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Study on barrier-free liquid crystal display device in considertion ofthe elderly visual environment

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ABSTRACT :*With the increasing of the elderly people, the proportion of people who have some disabilities is also increasing, and that is the significant burden to the whole society. So while entering the aging society, the review of elderly people measures and reform must be advanced rapidly. By the way, in recent years, the liquid crystal display is widely used in transportation and street advertising. The information(such as pictures)in it can be seen by various people but who are limited in the ones with normal color vision. For example, the cataract(a kind of visual disease)patients can not see the information in the liquid crystal display clearly. Therefore, the basic data of the elderly people are how to look for a liquid crystal display under the color environment is seems to be important. So the purpose of this research is to provide the basic data and corresponding color for the future.*

KEYWORDS: *Bold Aging society, Elderly person, Cataract, Barrier-free, Stable domain.*

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I. INTRODUCTION

An aging society is one in which the elderly population (aged 65 or older) accounts for an increasing proportion of the total population. Although Japan's longevity has been increasing at a slower pace than that of Western Europe's advanced countries, the recent decadal growth rate of the elderly population of Japan is much higher than that of Western Europe (about 2.2 times), and is 3.7-4.5 times higher than that of Western Europe. It is predicted that not only developed countries but also developing countries such as China will become an aging society around 2050[1)].

It is inevitable that human life expectancy will approach the biological life expectancy as socioeconomic conditions improve, and we can assume that the aging of the population, or the increase in longevity, is in the process. However, as the number of elderly people increases, the percentage of people with physical disabilities increases, which puts a heavy burden on society as a whole. The reality is that with the advent of an aging society, measures for the elderly must be reviewed and reformed at a rapid pace. Aging occurs in everyone, especially in the early stages of vision impairment (cataracts). Senile cataracts are caused by an age-related change in the crystalline lens of the eye, and are one of the same aging processes that can occur in healthy people, such as gray hair and skin wrinkles. Cataracts cause glare and make it difficult to see colors in the short-wavelength region. As Japan's population is rapidly aging, it is becoming an important issue to take measures against visual impairment caused by senile cataracts.

In recent years, liquid crystal displays (LCD) have been used for information boards in public transportation and for street advertisements[2)]. However, there are still some points to be improved. In particular, the number of people who view an LCD monitor varies from person to person, and not all of them are colorblind. In the cataract viewing environment, it is possible that people may perceive colors differently from those of young people due to the difference in spectral transmittance.

The purpose of this study is to investigate the differences in color vision between normal and elderly people under different illuminance conditions, and to provide basic data for future barrier-free color vision measures.

II. EXPERIMENT

2.1 Experimental conditions and methods

In this experiment, a liquid crystal display and goggles were used as a stimulus presentation device (Fig.1 and Fig.2). The goggles used in this study were quite severe goggles that simulated the condition of 0.4 visual acuity on the verge of surgery[3)].

Fig.1. Laboratory equipment (LCD)

Fig. 2. Experimental equipment (Cataract reproduction goggles)

