A Study on the Color Cognitive Characteristics of the Safety Signs in Underground Parking Lots of Brand Apartments from the Viewpoint of Color Universal Design

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Abstract: The purpose of this study is to identify the color recognition characteristics of the safety sign of the underground parking lot of the brand apartment in terms of color universal design, focusing on readability, visibility, harmony. The survey was conducted from November 2, 2021 to January 4, 2022 for 202 users of underground parking lots of brand apartments in Seoul. The collected data were analyzed by frequency analysis and descriptive statistics using SPSS 23.0. The results of this study are as follows: First, among the representative color scheme types of parking lot safety signs, the average of readability, visibility, harmony of Y-6 was the highest. Second, the types with high readability by the detailed color scheme type of safety sign were R-1, Y-3, G-1, B-1, visibility was R-1, Y-3, G-1, B-1, harmony was R-1, Y-2, G-1, B-2. Third, the average of readability, visibility, harmony of Y-6 representative types was the highest in the general color, color, elderly groups. Fourth, among the detailed color scheme types of safety signs, the highly readable types recognized by the general color scheme group were R-1, Y-3, G-1, B-1, visibility R-1, Y-3, G-1, B-1, harmony R-1, Y-2, G-1, B-2. The highly readable types recognized by the colored acronym D group were R-3, Y-3, G-1, B-2, visibility R-2, Y-2, G-1, B-2, harmony R-3, Y-3, G-1, B-2&3. The highly readable types of F-type group recognized by the colored acronym group were R-2, Y-3, G-1, B-1&2, visibility R-2, Y-3, G-1, B-1&2, harmony R-2, Y-3, G-1, B3. The high readability types recognized by the elderly group were R-1, Y-3, G-1, B-2, Positive R-1, Y-3, G-1, B-2, Harmony R-1, Y-3, G-2, and B-3. In conclusion, this study provides implications for establishing color guidelines for all users to optimize the color of the safety sign of the underground parking lot of the apartment.

Keywords: Color Universal Design, Brand Apartment, Parking Lot, Safety Sign, Color Recognition

1. Introduction

1.1. Research Background and Its Purpose

Apartments, which are residential areas where many households live, have become a representative apartment complex since the early 1960s when the mass supply and modernization of apartments began, until recently. In the meantime, apartments tended to be supplied in large quantities, mainly focusing on the quantitative aspect. However, as high-rise or brand apartments began to be built due to changes in convenience and lifestyle since 1988, the interior and exterior spaces surrounding the apartments have been changed. For example, improvements in the housing environment have been made to separate pedestrians and vehicles from the entrance of the housing complex, such as minimizing the parking ground and making the underground parking lot only for luxurious and overflowing vehicles.

The underground parking lot can help to improve the quality of the apartment residential environment by making the external pedestrian environment better and relieving parking problems. When using the underground parking lot of these apartments, users refer to safety signs with information such as traffic-related ones or directions. Safety signs of the underground parking lot of the apartment provide clear information on various safety devices such as SOS

signs and emergency bells to prevent accidents between pedestrians and cars [13].

Since most of the information users get while driving is recognized and acquired by sight, one of the most important factors to be considered in conveying accurate safety sign information is to secure visibility. Visibility, which makes the sign information conspicuous and easy to understand, is an essential element for a more effective safety sign design of the parking lot. In addition, readability should also matter in the sign design so that the meaning and information of the sign can be delivered smoothly in any environment without disturbing the user's visual perception. Particularly, in the sign design, it is possible to accurately and easily recognize the information of the sign by considering the harmony with the installed environment.

In particular, the underground parking lot is a public facility used by numerous residents, so it should be possible to use the safety sign system without any discrimination based on age, gender, physical disability, etc. However, the underground parking lot may make users feel stenophobia due to the spatial characteristics of the underground and since it lacks natural light and uses artificial lighting, it may be difficult to find or clearly recognize the safety sign of the parking lot installed nearby [1]. Jeong (2021) also argued that since the colors of the safety signs in the underground parking lot of brand apartments located in Seoul and the metropolitan area, were not harmonious, it was difficult to understand the information of the signs with the eyes of the elderly or the color-weak. The safety sign of underground parking lot turned out to have poor readability because the contrast of its color scheme was not harmonious and its brightness difference was not properly handled. This implies that the colors of the safety signs of the underground parking lots of some brand apartments were not determined in consideration of the color cognitive characteristics of all users.

When the color applied to the safety sign is harmonious and clear, the semiotic function and readability can be further enhanced, so color principles such as the contrast of chroma or brightness, color scheme, etc., should be effectively used in order for all users to be able to clearly recognize signs [9]. Lee (2019b)'s study also shows that the sign color makes it possible to clearly deliever information by improving the visibility and readability of users. This suggests that if the color has high readabilty, it can increase the efficiency and accuracy of information delivery.

Therefore, it is believed that it is necessary to understand the color recognition of the safety sign of the parking lot from the viewpoint of color universal design that considers all users such as general users, the elderly and the color-weak. That is, by examining whether the safety sign of the underground parking lot of the current bland apartment is clearly recognized, whether the information can be well identified, and whether the color scheme of the sign and the background color are harmonious, a color plan is needed so that all users can clearly recognize and identify the safety sign of the underground parking lot.

Therefore, in this study, we will try to understand the color cognitive characteristics of the safety sign of the underground parking lot of the brand apartment from the viewpoint of color universal design. In particular, by understanding the color cognitive characteristics of the safety sign of the underground parking lot, focusing on readability, visibility, and the harmony of color scheme, we will try to provide implications for the color plan, through which the information of the safety sign of the underground parking lot can be clearly delivered to all users, including the color-weak.

1.2. Study Method

In order to analyze the color cognitive characteristics of the safety sign of the underground parking lot of the brand apartment form the viewpoint of Color Universal Design (CUD), we tried to conduct a literature review and survey as the method of this study.

First, by examing the literature such as dissertations, academic journals, reports, and online materials, we understand the CUD and the safety sign of the underground parking lot. Second, in order to understand the color cognitive characteristics of the safety sign of the underground parking lot of the brand apartment form the viewpoint of CUD, we conduct a survey on the users of the underground parking lot of the brand apartment that is located in Seoul. We conclude by stating the implications, limitations, and suggestions based on the results we get by collecting and analyzing the data from the survey.

2. Theoretical Background

2.1. Color Universal Design

CUD is a design to provide an environment, services, information, and facilities that are easy to use for all people as well as color-weak such as cataracts, glaucoma, and color blindness [8]. The characteristics of the CUD are: first, the communication using colors is possible, second, a design with high visual aesthetics and harmony should be pursued, third, information should be easily delivered even to the color-weak, and fourth, the color scheme that is easy for everyone to recognize should be utilized [15]. Given these characteristics, information identification that is easy to recognize, intuitive and simple use of colors, readable designs that can be used by all individuals, etc., are suggested as the principles of CUD [4].

Japan's Color Universal Design Organiztion classified CUD into five types of color vision type: type A (Achromatopsia), type T (Tritanopia), type D (Deuteranopia), type P (Protanopia), and type C (Common) [6].

Among them, type C is the most widely used. Type C perceives light green and orange, yellow green and yellow as two different colors, respectively, but type D and P perceive them as the same colors, which means that there is a difference in color perception depending on the type of color vision.

In the case of Korea, since the universal design-related ordinance was enacted in 2008, we have made efforts to apply CUD to downtown, public environment, housing

environment, Etc [9]. However, since CUD is still mainly applied, focusing on accessibility or convenience in public environments [7], it is thought that the application of CUD to serve visual convenience for all users in various environments as well as public environments should be considered.

Table 1. *CUD classification.*

Classification			Conventinoal name	
Type A		Color Blindness		1 color type
Type T	Colorweak	Third color vision	Blue-yellow color blindness	2 color type
Type D		Second color vision	Red-green color blindness	
Type P		First color vision		Or more 3 color type
Type C	The general color visioned	Normal color vision		3 color type

* source: Kim (2018) [6]

2.2. Safety Sign

A sign is a generic term for marks, covers, signals, etc., and it refers to a form that is displayed as a symbol composed of various elements such as text, colors, pictograms, etc., to convey the contents of commands, requests, and information [5]. The role of the sign is to moderate the relationships between objects and people, or among people, and to make them communicate with each other, by visually conveying information. These signs are applied in a various environments such as public environments, housing environments, and urban environments. The sign consists of a unique content and systematic design, so the information of the environment can be more clearly recognized and identified, which helps the user to acquire necessary information [2].

