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A STUDY ON THE RELATIONSHIP BETWEEN CHILDREN'S DEVELOPMENTAL STAGES AND SENSE OF COLOR

ANALYSIS OF THE CHARACTERISTICS OF COLOR SCHEMES TO COLORING BOOK IMAGES BY IPAD

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ABSTRACT

It is well known that human sensitivity to color and expressive ability varies with age and gender. In addition, the perception, understanding, and comprehension of color vary according to developmental stage and color-related experiences. This study is one approach to research to clarify the relationship between such "sense of color" as above and the developmental stages of children.

In this study, the coloring behavior of teenage subjects; elementary school, junior high school, and university students, to coloring book images were investigated using iPads. The characteristics of coloring and color schemes used in the coloring books were analyzed to explore the relationship with the developmental stages of the children. The coloring book images, mandala-like patterns, used in the investigation were designed originally based on some preliminary investigations. In addition, the original palette of colors systematically arranged in hues and tones was specified to quantitatively analyze the characteristics of the colors used in the coloring book.

The results showed that the hues of colors used with high frequency in coloring books changed as the developmental stage progressed and that the range of tones by the combination of saturation and lightness widened.

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It was also found that the color schemes were simple and easy to understand at younger ages, while the complexity of the color schemes increased as the children grew older.

Keywords: developmental stages, color sense, color scheme, coloring book, color universal design

1 INTRODUCTION

In our recent studies, the methods have been examined to clarify the relationship between children's developmental stage, gender, and other factors and their "sense of color," taking into account their ability to understand and grasp colors, including color placement, as well as their experience and expressive ability (Muraki Asano et al., 2020). Based on the study, our research has been carried out to establish a school environment for "color universal design", taking into consideration that factors related to the formation of color vision in children include perceptual experiences during the growth process, color preferences due to psychological factors, and individual color vision characteristics (Atobe, 1992; Saito et al., 2010).

In this study, we carried out some surveys of elementary school students through university students to clarify the characteristics of color sense, color scheme, and design at each developmental stage, taking the following points into consideration. That is, these characteristics are probably tightly related to the sensory experiences (perceptual experiences) in the living environment. In this study, the same iPad coloring book method as in our recent study (Muraki Asano et al., 2020) was used.

The coloring books employed the design with as low concreteness as possible to avoid preconceptions in this study. Therefore, we analyzed the results as design characteristics, assuming that each image was intentionally constructed while arranging the colors. Furthermore, the purpose of this study was to use the findings of this research as an indicator that can be utilized to create a comfortable color environment for various life situations and spaces in the educational field.

2 METHOD

The method of this study was carried out in the following two phases.

2.1 Preliminary examination

The first phase was intended to determine the design, the color palette to be used for coloring, and the amount of coloring time per child.

Based on the mandala-type design, which is a design with patterns within a circle, used in the previous study (Muraki Asano et al., 2020), four new designs were devised to elicit free ideas from the children in order to investigate their color sense, color scheme, and design. The four designs are: "a circle with curves all facing in one direction," "a circle with curves facing in opposite directions for each layer," "a circle with straight lines all facing in one direction," and "a circle with straight lines facing in opposite directions for each layer," respectively.

To select one of these designs to be used in the next phase; the main examination, we conducted a two-step preliminary survey of 20 respondents (university students) as follows:

First step: The respondents were presented with the above four designs and asked to answer a questionnaire concerning the names of objects and words that come to mind when they see the designs and the time required to fill in the forms. As a result, it became clear that straight lines are more abstract and geometric than curved lines, so we decided to use two types of straight lines (Figure 1) for the coloring pages in the preliminary survey (Design *a* and Design *b*).

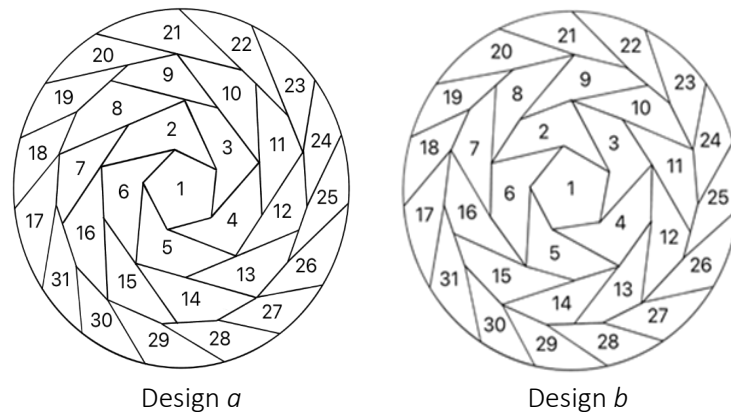


Figure 1. Two presented designs for coloring books focused on the preliminary examination.

