International comparison of ageing effects on color similarity

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ABSTRACT

The purpose of this study is to conduct international comparison of categorical colour perception of older adults for the standardization of colour combinations. Spans of fundamental colours of older adults were measured by using a method to subjectively judge the similarity of colours between a reference colour (representing a fundamental colour) and a number of test colours. A total of 13 fundamental colours and 200 test colours, which are distributed evenly in the Munsell Colour Space, were used. A space that contains similar colours to each fundamental colour in the Munsell Colour Space was defined. Twenty older adults and Twenty youngers participated the experiments in each of 6 countries: Chania, Germany, Japan, Korea, Thai, United States. Totally, data of 120 older adults and 120 youngers were obtained. It was found that every country has the similar tendency for the shape and size for the span of fundamental colors. Similar aging effects were also found among the 6 countires, which showed the span of each color was sifted to higher Chroma area with a limited size. Depending these results, ISO 24505:2016 Ergonomics -- Accessible design -- Method for creating colour combinations taking account of age-related changes in human colour vision were developed.

KEYWORDS: Colour similarity1, fundamental colours2, age effect3 (3 words maximum)

INTRODUCTION

Is is well known that the colour categories determined by the basic colour terms proposed by Berlin and Kay (1958) is the one of the important cognitive aspects of perception of the colours. For designing of visual signs and displays it is important to discriminate the colours to read the information conveyed by those signs and displays correctly. In the daily life, people often discriminate colours in visual signs by not only colour differences but also colour terms or similarities (colour groups). But the span of colour similarities are not clearly defined yet, and the clarify the spans of similarities particularly for fundamental colours in a color space, such as Munsell Colour Space, is quite useful for conspicuous colouring of objects or visual signs. Sagawa and Takahashi (2003) and Itoh and Sagawa (2007) measured the spans of fundamental colours using subjective evaluation method of colour-similarity and have shown them as areas in Munsell Color Space. Data have been defined for younger and older people as well as for low vision later to apply the colour similarity data for a wider design field and also for a wider people including people with visual disabilities with a method for creating conspicuous color combination.

Based on those studies, and in order to apply the data and method of colour combination worldwide, measurements have been continued in a systematic sampling way for international comparison for proposing the standardard data and the colour combination method for young and older adults. The present study aimed to show the data on the spans of fundamental colours of 6counties: Chania, Germany, Japan, Korea, Thai, and United States, and also the international comparison of the aging effects.

THEORY

Underlying concept of this study is the principal of Accessible Design given in ISO/IEC Guide 71:2014, "*Guide for addressing accessibility in standard*s". Accessibility is the idea of extending standard design to people

with special requirements (older persons and persons with dis-abilities) to maximize the number of potential users. This study conducted for the providing international data for colour combination for older people with an intention of increasing accessibility in the use of colour for various products.

EXPERIMENTAL

The method to measure the spans of fundamental colours is the same as we have employed in a series of studies applied for younger and older people and people with low vision and people with colour deficiency (Sagawa and Takahashi, 2003; Itoh and Sagawa, 2007; Itoh and Sagawa, 2013). The sample numbers of the reference colours and the test ones were slightly differed for respective subjects' groups. In the present case a total of 16 reference colours (5R4/14, 5R5/12, 5YR5/10, 5YR7/12, 5Y5/6, 5Y8/12, 5GY5/8, 5G5/8, 5BG5/8, 5B5/8, 5PB5/10, 5P5/10, 5RP5/10, N1.0, N5.0, N9.5) and 200 test colours with variable hue, value, and chroma were used.

As shown in Figure 1 the subject was given one of the 200 test colours and was asked to select any similar colour(s) to the test from the 16 reference colours that were displayed in front of the subject. There was no limitation for the number of the selection and no choice was allowed in case there is nothing similar to the test. This trial was continued until all the 200 test colours were done. To make sure the selection of "similar" colour(s), the subject was also asked to select the colour that looked "identical" to the test from the reference colours. These two criteria helped and had the subject clearly aware of the meaning of the "similar" judgment.

