IETI Transactions on Ergonomics and Safety
http://ieti.net/TES/

2019, Volume 3, Issue 1, 38-43, DOI: 10.6722/TES.201907_3(1).0005

AN EXPERIMENTAL STUDY ON THE CERTAIN EFFECTS OF COLORS ON THE PERCEPTION OF PRESCHOOL AND PRIMARY SCHOOL CHILDREN - IMPLICATIONS TO DESIGN

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Abstract The adult ergonomic design principles usually do not apply to children, because their needs, skills, and expectations differ. The purpose of this study is to explore preschoolers' and primary schoolers' color perception and memorization in the context of spatial orientation, in order to explore possibilities of implementation of colors in the design of the school interior. Our experiment involved 80 participants. This study mainly recruited children aged 5 - 9 years as research participants. After the investigation, we found that: (1) Children showed the highest accuracy in memorizing the yellow object (87.5 %), while they had demonstrated the lowest percentage of correct answers when memorizing the blue object (73.8 %); (2) Boys showed a higher accuracy in the perception of colored objects, compared to girls, for all four used colors; (3) Older children (third grade) showed better accuracy in memorizing the targeted properties of used test object of different colors (for all used colors) than younger children. These findings are considered in the context of the design of school equipment and surrounding.

Keywords: Color perception; spatial orientation; preschool children; primary school children; ergonomic design.

1. INTRODUCTION

Colors have a significant influence on the development of the visual system of newborns and children, having also a significant effect on the quality of their perception [1]. Consequently, drawing and coloring are important elements of children's lives. Children can draw and color variety types of pictures in accordance with their developmental levels, using their creativity. It is known that coloring and drawing have certain additional cognitive effects. The activities of coloring and drawing help children overcome distress and anxiety. The picture created by a child reflects the desires and feelings established in the unconscious, and point to the impression of the outside world. The content of the painting often reflects the previous experiences of a child. So, the coloring of a picture can be

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used as a method to express the cognitive reaction of a child in relation to the previously presented stimulus or performed task.

The choice of colors also affects comprehensibility and noticeability of the signs, and memory of warning messages [2-3]. The use of colors in the design of signs often do not show gender preference. It is thus questionable whether the gender difference should be considered as a factor of the influence in connection with color preferences in other areas of designing.

The main goal of this research is to explore whether the choice of color can have an effect on the memorization of objects in space. In connection with that, it should be considered differences regarding the gender and age of children. In addition, it is interesting to find possible solutions concerning the use of colors in designing various elements of school equipment.

2. METHODOLOGY

The research sample consisted of 80 children. Of the total number of the respondents, 44 (55%) were females and 36 (45%) males. The sample is comprised of several groups: preschool children (aged from 5 to 6 years); children attending primary school, from the first (aged from 6 to 7 years), second (aged from 7 to 8 years) and third grade (ages from 8 to 9 years).

For the purposes of testing, four identical boxes in shape and size were used. Dimensions of the boxes were: height 30 cm, length 40 cm and width 35 cm. The boxes were red, green, yellow and blue color. Before conducting the experiment, the layout of the building was analyzed, so four mentioned boxes were arranged in four different positions in the school building. The boxes were placed in the hallway of the building. The examiner informed the participants about the test. The subjects were expected to remember the color of each of the boxes, in the context of their positions. Once they have confirmed that all the instructions were completely understood, the children were taken on the experiment route accompanied by examiners. On this walk, their task was to look around in order to pay attention to some details in the building, as well as to the color of the boxes. The respondents did not have to search for a particular box. The examiner insisted that the subject stay a few seconds near each of the boxes and to touch each of them. Upon completion of the tour, the tester and the child went to the separate room, from which the position of the boxes in the hallway could not be seen.

According to the protocol, participants received a piece of A4 paper, with boundaries of the corridor and locations of all four boxes drawn. The task was to paint the boxes with different colors, based on the respective positions of the boxes in space. Respondents had available four crayons: red, green, blue and yellow (in accordance with the color of the boxes used). Time to perform this task was not limited, as in the research of Trifunović et al. [4].

After the completion of the task, the children's drawings were analyzed quantitatively. The accuracy of the coloring of the box was analyzed. For example, a box which the respondent first passed next to,

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while walking down the hall, was yellow. If the child colored it in red, the resulting input is designated as yellow-red. This has been considered as an error and indicates which colors the respondent confuse with the original color of the box.

