[2015 Summer/Fall URP] KAIST URP Program

Individual Research Project Final Report

Creative Project

시각장애인을 위한 크라우드소싱 기반의 색상 경험 시스템 디자인

Color Experience Design with Crowdsourced System for the Visually Impaired

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As a participant(s) of the KAIST URP program, I (We) have completed the above research and hereby submit the final report on the research.

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Abstract

There have been several solutions for improving accessibility of visually impaired people such as screen readers, screen magnifiers, and braille interfaces. However, people with visual impairments still far from the visual elements of daily life and one of the biggest issues we found was the trend. Then we started from delivering them information about colors which have important portion of the public trend.

We tried crowdsourced color lexicons as a solution to give thoughts and emotions about colors to the visually impaired because trends are formed by the public. After gathering various expressions by online surveys, we created web based prototype for testing our concept. Our prototype was designed to be familiar with online shopping experiences which have high accessibility than going to department stores or markets outside, and we recruited three visually impaired people and did the user study. And we got three important findings through our study.

First, crowdsourced color lexicons helped visually impaired people to imagine colors concretely and clearly. And second, the visually impaired can understand colors from the expressions they can comprehend. The last finding is that people with visual impairments have also their own tastes on fashions but it is hard to pursue their styles due to limitations of accessibilities.

Keywords: Crowdsourcing; Color Lexicon; Visually Impaired; Trend; Clothes; Online Shopping; Accessibility.

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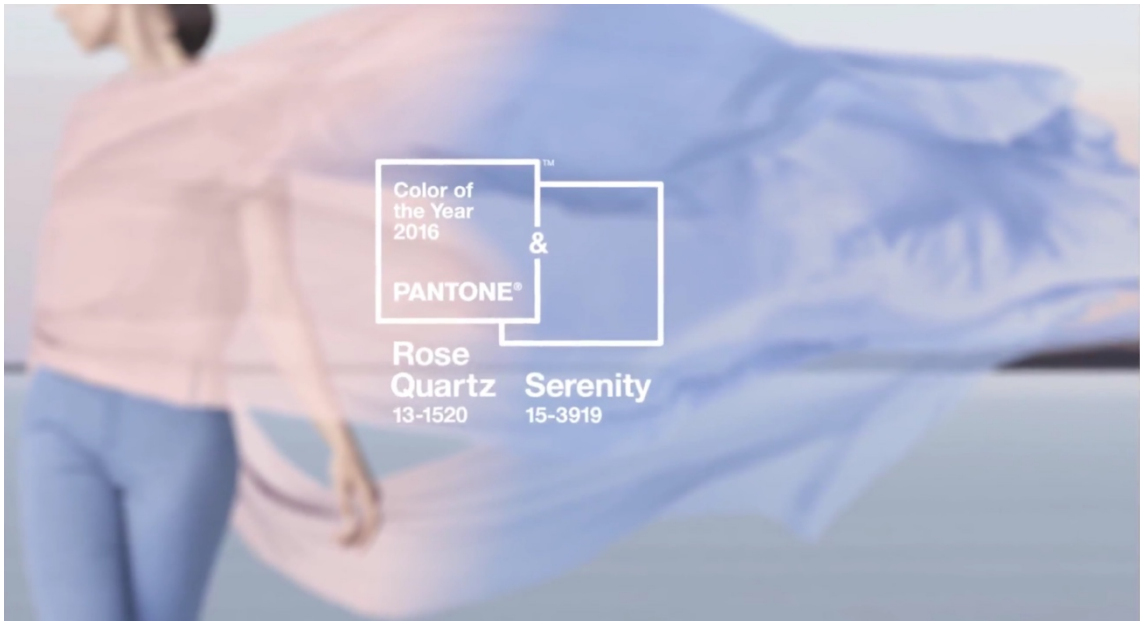
1. Introduction

1.1 Research Background

"*How the visually impaired see the clothes?"* this question sounds weird because they cannot see the things and most of the people haven't think about that topic. Fortunately, our society keeps trying to solve accessibility problems of the visually impaired. Many laws are also proposed and enforced to make better environment for them. Assistive technology which includes screen reader, screen magnifier, and some braille watches. Free development tools like voice recognition (speech to text) and speech synthesis (text to speech) in Web Speech API of W3C group are opened to the public. And recently, TensorFlow [1], which can recognize what object is in a picture with very high precision rates, was published as an open source software library. So it's not the far future when people who are visually impaired are able to catch all things in their sights. But visual objects are not the only simple objects.