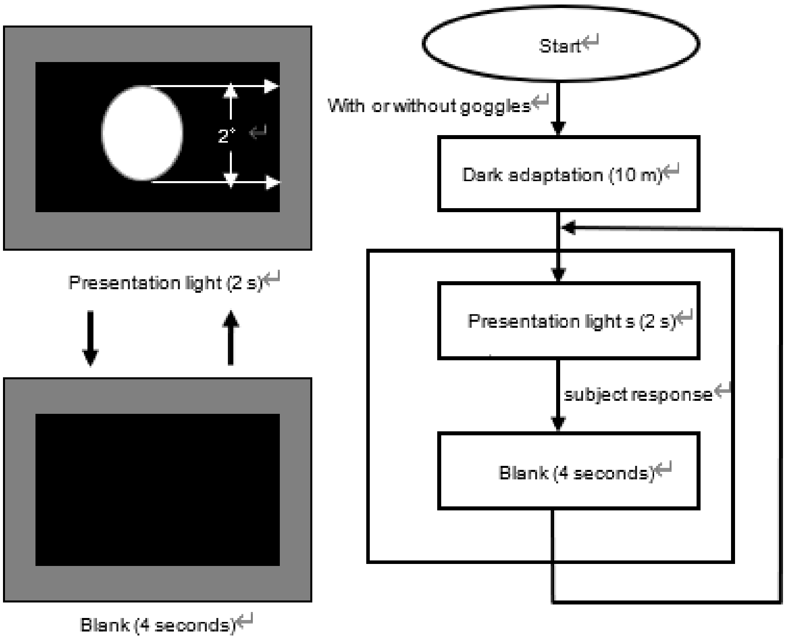


Fig. 3.Diagram of Experimental Procedures

In this experiment, we assumed that the LCD were used in a room with an information board in a public place such as a public transportation facility or a public institution. The experimental intensity was set at 600 lx and 1200 lx, in addition to 0 lx in the basic dark viewing test. Before the experiment, subjects perform 10 trials of dark adaptation in advance. Afterwards, they observe a circular stimulus light with a visual size of 2° (7 cm in diameter) displayed on an LCD display and practice it as a preliminary experiment. After the subject becomes familiar with the flow of the experiment, the main experiment starts. They are asked to respond to the stimulus light as they perceive it and to name the color of the stimulus light freely[4)]. The test stimulus light is presented for 2 seconds and then the blank is presented for 4 seconds. In the same way, the test stimulus light and the blank is presented alternately (Fig.3).

Measurements were performed with and without goggles for the elderly and with actual elderly subjects. The number of subjects was 5 colorblind people (male students, mean age 26.8 years,age range: 25 to 31 years old) and five elderly people over 70 years old (all male, mean age: 72.4 years old, age range: 70 to 76 years old) registered at the Toyama City Silver Human Resources Center. The number of trials for the young subjects was five when they wore the goggles and five when they did not wear the goggles, and the number of trials for the actual elderly subjects was five[5)].

2.2 Selection of test stimulus light samples

The presented stimulus light used in this experiment is a chromaticity point on a u'v' chromaticity diagram. u'v' chromaticity diagrams are corrected to eliminate the difference in scales between the two colors because the xy chromaticity diagram has different scales depending on the color. Using the u'v' chromaticity diagram, the difference between the two colors can be plotted accurately as a distance on the chromaticity diagram. This is called an equal chromaticity diagram because the differences between the two colors are evenly plotted. Because of the above features, we think that u'v' chromaticity diagram should be used to explain the differences in the range of color reproduction in a chromaticity diagram. In this experiment, u'v' chromaticity diagram was used for the stimulus light, and the side and interior of the triangle were determined based on the three highest chroma of red, green and blue vertices of the triangle. From No.4 to No.13, 10 points are assigned to the 10 points on the line segment connecting R and G of the highest saturation. Similarly, the next 10 points are on the line segments of the highest saturation B and R. The next 10 points are on the line segments of the highest saturation B and R. Thus, the numbers are assigned to swirl inward. A total of 78 colors were selected in this way. The order of presentation of the stimulus light was set to random to avoid the effect of the previous stimulus light (Fig. 4.)

