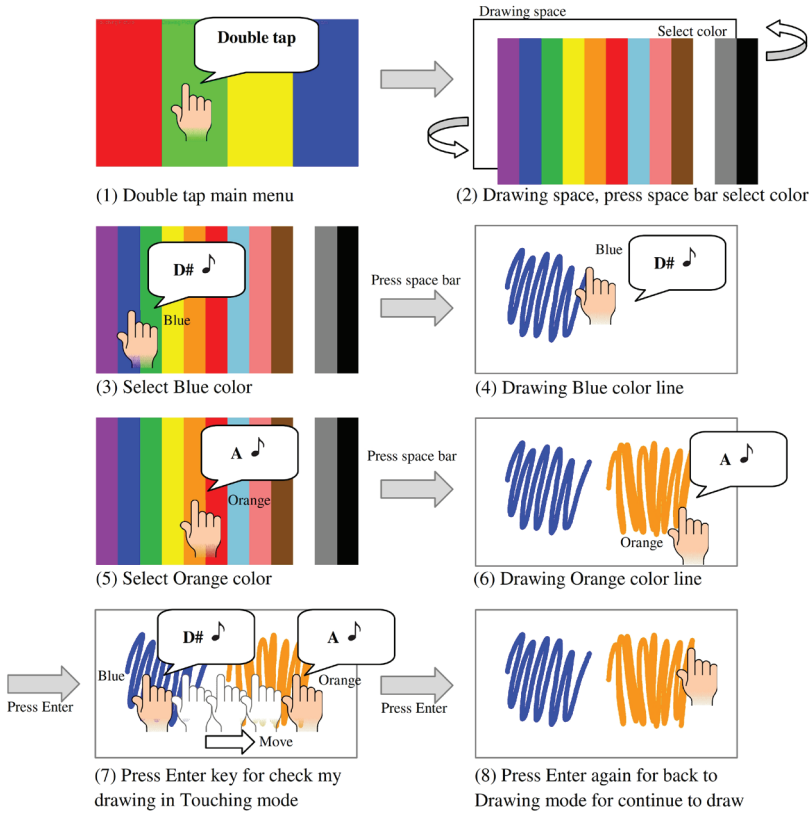


Figure 8 Using the drawing and painting program

Painting program, users had to select a color by dragging or pointing their fingertip from the palette by pressing "Spacebar" key to switch the palette screen. They would hear a sound at the same time from the position that fingertip was pointing. For example, blue is "C#" note, orange is "A" note and so on. After that, when the users pressed "Spacebar" key again to change or close the palette and appear the painting screen. The color was selected, and it can be painted on the screen. If they press "Enter" key, it will be in the touching mode for checking the color and shape that they painted, and press "Enter" key again to go back to painting continuously. Since the participants are congenital blind, the author designed the user interface as straightforward as possible without any complexity in the usage and the workspace is displayed in full-screen.

Results of the Research

The fieldwork for data collection was tested with the participants by the prepared tools. The interview could be flexible in order to follow the situations. The pictures of test method for touching were with the master pieces including, Kasimir Malevich's "Supreme", Vincent van Gogh's "The Starry Night", Franz Marc's "Horse in a Landscape", Serge Poliakoff's "Composition verte, bleue, rouge et jaune", and Piet Mondrian's "Composition" which were simplified some details and colors. The participants touched the pictures with the touching program. When they perceived and remembered colors and positions on the pictures, they would be able to explain and criticize these artistic paintings and they would obtain the satisfaction, enjoyment and impression. The results of analysis were showed as follows:

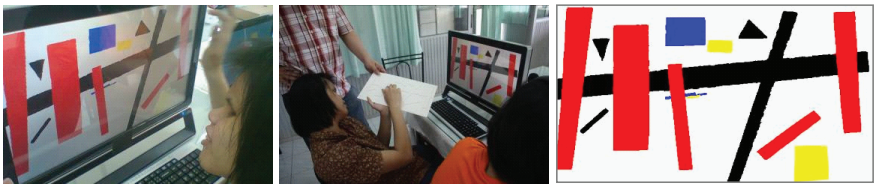


Figure 9 Touching the painting of "Supreme"