By summarizing the data collected from a number of subjects, the probability of the "similar" selection among subjects for a given pair of reference vs test colour was obtained, and this calculation applied to any combination used in the experiment. These probability data were used to specify the similarity (to a fundamental colour) and an area based on a given level of similarity in the Munsell Color Space.

Totally 285 subjects (Young: 146, Older: 139) in 6 countries were participated. Average age are 23.3(±2.6) for young people and 66.9(±8.6) for older people. The details of number and age of subjects are in Table 1 and 2.

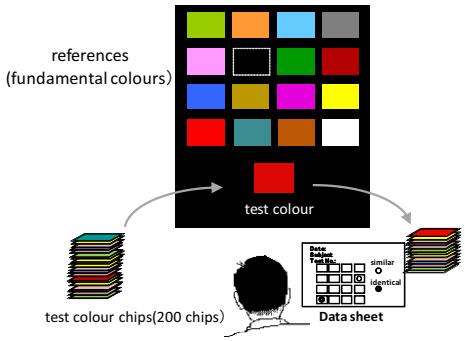

Figure 1: Experimental settings.

Table 1. Number and age of subjects (6 countries)

	number	male	femal	age(ave)	age(SD)
Young subjects of 6 country	146	76	70	23.3	2.6
Older subjeects of 6 country	139	68	71	66.9	8.6
Total	285	144	141		

RESULTS AND DISCUSSION

Figure 2 shows an example for the comparison of 6 countries' spans of red (5R5/12) fundamental colour. Upper figure shows the data for older subjects and lower one for young subjects. The span is expressed at 4 cross sections along with the Value axis (V3, V5, V7, and V9) which align vertically for each country. For each cross section of each country the contours of spans at different similarity levels are shown with different colour (10% in red, 30% in green, 50% in blue, and 70 % in purple).

Though, the shape of each span is not exactly the same, every span of red (5R5/12) locates at nearly same position in the colour space distributing between red-purple and orange. In addition, it was found that every country has the same tendency for aging effects, that is the span of each color for older people is shifted to higher Chroma area.