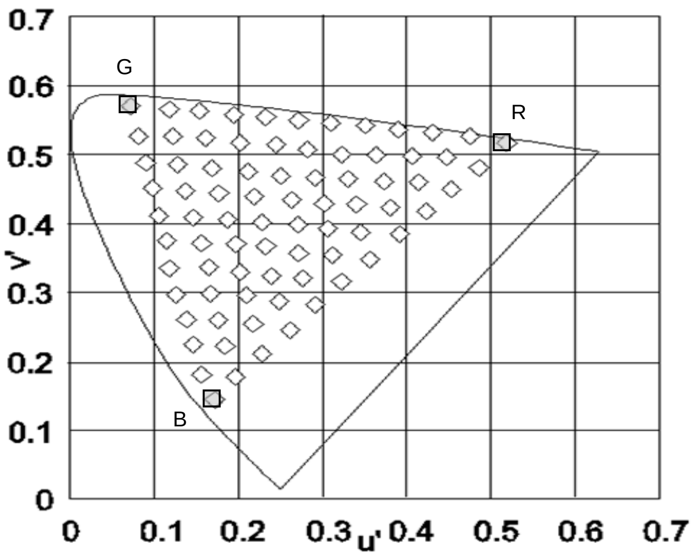


Fig. 4. u'v'evenness chromaticity chart

2.3 Determination of stable and unstable regions of visibility for test stimulus light

In this experiment, we collect and statistic the data of each chromaticity and analyze the visibility characteristics of each chromaticity based on the response probability to each chromaticity[6)]. The response probability is 75% or more at the chromaticity points. The chromaticity points with a response probability of 75% or less are regarded as stable chromaticities. Each chromaticity point that responds to the same color is considered to be a stable region for that color. (Fig.5).

The colored area on the graph shows the stable region of visibility where the response rate exceeds 75%, and the uncolored area shows the unstable region. Visibility characteristics for the colors of the barrier-free area, young and elderly people are analyzed from the response color names and the distribution of stable areas.

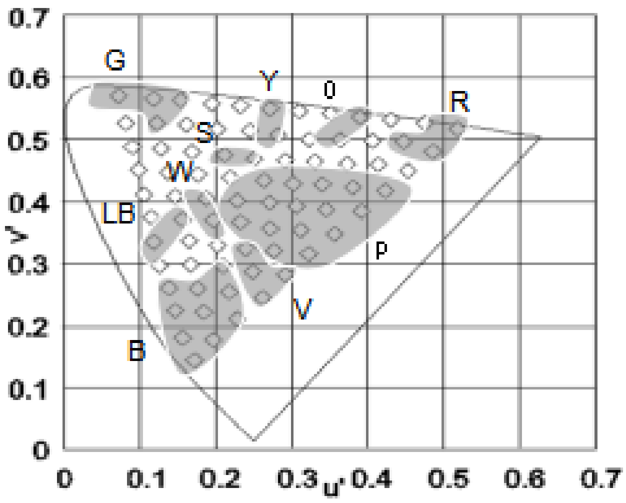


Fig. 5. 0lxIllumination younger

III. EXPERIMENTAL RESULTS

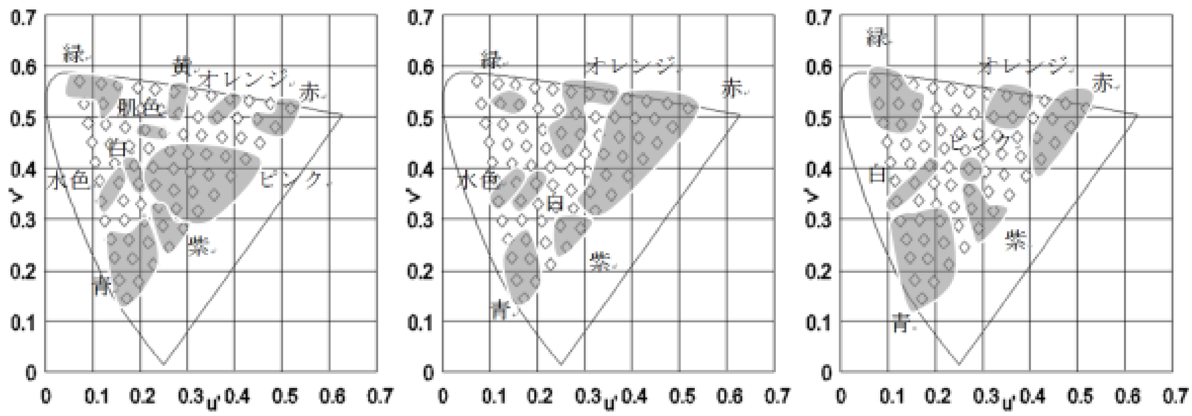
3.1 Experimental results in night vision

The results of the darkroom illumination at 0 lx are shown in Fig.6 to Fig.7. The results are shown for the young people's viewing environment, the simulated elderly people's viewing environment[7)], the elderly people's viewing environment and the color vision barrier-free region at 0 lx.

