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Original Paper

A Method to Evaluate the Psychological Impression of Color in Welfare Facilities and Hospital Interiors

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Abstract

The aim of this study was to develop objective criteria for the evaluation of the psychological impression of color from welfare facilities and hospital interiors. The "balance point concept" proposed by Moon and Spencer was upgraded and applied to the architectural field. The calculation and analysis were possible due to the current level of computer equipment. To investigate the validity of the concept, experiments were carried out in welfare facilities in Miyagi prefecture. The subjective evaluations were in correlation with the computer measurements, which proves the impact of the selected factor upon human perception.

1. Introduction

The necessity for construction of public facilities such as welfare facilities and hospitals for the aged has increased in an aging society like the Japanese one. The color coordination of architectural interior planning in welfare facilities and hospitals is not systematically carried out, consequently moderate color coordination (soft, warm and calming colors) is apt to be adopted in an actual construction. Our preceding survey of welfare facilities in Miyagi prefecture indicates that a fairly good color coordination actually dominates in welfare architecture (Appendix). However, the psychological impression of the passable color coordination of interior has been unknown. There is the possibility of another color coordination that has a conspicuous combination of complex colors.

Moon and Spencer[1] proposed the balance point concept. According to them, the balance point is important because it gives a measure of the overall color effect. By the choice of a proper balance point the painter can emphasize desired psychological effects. The concept states that for two color patches with areas S_1, S_2 and trichromatic coordinates (X_1, Y_1, Z_1), (X_2, Y_2, Z_2) there is a point in the color space which is representative for the total color effect. The coordinates of the balance point are:

$$X = \frac{X_1S_1 + X_2S_2}{S_1 + S_2}; Y = \frac{Y_1S_1 + Y_2S_2}{S_1 + S_2}; Z = \frac{Z_1S_1 + Z_2S_2}{S_1 + S_2} \quad (1)$$

It is desirable to establish a method for the evaluation of the relationship between the color coordination of the interior and its psychological effect upon the users of a welfare facility or a hospital. In the present paper a method for evaluation of the relation is proposed and some supporting evidence is shown.

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2. Definition of the color balance point

2.1 Concept of the balance point

The proposed method is adequate for artificial environments with soft and moderate color compositions, which supposedly can be found in welfare facilities and hospitals. It extends the concept of Moon and Spencer[1] to computer analysis of interiors using color images.

All forms in the space are represented by their surface colors; they are shaded depending on the illumination and distance. The human eye analyzes these colors and then composes the forms. If we put aside the spatial information, forms and dimensions, we see only surface colors (or color points-pixels, when we look at an image). While our eye studies an interior, it stops at every color spot and gradually all of the composition colors have their impact applied. After the integration of the color information, we can associate it with a single color, a point in the color space.

We suggested that the impression from a given image of architectural space or from the real space is related to this single parameter derived from interior images. In the present thesis, the color balance point will be proposed as one of the measures of the real space color impact.

2.2 Definition of the balance point

The mathematical definition of the balance point is a simple set of equations. The inevitable necessity of using computers makes the task even simpler. The images on the computer monitor are presented by pixels and this is the most detailed information we could obtain. The color of the pixels could be described by the means of CIE-L*a*b* color space, which for the purpose of this thesis is more convenient. For an image consisted of N pixels $p_{(i;j)}$, the balance point $(L^*_m a^*_m b^*_m)$ in L*a*b* system is defined as follows:

$$L^*_m = \frac{1}{N}\sum_{i=1}^{N} P_{L^*(i;j)}; a^*_m = \frac{1}{N}\sum_{i=1}^{N} P_{a^*(i;j)}; b^*_m = \frac{1}{N}\sum_{i=1}^{N} P_{b^*(i;j)} \tag{2}$$

In L*a*b* color space the deviation of the balance point from the "0" mark is a measure of how the color is asymmetrically located from the neutral gray axis. Also it means that in each pair of complementary colors (red-green, blue-yellow), one color overwhelms the other. If in one image the balance point is on the neutral zero axis, that means that the values of the pairs are equal. In a real interior, where the color patches are in sophisticated interrelation, the balance point will be a measure for the color balance. Such an option for color planning can be useful when the architect wants to control the range of color perceptions, which the consumer of the architectural work has. This is especially valid for welfare facilities and hospitals where moderate color compositions are desirable.