In the case of safety signs applied to the underground parking lot of the apartment houses, they are applied to provide relevant information such as routes and facility guidance for users in an emergency or safe parking [15]. In particular, the safety sign of the underground parking lot, which is created in consideration of the spatial characteristics of the underground, is mainly composed of red colors with high chroma that users can quickly recognize, which makes it possible to prevent accidents of pedestrians and vehicles. The color of this safety sign is an important medium that conveys the intention and message of sign information as a visual language.

However, it was pointed out that it was difficult for users, who have visual impairment or poor color recognition ability, to recognize colors because the color scheme of the ackground colors and the safety signs that were applied to underground parking lots of many apartment houses, was not harmonious [3]. Furthermore, in the case of the color plan related to safety signs in domestic underground parking lots, where it is difficult to identify main entrances, pedestrian passages and crossings near intersections due to insufficient standards for the classification of clear colors, it has some problems in that it may impair the safety of pedestrians, and make it diffucult for users to identify information. Since the underground parking lot is a place where vehicles and people are moving at the same time, it is necessary to apply the safety sign color that can be clearly recognized by users in order to smoothly use the underground parking lot and to prevent accidents and confusion caused by information.

2.3. Preceding Research on Color Universal Design and the Safety Sign of the Underground Parking Lot

In Korea, there are more than 1.5 million color-weak populations and an increasing number of elderly people due to an aging society, so the argument that a public design in consideration of their situation is required, has been raised. In this situation, the studies related to the CUD are mainly trying to understand the sign system applied to the public environment, but the studies related to safety signs in the housing environment have been difficult to find.

In the studies analyzing the present condition of the CUD of subway signs [9, 15], it was argued that clear color recognition was not achieved due to the lack of contrast of brightness in signs, making it difficult for the visually impaired to see them clearly. Therefore, it is suggested that color designs are needed to enhance the recognition and readability of colors applied to signs. In addition, in overseas studies that examined the colors of signs in public transportation facilities such as subway stations and bus terminals [11], it was argued that guidances which were easy to understand, and constructions of easy-to-use facilities were required, for which the colors in consideration of color recognition, were also required as their components. In a similar way, Tanaka (2004) also suggested that since the color-weak have poor discernment in color difference due to yellowing or color blindness, compared to the general color-visioned [14], the visibility of public signs should be improved in consideration of background colors, picture colors, and the contrast of brightness. As such, in order to smoothly acquire and use information related to public signs, it is required to review and consider the characteristics of colors applied to safety signs.

There were also studies that analyzed airport signs. Among them, there was a study that suggested the color scheme by analyzing the light-free guide sign system of Incheon International Airport, which had been made in consideration of the location of lighting and angle, and eye level so that users could see the sign system well from the viewpoint of CUD. In this study, the harmony of the color scheme by the colors of the sign system and readability, was analyzed according to the font size of the light-free guide sign system and the distance between the sign system and the subject. As a result, when considering low chroma and low brightness for background, and high chroma and high brightness for emphasis, it was found that the readability of the sign was improved and the color scheme was harmonious.

Based on the analysis of guide signs in 19 international airports around the world, Ryu and You (2013) argued that the number of signs in airports should be reduced for better readability of information [12]. Based on these studies, in the case of the CUD currently applied to the domestic public environment, it can be seen that the readability and recognition are not good since the brightness is not properly considered, so it seems that the brightness contrast should be considered in planning the CUD colors.

Two research theories related to the signs of the housing environment were conducted, and among them, the study on the colors of guide signs of the pedestrian space outside the apartment complex, from the viewpoint of CUD can be seen. According to the color evaluations of this study that were conducted on the color difference, brightness difference, and chroma difference for 10 major domestic brand apartments, the letter color was mainly achromatic, so it was in harmony with the background color. It was found that if the guide sign has a brightness difference of 4 or more and a chroma difference of 7 or less, and it has the darker background color than the sign itself, the user's visibility becomes higher. Based on the results of analyzing the present condition of the color scheme of the SOS signs in the underground parking lots of domestic brand apartments, Jeong (2021) argued that the appropriate principles of color scheme should be applied to safety signs of parking lots.

Overall, through the preceding studies, it can be seen that the color scheme should be harmoniously combined to improve the visibility or readability of the sign. In particular, in the case of the preceding studies that analyzed the colors of safety signs in public environments, they suggest that the brightness contrast should be considered for the color problems derived based on the research results. However, it seems that the suggestions for the color plan for effective color recognition, such as how to consider the brightness contrast, are insufficient. Moreover, since most of the preceding studies, which have been reviewed above, were conducted on the general color-visioned, it is thought that there is a limitation in not actually examining the color cognitive characteristics of the safety signs in public environments or housing paces from the viewpoint of the color-weak. This does not seem to take into account the situation of the elderly or the color-weak who lack color cognitive ability. Therefore, it is necessary to examine whether there is a difference in the readability or visibility of the safety sign depending on the color cognition of the color-weak, the general color-visioned, and the elderly for the same safety sign. Based on the preceding studies reviewed above, in this study, we mainly intend to set the following as viewpoints of evaluation: whether the colors applied to the safety signs in the underground parking lot of a brand apartment are intuitively recognized and conspicuous, how easily the information of the signs is read and understood, and whether the colors of the safety signs do harmonize with the surroundings.

Table 2. Viewpoints of evaluation of this study.

Classification	Evaluation contents
1. readability of safety signs	Is the safety sign information fully understood and read?
2. visibility of safety signs	Is the safety sign background color and letter color clearly distinguished and easily refognized?
3. harmony of safety signs	Is the combination of the background color and the letter color of the safety sign harmonious?

3. Method of Research

3.1. Investigation Method

In this study, the following investigation method was conducted to find out the color cognitive characteristics of the safety signs applied to the underground parking lot of the brand apartment from the viewpoint of CUD.

First, we exame the characteristics of readability, visibility, and harmony by type of representative color schemes of safe signs of the underground parking lot of brand apartments. Second, we exame the characteristics of readability, visibility, and harmony by type of detailed color schemes of the safe signs of the underground parking lot of brand apartments. Third, from the viewpoint of CUD, we compare the color cognitive characteristics of readability, visibility, and harmony by type of representative color schemes of the safe signs of the underground parking lot of brand apartments by group of the general color-visioned, the color-weak, and the elderly. Fourth, from the viewpoint of CUD, we compare the color cognitive characteristics of readability, visibility, and harmony by type of detailed color schemes of the safe signs of the underground parking lot of brand apartments by group of the general color-visioned, the color-weak, and the elderly.

3.2. Measurement Tool Configuration

The measurement tools of this survey were composed as follows.

First, by modifying and supplementing Lee (2019b)'s tools, the readability, visibility, and harmony of color schemes of the safe signs of the underground parking lot of brand apartments, were composed of questions to check the readability, visibility, and harmony of color schemes of the safe signs, which were measured on a Likert scale ranging from 1 (not at all) to 5 (very much). Second, the demographic characteristics of the study subjects consisted of gender and age, residence and educational background, number of years of living in an apartment, and the status of color weakness.

3.3. Investigation Procedure and Data Collection

In order to compose a stimulus for examining the color cognitive characteristics of the safety signs of the underground parking lot, we referred to the preceding study [3] that suggested the color scheme by analyzing the present condition of the color of the emergency bell sign in the underground parking lot of a domestic brand apartment. According to the study, the color of the emergency bell sign most used in brand-new apartments in the metropolitan area that were completed in the last 5 years, is

red according to the Public Design Color Standard Guide based on 7.5 YR 4/14. In addition, red, yellow, green, and blue were selected as representative colors of the color scheme of safety signs because the frequency of use was the highest in type 3 color scheme (red sign+colored background).