As a result, the response chromaticity and chromaticity range of the visual environment for the elderly differed significantly between the young and the elderly compared to the youthful viewing environment. The responsive colors in the younger viewing environment almost reproduce the color arrangement on the u'v' chromaticity diagram. However, in the simulated old-age viewing environment, the color range is narrower or extremely wide than that in the young-age viewing environment, although the colors derived from the young-age viewing environment are derived. The range of red and orange colors is extremely wide, and the range of yellow-green colors is reduced. In the visual environment for the elderly, the moderate cataract environment simulates the Although a stable region did not appear as extreme as the environmental one, it was not as stable The areas decreased to red, orange, green, light blue, blue, purple, pink and white.

No skin-colored or yellow regions appeared in the visual environment for the elderly. Therefore, it is difficult for the elderly people to recognize the above neutral colors and the overall direction of the color component is shifted in a strong direction. We have found that this is the case in the elderly. This is the first time that the spectroscopic transparency of the lens in the elderly It is shown that the color discrimination ability is reduced due to low over-rates. Visual impairment is thought to occur in color recognition. As a result, although the same colors are recognized in the old-age viewing environment as in the young-age viewing environment, the regions of appearance are very different. In other words, we need to pay attention to this point in actual applications, because the recognition of certain chromaticity points is different between the young and the elderly[8)].

We reproduced a fairly severe cataract in a simulated elderly visual environment. Severe cataracts can significantly interfere with daily life. However, in reality, there are few people who live with severe cataracts without surgery, so the barrier-free zone was determined using the results of experiments on young people and the results of experiments on actual elderly people, except for the results of the simulated elderly people's vision environment. As a result, seven color barrier-free regions (red, orange, green, blue, purple, pink and white) were derived from the graph in Fig.9. From these results, it is desirable to use these seven colors to achieve visual barrier free in the room with 0 lx illumination.



A.0lx Juvenile visual B.0lx Simulated elderly visual C.0lx Elderly visual environment

Fig.6 Stable region of visibility at 0lx illumination

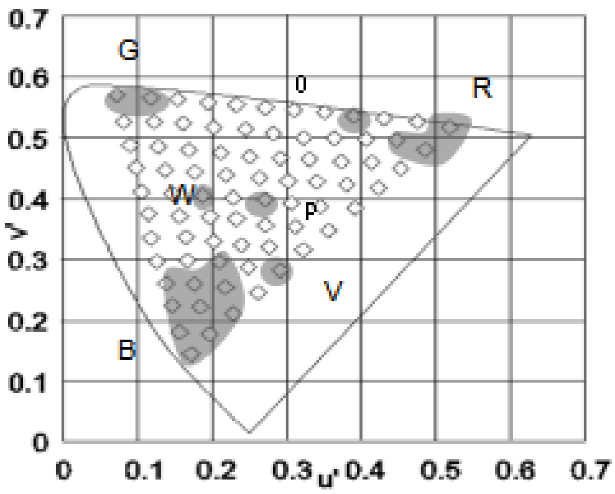


Fig. 7.Wind turbine monitoring system

3.2 Results of the experiment in plain sight

In the experiment of daylight viewing, we set the illuminance at 600lx and 1200lx, which are simulated environments where LCD are actually used, and conducted the experiment. In the same way as in the night vision experiment, the experiment was conducted for young people at 600 lx and 1,200 lx illumination, and for elderly people in a simulated environment[9)].

The results are shown for the visual environment, the aged person's visual environment and the color vision barrier-free region.