3. Human impression survey

In order to clarify the relation between the proposed "balance point" parameter and the human impression from the interior colors of spaces, a measurement of the balance point and a human impression survey have been carried out for a welfare building - Taiwa-town, Health & Welfare Center * (located in

*Designed by International Development Consultants Co., Ltd., Kusuyama Sekkei and Kuniaki Ito. During the design of this building, the color concept was centered around the association with the gray color that could be seen in section of rice field soil, the atmosphere of rich agricultural fields and mountains that surrounds the town. Probably that image has been sunk deeply into the subconscious sphere of thinking and memory of the Taiwa-town people. There was the desire to create a building, whose spaces and colors imply the smell of the indigenous soil. Making this color a keynote, the spaces are differentiated according to their functions.

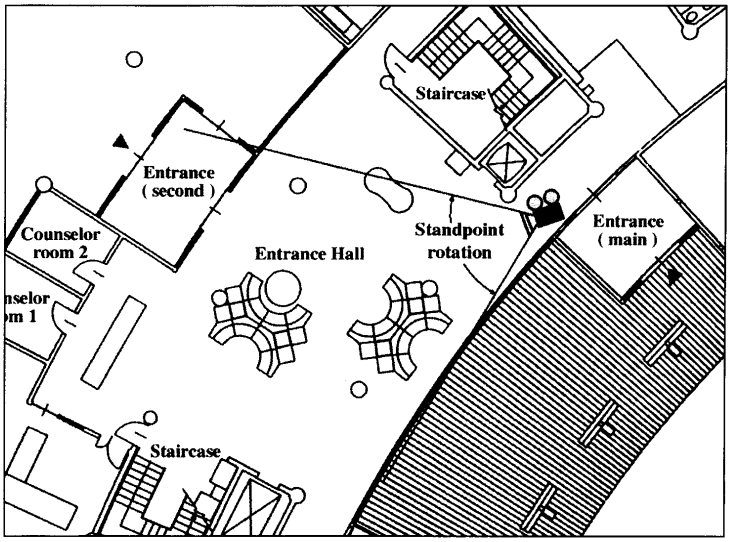

Fig. 1 Recording sequential images by video camera. Scheme

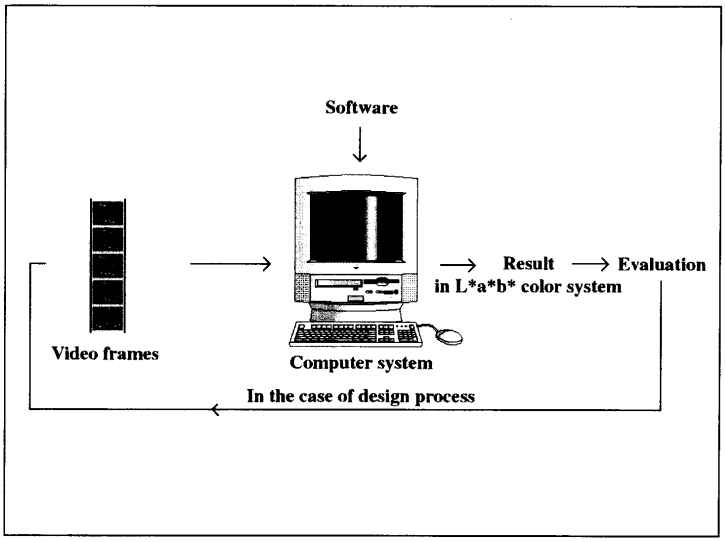

Fig. 2 The process of balance point measurement and analysis

the northern part of Miyagi prefecture).

Three rooms were selected as a target to evaluate the relation between the entrance hall, the relaxation hall and the lecture hall. These spaces were considered to be the core of the center.

3.1 Conditions to calculate the balance point

(1) Taking images

For analysis of real buildings video footage is preferable. The frames follow the logical sequence of a visitor's movement with time specification and there are no selected or arbitrary shots.