Although there are many applications and hardware for visually impaired people to differentiate what the object in front of them is, what color of it is, and where a button is, it is still hard to follow social and cultural trends in visual aspect through such products. One of the biggest problems is the absence of social trends. Especially, they hardly communicate with colors which is a large part of social trends. They can easily know what the name of a color is, but they cannot precisely imagine the color just with that name. And as we all know, a color is not a simple thing that is possible to be described with one word, but it includes several meanings and concepts. For example, Pantone a



[Figure 1] Pantone color of the year 2016

famous color institute proposes colors of the next year in every year as social trends (e.g. colors of the year 2016 are Rose Quartz and Serenity.) (Figure 1) In addition, every country has its own flags, and colors on those flags contain meaningful symbols stood for showing cultures and traditions of the people.

Through context inquiry that observed how visually impaired people shop we found out that as visually impaired people consider how to dress and take care of their looks and styles, they also feel curious about colors of their clothes and accessories. We will show the details of CI and results at a later paper. Commonly, they use two ways of getting information about colors. One is asking to their friends or assistants, and the other is using devices or software which detect colors and speak out the names of colors based on Color ID Free [2] and Color Reader HD [3]. It is a lot easy and useful to get color names and descriptions about certain colors from color identifiers and assistants. However, people with visual impairments face limitations when they think how the colors looks like to others and imagine appearance of clothes as an example, because they cannot

get enough blocks of information to make full sense of colors such as emotions, feelings, and cultures which mean social trends of them.

Social trends represent thoughts, mentalities, and sympathies of the public. One of the way which can represent social trends in real time is a crowdsourced color lexicon to make close connections between the visually impaired and social trends. When people see a color, each person feels and thinks different ideas about the color. For example, someone may say a word, an apple, and other can think a red carpet when they look a color, bright red. And people who see other color, dark red, likely to imagine a glass of wine or a brick. Through gathering those various ideas, we can emerge universal thoughts of the colors. Then we tried to deliver those common senses of colors to visually impaired people for helping them to better understand colors in the point of meaning in social trends and cultures. We could get what emotional effects and changes are came out from our user tests which provide color descriptions with crowdsourced lexicons.

1.2 Research Purpose

The main aim of this study is to make visually impaired people to understand and feel social meanings and trends in colors through crowdsourced color lexicons. Then, we observed how the visually impaired interact with the color lexicons and imagine a color to investigate how crowdsourced color lexicons affect them in the positive or negative aspects. And we proposed design implications which can be used valuably when future designers design a color identifier and reader for people with visual impairments.

1.3 Research Method

To achieve our research goal, we designed **crowdsourcing system** which helps visually impaired people to get closer with social trends from colors. Then we started from **a context of clothes shopping**. Because the color has too broad meaning, we focused on the color of clothes firstly. Clothes are important in daily life and cannot be described without colors. For example, we should wear proper clothes with suitable colors for special situations such as funerals and weddings. And also we look what colors of clothes people wear and judge their moods and emotions. In addition to the first reason, shopping is very important experience to visually impaired people as it provides new touches between them and colors which they don't know well. And we did contextual inquiry for gathering issues about how they normally do commercial activities.

In order to discuss the potential of our system, we conducted a user test with 3 people with two tasks for each user. The user test was composed of four parts: introduction, pre-interview, main tasks, and post-interview. In main tasks, we proposed the system we designed by using crowdsourced color lexicons, let them to use it, and asked them some questions about usability issues and emotional aspects.

2. Related Works

2.1 VizWiz: Answering Visual Questions by Crowds

There was a research with a smartphone application VizWiz [4, 5]. This application was developed for helping the visually impaired to get answers about several visual questions such as *"What color of this necktie?"* and *"Where is the stop button on this electronic device?"* And the research proposed crowd works as a solution. When a visually impaired person asked a question about visual things with using the smartphone and capture the image of what the one felt curious about, another person who has normal vision would answer to that question from a web interface. In this research, the visually impaired got many helps from people who were recruited from Amazon Mechanical Turk.