However, in the simulated and actual viewing environments, the stable regions decreased further and the intermediate colors were hardly recognized. The color barrier-free region was reduced to a total of six colors (red, orange, green, blue, violet and white). In other words, compared to the results of 0 lx illuminance, it is confirmed that the visibility is further reduced in color discrimination.

As for the number of response colors for each chromaticity, the young have four chromaticities for the maximum response color of five, while the elderly have five chromaticities for the maximum response color of six and ten for the maximum response color of five. These results suggest that the elderly people have more difficulty in discriminating colors because they have more variability in the recognition of the same chromaticity points (Fig.8.)

There is also a significant difference between the response probabilities of the young and the elderly in terms of the response probabilities for each color point. Taking red, green, and blue as examples, the younger people's responses were concentrated in high percentages, while the elderly people showed a tendency to have a large variation in the percentages of responses and to have a wider range of responses than the younger people[10)]. In contrast, the older people tended to have a wider range of responses than the younger people. (Fig.9 and Fig.10.)

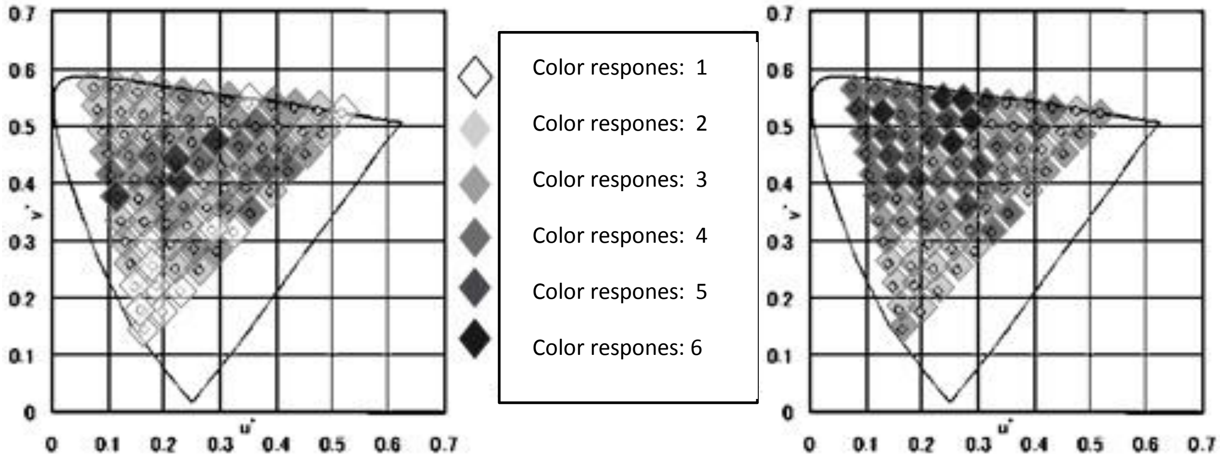
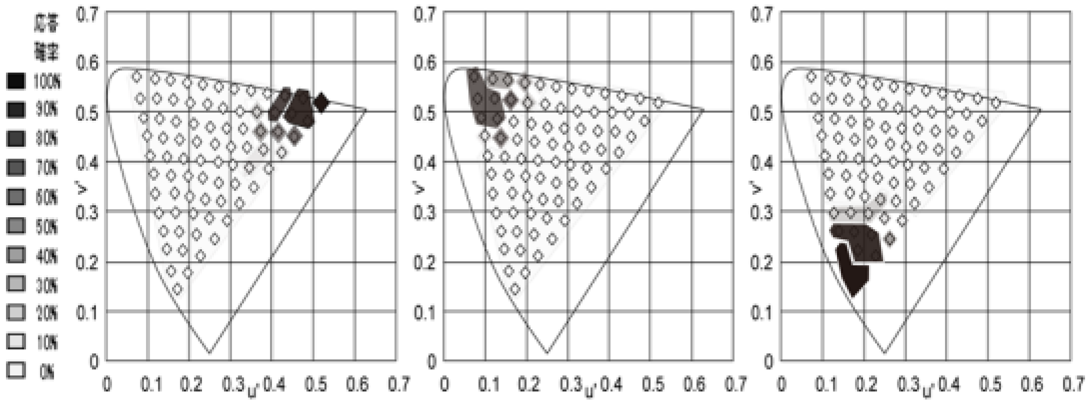
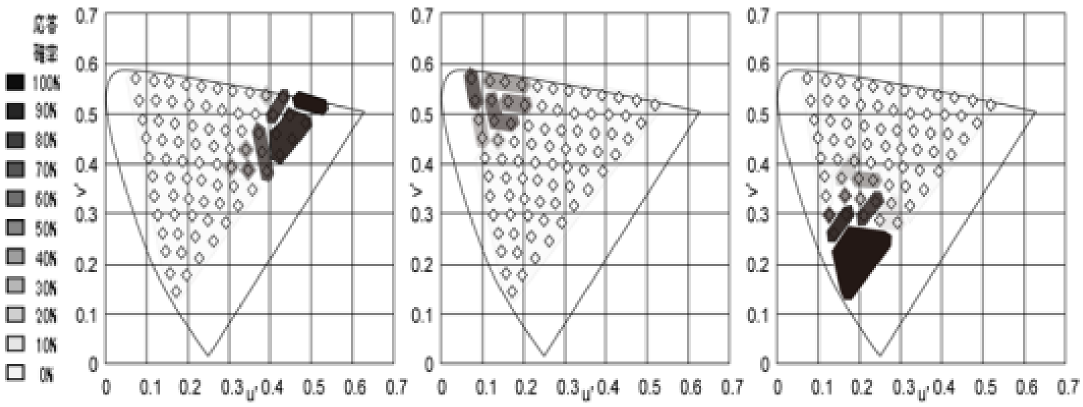