Second step: A coloring investigation using iPads was carried out on the respondents. At the same time, we conducted a questionnaire about the coloring book. The color palette used consisted of the 113 colors proposed in the study as mentioned above, with color symbols attached. The actual colors of the color palette are shown in Figure 2. These colors were obtained by systematically varying the colorimetric values. (The application used for creation was ibis Paint X). The coloring time was limited to 2 minutes.

The results show that a higher percentage of the respondents answered that the image of Design *a* was more likely to precede the coloring of Design *b*. Therefore, Design *b* shown in Figure 1, was selected as the final design for this study. In addition, since no problems were found with the number of colors in the proposed color palette, it was decided to adopt it. However, the survey time was changed to 3 minutes based on the results of the questionnaire.

v1	v2	v3	v4	v5	v6	W
v7	v8	v9	v10	v11	v12	ltGy
v13	v14	v15	v16	v17	v18	mGy
lt1	lt2	lt3	lt4	lt5	lt6	dkGy
lt7	lt8	lt9	lt10	lt11	lt12	Bk
lt13	lt14	lt15	lt16	lt17	lt18	
dp1	dp2	dp3	dp4	dp5	dp6	
dp7	dp8	dp9	dp10	dp11	dp12	
dp13	dp14	dp15	dp16	dp17	dp18	
ltg1	ltg2	ltg3	ltg4	ltg5	ltg6	
ltg7	ltg8	ltg9	ltg10	ltg11	ltg12	
ltg13	ltg14	ltg15	ltg16	ltg17	ltg18	
g1	g2	g3	g4	g5	g6	
g7	g8	g9	g10	g11	g12	
g13	g14	g15	g16	g17	g18	
p1	p2	p3	p4	p5	p6	
p7	p8	p9	p10	p11	p12	
p13	p14	p15	p16	p17	p18	

Figure 2. Suggested color palette.

2.2 Main examination

The respondents of the main examination were a total of 187 students (95 males, 92 females), including as follows: 63 fifth-grade students at Hakodate Elementary School attached to the Hokkaido University of Education, 103 third-grade students at Hakodate Junior High School attached to the Hokkaido University of Education, and 21 second-year students at the Hokkaido University of Education Sapporo. Survey period: October to December 2020. The designs used in this study, the color palette, and the amount of time spent coloring per student were as indicated in the preliminary survey described above.

In analyzing the results of this study, a total of 180 respondents (92 males and 88 females), excluding those who painted colors other than those in the specified palette, were considered valid responses and were included in the data analysis.

The results of the previous study, conducted at Sapporo Elementary and Junior High Schools affiliated with the Hokkaido University of Education, were used for comparison and discussion with the results of this study.

3 RESULT

Figures 3(1)-(3) show a summary of the number of respondents who used each color of the palette for coloring by developmental stage. From these results, the colors of the original palette in this study are represented by hues and tones that are close to each other on the PCCS color system and are summarized and analyzed as frequently occurring hues and tones by developmental stage in Figures 4(1)-4(3). This analysis shows that elementary school students frequently use cyan, yellow, and red hues, and that the most frequently used tones are mainly in the bright and clear color groups. The junior high school students showed the same hue

frequency as the elementary school students, but their tones were more dispersed than those of the elementary school students, with the appearance of intermediate colors and dark purplish colors. The hues were more dispersed among university students, and the tone, p (pale), was less frequent than in the other developmental stages.