The solution worked for getting information of visual elements like directions, colors, and shapes. But the processes were operated one question by one or two people for each task, it couldn't deliver sufficient answers to people with visual impairments when the question was subjective. In our research, we will propose a solution to provide thoughts of the public about colors which are subjective from a person to a person so that the visually impaired can better imagine colors with getting crowdsourced answers.

2.2 Providing Combinations of Simple Adjectives and Basic Color Names

As the visually impaired usually use smartphones for searching and getting information, many color identifiers and readers exist for them. Similar to other applications, this color reader that is Color ID Free let visually impaired individuals take

photos of what they want to know about colors and inform them color names. The difference among others, this service provide two modes for offering color names. One is the Exotic Colors mode and the other is the Simple Colors mode. The exotic colors mode gives color names such as Killarney for #397331 color and Lemon Ginger for #b0a321 color. Otherwise, the simple colors mode tells them simple expressions that are combinations of adjectives and basic color terms. For instance, for the color Lemon Ginger above, it offers ‘moderate greenish yellow.’

This approach helps the visually impaired to understand and imagine various colors with simple expressions. But colors are not objective things but subjective elements that can move people’s emotions and also imply today’s trends. In this paper, we tried to make visually impaired people feel empathy with other people among several colors by using subjective expressions from the public.

2.3 CLex: Creating Color Terms by Crowdsourcing

There was a research to make color lexicons through crowdsourcing. The research CLex [6] designed crowd task for gathering expressions of colors from the public and implemented tasks to workers on Amazon Mechanical Turk. And asked about 11 basic colors (white, black, red, green, yellow, blue, brown, pink, purple, orange and gray) known as the B&K order. It collected data with three questions about names, emotions, and concepts. In our research, we applied the similar concept to the visually impaired and designed crowd tasks with contexts of clothes shopping to get more specific terms from people.

3. Designing Crowdsourcing System

We designed a crowdsourcing system for observing how crowdsourced color lexicons affect visually impaired people. And also we wanted to know that how our system helps them understand social trends better than before. So we made a survey for crowdsourcing data from people and a prototype of an e-commerce website using TTS (Text to Speech) APIs of W3C with following design concerns from contextual inquiry we did.

3.1 Design Concerns from Contextual Inquiry

We had to figure out which factors affect the visually impaired in their shopping process so that we expected getting design concerns related with the study's theme. So we made plan to implement CI(contextual inquiry) which is a kind of user-centered research method usually conducted in form of interview while the research observe how the user(the subject) works in context and discuss what they did an why. And we expected that we can found out some quality of hints which is needed when we build crowdsourcing system for visually impaired. We did contextual inquiry with two blind people. We looked around in a department store for shopping their clothes together. In the contextual inquiry, we asked questions about details when they chose clothes and guided subjects for experiencing how guides and the visually impaired interact with each other. We recorded all interviews during the inquiry, wrote down transcripts, and analyzed them for emerging design concerns below.

1) How other people judge their appearance is important

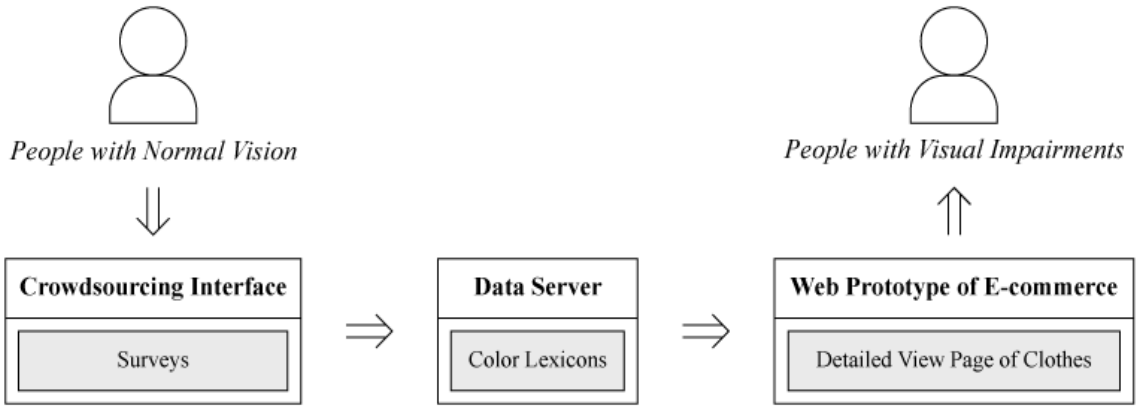
When we did contextual inquiry with two blind people, they were asked to describe the colors of clothes they chose. Then we told them about colors, and reactions are various among different descriptions. But the one question was always followed after our explanation about colors. That was, *"How will people feel when I wear clothes of those colors?"* This curiosity was very important to them, and the answer was influential and was operated as criteria to them for the clothes rather they buy it or not. It was crucial that they more deeply considered what others' rather than themselves' thoughts, comments, and opinions about visual elements such as, *"It looks elegant,"* and *"that makes me feel like a gentleman."* In short, from these insights, we paid attention to design crowdsourcing system to get more valuable data which mean that the data should include people's thoughts.