Table 1 The interview and conversation from touching of "Supreme"

Person	Interview and Transcription	Analysis
Researcher	"OK, open the picture." (Open picture)	
Participant	"This is white, it is empty surely" "There is black, this is white, this is red and black, this is white that is so long from here to there."	She could remember sound pitches and could identify some colors.
Researcher	"Try to evaluate an idea about this picture, How it is?"	
Participant	"White is above more than at the side, and the next is red, and there is white below. There are some black and the next is white again and black again. It's almost white that is scatter."	She could describe about this picture.
Researcher	"Now you found that the picture is an abstract, right? OK, anything else? Do you like it?"	
Participant	"I think this picture is complex." "Ha ha, I feel impassive."	She perceived this picture but did not like it.

Figure 10 Touching the painting of "The Starry Night"

Table 2 The interview and conversation from touching of "The Starry Night"

Person	Interview and Transcription	Analysis
Researcher	"OK, it's begin."	
Participant	(Use a fingertip to touch all screen and describe) "This is a black, it's the highest point, I remembered it." "This is a light blue, Yep! The black are more, here is a light blue, Oh! The black are more and upper, This is the sky." "What is it? The night? It must be the moon. Yep! This is black, and this is light blue, this is the strange." "There is the black from here to there, and upper is the sky and it is the center of screen and it is light blue, this is a blue."	She could perceive the colors and remember the sound pitches. She knew some color positions and described this picture from her experience to known already to touch before.
Researcher	"Can you evaluate it that is beautiful or not, or indifferent and anything else?"	
Participant	"It's almost black and emphasize the opaque color, I think." "It should feel to depress and so sad, something like this." "Is it beautiful? Umm..it may be beautiful in depress style, isn't it? I think it is base on that I cannot see it, I maybe use my feeling and imagination which I recognized, you know? I cannot see with my eyes, if it's depressing, I feel so sad. Umm..it maybe not beautiful, isn't it? Something like that. I'm not sure."	She could interpret and evaluate the artistic painting that touched, although she was not confident.
Researcher	"If I say that this figure is accepted all around the world that it is so beautiful. Do you believe, don't you? Do you think it"	
Participant	"Oh wow! Is it be accepted all? Heh heh." "It's maybe beautiful. I think it's up to you, as people aspect, but they're almost thought it so beautiful, I maybe think also. But, is it aspect?" "Yes, heh heh, I maybe believe that is beautiful to follow them, but when I touched it, I think it maybe so beautiful into depress, something like that, I use criterion from my feeling to see it."	There was an idea by herself. She could split a belief and attitude from perception of this painting.

Figure 11 Touching the painting of "Horse in a Landscape"

Table 3 The interview and conversation from touching of "Horse in a Landscape"

Person	Interview and Transcription	Analysis
Researcher	"This picture is Horse in a Landscape." "OK, let's go. See what you can do. "	
Participant	(Use a fingertip to explore the picture. Move with rules, straight and move to the top of frame) "Here is yellow. Oh! This is the sound pitch of blue. This is red and yellow." "This picture has some green, blue, red, yellow, anything else?"	She could perceive the colors from remember the sound pitches and the color positions of picture.
Researcher	"No more." "How do you think about this picture? Do you like it?"	
Participant	"Are there only red and blue, right? Background is yellow." "Yellow and green are above." "If I compare with color and my feeling, it maybe lively, right? Ha ha." "If I think in color, it's OK, it has lively more than Van Gogh's painting." "Yes, it's complex, it has various color. Ha ha."	She could perceive and remember the colors of picture and bring toward her painting by copying this picture. She could criticize and compare other artists' pictures.
Researcher	"OK, this figure is maybe seem that lively more than Van Gogh's painting?"	
Participant	"Yes, I think so. I use my feeling with color, like a, I'm a center, ha ha." "I think he use yellow, it's something like this, it's OK, you know? It look lively but Van Gogh's painting is affected my feeling, it's the night, something like that."	She could interpret and evaluate the picture that touched to make her new experience.
Researcher	"Are you OK in this activity of this research with this device and software."	
Participant	"Oh! Yes, it's excellent, it make me to understand the pictures or artistic paintings, when the picture was took about it by my friends, I ever hear name only that Van Gogh artist, right? And who told me that what image do not know and do not understand? But now I touched it, Oh! This picture is black and it is this, even though I could not access full to 100 percents but it made me to know that is Van Gogh's painting. Now I can be talking about it with my friends who ever have seen."	She appreciated the advantages to using device and software. She made her new experiences, knowledge and attitudes and she could perceive and communicate to the others.