A questionnaire stimulus, which is composed of a total of 36 color schemes, was constructed by applying 'red' which is most used as a sign color, to 4 types of background colors divided into a total of 9 levels: high, medium, low brightness and high, medium, low chroma. (Figure 1 reference).
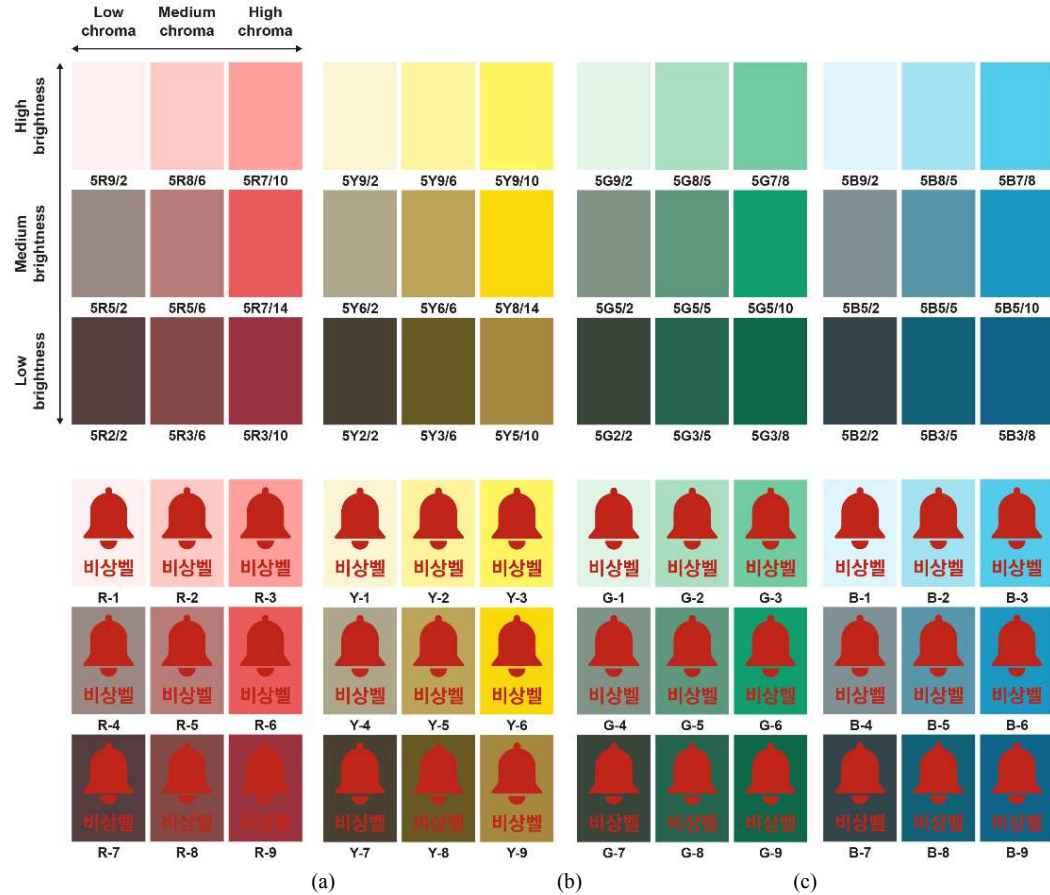
Figure 1. *Examples of questionnaire stimuli.*

The Human Visual System (HVS) by type of representative and detailed color scheme of the safety signs of the underground parking lot, which is constructed in this study, is as follows Table 3.

Table 3. Color, Brightness, and Chroma by type of color schemes of the safety signs in this study.

classification		sign	1	2	3	4	5	6	7	8	9
Red sign + Red background	H	7.5YR	5R								
	V	4	9	8	7	5	5	7	2	3	3
	S	14	2	6	10	2	6	14	2	6	10
	Brightness difference	-	5	4	3	1	1	3	2	1	1
Red sign + Yellow background	H	7.5YR	5Y								
	V	4	9	9	9	6	6	8	2	3	5
	S	14	2	6	10	2	6	14	2	6	10
	Brightness difference	-	5	5	5	2	2	4	2	1	1
Red sign + Green background	H	7.5YR	5G								
	V	4	9	8	7	5	5	5	2	3	3
	S	14	2	5	8	2	5	10	2	5	8
	Brightness difference	-	5	4	3	1	1	1	2	1	1
Red sign + Blue background	H	7.5YR	5B								
	V	4	9	8	7	5	5	5	2	3	3
	S	14	2	5	8	2	5	10	2	5	8
	Brightness difference	-	5	4	3	1	1	1	2	1	1

The produced stimuli were surveyed from November 2, 2021 to January 4, 2022, targeting 202 users of the underground parking lot of a brand apartment in Seoul.
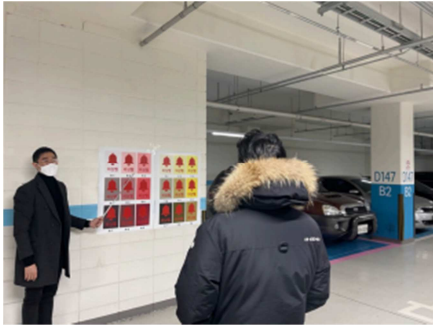
Figure 2. *Survey evaluation environment.*

In reference to a preceding study [9] claiming that a sufficient distance interval was necessary to recognize the information of a sign, the survey evaluation environment for understanding the color cognitive characteristics of safety signs was maintained at an interval of 624Lux/5m in the illuminance environment, and then the evaluation items of the questionnaire were checked (Figure 2 reference).

3.4. Data Analysis

The data analysis of this study was performed using the statistical package 23.0 program as follows.

First, frequency analysis was performed to find out the demographic characteristics of the subjects. Second, descriptive statistics was performed to compare the averages of readability, visibility, and harmony of the safe signs of parking lots by group of the general color-visioned, the color-weak, and the elderly.

4. Result of Research

4.1. Demographic Characteristics of the Subjects

Table 4 shows the results of frequency analysis to find out the demographic characteristics of the subjects of this study.

Table 4. *Demographic characteristics of the subjects of this study.*

Classification		N=202	%
Gender	Female	102	50.0
	Male	100	50.0
Age	10's (10-19yr)	1	0.2
	20's (20-29yr)	18	8.8
	30's (30-39yr)	34	17.0
	40's (40-49yr)	40	20.0
	50's (50-59yr)	34	17.0
	60's (60-69yr)	33	16.0
	Over 70 years	42	21.0
Residential area	Seoul	119	59.0
	Gyeonggi-do	56	28.0
	Incheon	4	2.0
	Other areas	23	11.0
Educational background	graduated from middle school	1	0.2
	graduated from high school	53	25.8
	graduated from university	89	44.0
	graduated from graduate school	55	27.0
	Etc.	4	2.0
Number of years of residence	1 years or less	9	4.0
	13 year	16	8.0
	4-6 year	15	7.0
	7-9 year	15	7.0
	10 years or more	147	73.0
Status of color weakness	Normal	190	94.0
	P-type	3	1.0
	D-type	9	4.0

In terms of gender, there were slightly more females with 102 females (50.0%) and 100 males (50.0%), and 42 people (21.0%) over the age of 70 showed the highest response rate. As for the residential area, Seoul had the highest number of 119 people (59.0%), and in terms of educational background, 89 students (44.0%) graduated from university most. And the number of years of residence was more than 10 years, with 147 people (73.0%) exceeding the majority. Regarding the status of color weakness, the majority were 190 people (94.0%) with general color vision, 3 people (1.0%) with red blindness (P-type), and 9 people (4.0%) with green blindness (D-type).

4.2. The Characteristics of Readability, Visibility, and Harmony by Type of Representative Color Schemes of the Safe of the Underground Parking Lot

Descriptive statistics was performed to find out the color cognitive characteristics of readability, visibility, and harmony by type of representative color schemes of the safe signs of the underground parking lot, and then, the mean and standard deviation based on that were calculated (Table 5). As a result, the average of readability for R-6, which is a representative type of Red sign+red color scheme, was 2.80, that of visibility 2.38, and that of harmony 2.51. The average of readability for Y-6, which is a representative type of Red sign+yellow color

scheme, was 4.30, that of visibility 4.31, and that of harmony 3.81. The average of readability for G-6, which is a representative type of Red sign+green color scheme, was 3.15, that of visibility 3.08, and that of harmony 2.64. The average of readability for B-6, which is a representative type of Red sign+blue color scheme, was 3.14, that of visibility 3.02, and that of harmony 2.72. Through this, it was found that the subjects recognized that the Red sign + the yellow background safety sign, Y-6, was the most readable and clearly recognized, and its color scheme was harmonious.