2) Experiences are varies from person to person

As we explained about colors of clothes through word by word, it was sometimes inefficient to using words from our experiences. Because they did not have the same experiences and memories as the guide who describes a color, we should change the theme or the way of telling thoughts and feelings about colors. For example, if they heard the words, *"It's like a baked tomato,"* and haven't ever eaten it, they couldn't sympathize with our saying. On the other hand, when we said that its color is like an infrared lamp, they understood concepts of the colors. It definitely not enough to visually impaired people to get explain about colors whey they are shopping from few number of assistant so that we expect the crowdsourcing system is going to works well.

3.2 Crowdsourcing System

We designed and developed a crowdsourcing system for making and delivering crowdsourced color lexicons to the visually impaired. The system is composed of three parts: a crowdsourcing interface with people who have normal vision, a data server which gather the data, analyze it, and construct color lexicons, and a web prototype interface of online shopping mall of clothes (Figure 2).



[Figure 2] Crowdsourcing system with three main parts

3.2.1 Crowdsourcing Interface

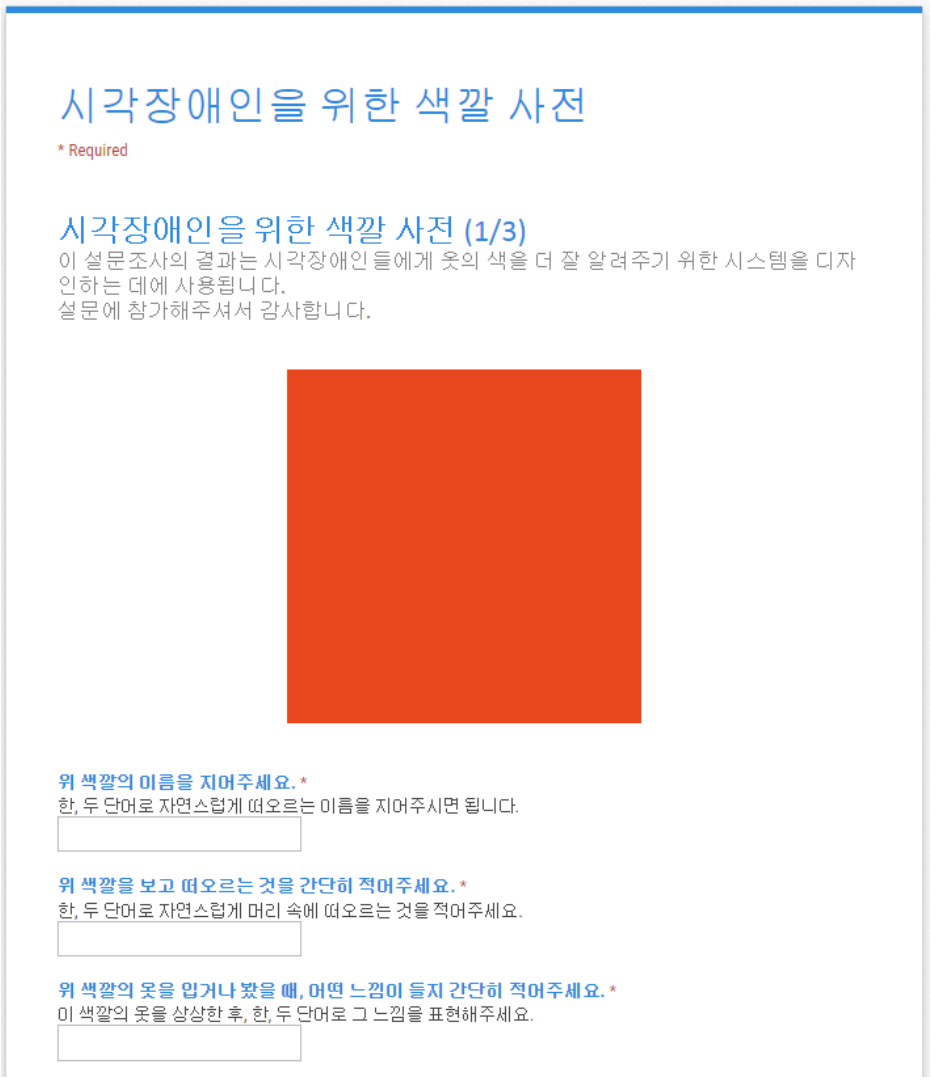
For collecting users' thoughts and senses about colors, we constructed an online survey by using web based survey system, Google Form (Figure 3). As we mentioned designed concerns in 3.1, we made questions for getting various impression of colors from the public. We started with six colors of clothes which are on sale from one of e-commerce stores, UNIQLO which is flat-design brand so it rarely make repulsion from most of people. Then the online survey was designed with three questions for each color. Three questions consist of:

1) What is the name of this color?

2) What can you imagine or think with this color?

3) How will you feel when you see the clothes with this color?

We set the first question to rename existing colors to generate new name which reflect social trends so that it could be flexible on social change. In similar context, we set second question to giving new explanation to visually impaired people. And last question is to



[Figure 3] Online survey for crowdsourcing color expressions

be connection between shopping process especially relevant to online shopping process and color perception of the sighted people. We asked people to write answers with one or

two words to avoid complicated expressions which are hard to be manipulated for making color lexicons. People who participated in this crowdsourcing online survey asked to firstly see a color and next answer to three questions. Expected run-time of each task that is commenting on three queries was lower than five minutes, but a subject in pilot test with this survey said, *"Although it is not a time consuming process, it was not quite light and easy task."* So we designed our survey with three colors for each person.

3.2.2 Data Server

We extracted raw data from survey results provided by Google Form and saved in our data server. Then we changed the data into flat strings and divided each string into word by word through a python library KoNLPy [7] which helps natural language processing (NLP) easily. We counted all expressions and sorted by frequency of them. And we linked these words as a lexicon to a color.

3.2.3 Web Interface of E-commerce

As today's shopping environment for the visually impaired is not well organized, they have low accessibility of visiting department stores or outlets without any help such as guides, friends, and family members. And because letting visually impaired individuals do commercial activities on their own helps them to be independent, we chose to focus on an experience through a prototype of online shopping mall.

A web based prototype interface was constructed by using text to speech (TTS) technique. We developed our prototype with basic and common TTS library provided by W3C to make the interface neutral. Then main interactions between the web prototype and the visually impaired were designed to be controlled by keyboard interrupts not to be

unfamiliar to subjects. Basically, the web prototype is framed as similar as a detailed view page of a clothes shopping mall without checkout buttons. And it consists of three sections about clothes: photos (Figure 4-a), basic information (Figure 4-b), and crowdsourced color lexicons (Figure 4-c). This prototype operates when the visually impaired click the

[Figure 4] Online shopping mall prototype of detailed view page

space bar, and then it reads the name of a cloth and common information with basic color names defined by e-commerce services. Next, if the users want to hear details about each color, they can push number keys mapped with colors and get words of crowdsourced

color lexicons through voice user interface. By using this interface, we hoped people with visual impairments would be able to get more concrete ideas and trends from colors of clothes through crowdsourced color lexicons, and the prototype could increase their independency.

