A Study on Improving Efficiency of Color Matching Function Measurement Using Selection Techniques

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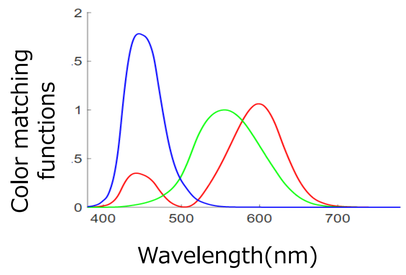
Introduction

Color Matching Functions(CMFs)

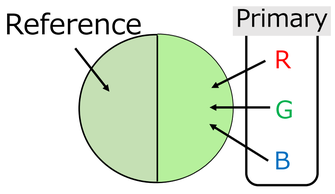
・represent color vision in terms of tristimulus values (ratios).

・differ from among people.

▶ Colors of different spectral distributions appears differently, even though their chromaticities are the identical.



Color matching experiment



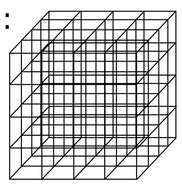
Conventionally, the subject adjusted the intensity of the RGB primaries. It is not an easy task, especially for naïve subjects, due to **its complex operation**(high degree of freedom). Also, **it required a long time** to complete a match.

If the procedure could be **simplified**, it would be easier to measure CMFs.

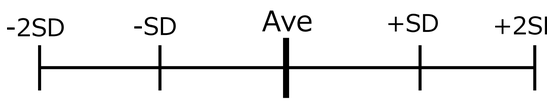
Previous study[1)]

Subjects were asked to select the best match among 5×5×5 candidates, which were independently defined in RGB. (**Simple method**)

Image:

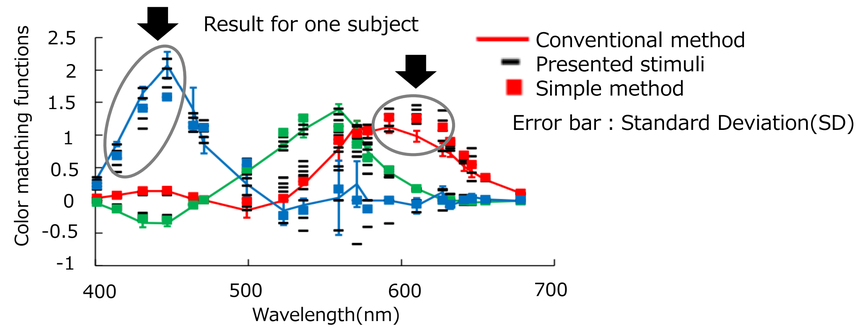


(Average is calculated with previous 14 subjects CMFs data.)



▶ As a result, it was easier and took less time.

However, obtained CMFs were inconsistent in some regions compared with those obtained with the conventional method.



Problems

・It was necessary to memorize the candidate matching colors and compare with the presented stimuli.

・Fine tuning was not allowed, as the discrete candidate colors were set in advance.

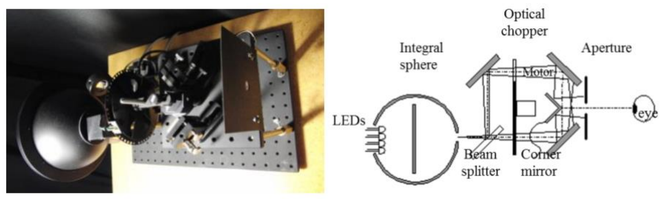
Purpose

Propose a method for measuring CMFs which can attain certain accuracy and time efficiency simultaneously

Method

✓ Apparatus

A LED based CMF measurement apparatus, developed in Yamagata Univ.,[2)] were used.



✓ Subjects

6 students (Male:5, Female:1)

・Normal color vision

・4 subjects had experience in CMF experiment with the conventional method. 2 subjects conducted both methods, and the time were measured.

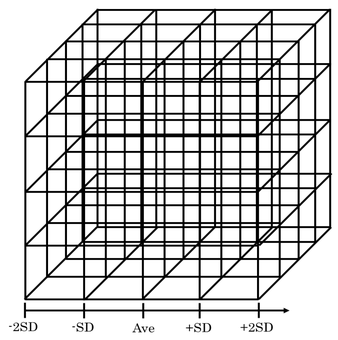
✓ Task

・The subject was asked to select the best color among 125 candidate colors.

・5 levels for each R, G, and B were set based on the SD of the preliminary experiment.

・20 reference colors were used.

・Each subject repeated 3. times for each reference color.