Fig. 8.Response chromaticity of the young and elderly viewing environments at 600 lx



RED GREEN BLUE

Fig. 9.Response probability of the three primary colors at 600 lx for younger



RED GREEN BLUE

Fig. 10.Response probability of the three primary colors at 600 lx for older

From the experimental results of 1200lx, six color regions (red, orange, green, blue, purple and white) were derived from the results of the color barrier-free region. Simulated and actual viewing environment for the elderly

The results show that the stable region is further reduced and the intermediate colors other than orange and violet are not recognized. In the elderly people's viewing environment, the number of response colors at each chromaticity was larger than that in the young people's, and the color recognition of the elderly people was uneven, as was the result of the experiment of 600lx.

From the above experiments, the number of response colors and the stable area decrease gradually with the increase of room illumination, and the color discrimination ability becomes unstable. The reason for this is thought to be the effect of illumination. The lens of the elderly is characterized by lower spectral transmittance than that of the young. When light from lighting penetrates the cloudy crystalline lens, diffuse reflection occurs, leading to further deterioration of color vision as well as the original visual characteristics of the cataract environment.

IV. CONCLUSION

In this experiment, we collected basic data on color vision in a cataract vision environment and selected a color barrier-free display color based on the results of this study. In this experiment, it is important to investigate the difference in color vision between the elderly and the color-vision-aware people. This experiment suggested that a certain amount of color should be used in order to make a color display suitable for elderly people. As a result, it was found that there was a difference in the color discrimination between young and elderly people.

From the result, seven color ranges of red, orange, green, blue, purple, pink and white were derived as stable colors for 0lx, and six color ranges of red, orange, green, blue, purple, pink and white were derived as stable colors for 600lx and 1200lx. Although the stable response color names were the same, the distribution of the stable area was different. Comparing the results of the present experiment with the room illumination of 0 lx, 600 lx and 1200 lx, it became difficult to discriminate the intermediate color and the distribution of the stable region of visibility was very different for the recognition of the same color under the visual environment of the elderly. It was found that the elderly people were more affected by the color vision of their eyes by the change of illuminance than the young people.

Therefore, we can conclude that illuminance changes have a significant effect on the color perception in the visual environment of the elderly.

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