4. Primary User Study

4.1 Overview of User Study

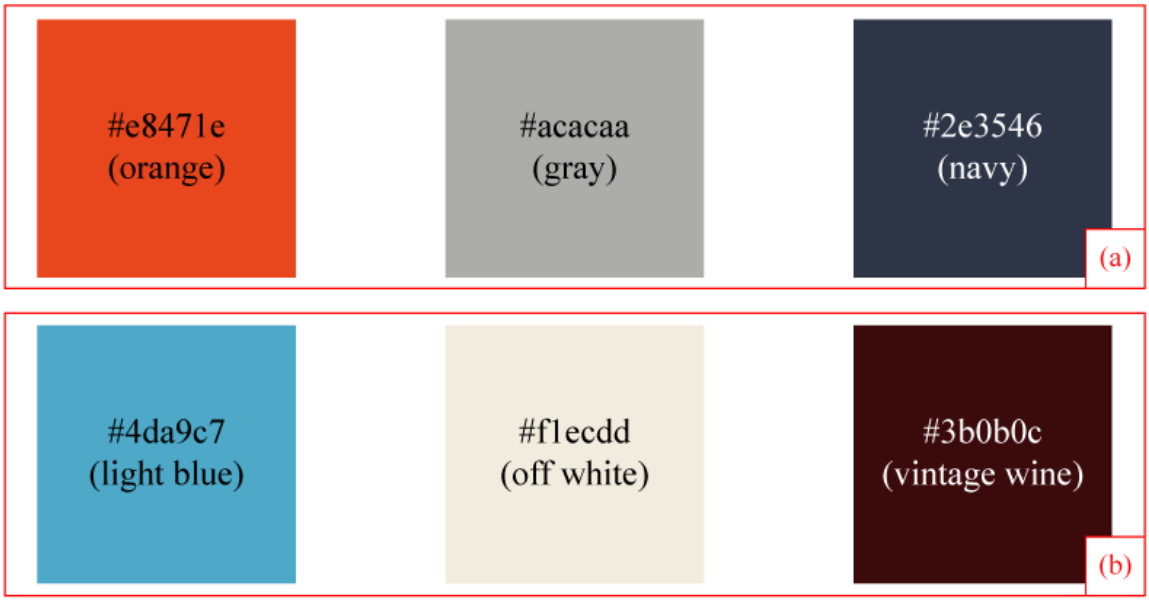
We conducted a user study to get answers on how crowdsourced color lexicons affect the visually impaired within the context of clothes shopping through the web interface. And also we wanted to observe what elements can improve their independency and comprehension of trends through colors. The user study implemented with the data gathered from online surveys and the web interface we developed.

4.2 Crowdsourced Color Lexicons

Before we conducted a user test with the visually impaired, we should collect crowdsourced data from the public to make crowdsourced color lexicons. We published an online survey through online social networking services (SNS) such as Facebook and Twitter. Then overall 123 people participated in our crowdsourcing survey that lasted for five days.

4.2.1 Getting Crowdsourced Data

The online survey sheet was constructed by using Google Form service which can easily publish surveys and extract raw data to use. Because the sheet is designed for collecting crowd's thoughts about colors, its run-time should be short to make as many as possible people participate in our survey. So we planned a single task spent within less than five minutes for each person.



[Figure 5] Six colors for crowdsourcing expressions

We asked people about total six colors (Figure 5) for our user test. These six colors were selected from clothes an online shopping mall UNIQLO. Not to gather sexually biased data for colors, we chose the colors from unisex clothes which can be worn both men and women. And when the colors were exposed to the public, we provided the colors as simple rectangular shaped swatches to avoid other influences like textures, shadows, and patterns. For controlling spending time, we divided into two groups by the last number of participants' cellphone number: even numbers for group A (Figure 5-a) and odd numbers for group B (Figure 5-b).

4.2.2 Results

We collected 123 people's answers (57 for group A and 66 for group B) and handled raw data to form crowdsourced color lexicons. By using python NLP library KoNLPy, we extracted all nouns from the survey results and sorted by frequency of each word with excepting common nouns related to fashion such as 'cloth', 'feel', and 'color.' (Table 1) Then we removed words that are counted less than 2 times to avoid unrelated