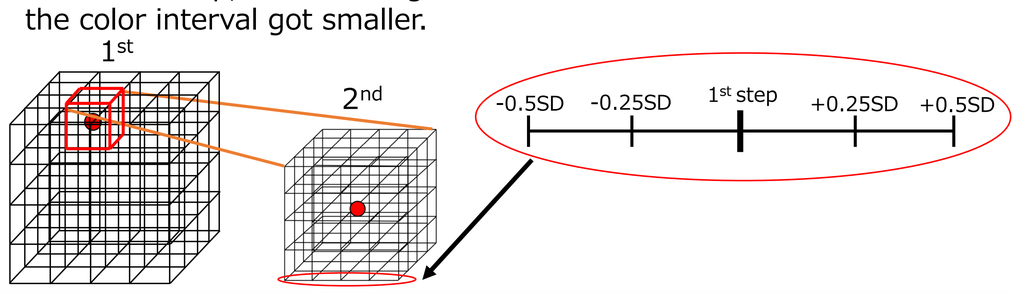
In addition to the method adopted in the previous study (simple method), two new method were proposed.

① Store function method

In this method, the subject could ”store” the candidate color, and could freely recall it and compare with the present color.

② Two-step procedure method

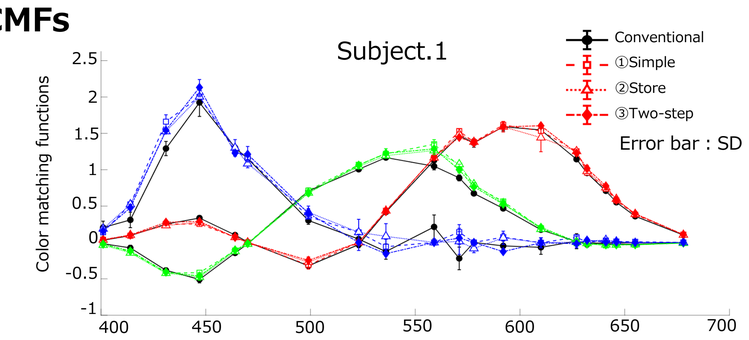
In the 1st step, the subject would select from a wide range of the color. In the 2nd step, the color region of the stimulus was reduced so that the color interval got smaller.



Results & Discussion

✓Accuracy

・**CMFs**



In order to verify the performance of the methods, it is necessary to compare the accuracy of the matching. Hence, **deviation from conventional method** was calculated.

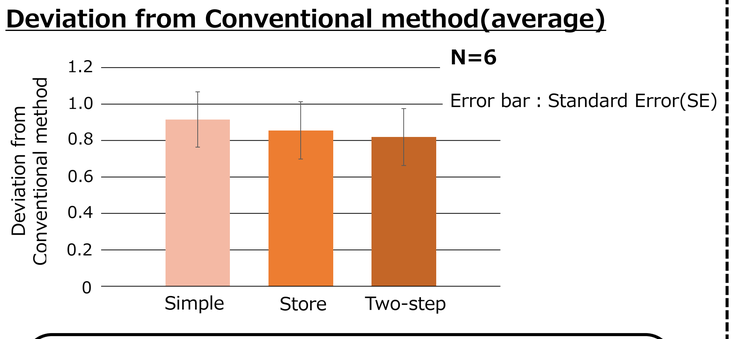
・**Deviation from Conventional method**

$$\sqrt{\sum_{i=1}^{20}\left(R'(\lambda_i)-R(\lambda_i)\right)^2+\sum_{i=1}^{20}\left(G'(\lambda_i)-G(\lambda_i)\right)^2+\sum_{i=1}^{20}\left(B'(\lambda_i)-B(\lambda_i)\right)^2}$$

R', G', B': CMFs of ①,②,③

R, G, B: CMFs of Conventional method

Deviation from Conventional method(average)



Compared with the Simple method, **deviation tends to be smaller for both new methods.**

・The individual’s matching point were as close as possible.

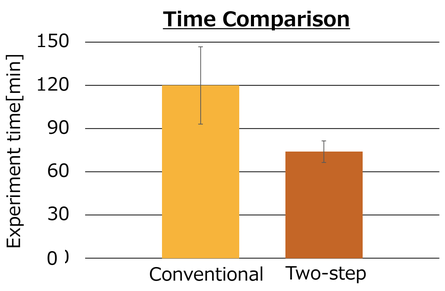
Therefore the method of memorizing seems effective.

✓ Time

Experiment time(average) N=6

Time for the two-step method is slightly longer than for the simple method.

Time Comparison



N=2

Error Bar : SE

・Time for the two-step is about 40% less than the conventional method.

The time is sufficiently shorter than Conventional method.

・There were not much differences in CMFs among three methods. ▶ **The size of the grid was not optimized. If two-step procedure were used, it would not be necessary to use SDs**

・Average value used for the task was constant for every subjects. ▶ **If the color region (color cube) were determined for each subject, the task would be easier, and the experiment could be more efficient.**

・Deviation tends to be smaller even with store function. ▶ **Further improvement would be expected if two methods were merged.**

The two-step procedure has the potential to be a method that balances color matching accuracy and experiment time.

1) Y. Yamauchi, Y. Kamimura and R. Liu, “A simple method for the measurement of the color matching functions”, Optica Fall Vision Meeting, New York, USA(2022)
2) M. Suzuki, Y. Yamauchi, T, Suzuki and K. Okajima, “A Novel method to Measure Color-Matching Functions”, AIC2012(2012)

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