3. RESULTS AND ANALYSES

Statistical analysis was performed by the statistical software package IBM SPSS Statistics v. 22. Based on the results of descriptive statistics and cross-tabulation it was presented the basic statistical analysis of data obtained in the experiment. Normality distribution was tested by inspection of histograms and the Kolmogorov-Smirnov test. As the Kolmogorov-Smirnov test has determined that results do not significantly deviate from a normal distribution, the decision was to use Student's T-test and ANOVA. Dunnett's T3 Post Hoc test has been used for additional comparison. All tests were carried out based on the recommendations of the textbook "SPSS Survival Manual" [5]. The threshold of statistical significance (α) is set at 5%.

3.1. Descriptive Statistics

The accuracy in choosing the appropriate color of boxes is shown in Figure 1. Children showed the highest accuracy in painting for yellow boxes (87.5%), while they had demonstrated the lowest percentage of correct answers when coloring the blue boxes (73.8%).

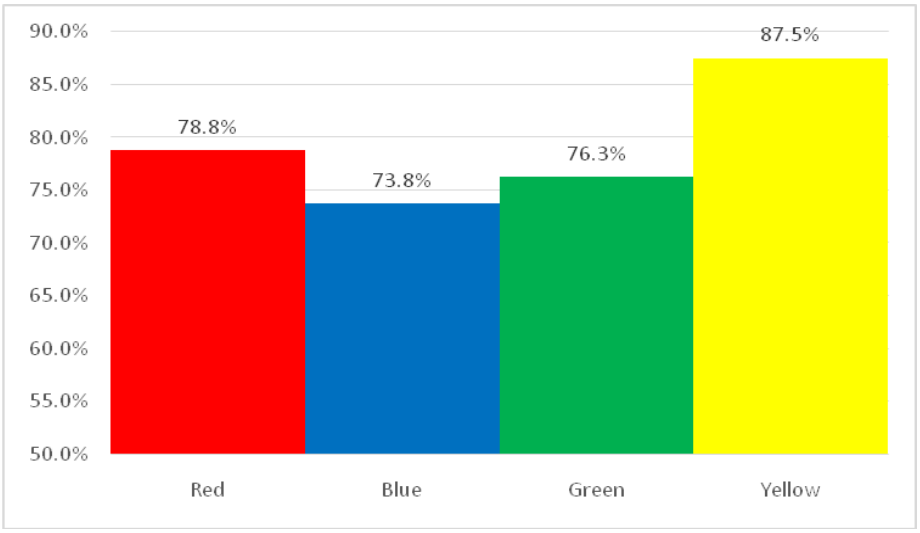

Fig. 1. The percentage of correct answers (of all participants).

If errors in coloring occurred, it was examined which colors were mixed with each other (e.g., the child could paint the red box with blue, yellow or green colored pencils, all referred to as the wrong answer, Table 1.). In general, the worst results have been shown for dyeing the blue boxes, which were usually mixed with yellow, red (in both cases 2.5%) and green (20%).

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Table 1. Errors in painting the boxes of various colors (mixing of the real color of the certain box with other colors).

a) Errors connected with the yellow box				b) Errors connected with the green box			
Yellow	Green	Blue	Red	Yellow	***Green***	Blue	Red
/	5.0%	5.0%	10.0%	7.5%	/	17.5%	2.5%
c) Errors connected with the blue box				**d) Errors connected with the red box**			
Yellow	Green	***Blue***	Red	Yellow	Green	Blue	***Red***
2.5%	20.0%	/	2.5%	10.0%	2.5%	2.5%	/

3.2. Age Differences

In a certain extent, age differences have been reflected in the ability to choose the appropriate color in the boxes coloring task (Table 2). Preschool children showed the highest precision in dyeing the green boxes (75.0%), the first-grade children achieved the highest score for blue boxes, while the second grade realized the highest accuracy for yellow boxes. The oldest group showed the best performance (with no errors on coloring task).

Table 2. The reflection of age differences on the percentage of accurate responses for different colors.

%	Red	Blue	Green	Yellow
Preschool	45.0%	55.0%	75.0%	70.0%
First grade	83.3%	94.4%	83.3%	88.9%
Second grade	86.4%	50.0%	50.0%	90.9%
Third grade	100.0%	100.0%	100.0%	100.0%

Table 3. Significant differences in performance between age groups for all four investigated colors.