Color (hexacode)	Expression (sorted by frequency)
Orange (#e8471e)	홍시, 다홍, 빨강, 주황, 당근, 토마토, 불, 열정, 오렌지, 귤, 양귀비, 피, 사과, 단풍, 노을, 생기, 감
Gray (#e8471e)	회색, 시멘트, 쥐, 콘크리트, 시크, 연기, 그레이, 겨울, 비둘기, 도시, 먼지, 쥐색, 안개, 잿빛, 먹구름, 단정, 도로, 늑대, 세련, 차
Navy (#e8471e)	밤하늘, 밤, 하늘, 바다, 검정, 세련, 남색, 어둠, 어두움, 네이비, 단정, 곤색, 겨울, 연회색, 쥐, 남회색, 심해, 고요, 밤바다, 먹색, 코트, 고급, 새벽녘, 매력적, 김, 심플, 겨울바다
Light blue (#e8471e)	하늘, 바다, 청록, 시원, 소라, 청량, 파랑, 호수, 가을, 푸른, 눈, 우울, 민트, 불투명, 가벼운, 블루, 물
Off white (#e8471e)	베이지, 아이보리, 상아, 크림, 모래, 이불, 느낌, 우유, 니트, 사람, 안정감, 벽지, 스웨터, 바닐라, 피부, 종이, 쌀, 순수
Vintage wine (#e8471e)	와인, 나무, 피, 느낌, 고혹, 버건디, 흙, 가을, 밤, 초콜렛, 고동, 성숙, 고급, 단정, 강인, 진한, 적색, 벽돌, 섹시

[Table 1] Results of crowdsourced expressions for six colors

concepts. It was interesting that the collected expressions had very wide and various spectrums to look at a color, but every color has one more concepts which were mentioned by the majority of participants.

We got results similar to the related work, CLex. However, we found interesting points from our collected expressions. First, by asking a question about appearance, we could gather words which imply thoughts of people when they look a cloth of a color such as ‘chic style’, ‘a dandy’, and ‘a mature sense.’ In addition, we noticed that colors that have similar hue values among them were described with comparable words. For example, between navy color (#2e3546) and light blue color (#4da9c7), both colors were labeled with ‘sky’ and ‘sea.’ But details were different as the navy color was expressed by ‘sky of night’ and ‘sea of winter.’ On the other hand, the light blue color was defined as ‘blue sky’ and ‘cool sea.’ Then, to sum up, we created simple tag clouds with collected

and processed data (Figure 6).

[Figure 6] Word clouds for each colors with crowdsourced expressions

4.3 User Study of Online Shopping Mall Prototype

We developed web based prototype for testing our concept to visually impaired individuals. We contacted to school teachers working at the school for the visually impaired in Daejeon and recruited three people for our user study.

4.3.1 Study Method

As the study focused on how the crowdsourced color lexicons affect people with visual impairments, we constructed a prototype for just detailed view page of clothes. Because other elements such as navigation menus, list views, and check out pages could distract our subjects' attentions, we provided a simple web page with only fundamental components for looking at clothes in e-commerce experience.

Our user study was constructed with three sessions. First, before subjects use our prototype, we offered basic information of our research and study goal and asked them

questions about common things related to clothes shopping and trends. Next, the participants were requested to be in a scenario we brought that is related to a situation when they do online shopping. The user study was implemented with the story that a visually impaired individual wanted to buy winter clothes, selected one, and got in trouble with choosing a color of the clothes. Then our subjects used the prototype of detailed view pages and did interviews which consisted of simple questions about their experiences between hearing simple color names and getting crowdsourced color lexicons for each task. And we designed two tasks for each subject for getting design considerations of delivering crowdsourced color lexicons to the visually impaired: one task provided randomly sorted list of expressions for each color and the other task gave words sorted by the number of people who mentioned them. Finally, we asked wrap-up questions to emerge the individuals' various imaginations, thoughts, and experiences with our prototype.

4.3.2 Findings

We did user studies with three people who are teachers of the school for the visually impaired in Daejeon. During the user test, we recorded conversations under the subjects' agreements, transcribed all words, and analyzed by using the affinity diagramming method. Each test consumed 20 minutes in average. Through analyzing the quotes of subjects, we got three important findings. We recruited three people for our primary user study and will describe them as P# (gender, age) in findings with their quotes.