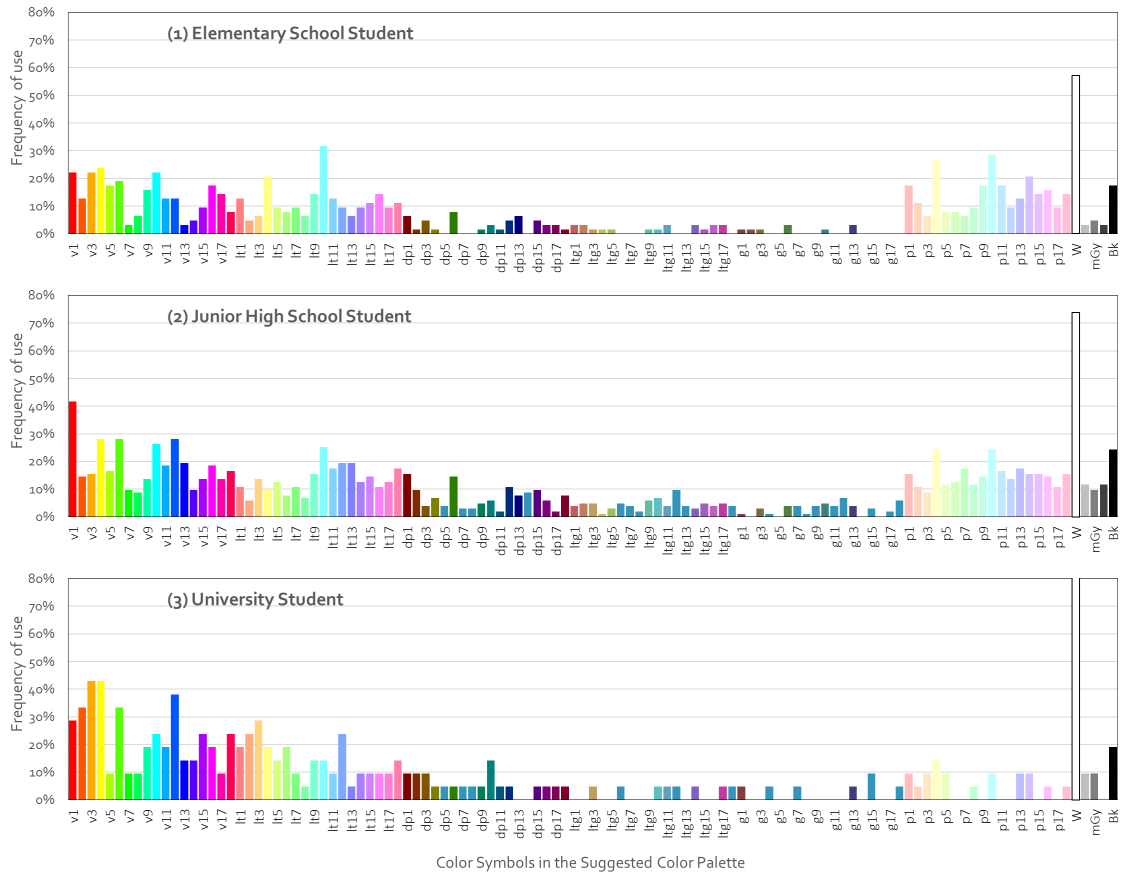


Figure 3. The number of respondents who used each color of the palette by developmental stage.

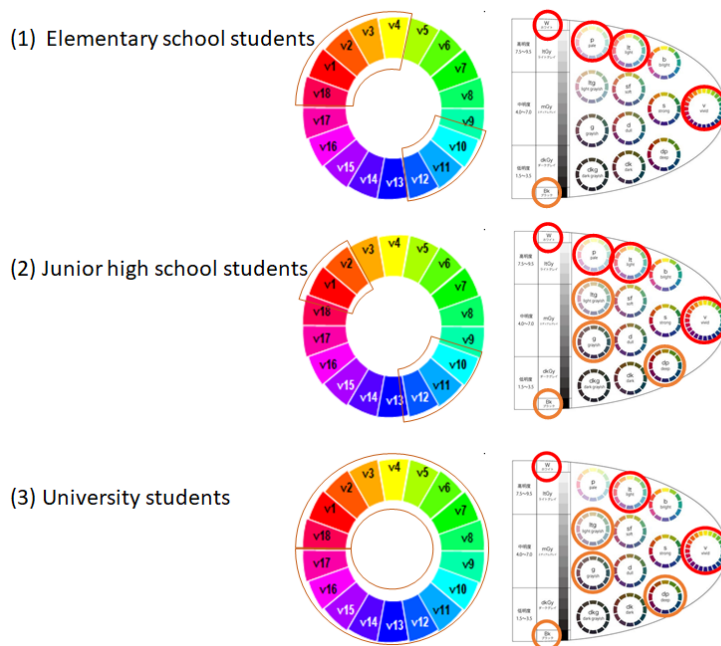


Figure 4. The number of respondents who used each color of the palette by developmental stage.