In the actual survey, short video segments were taken with nonprofessional video camera. The camera was positioned at key points of the three spaces.

For the entrance hall, for example, a position immediately inside the main entrance of the building was taken as a vantage point (Fig. 1). By rotating the camera, the footage included a panoramic view of the

Table 1 Answers for color impression

	Valid answers	Lightness L*	Hue average a* (g-r)	Hue average b* (b-y)
Entrance hall	33	73.92	7.75	6.9
Relaxation hall	22	80.91	2.94	17.82
Lecture hall	22	67.25	-0.25	3.73

space. Later sequences of frames were extracted (one frame per second) and the digital images (resolution - 640/480) were stored in a computer.

(2) Calculation of the balance point

The balance points of the frames were calculated with image processing software, developed by the authors, that permits access to the color value of the pixels. For the calculations were used the equations as in (2) above. The scheme of the process is shown in Fig. 2.

3.2 Surveying human impression

(1) The experiments questionnaire

The experiment was carried out in June 1999, in Taiwa-town, Health & Welfare Center. The primary question provided for the respondents in the experiment was "What color comes to your mind when you close your eyes and start thinking about the *Relaxation Hall*? Please indicate the color using this color table." Every respondent had to use a standard answer sheet (in Japanese) and a table with 144 chromatic and 12 achromatic color samples, with known coordinates in L*a*b* color space, for choosing answers when asked about the colors.

Concerning the scope of this paper, the question was aimed to clarify if the visitors experience a sensation of the space that is near the balance value calculated for images of the space? After the experiment the answers were turned into computer data and compared with the data obtained from the sequences of frames.

(2) Respondents

There were 38 respondents, office workers, supporting staff and visitors (about half of the visitors who were asked to cooperate, agreed to do so). The group comprised 18 men and 20 women, representing 6 age categories, from under 20 to over 80 years. Additionally, in the first week of July, a group of 11 university students (10 men and 1 woman) participated in the experiment.

Concerning the aged visitors, answers were given orally and filled in by another person. These participants in some cases were not able to give reasonable or any kind of answer, which was considered.

4. Results and discussion

Valid answers for the color impression from the three rooms are shown in Table 1. Fig. 3-6 are the results counted for each room. Because the color impression is represented in L*a*b* color system, it is capable of being counted and plotted on a two dimensional scattergram, with green - red axis (a*) and blue-yellow axis (b*) as in Fig. 3,5,6 or with green-red axis (a*) and lightness axis (L*) as in Fig. 4.

The black rhombus shows the value of the calculated balance point, and the white rhombus is the mean value from the answers given in the questionnaire. Circles represent answers (colors); the size of the circles is proportional to the number of given answers.

Most of the answers, which the respondents selected from the table with color samples are yellowish,

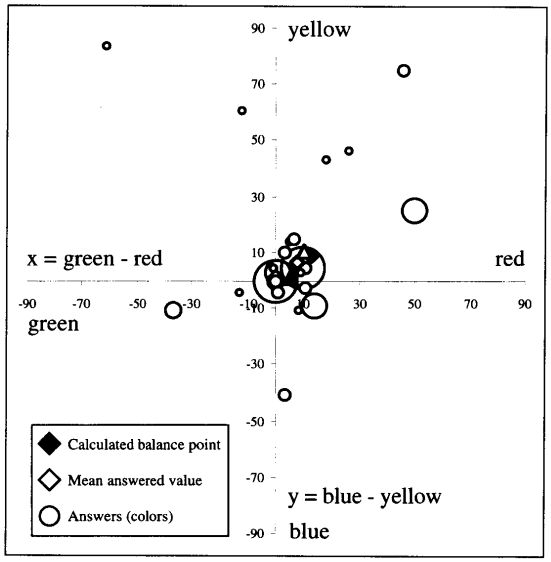

Fig. 3 Distribution of Answers-Entrance Hall (by Hue in L*a*b* System) Each circle means an answered color and the number of answers is expressed by the size of the circle.