Table 5. *The subjects of this study's characteristics of readability, visibility, and harmony by type of representative color schemes of the safe of the underground parking lot.*

Classification		M	SD
R-6	Readability	2.80	1.13
	Visibility	2.38	0.93
	harmony	2.51	1.18
Y-6	Readability	4.30	1.01
	Visibility	4.31	.99
	harmony	3.81	1.14
G-6	Readability	3.15	1.14
	Visibility	3.08	1.20
	harmony	2.64	1.15
B-6	Readability	3.14	1.10
	Visibility	3.02	1.02
	harmony	2.72	1.07

4.3. The Characteristics of Readability, Visibility, and Harmony by Type of Detailed Color Schemes of the Safe of the Underground Parking Lot

4.3.1. The Characteristics of Readability, Visibility, and Harmony by Type of RED Sign+Red Color Schemes of the Safe of the Underground Parking Lot

Among the detailed types of the Red sign+red color scheme, the type with high readability, visibility, and harmony was indicated as R-1 (Table 6). That is, based on the results of R-1's readability average of 4.29, visibility average of 4.26, and harmony average of 3.89, it can be seen that the subjects of this study recognized R-1 as the most readable, visible, and harmonious among the subtypes of Red sign+red color scheme.

Table 6. *The subjects of this study's characteristics of readability, visibility, and harmony by type (red) of detailed color schemes of the safe of the underground parking lot.*

Classification		M	SD
R-1	Readability	4.29	1.05
	Visibility	4.26	1.01
	harmony	3.89	1.04
R-2	Readability	3.80	1.12
	Visibility	3.81	.97
	harmony	3.72	1.03
R-3	Readability	3.36	1.04
	Visibility	3.28	.91
	harmony	3.21	1.01
R-4	Readability	2.89	1.02
	Visibility	2.85	.97
	harmony	2.56	1.06

Classification		M	SD
R-5	Readability	2.54	.98
	Visibility	2.49	.97
	harmony	2.29	.99
R-7	Readability	2.81	1.10
	Visibility	2.79	1.05
	harmony	2.49	1.11
R-8	Readability	2.00	1.03
	Visibility	2.01	1.03
	harmony	1.99	1.11
R-9	Readability	1.61	1.02
	Visibility	1.57	.97
	harmony	1.62	1.03

4.3.2. The Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Yellow Color Schemes of the Safe of the Underground Parking Lot

Among the subtypes of Red sign+yellow color scheme, Y-3 showed high readability (M= 4.21) and visibility (M= 4.18), and in the case of harmony, the average value of Y-2 (M=3.81) showed the highest one (Table 7). In particular, in the case of Y-1, Y-2, Y-3, considering that those are sign types with the brightness difference of 5, it can be seen that the greater the brightness difference, the higher the readability and visibility of the safety sign in the Red sign+yellow color safety sign type.

Table 7. *The subjects of this study's characteristics of readability, visibility, and harmony by type (yellow) of detailed color schemes of the safe of the underground parking lot.*

Classification		M	SD
Y-1	Readability	4.16	.94
	Visibility	4.15	.98
	harmony	3.76	1.03
Y-2	Readability	4.16	.97
	Visibility	4.14	.97
	harmony	3.81	1.06
Y-3	Readability	4.21	1.05
	Visibility	4.18	1.04
	harmony	3.80	1.07
Y-4	Readability	3.27	1.16
	Visibility	3.26	.95
	harmony	2.85	.93
Y-5	Readability	3.02	.91
	Visibility	2.99	1.00
	harmony	2.63	.96
Y-7	Readability	2.90	1.01
	Visibility	2.84	1.07
	harmony	2.56	1.02
Y-8	Readability	2.29	1.01
	Visibility	2.26	1.04
	harmony	2.07	1.05
Y-9	Readability	2.60	1.05
	Visibility	1.57	.97
	harmony	1.62	1.03

4.3.3. The Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Green Color Schemes of the Safe of the Underground Parking Lot

In the case of the subtypes of the Red sign+green color

scheme, G-1 showed the highest average value for readability (M=3.93), visibility (M=3.91) and harmony (M=3.27) compared to other types (Table 8). Also, compared to other subtypes, the average values of readability (M=3.74), visibility (M=3.77) and harmony (M = 3.22) of G-2 and readability (M=3.59), visibility (M=3.53) and harmony (M=3.06) of G-3 were relatively high. Based on the fact that the brightness difference of G-1 is 5, that of G-2 is 4, and that of G-3 is 3, it is thought that if the brightness difference of 3 or more is applied to the color scheme of the safety sign consisting of Red sign+green color scheme, information identification, readability and the harmony of the color scheme of the sign can be improved.

Table 8. *The subjects of this study's characteristics of readability, visibility, and harmony by type (green) of detailed color schemes of the safe of the underground parking lot.*

Classification		M	SD
G-1	Readability	3.93	1.06
	Visibility	3.91	1.08
	harmony	3.27	1.13
G-2	Readability	3.74	1.05
	Visibility	3.77	1.04
	harmony	3.22	1.14
G-3	Readability	3.59	1.02
	Visibility	3.53	1.03
	harmony	3.06	1.10
G-4	Readability	2.89	1.01
	Visibility	2.77	.96
	harmony	2.47	.95
G-5	Readability	2.83	1.08
	Visibility	2.77	1.04
	harmony	2.51	1.08
G-7	Readability	2.93	1.15
	Visibility	2.90	1.09
	harmony	2.64	1.11
G-8	Readability	2.59	1.14
	Visibility	2.48	1.11
	harmony	2.31	1.08
G-9	Readability	2.54	1.17
	Visibility	2.51	1.13
	harmony	2.33	1.14

4.3.4. The Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Blue Color Schemes of the Safe of the Underground Parking Lot

Among the subtypes of the Red sign+blue color scheme, the type with the highest average of readability (M=3.92) and visibility (M=3.88) was B-1. As for the harmony, B-2 (M=3.28) showed the highest average value, followed by B-1 (M=3.23), B-3 (M=3.10), B-7 (M=2.63), B-4 (M=2.58), B-5 (M=2.50), B-9 (M=2.23), B-8 (M=2.22). Through this, it can be seen that the subjects of this study think that the larger the brightness difference of the type, the easier it is to recognize and identify information.

Table 9. *The subjects of this study's characteristics of readability, visibility, and harmony by type (blue) of detailed color schemes of the safe of the underground parking lot.*

Classification		M	SD
B-1	Readability	3.92	1.11
	Visibility	3.88	1.10
	harmony	3.23	1.13
B-2	Readability	3.80	1.05
	Visibility	3.80	1.05
	harmony	3.28	1.07
B-3	Readability	3.65	1.07
	Visibility	3.67	1.09
	harmony	3.10	1.17
B-4	Readability	2.89	1.09
	Visibility	2.85	1.07
	harmony	2.58	.98
B-5	Readability	2.82	1.07
	Visibility	2.80	1.07
	harmony	2.50	1.05
B-7	Readability	2.95	1.21
	Visibility	2.94	1.20
	harmony	2.63	1.16
B-8	Readability	2.51	1.20
	Visibility	2.47	1.12
	harmony	2.22	1.10
B-9	Readability	2.44	1.06
	Visibility	2.42	1.13
	harmony	2.23	1.08

4.4. The Comparison of the Characteristics of Readability, Visibility, and Harmony by Type of Representative Color Schemes of the Safety Sign

To compare the characteristics of readability, visibility, and harmony by type of representative color schemes of the safe signs of the underground parking lot by group of the general color-visioned, the color-weak, and the elderly, the general color-visioned, the color-weak, and the elderly group over 65 years were divided according to the status of color weakness. There were 190 people in the general color-visioned group, 9 people in the D-type of the color-weak group, 3 people in the P-type of the color-weak group, and 74 people in the elderly group. The number of people in the color-weak group was smaller than that of other groups, but in the preceding study [9], it was investigated that when comparing the difference in the readability of the public signs of airports, the general color-visioned group was 61 people and only the green color-weak of the color-weak group was 4. Therefore, it was thought that meaningful research results could be derived from the three groups classified in this study as well.