	Preschool	First grade	Second grade	Third grade
Preschool	/	Blue*	Red*	Blue* Red*
First grade	Blue*	/	Blue*	No
Second grade	Red*	Blue*	/	Green* Blue*
Third grade	Blue* Red*	No	Green* Blue*	/

* - Statistically significant differences (Post hoc Dunnett's T3 tests)
No – No statistically significant differences (Post hoc Dunnett's T3 tests)

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For the determination of the existence of possible differences between age groups in terms of the accuracy of the completion of the task, the series of one-way ANOVA tests were realized. Post hoc Dunnett's T3 tests ($p < .05$) revealed the certain differences in performance depending on age of subjects, for red ($F = 8.443$; $p < 0.001$), green ($F = 5.902$; $p < 0.001$) and blue ($F = 9.100$; $p < 0.01$) color, except for yellow. Significant differences in the accuracy of the execution of the task between age groups for all four investigated colors are shown in Table 3.

3.3. Gender Differences

Taking into account the gender, the accuracy in choosing the appropriate color for painting the boxes is shown in Figure 2. Boys showed the highest accuracy for the yellow color of boxes (94.4%). Also, for the yellow and red boxes, girls showed the highest accuracy (81.8% and 75.0%, respectively). Boys showed better performance than girls in coloring the boxes, for all of the four investigated colors, but these differences failed to reach statistical significance.

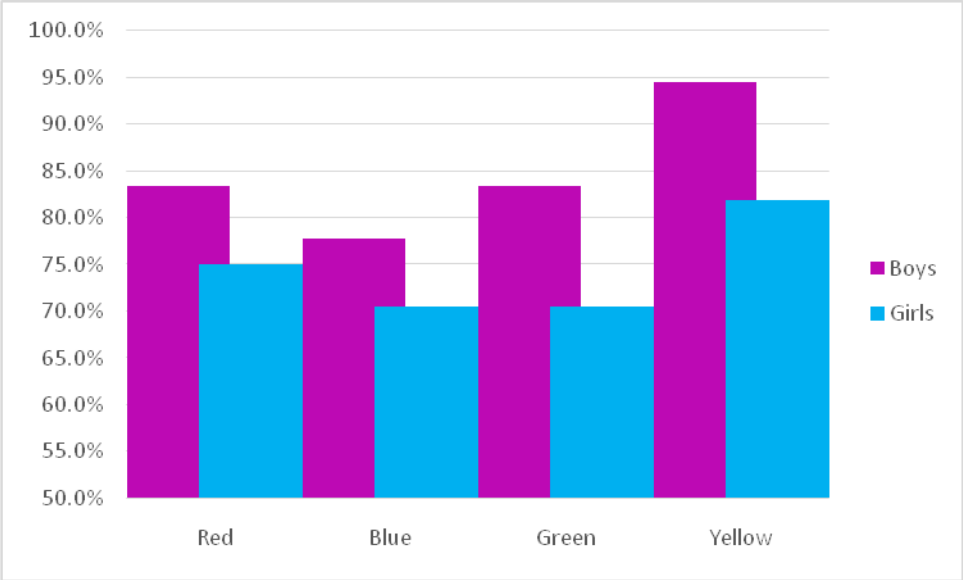

Figure 2. Gender differences in the percentage of correct answers.

4. CONCLUSION

Based on the data collected and the analysis conducted in this research, several conclusions can be derived:

• Children showed the highest accuracy when the yellow color was used for objects - boxes (87.5%), while they demonstrated the lowest percentage of correct answers regarding the blue boxes (73.8%);

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• Boys showed better performance than girls in the task with four used colors of boxes, for all investigated colors, but these differences failed to reach statistical significance;

• The results indicate that older children (third grade) show better accuracy in memorizing the colors of the object (for all four colors) than younger children.

It is interesting to consider these findings in the context of the design of school equipment and environment. According to the results, it seems that colors of objects do not have obvious influence on memorization of objects for third-grade children. Since the objects in the experiment differed only in color, it can be concluded that yellow color attracts the attention of young pupils (second grade and below) more than RGB colors, and has a positive impact on the memorization. In accordance with that, for design purposes, the yellow color can be used for objects that should attract pupils attention. For example, the desk for a teacher could be colored in yellow.

It can be noticed that the worst result has been achieved for the blue color. It is interesting that newborns also have difficulties in the perception of blue color [1]. However, the third-grade pupils, as previously mentioned, did not have difficulties with the perception of blue color. In general, in accordance with the results presented, yellow and red color can be used for objects that should attract the attention of pupils, while green and blue color could be used for coloring the objects and the environment that require less attention.

Acknowledgments

This study was supported by The Ministry of Education, Science and Technological Development of Serbia (projects 36027, 36022 and 36006).

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