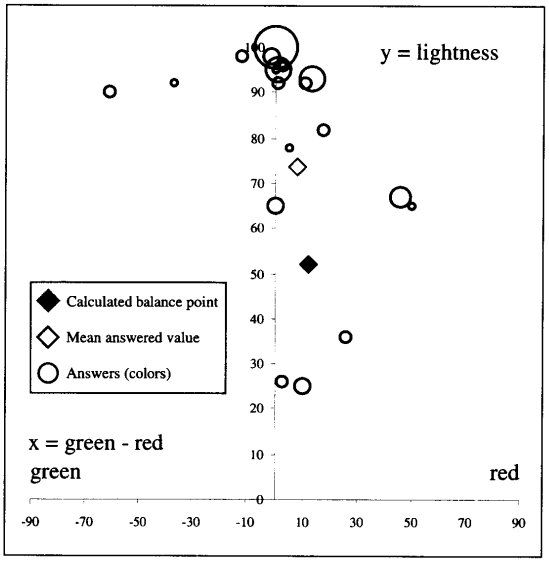

Fig. 4 Distribution of Answers-Entrance Hall (by L* and a* in L*a*b* System) Each circle means an answered color and the number of answers is expressed by the size of the circle.

reddish and brownish grays or different pure grays, which correspond to the calculated values of the color balance points. There are few answers which deviate from the mean stream. Most probably these answers were arbitrary, but even if they are included, it does not change the result in general.

A comparison of Fig. 3 and Fig. 4 shows that the hue of the calculated balance point is a more precise parameter than the lightness of the calculated balance point. The main reason is that the human eye is much more adaptable to the available brightness than any camera.

It is obvious that the measured balance point and the mean of the answers are within the main cluster of given answers, near to each other. That means, when the attention is concentrated on the fact that there is color, not available in the interior, but representing the mixture of all color, it can be determined.

If the scattergram is regarded as a joint probabilistic function, Hotelling's T^2 method could be used in order to verify that the hue of the balance point is a representative value for the answers of color impression. Table 2 shows the calculated F-statistic values (α). The three α values satisfy the 0.05 level of significance

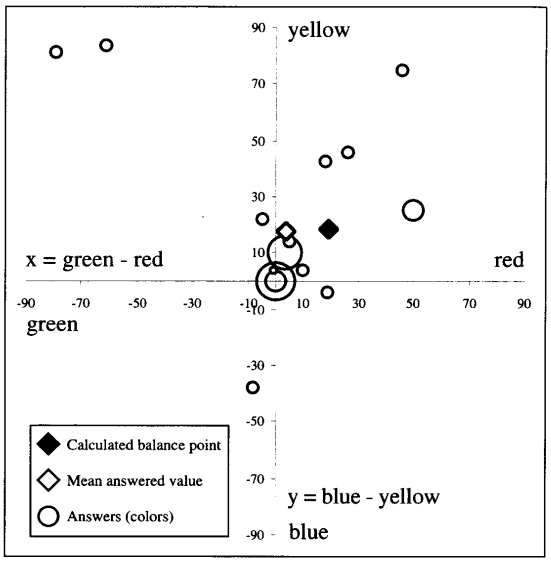

Fig. 5 Distribution of Answers-Relaxation Hall (by Hue in L*a*b* System) Each circle means an answered color and the number of answers is expressed by the size of the circle.

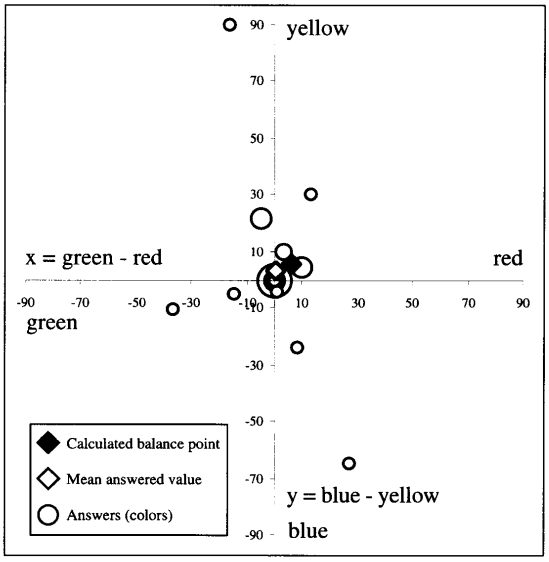

Fig. 6 Distribution of Answers-Lecture Hall (by Hue in L*a*b* System) Each circle means an answered color and the number of answers is expressed by the size of the circle.

routinely used in behavioral sciences[2].