Table 10 shows the difference in readability, visibility, and harmony by type of representative color schemes of the safe signs of the underground parking lot recognized by the three classified groups. As a result, it was found that the average of readability, visibility, and harmony for all the groups of the general color-visioned (readability 4.28, visibility 4.29, harmony 3.77), the color-weak (D-type=readability 4.67,

visibility 4.67, harmony 4.22/F-type=readability 4.67, visibility 4.67, harmony 4.67) and the elderly (readability 4.11, visibility 4.14, harmony 4.03), was the highest in Y-6, which is a representative type of Red sign+yellow color, compared to other representative color scheme types. Through this, it can be seen that from the viewpoint of CUD, the representative color scheme of the safety sign recognized significantly by all users is the Red sign+yellow color scheme. In particular, in this color scheme, the average value of readability, visibility, and harmony of the color-weak group was the highest, so it is thought that yellow should be considered most as a suitable color for the Red sign for the safety sign of the underground parking lot.

Table 10. *The comparision of the characteristics of readability, visibility, and harmony by type (blue) of detailed color schemes of the safe of the underground parking lot of the general color-visioned, the color-weak, and the elderly.*

Classification			M	SD
	readability	The general color-visioned	2.78	1.11
		The color-weak type D	3.11	1.62
		The color-weak type P	3.00	1.73
		The elderly	3.01	1.12
	Visibility	The general color-visioned	2.38	.91
		The color-weak type D	2.11	1.17
		The color-weak type P	2.67	2.08
		The elderly	2.42	.98
	Harnomy	The general color-visioned	2.53	1.16
		The color-weak type D	2.22	1.39
		The color-weak type P	2.67	2.08
		The elderly	2.61	1.04
	readability	The general color-visioned	4.28	1.02
		The color-weak type D	4.67	1.00
		The color-weak type P	4.67	.58
		The elderly	4.11	1.09
	Visibility	The general color-visioned	4.29	.99
		The color-weak type D	4.67	1.00
		The color-weak type P	4.67	.58
		The elderly	4.14	1.06
	Harnomy	The general color-visioned	3.77	1.14
		The color-weak type D	4.22	.97
		The color-weak type P	4.67	.58
		The elderly	4.03	1.02
	readability	The general color-visioned	3.17	1.13
		The color-weak type D	2.89	1.36
		The color-weak type P	2.33	1.12
		The elderly	3.18	1.09
	Visibility	The general color-visioned	3.11	1.17
		The color-weak type D	2.67	1.80
		The color-weak type P	2.33	1.12
		The elderly	3.11	1.18
	Harnomy	The general color-visioned	2.65	1.13
		The color-weak type D	2.56	1.67
		The color-weak type P	2.33	1.12
		The elderly	2.92	1.12
	readability	The general color-visioned	3.14	.10
		The color-weak type D	3.44	1.01
		The color-weak type P	2.33	.58
		The elderly	3.09	.94
	Visibility	The general color-visioned	3.02	1.02
		The color-weak type D	3.44	1.01
		The color-weak type P	2.33	.58
		The elderly	3.00	.97
	Harnomy	The general color-visioned	2.71	1.07
		The color-weak type D	3.00	1.23
		The color-weak type P	2.33	.58
		The elderly	2.95	.99

4.5. The Comparison of the Characteristics of Readability, Visibility, and Harmony by Type of Detailed Color Schemes of the Safety Sign
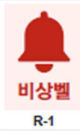
4.5.1. The Comparison of the Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Red Color Schemes of the Safety Sign

Among the detailed type of Red sign +red color scheme, in case of the general color-visioned group and the elderly group, the average of readability, visibility, and harmony for R-1 was the highest (Table 11). In the case of D-type group of the color-weak, the average of readability for R-3 was high, and the average of the group's visibility and harmony for R-2 was high. In the case of P-type group of the color-weak, compared to other subtypes, the average value of readability, visibility and harmony for R-2 was 4.00, showing the highest value. These results suggest that, from the viewpoint of CUD, the safety sign of the Red sign+red color scheme with a large brightness difference, is easy for all users to identify from a distance, and they also harmoniously recognize the readability of information and color scheme, which the above signs have.

Table 11. The comparison of the characteristics of readability, visibility, and harmony by the Red sign+red color schemes of the safe of the underground parking lot of the general color-visioned, the color-weak, and the elderly.

Classification			M	SD
	readability	The general color-visioned	4.30	1.03
		The color-weak type D	4.11	1.17
		The color-weak type P	3.33	1.53
		The elderly	4.11	1.21
	Visibility	The general color-visioned	4.28	1.00
		The color-weak type D	4.33	1.00
		The color-weak type P	3.67	1.16
		The elderly	4.04	1.15
R-1	Harnomy	The general color-visioned	3.91	1.04
		The color-weak type D	3.89	.93
		The color-weak type P	3.67	1.16
		The elderly	3.88	1.05
	readability	The general color-visioned	3.82	1.02
		The color-weak type D	4.33	1.32
		The color-weak type P	4.00	1.00
		The elderly	3.62	1.13
	Visibility	The general color-visioned	3.81	.98
		The color-weak type D	4.56	1.33
		The color-weak type P	4.00	1.00
		The elderly	3.55	1.08
R-2	Harnomy	The general color-visioned	3.75	1.03
		The color-weak type D	4.00	1.23
		The color-weak type P	4.00	1.00
		The elderly	3.53	1.02
	readability	The general color-visioned	3.38	1.04
		The color-weak type D	4.44	1.33
		The color-weak type P	3.67	1.12
		The elderly	3.26	1.09
	Visibility	The general color-visioned	3.29	.91
		The color-weak type D	4.22	1.30
		The color-weak type P	3.67	1.12
		The elderly	3.16	.92
R-3	Harnomy	The general color-visioned	3.22	1.02
		The color-weak type D	4.11	1.36
		The color-weak type P	3.67	1.12
		The elderly	3.16	.99
	readability	The general color-visioned	2.91	1.03
		The color-weak type D	3.22	.44
		The color-weak type P	1.67	.58
		The elderly	2.88	1.03
R-4	Visibility	The general color-visioned	2.87	.89
		The color-weak type D	3.11	.93
		The color-weak type P	1.67	.58
		The elderly	2.88	.98

Classification			M	SD
R-5	Harnomy	The general color-visioned	2.57	1.08
		The color-weak type D	3.44	.53
		The color-weak type P	1.67	.58
		The elderly	2.85	1.03
	readability	The general color-visioned	2.55	.98
		The color-weak type D	3.11	1.05
		The color-weak type P	2.00	1.00
		The elderly	2.64	.97
	Visibility	The general color-visioned	2.52	.96
		The color-weak type D	3.11	1.05
		The color-weak type P	2.00	1.00
		The elderly	2.58	.94
R-7	Harnomy	The general color-visioned	2.29	.98
		The color-weak type D	2.78	1.09
		The color-weak type P	2.00	1.00
		The elderly	2.59	.92
	readability	The general color-visioned	2.77	1.10
		The color-weak type D	3.22	.67
		The color-weak type P	3.00	1.00
		The elderly	2.72	1.15
	Visibility	The general color-visioned	2.76	1.04
		The color-weak type D	2.78	.67
		The color-weak type P	3.00	1.00
		The elderly	2.70	1.10
R-8	Harnomy	The general color-visioned	2.43	1.11
		The color-weak type D	2.89	.78
		The color-weak type P	3.00	1.00
		The elderly	2.72	1.15
	readability	The general color-visioned	2.01	1.04
		The color-weak type D	2.22	1.30
		The color-weak type P	2.33	.58
		The elderly	2.19	1.06
	Visibility	The general color-visioned	2.02	1.03
		The color-weak type D	2.00	1.41
		The color-weak type P	2.33	.58
		The elderly	2.15	.99
R-9	Harnomy	The general color-visioned	1.99	1.12
		The color-weak type D	1.56	1.33
		The color-weak type P	2.33	.58
		The elderly	2.26	1.02
	readability	The general color-visioned	1.61	1.02
		The color-weak type D	2.44	1.24
		The color-weak type P	2.00	.00
		The elderly	1.76	1.06
	Visibility	The general color-visioned	1.57	.96
		The color-weak type D	2.44	1.24
		The color-weak type P	2.00	.00
		The elderly	1.69	.99
	Harnomy	The general color-visioned	1.62	1.03
		The color-weak type D	1.56	1.01
		The color-weak type P	2.00	.00
		The elderly	1.81	1.09