Figure 12 Touching the painting of "Composition verte, bleue, rouge et jaune"

Table 4 The interview and conversation from touching of "Composition verte, bleue, rouge et jaune"

Person	Interview and Transcription	Analysis
Researcher	(Open figure) "OK, to begin." "I hint a litter, this picture may be have no some contents, for example, it's not a tree, something like that. You must try to explore it, what color do you find or what shape and where?" (The participant begin to touch) "What is color?"	
Participant	"This is grey, this is light blue and curve shape, so here it is, this is red, red is circle."	She could perceive and remember sound pitches.
Researcher	"How do you like it? How large is light blue?" "Some time, might be find that the large color is a background, you know?"	
Participant	"Yes, it's so large." "It's like the sky and cloud." (Continue to touch) "Grey, red and light blue, right?"	She could explain and imagine to the picture.
Researcher	"There is yellow, you know? Here it is." (The researcher touch a participant's hand to point on the picture) "Here it is, this is yellow."	
Participant	"Yep, the yellow of moon."	There was an imagination.
Researcher	"Where are some grey on this picture?"	
Participant	"Here it is and it is here." (Point to left and right corner at the down of picture) "and this is red."	She could remember the positions and shapes.
Researcher	"How do you think about it? Are they some shapes, or not?"	
Participant	"It look like, ha ha, like a sun, sky and cloud, I think"	There was an imagination.
Researcher	"OK, this picture is abstract, it's free form shapes and make by using composition, there are grey shapes on the right and left to balance, and also red shapes on left and right, there is yellow on the center above." (The researcher explain about this picture) "When you listened me to explain already, Do you like it?"	
Participant	"Yes, I like it as before."	There was a satisfaction.

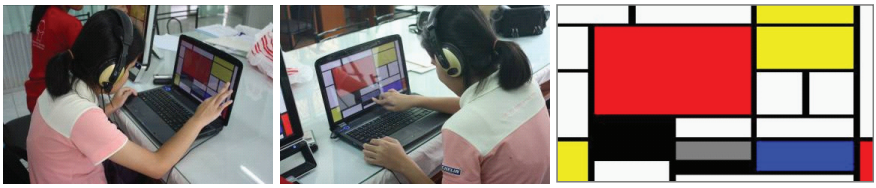


Figure 13 Touching the painting of "Composition"

Table 5 The interview and conversation from touching of "Composition"

Person	Interview and Transcription	Analysis
Researcher	"This is Mondrian's painting. OK, try it."	
Participant	"This is black, this is red, this is white, and also there is grey." "This is red and black, this is blue. It's a short, I don't know. Black is like a rectangular shape."	She could remember the sound pitches and found the colors.
Researcher	"Ah! It's correct." "Do you know that is also some black lines?" "Do you know that is a rectangular shape?"	
Participant	"Yes, I know that is a rectangular shape." "Red is a rectangle, and white is a straight line, Oops! Just a moment, the white is a downward straight line, and become to black below." "Why grey is…"	She could perceive the shapes and knew that there were some rectangular shapes in this picture.
Researcher	"What's wrong? Grey is what? It's a little?"	
Participant	"Yes, it is." "Black is some lines which are downward straight line." "And where is yellow?"	She knew and understood about shape and line.
Researcher	"OK, here. How about is this picture? It seems that is in order, right?"	
Participant	"Black is at the edge, it is a border of yellow." "It seem be in order, black is some borders."	She could perceive the colors and shapes.
Researcher	(The researcher described about art history in brief) "Are you OK? How do you think about this picture is so beautiful which is made some black tables and borders."	
Participant	"It's so beautiful."	There was a satisfaction.