1) Crowdsourced color lexicons helped visually impaired people to imagine colors concretely and clearly

First of all, the crowdsourced color expressions were very helpful to make the

visually impaired imagine the colors precisely. As P3 (F, 37) mentioned, the crowdsourced expressions made them to think more concrete colors than before. And P2 (M, 52) thought those colors from his experiences when he had normal vision with our gathered words about colors. He also commented that he could imagine the colors even if the colors were not familiar to him when he listened gathered expressions. A participant, P1 (F, 52), of our study tried to catch the feelings from the words and then she made her own images of colors by using those emotions:

"(P3) I just was able to think it is dark gray when I heard two words of the lexicons: a wolf and the road."

"(P2) I haven't ever seen the color, light blue. So it is very vague, but through your prototype I could get useful information and make the images of the color."

"(P1) in the words about the color, light blue, many expressions were impressive and delightful for me. Those words I like made me to feel the color positive."

Second, the participants experienced that their imagines were not correct and changed their decisions to buy another clothes. During our study, all participants felt hard to imagine colors from only the names of them. In addition, when P1 (F, 52) just listened the name of colors, she selected vintage wine color. However, after she heard the crowdsourced color lexicons, she changed her mind to navy color:

"(P2) I cannot imagine the color of these days because there are so many colors which are hard to explained and described just like primary colors."

"(P1) I'll change to navy color because it is more suitable with this season. I heard that the word 'fall' in vintage wine color lexicon, and the word 'winter' was included in navy color lexicon."

Lastly, participants could imagine their appearances when they wear the clothes during the user study. After P3 (F, 37) heard crowdsourced expressions about off white color, she depicted her image of wearing the clothes of that color. And also she tried to connect colors and touches of clothes and to imagine the combination of those two visual and tactile element:

"(P3) I could imagine that I would be shown as fatty woman when I wear this clothes with off white color after listening the expressions of that."

"(P3) because I couldn't see visual things, I prefer tactile elements. And I thought that cashmere sweater would be very soft and smooth and make harmony with off white color."

In conclusion, all participants of our user study were able to make their decisions what clothes would be better to purchase more easily with crowdsourced color lexicons than just with the names of colors. The gathered expressions made them concrete ideas of colors, and it helped to choose a clothes: *"(P2) through several expressions, I could make precise images of colors. And it helped me a lot to make my decision what clothes I will purchase."*

2) The visually impaired people understand colors from the expressions they can comprehend.

In our user study, all participants said that the ranks were not useful and meaningful for them because they did not matter what most people mentioned but matter what expressions were included. They got concrete images at the moment when they listened the words that they could make connection between a color and a word: *"(P1) I think it has no meanings in those ranks. Colors are subjective things that could be accepted differently from person to person."*

And it was critical that they asked objective figures such as brightness and a chroma of colors when they couldn't imagine particular colors through the crowdsourced color lexicons: *"(P2) I can think what emotions are extracted from that color, but it will be more helpful if I can get how the color is bright or dark."*

3) Visually impaired people have their own tastes on fashions

As we mentioned in the introduction part, we could get this finding also through our study. P2 (M, 52) didn't listen the list of expressions about orange color because he did not like that color, and then he concentrated on what he prefer to. But in the real world, it is hard to get appropriate information about visual elements such as colors, so the visually impaired should consider others' opinions of their appearances:

"(P2) Orange is out! I don't like the color. So I will not care about it and listen the words about that."

"(P3) It would be better if the system offers sales rankings of clothes."

"(P2) I will buy vintage wine color rather than navy color I like when I listen that the vintage wine color is more suitable with me."

5. Conclusion

The fact gotten from research phase which includes CI, interview and secondary research that visually impaired person also want to feel colors as sighted people led this study. Crowdsourcing is appropriate method in point of that it can represent color expression, reflecting social trends. We design crowdsourcing model to build color dictionary for visually impaired people and it yield new modifiers to describe color. On the basis of our shopping mall interface produced by color dictionary gotten from crowdsourcing, we did user test with actual visually impaired and the main idea was that visually impaired can apply new color modifiers in addition to it’s original name in their mind. In experiment they could make their decision more easily with color dictionary explanation. We look forward to that this study can be helpful to visually impaired and also to sighted people in that not only in shopping process but also other situations whenever some visual feature should be explained such as furniture purchasing. Future work will be crossing verification that evaluate the crowd sourcing system we designed so that it can make positive feedback cycle continuously.

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