4.5.2. The Comparison of the Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Yellow Color Schemes of the Safety Sign

For Y-3 among the subtypes of the Red sign +yellow color scheme, the general color- visioned group was shown to perceive high readability and visibility, the D-type group of the color-weak was shown to perceive high readability and harmony, and the P-type group of the color-weak and the elderly group were shown to perceive high readability, visibility, and harmony (Table 12). For the type of Y-2, the general color- visioned group perceived them most harmoniously and the D-type of the color-weak perceived the highest visibility. Through this, it can be seen that the types

of the Red+yellow color scheme, which are significantly recognized by the subjects of this study, are Y-2 and Y-3. Therefore, as a safety sign for an underground parking lot that all users recognize significantly from the viewpoint of CUD, considering the V value of 9, the brightness difference

of 5, and the S value of about 6 and 10 in the color principle of the Red sign+yellow color scheme, it is thought that the sign can be found even from a distance, and the identification of its information will be efficient.

Table 12. *The comparision of the characteristics of readability, visibility, and harmony by the Red sign+yellow color schemes of the safe of the underground parking lot of the general color-visioned, the color-weak, and the elderly.*

Classification			M	SD
Y-1	readability	The general color-visioned	4.17	.93
		The color-weak type D	4.11	1.17
		The color-weak type P	3.67	.58
		The elderly	3.72	1.01
	Visibility	The general color-visioned	4.15	.99
		The color-weak type D	4.33	1.00
		The color-weak type P	3.67	.58
		The elderly	3.70	1.00
	Harnomy	The general color-visioned	3.75	1.04
		The color-weak type D	3.89	.93
		The color-weak type P	3.67	.58
		The elderly	3.53	.97
Y-2	readability	The general color-visioned	4.15	.96
		The color-weak type D	4.33	1.32
		The color-weak type P	4.00	.00
		The elderly	3.85	1.02
	Visibility	The general color-visioned	4.13	.96
		The color-weak type D	4.56	1.33
		The color-weak type P	4.00	.00
		The elderly	3.80	1.03
	Harnomy	The general color-visioned	3.79	1.05
		The color-weak type D	4.00	1.23
		The color-weak type P	4.00	.00
		The elderly	3.78	.97
Y-3	readability	The general color-visioned	4.18	1.03
		The color-weak type D	4.44	1.33
		The color-weak type P	5.00	.00
		The elderly	3.96	1.19
	Visibility	The general color-visioned	4.17	1.07
		The color-weak type D	4.22	1.30
		The color-weak type P	5.00	.00
		The elderly	3.97	1.17
	Harnomy	The general color-visioned	3.77	1.15
		The color-weak type D	4.11	1.36
		The color-weak type P	5.00	.00
		The elderly	3.92	1.13
Y-4	readability	The general color-visioned	3.28	.96
		The color-weak type D	3.22	.44
		The color-weak type P	2.33	.58
		The elderly	2.84	.81
	Visibility	The general color-visioned	3.28	.93
		The color-weak type D	3.11	.93
		The color-weak type P	2.33	.58
		The elderly	2.89	.82
	Harnomy	The general color-visioned	2.83	.92
		The color-weak type D	3.44	.53
		The color-weak type P	2.33	.58
		The elderly	2.86	.94
	readability	The general color-visioned	3.03	1.00
		The color-weak type D	3.11	1.05
		The color-weak type P	2.33	.58
		The elderly	2.73	.98

Classification			M	SD
Y-7	Visibility	The general color-visioned	2.99	.96
		The color-weak type D	3.11	1.05
		The color-weak type P	2.33	.58
		The elderly	2.80	.95
	Harnomy	The general color-visioned	2.63	1.01
		The color-weak type D	2.78	1.09
		The color-weak type P	2.33	.58
		The elderly	2.80	.94
	readability	The general color-visioned	2.89	1.10
		The color-weak type D	3.22	.67
		The color-weak type P	2.67	.58
		The elderly	2.65	1.01
Y-8	Visibility	The general color-visioned	2.85	1.04
		The color-weak type D	2.78	.67
		The color-weak type P	2.67	.58
		The elderly	2.69	.96
	Harnomy	The general color-visioned	2.55	1.02
		The color-weak type D	2.89	.78
		The color-weak type P	2.67	.58
		The elderly	2.72	1.00
	readability	The general color-visioned	2.28	1.04
		The color-weak type D	2.22	1.30
		The color-weak type P	2.67	.58
		The elderly	2.36	.93
Y-9	Visibility	The general color-visioned	2.27	1.04
		The color-weak type D	2.00	1.41
		The color-weak type P	2.67	.58
		The elderly	2.43	.99
	Harnomy	The general color-visioned	2.08	1.04
		The color-weak type D	1.56	1.33
		The color-weak type P	2.67	.58
		The elderly	2.38	.98
	readability	The general color-visioned	2.62	1.04
		The color-weak type D	2.44	1.24
		The color-weak type P	1.67	1.16
		The elderly	2.55	1.08
	Visibility	The general color-visioned	2.53	.99
		The color-weak type D	2.44	1.24
		The color-weak type P	1.67	1.16
		The elderly	2.51	1.08
	Harnomy	The general color-visioned	2.33	.99
		The color-weak type D	1.56	1.01
		The color-weak type P	1.67	1.16
		The elderly	2.55	1.09

4.5.3. The Comparison of the Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Green Color Schemes of the Safety Sign

For G-1 among the subtypes of the Red sign+green color scheme, the general color-visioned group and the D-type and P-type groups of the color-weak perceived the highest readability, visibility, and harmony, and the elderly group perceived the highest readability and visibility (Table 13). For G-2, the elderly group was shown to perceive most harmoniously and the average value for G-1 of the Red sign+green color scheme was higher in the color-weak group than the general color-visioned, which is inferred to mean that the G-1 sign color scheme composed of H=5G, V=9, S=2 and brightness difference=5, is perceived more significantly by people with color weakness than those with normal color weakness. Therefore, when planning a safety sign color with a green background color applied to a Red sign, it is thought that the results of this study will have to be reflected so that users can harmoniously recognize the color scheme.

Table 13. The comparision of the characteristics of readability, visibility, and harmony by the Red sign+green color schemes of the safe of the underground parking lot of the general color-visioned, the color-weak, and the elderly.

Classification			M	SD
G-1	readability	The general color-visioned	3.92	1.06
		The color-weak type D	4.22	1.09
		The color-weak type P	4.00	1.00
		The elderly	3.53	1.01
	Visibility	The general color-visioned	3.89	1.08
		The color-weak type D	4.11	1.05
		The color-weak type P	4.00	1.00
		The elderly	3.50	1.02
	Harnomy	The general color-visioned	3.23	1.14
		The color-weak type D	3.89	.93
		The color-weak type P	4.00	1.00
		The elderly	3.38	1.00
G-2	readability	The general color-visioned	3.74	1.04
		The color-weak type D	3.78	1.39
		The color-weak type P	3.67	1.16
		The elderly	3.36	.95
	Visibility	The general color-visioned	3.77	1.02
		The color-weak type D	3.89	1.45
		The color-weak type P	3.67	1.16
		The elderly	3.46	.94
	Harnomy	The general color-visioned	3.19	1.13
		The color-weak type D	3.78	1.39
		The color-weak type P	3.67	1.16
		The elderly	3.40	.95
G-3	readability	The general color-visioned	3.58	1.02
		The color-weak type D	3.78	1.09
		The color-weak type P	3.33	1.53
		The elderly	3.41	.95
	Visibility	The general color-visioned	3.54	1.01
		The color-weak type D	3.44	1.13
		The color-weak type P	3.33	1.53
		The elderly	3.39	.98
	Harnomy	The general color-visioned	3.04	1.10
		The color-weak type D	3.56	1.13
		The color-weak type P	3.00	1.00
		The elderly	3.31	.99
G-4	readability	The general color-visioned	2.89	1.03
		The color-weak type D	2.89	.78
		The color-weak type P	2.33	.58
		The elderly	2.70	.93
	Visibility	The general color-visioned	2.78	.97
		The color-weak type D	2.56	.88
		The color-weak type P	2.67	.58
		The elderly	2.66	.91
	Harnomy	The general color-visioned	2.45	.95
		The color-weak type D	3.00	.87
		The color-weak type P	2.33	.58
		The elderly	2.69	.91
G-5	readability	The general color-visioned	2.86	1.08
		The color-weak type D	2.44	.88
		The color-weak type P	1.67	1.16
		The elderly	2.72	1.09
	Visibility	The general color-visioned	2.81	1.04
		The color-weak type D	2.33	.87
		The color-weak type P	1.67	1.16