This is the painting activity of the research. It is not the main topic of this article but the author would like to show these additional figures. The participants can use the device and painting program that showing their artworks in 2D artistic paintings. They draw and paint in colors and shapes by themselves without any help. The test methods for painting are, such as

painting by copy with the original pictures, painting with the imagination, emotion, and painting with the topic assigned. The results are shown below.

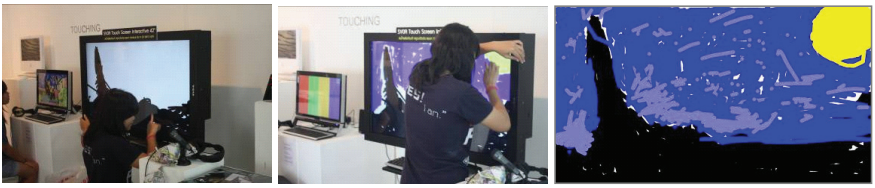


Figure 14 Painting by copying with the original picture of "The Starry Night"

Figure 15 Painting by copying with the original picture of "Horse in a Landscape"

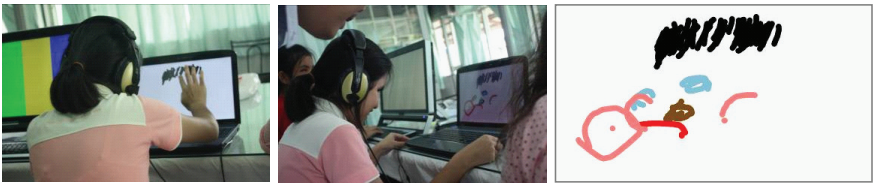


Figure 16 Painting from the participants' imagination

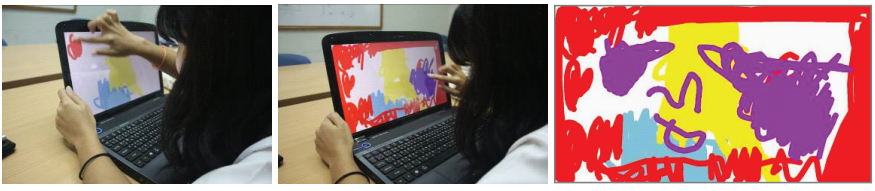


Figure 17 Painting from the participants' emotion and feeling

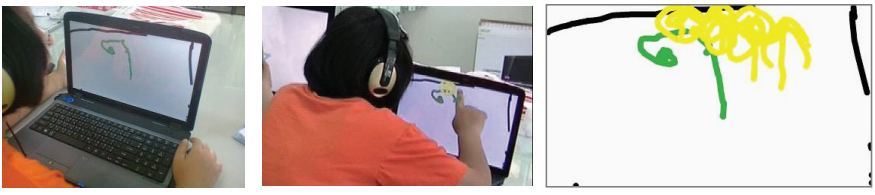


Figure 18 Painting with the topic title of "Tree and flower"

Figure 20 Painting with the topic title of "Sea, Beach and Sky"

Figure 21 Painting with the topic title of "My Dream"

Figure 22 Painting with the topic title of "My Body"

The researcher inquired 7 congenitally blind participants for their satisfaction. It is presented by total and average score from 5 interval scales (Narong Phopruegsanun, 2008: 212-213) as follows:

Table 6 Table of the total and average scores from satisfaction questionnaire

Questionnaire and Participants	A	B	C	D	E	F	G	Average	100%
Obtained the knowledge and experiences.	4	5	5	4	4	4	3	**4.14**	**82.85**
Color perception and touched the artistic paintings.	5	4	5	5	5	4	4	**4.57**	**91.42**
Expressed with drawing and painting.	5	4	5	5	4	3	3	**4.14**	**82.85**
Learning in the art lesson.	4	4	4	5	5	4	4	**4.28**	**85.71**
Difficulty-easy to using the device.	3	3	3	3	3	3	3	**3**	**60**
Will you train to high level in next time?	5	4	4	4	5	3	4	**4.14**	**82.85**
Time period to participate the activity.	4	2	2	4	4	3	2	**3.3**	**60**
The next opportunity to participate the activity.	4	4	4	4	4	4	4	**4**	**80**
The advantage of the device and software.	5	5	5	5	5	5	4	**4.85**	**97.14**
Do you agree with developed this device the next?	5	5	5	5	4	4	5	**4.71**	**94.28**

Remark: 1 = very less, 2 = less, 3 = moderately, 4 = good, 5 = very good

The results from the satisfaction questionnaire indicates that the participants were satisfied and agreed with the advantages of the device and software by giving good to excellent scores. They were satisfied with the activity and endorsed to develop the device and software to the next level.

Conclusion

The congenitally blind participants touched the artistic paintings which were simplified in detail and reduced in colors in order for the beginners to easily perceive when using the device and touching program. They were able to perceive the colors on the paintings, which were represented by sound pitches of musical notes.In addition, they could perceive the approximate shapes. The participants were able to explain the contents and compositions of the picture even though they did not perceive as well. However, if they had more time and they were familiar with the device and software, they would be able to perceive it much better. This device and software could help the congenital blind to perceive and access the picture. They expressed impression and satisfaction while perceiving the world master piece paintings as good to excellent. Overall, they were satisfied with the activity and agreed for the development of this device and software to the next level.

Furthermore, the participants could use the painting program to express drawing and painting in colors. These activities made good impression and satisfaction to the participants. They could select and paint some colors and shapes by themselves without any help.

Discussion

This research introduced a technique for the congenital blind to perceive colors by pairing colors to sound pitches and utilizing the touch-screen technology.

The congenital blind used the software and device that included touch-screen monitor in this research. They were trained in a training course, for example, to understand the device, understand the relationship between the monitor-screen border and fingertip movement, and they were trained

to remember the corresponding sound pitches of musical notes. Once they learned and understood how to use the device and software conceptually, they were able to use it well. They were satisfied, pleased, and impressed from all research activities.

The participants touched the artistic paintings, such as Kasimir Malevich's "Supreme", Vincent van Gogh's "The Starry Night", Franz Marc's "Horse in a Landscape", Serge Poliakoff's "Composition verte, bleue, rouge et jaune", and Piet Mondrian's "Composition" which were simplified in some details and colors. The participant could explain and criticize them. This research activity gave them new knowledge and experiences.

The participants could not remember some sound pitches because there was limited time during the activity. Nevertheless, if they were able to use the device more often, they would be able to remember and did it better. From this experiment, it shows that the device and software can be used as a tool for learning art.

The technique which is the comparison and pairing between colors and sound pitches is not the music and is not replaceable together actually but they are represented by coding. However, the technique can help the blind to touch and perceive colors and shapes of paintings by using touch-screen device and software that is developed specifically for this research. The blind, who are living in another countries, can use the touch-screen device and install this software quite easily for colors and shapes perception of pictures. The pictures are simplified colors and details which are the digital images. They can share pictures worldwide via the internet.

Suggestion

This research study can be further improved. One can develop software for use with other devices such as tablet and touch-screen on different operating systems. If the blind can use the device and software with more choices of sound pitches and colors, i.e. full version of the research (77 colors), they will be able to perceive the artistic pictures in much more detail and express their feelings of the paintings much better.

The device and software can be used for learning and teaching in art education, such as art history, art criticism, art practice and art aesthetic for these students, and it can also be integrated to other fields. The software can also be developed to add more features and complexity, such as bushy and thin lines, selected line types, simulation of color mixing, etc. The author hopes that the development of these tools and devices can actually help fulfill the blind and their life with art.

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