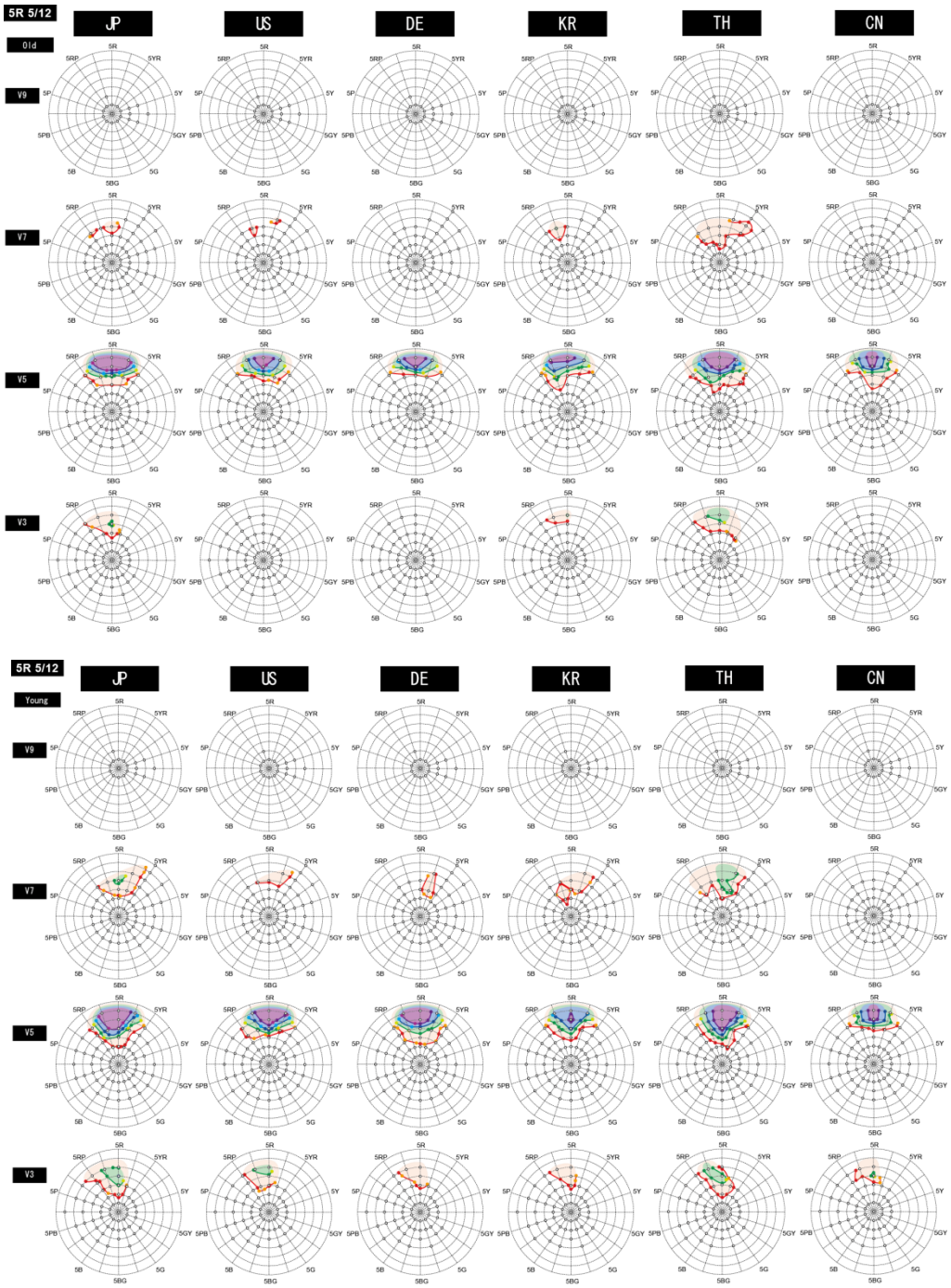

Figure 2: Comparison of 6 countries for the span of colour similarity to red (5R5/12)
Upper: Older subjects, Lower: Young subjects.

To see the age-related change in the span of colour similarity more clearly, the averaged contour of the span of similarity over the 6 countries for young and older people were plotted together in Figure 3. The contours are shown for each level of similarity from 10 % to 70 % in 20 % steps. For all the similarity levels the difference between young (dashed lines) and older people (solid lines) is clear, showing that the span of older people is smaller than that of young people, which is consistent with earlier findings (Sagawa and Takahashi, 2003).

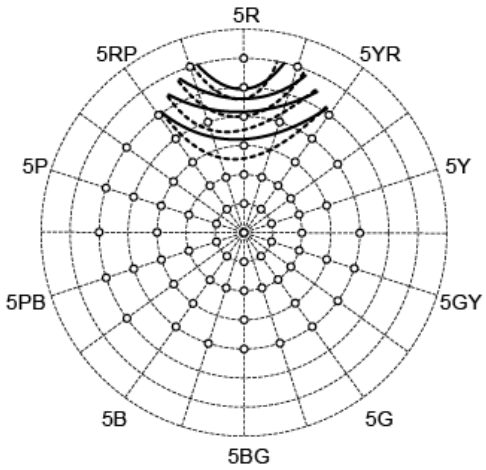

Figure 3: Comparison of older and young subjects for the span of red (5R5/12) colours at value 5.
Solid line: Average of older adults, solid line: Average of young subjects.

CONCLUSION

Comparison of the span of fundamental colours are investigated. It was found that every country has the same tendency for aging effects, which is the span of each colors are sifted to higher Chroma area. According to this results, ISO 24505:2016 Ergonomics -- Accessible design -- Method for creating colour combinations taking account of age-related changes in human colour vision were developed.

REFERENCES

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