Classification			M	SD
	Harnomy	The elderly	2.73	1.05
		The general color-visioned	2.53	1.09
		The color-weak type D	2.56	.88
		The color-weak type P	1.67	1.16
		The elderly	2.77	1.12
	readability	The general color-visioned	2.92	1.16
		The color-weak type D	3.33	1.12
		The color-weak type P	2.67	.58
		The elderly	2.70	1.10
G-7	Visibility	The general color-visioned	2.88	1.09
		The color-weak type D	3.33	1.12
		The color-weak type P	2.67	.58
		The elderly	2.70	1.04
	Harnomy	The general color-visioned	2.57	1.09
		The color-weak type D	4.00	.87
		The color-weak type P	2.67	.58
		The elderly	2.72	1.07
	readability	The general color-visioned	2.58	1.13
		The color-weak type D	2.78	1.48
		The color-weak type P	2.67	.58
		The elderly	2.63	.99
G-8	Visibility	The general color-visioned	2.47	1.09
		The color-weak type D	2.67	1.58
		The color-weak type P	2.67	.58
		The elderly	2.59	.96
	Harnomy	The general color-visioned	2.26	1.06
		The color-weak type D	3.11	1.45
		The color-weak type P	2.67	.58
		The elderly	2.62	.99
	readability	The general color-visioned	2.53	1.15
		The color-weak type D	2.78	1.72
		The color-weak type P	3.00	.00
		The elderly	2.72	1.05
G-9	Visibility	The general color-visioned	2.49	1.11
		The color-weak type D	2.78	1.72
		The color-weak type P	3.00	.00
		The elderly	2.70	1.00
	Harnomy	The general color-visioned	2.27	1.12
		The color-weak type D	3.44	1.33
		The color-weak type P	3.00	.00
		The elderly	2.74	1.01

4.5.4. The Comparison of the Characteristics of Readability, Visibility, and Harmony by Type of Red Sign+Blue Color Schemes of the Safety Sign

For B-1 among the subtypes of Red sign+blue color scheme, as shown in Table 14, the general color-visioned group showed the highest average of readability and visibility, and the P-type group of the color-weak showed the highest average of readability. As for B-2, it was reported that the general color-visioned group perceived harmony most highly, the D-type group of the color-weak perceived readability, visibility and harmony most highly, the P-type group of the color-weak perceived readability most highly, and the elderly group perceived readability and visibility most highly. For B-3, the D-type and F-type groups of the color-weak, and the elderly group perceived most harmoniously, and particularly the elderly group showed the high average value of visibility for this type. Through the above results, it can be seen that the greater the brightness, chroma, and color difference between the color of the sign and the blue color scheme, the higher the readability, visibility, and the harmony of color scheme.

Table 14. *The comparision of the characteristics of readability, visibility, and harmony by the Red sign+blue color schemes of the safe of the underground parking lot of the general color-visioned, the color-weak, and the elderly.*

Classification			M	SD
B-1	readability	The general color-visioned	3.92	1.11
		The color-weak type D	4.00	1.02
		The color-weak type P	3.67	1.53
		The elderly	3.42	1.12
	Visibility	The general color-visioned	3.87	1.11
		The color-weak type D	4.00	1.00
		The color-weak type P	3.67	1.53
		The elderly	3.39	1.08
	Harnomy	The general color-visioned	3.22	1.13
		The color-weak type D	3.44	1.13
		The color-weak type P	3.67	1.53
		The elderly	3.28	1.08
B-2	readability	The general color-visioned	3.78	1.05
		The color-weak type D	4.11	1.05
		The color-weak type P	3.67	1.53
		The elderly	3.53	1.02
	Visibility	The general color-visioned	3.79	1.04
		The color-weak type D	4.11	1.05
		The color-weak type P	3.67	1.53
		The elderly	3.57	1.05
	Harnomy	The general color-visioned	3.25	1.06
		The color-weak type D	3.56	1.01
		The color-weak type P	4.00	1.73
		The elderly	3.45	1.04
B-3	readability	The general color-visioned	3.64	1.07
		The color-weak type D	4.00	.71
		The color-weak type P	3.33	1.53
		The elderly	3.53	1.06
	Visibility	The general color-visioned	3.66	1.09
		The color-weak type D	3.89	.93
		The color-weak type P	3.33	1.53
		The elderly	3.57	1.01
	Harnomy	The general color-visioned	3.08	1.17
		The color-weak type D	3.56	1.01
		The color-weak type P	3.33	1.53
		The elderly	3.53	1.02
B-4	readability	The general color-visioned	2.93	1.09
		The color-weak type D	2.56	1.01
		The color-weak type P	1.67	.58
		The elderly	2.74	1.09
	Visibility	The general color-visioned	2.89	1.07
		The color-weak type D	2.33	.71
		The color-weak type P	1.67	.58
		The elderly	2.72	1.01
	Harnomy	The general color-visioned	2.58	.99
		The color-weak type D	2.89	.78
		The color-weak type P	1.67	.58
		The elderly	2.70	.99
B-5	readability	The general color-visioned	2.83	1.08
		The color-weak type D	2.89	.93
		The color-weak type P	2.00	1.00
		The elderly	2.78	1.02
	Visibility	The general color-visioned	2.84	1.07
		The color-weak type D	2.33	.71
		The color-weak type P	2.00	1.00
		The elderly	2.81	1.00
	Harnomy	The general color-visioned	2.48	1.06
		The color-weak type D	3.00	.87
		The color-weak type P	2.00	1.00
		The elderly	2.74	.97

Classification			M	SD
B-7	readability	The general color-visioned	2.93	1.23
		The color-weak type D	3.44	.88
		The color-weak type P	2.67	.58
		The elderly	2.77	1.11
	Visibility	The general color-visioned	2.93	1.21
		The color-weak type D	3.22	1.09
		The color-weak type P	2.67	.58
		The elderly	2.80	1.16
	Harnomy	The general color-visioned	2.57	1.15
		The color-weak type D	3.89	.78
		The color-weak type P	2.67	.58
		The elderly	2.74	1.22
B-8	readability	The general color-visioned	2.48	1.11
		The color-weak type D	3.11	1.27
		The color-weak type P	2.33	.58
		The elderly	2.65	1.15
	Visibility	The general color-visioned	2.44	1.11
		The color-weak type D	3.22	1.20
		The color-weak type P	2.33	.58
		The elderly	2.62	1.12
	Harnomy	The general color-visioned	2.18	1.08
		The color-weak type D	3.11	1.27
		The color-weak type P	2.33	.58
		The elderly	2.59	1.11
B-9	readability	The general color-visioned	2.41	1.05
		The color-weak type D	3.00	1.12
		The color-weak type P	2.33	.58
		The elderly	2.66	1.04
	Visibility	The general color-visioned	2.41	1.13
		The color-weak type D	2.78	1.20
		The color-weak type P	2.33	.58
		The elderly	2.70	1.10
	Harnomy	The general color-visioned	2.18	1.07
		The color-weak type D	3.11	1.17
		The color-weak type P	2.33	.58
		The elderly	2.64	1.03

4.6. Summary of Study Reselt

The results of the above study can be summarized as follows (Table 15).