Hierarchical cluster analysis was conducted on the color position data and CIE L*a*b* values for the coloring book designs, applying the Ward method to the distance between the data. The results are shown in Figure 5 as a dendrogram.

Figure 6 shows the frequency of occurrence of each developmental stage in each of the eight clusters when divided by height=1000. The second cluster is the most common for all developmental stages, while elementary school students are in the fifth cluster, junior high school students in the third cluster, and college students in the first and second clusters. A comparison of the color scheme and design of the coloring books in each cluster revealed differences not only in hue and tone characteristics by developmental stage but also in color placement tendencies.

In various places and facilities in daily life, there are spaces and signs with color schemes that are difficult for children with a diverse color vision to identify (Mizunoya et.al, 2009). This is the same problem that remains even in today's schools, where "color universal design" has been taken into consideration, and it is pointed out that it hinders children's learning. These results indicate that there is a need to reduce these problems and to structure the color scheme and design of teaching materials, teaching tools, and displays so that all children can learn easily.

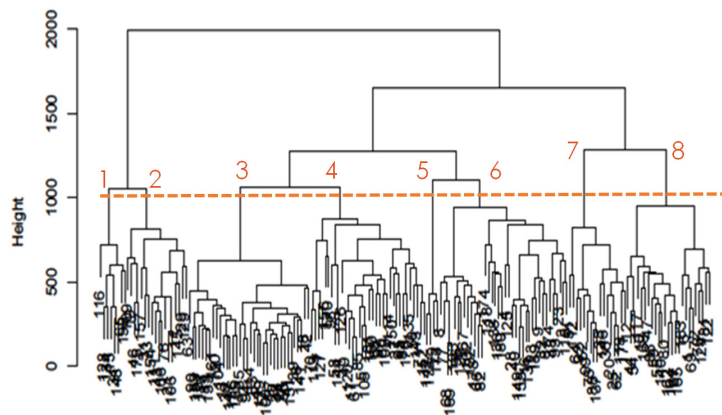


Figure 5. The dendrogram by the Hierarchical cluster analysis and Cluster No.

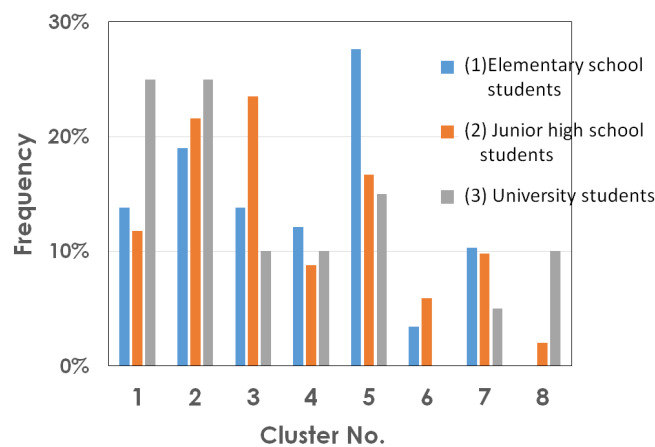


Figure 6. Frequency of each developmental stage in each cluster.

4 SUMMARY

This study shows that, in the elementary school age group, the influence of colors frequently seen in daily life was significant in the process of forming a sense of color. However, as the developmental stage increased, the range of interest in both hues and tones gradually diversified. Furthermore, elementary school students did not show any significant differences in coloring and design tendencies among individuals, and the results of all coloring pictures were similar in design. In contrast, junior high school students showed a great variety in design, which may be related to the fact that they begin to have their own sensitivities and preferences as they reach adolescence. College students tended to use a greater variety of colors, while there was less diversity in color patterns, and they tended to use gradations or some other regularity in the arrangement of colors.

Based on the results of this study, we are making suggestions for educational environments from the viewpoint of how colors used in daily life can be combined and designed to be more effective. For example, we propose the following as basic suggestions; for younger children, consider the diversity of color vision and avoid color schemes that are difficult to identify as much as possible, color schemes should take into account the unique aspect of preference or seasons of the regions they come into contact with on a daily basis; and for adolescents, while considering the diversity of sensibilities, keep in mind color schemes that have a clear purpose for puberty students, color schemes should be designed with a clear objective in mind, while taking into account the diversity of sensibilities.

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