The conclusion is that the experiment in three functionally unrelated spaces of Taiwa-town, Health & Welfare Center shows that the "balance point" truly reflects the impression, directly or indirectly, created by the color environment of the selected rooms. The proposed method for analysis is intended primarily for practical usage, so complicated procedures should be avoided. It should be considered that the subject of this research is difficult to explain only by mathematical means and thus, in any case, it will remain in certain parts subjective: a problem which is intrinsic to human nature. Everybody has his own preferable colors and individual taste for color composition, although there are results showing some dependencies in color preferences[3].

As it was previously mentioned, colors have specific psychological and physiological effects upon humans. The planning of color usage is a powerful tool for architects.

In addition to this, it must be underlined that we do not deny the importance of the scene color

Table 2 T^2 testing result. α: the upper sided α point in F distribution

	F - statistic (α)
Entrance hall	0.235
Relaxation hall	0.054
Lecture hall	0.056

composition, accents, gradations, dominant colors or the fact that the juxtaposition of two colors is an important factor for their perception. We propose that the parameters explained here could be useful if it is applied simultaneously with those which are well known. The reasons are:

1) It is a convenient way to control the balance of colors presented in given interior. Real interiors have sophisticated color compositions consisting of uncountable nuances and it is practically impossible to be done with accuracy without computer; as if, for example, we merely look at the interior or if we see an image of it.
2) Having the color balance point is a starting position to analyze the interior for dark and light balance, spatial orientation and the evaluation of color accents.

5. Conclusion

A simple method of determining the color impression of interior in public welfare buildings was described. It was shown that the "balance point" is related to the human impressions from the rooms in the welfare building. Consequently, the "balance point" concept is capable of approximating the atmosphere of rooms for public welfare buildings, where it has the most adequate application.

6. Acknowledgment

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Appendix

Fourteen welfare facilities in Miyagi prefecture were surveyed[4]. The balance points of at least three spaces in each building were measured. Fig. 7 shows the distribution of the balance points according to

a*b* (Hue) in L*a*b* color system.

It is obvious from the measured color distributions welfare facilities have tendencies to have positive a* value and be lower in saturation. That means this type of buildings has moderate (soft, warm, calming) interior colors.

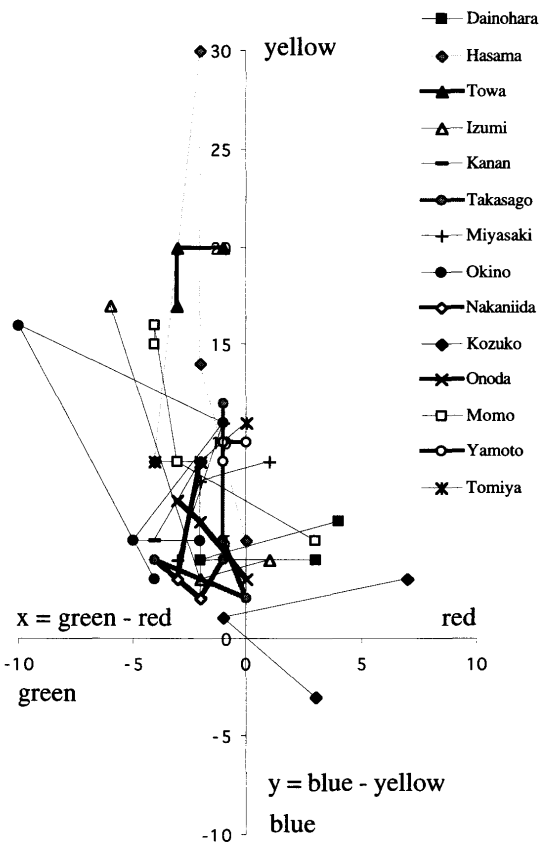

Fig. 7 Distribution of the balance points of welfare facility interiors according to a*b* in L*a*b* color system