First, as for Y-6 among the types of the representative color schemes of the safety signs of the underground parking lot, the subjects of this study perceived the readability and harmony of the color scheme most highly, and as for G-6, they perceived visibility most highly. This suggests that the color scheme of the safety sign and background color, is also important, so it is thought that it is necessary to plan a color that can easily convey the information of the sign even in an emergency by applying a yellow color with a large brightness difference.

Second, the types with high readability by type of detailed color scheme of the underground parking lot safety sign, were R-1, Y-3, G-1, B-1, the types with high visibility were R-1, Y-3, G-1, B-1, and the types with high harmony were R-1, Y-2, G-1, B-2. Based on these results, it is inferred that when the brightness difference is increased in the color scheme of the sign, the sign will be clearly and quickly recognized and the readability of its information will increase.

Third, all the groups of the general color-visioned, the color-weak, and the elderly showed the highest average values of readability, visibility, and harmony for Y-6, compared to other types. It is better to use the three primary colors, red, yellow, and blue, which are very easy to notice and identify, and to avoid color matching with similar colors for better readability and identification [10]. In light of this, from the viewpoint of CUD, the safety sign consisting of the Red sign+yellow color scheme, is inferred as a color suitable for delivering information more conveniently and effectively to the users with various visible abnormalities.

Fourth, with respect to the color cognitive characteristics of the Red sign+red color scheme subtypes by group of the general color-visioned, the color-weak, and the elderly, the type with high readability was R-1 for the general color-visioned and the elderly groups, R-3 for the D-type group of the color-weak, and R-2 for the P-type group of the color-weak. The type with high visibility wass R-1 for the general color-visioned group, R-2 for the D-type and P-type group of the color-weak, and R-1 for the elderly group. The type with high harmony was R-1 for the general color-visioned and the elderly group, R-3 for the D-type of the color-weak,

and R-2 for the P-type of the color-weak. In the eyes of the color-weak, red is perceived as dark brown tone of less than medium brightness, so it may be difficult to identify the sign [3]. However, it can be seen from the results of this study that underground parking lot users tend to recognize that the safety sign with a clear contrast of the Red sign+red color scheme has an excellent visual identification effect.

Among the detailed types of the Red sign+yellow color scheme, Y-3 was recognized as the most readable type for all the groups of the general color-visioned, the color-weak, and the elderly. The type with high visibility was Y-3 for the general color-visioned group, Y-2 for the D-type of the color-weak, and Y-3 for the P-type of the color-weak and the elderly group. The type with high harmony was Y-2 for the general color-visioned, Y-3 for the D-type of the color-weak, and Y-3 for the P-type of the color-weak and the elderly group. Based on the fact that the values of brightness and chroma of Y-2 and Y-3 are 6 or more, when planning the color of the safety sign of the Red sign+yellow color scheme from the viewpoint of CUD, if the values of brightness and chroma are greatly reduced, it is thought that the readability and visibility of the sign will increase, and the color scheme can be recognized more harmoniously.

Contrary to the above, with respect to the readability, visibility, and harmony of the subtypes of the Red sign+green color scheme, the general color-visioned and the color-weak group showed the highest average values of the readability, visibility, and harmony for G-1. On the other hand, in the elderly group, the type with high harmony was G-2, and the type with readability, and visibility was G-1. In the case of G-1 and G-2, they belongs to the types of the sign whose brightness difference is 5, so when planning the color of the Red sign+green color scheme from the viewpoint of CUD, if there is a large brightness difference with high chroma and low brightness, it is judged that the effectiveness of information identification of safety signs can be further increased.

Lastly, the type with the highest readability among the color cognitive characteristics of the Red sign+blue color scheme subtypes was B-1 for the general color-visioned group, B-2 for the D-type group of the color-weak, B-1 and B-2 for the F-type group of the color-weak, and B-2 and B-3 for the elderly group. The type with high visibility was B-1 for the general color-visioned group, B-2 for the D-type group of the color-weak, B-1 and B-2 for the F-type group of the color-weak, B-2 and B-3 for the elderly group. The type with the highest average value was B-2 for the general color-visioned group, B-2 and B-3 for the D-type group of the color-weak, B-3 for the F-type group of the color-weak, and B-3 for the elderly group. These results mean that when the color scheme of the safety sign is highly saturated, readability and visibility are recognized as high, and when it has medium and high brightness of 5 or more, and the brightness difference is high, it is recognized as harmonious. Therefore, it is thought that the safety sign color should be established in consideration of the high brightness difference in the relation and contrast between the information delivery of the sign and the color scheme.

Table 15. *Summary of the findings of this study.*

Color cognitive characteristics		all	The general color-visioned	The color-weak type D	The color-weak type P	The elderly
Representative color cheme type	readability Visibility harmony	Y-6	Y-6	Y-6	Y-6	Y-6
Red sign+ Red color scheme	readability Visibility harmony	R-1	R-1	R-3 R-2 R-3	R-2	R-1
Redsign+ Yellow scheme	readability Visibility harmony	Y-3 Y-2	Y-3 Y-2	Y-3 Y-2 Y-3	Y-3	Y-3
Red sign + Green scheme	readability Visibility readability	G-1	G-1	G-1	G-1	G-1
Red sign+ Blue scheme	readability Visibility readability	B-1 B-2	B-1 B-2	B-2 B-2&3	B-1&2 B-3	B-2&3 B-3

5. Conclusion and Proposal

The safety sign of the underground parking lot of brand apartments should accommodate the various demands of residents and consider users with a design so that everyone can use it more fairly and conveniently. If, when using the underground parking lot, the visual use of safety signs is inconvenient and it is difficult to get the desired information, both the use of the underground parking lot and the quality of the residential environment may be lower. Therefore, from

the viewpoint of color universal design, the color of the safety sign of the underground parking lot of the brand apartment should be improved. In this respect, this study has examined the color cognitive characteristics of underground parking lot safety signs recognized by the general color-visioned, the color-weak, and the elderly.

Through the study results, it could be seen that when the brightness difference between the background color and the letter color is 4 or more, and particularly, the letter color is red on the yellow background color, the readability, harmony, and visibility of the safety sign color are significantly recognized.

In this way, through this survey, we could understand that the readability, visibility, and harmony of information are increased by the color scheme of safety signs, which supported the purpose of the study that it is necessary to improve the color of safety signs in underground parking lots of brand apartments. Therefore, when establishing the color of the safety sign of the underground parking lot of the brand apartment that will be distributed in the future, it will have to be planned in consideration of the following points. First, from the viewpoint of the color universal design, the information of the sign that the underground parking lot user has to acquire should be applied referentially with the Red sign + yellow color scheme. Second, in order to increase the readability and visibility of sign information, it is recommended to apply a high brightness of 4 or more, which is the brightness difference between the background color and letter color of the parking lot safety sign. Third, if you consider readability and harmony based on the red letter color in the parking lot safety sign, we suggest a yellow background color, and if you intend to increase visibility, we suggest a green background color.

In conclusion, in the hope that the safety sign color of the underground parking lot of the brand apartment will be improved so that the color universal design will be applied to the underground parking lot, this study is significant in that it provided implications for the establishment of the color of the public housing environment sign system according to the color sense of the general color-visioned, the color-weak, and the elderly.

However, there are some limits in that this study selected only emergency bells as the subject of the study of parking lot safety signs, and in that the ratio of the color-weak and the elderly who participated in this survey was smaller than that of the general color-visioned. In addition, we failed to examine the significant difference verification of the color scheme type of the safety sign significantly recognized by those surveyed, and also failed to control the characteristics of the lighting environment in the survey evaluation environment of this study, which also remains as limitations of this study. Based on these limitations, in future studies, it is proposed to broaden the scope of investigation targets such as SOS signs, fire extinguishers, and slow-down signs, and to similarly match the proportions of each group surveyed. Also, in order to derive more objective survey results, if the color cognitive characteristics of safety signs are understood by controlling the significant difference verification results, which could not be dealt with in this study, or by controlling the lighting environment according to space and places, more significant results seem to be able to derived.

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