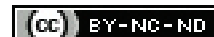


# Effect of Colours on Perception and Cognition of Students Belonging to Two Different Age Groups: A Cross-sectional Study

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## ABSTRACT

**Introduction:** Colour is believed to stimulate senses. It improves the attention span and helps in developing cognitive abilities and hence, can be beneficial in the educational set-up. There is a void in literature about usefulness of colours in the education settings in India.

**Aim:** This study was conducted to assess students' preference, perception, emotional responses, memory, and cognition related to colours.

**Materials and Methods:** A cross-sectional study conducted over a period of two months (January-February 2018) comprised of 300 students divided into two equal groups: Group A with 13 to 18 years of age, Group B with 19 to 25 years of age. On four consecutive days, both the groups were exposed to the same power point slide with some words highlighted with a single colour (red: material related to discovery of earth's polarity, blue: material

related to arbovirus, yellow: material related to pathophysiology of diabetes mellitus, or green: material related to Mangalyan). At the end of the fourth session, a validated questionnaire was used to evaluate the students' perceptions and responses to various colours. The data were analysed using R software v 3.6.1. The Kruskal-Wallis test was used to find significant differences within the group,  $p < 0.05$ .

**Results:** In group A, the highest mean preference was observed for the colour red (mean =  $8.02 \pm 2.83$ ;  $p = 2.20 \times 10^{-16}$ ), blue was found to be a soothing colour ( $n = 65$ ) and yellow helped in better recollection of facts ( $n = 44$ ). In contrast, in group B, the highest mean preference was observed for the colour blue (mean =  $8.35 \pm 3.59$ ;  $p = 5.90 \times 10^{-15}$ ). Yellow was considered a more soothing colour ( $n = 43$ ), and black helped in better recollection ( $n = 41$ ).

**Conclusion:** Colour perception varies in different age groups. It also affects emotions, memory, and influences mood disposition.

**Keywords:** Attention, Education system, Emotions, Senses

## INTRODUCTION

Colour is a visual enhancement element that is vital in improving the learning process [1]. It is known that visual stimulation through colour helps in improving the attention span, developing cognitive abilities and in refreshing one's perception. Finding an appropriate colour for educational settings is complex as it involves personal preferences, perceptions and differences in emotional response [1].

Human memory is stimulated by different contrasting values of colour [2]. Colours have been proven to be effective in patients with dyslexia and autism as it helps in minimising reading difficulties [3,4]. Colours are instrumental in regulating emotions/mood. Light reflected from coloured objects is converted into electrical impulses by the retina and relayed to the brain that governs our hormones and endocrine system and in turn affects various aspects of cognition and perception [5].

Educators also use different colours to improve learning outcomes. It has been noticed that red ink is conventionally used by teachers to check assignments. It is done to draw an individuals' attention towards their errors. Red is perceived to be a threatening colour but also makes one apprehensive and improves the learning outcome, in that it reduces the repetition of errors [6]. Colours, therefore, have a significant role to play in the educational set up [7].

In the educational setting, high demands are placed on students for academic excellence. There needs to be strategies to enhance cognitive abilities which in turn will facilitate the learning process. It has been seen in the study conducted by Olurinola O and Tayo O, that colour helped in increasing retention rate of learners [7]. Studies on the usefulness of colour in educational settings in India are few [6,8]. Therefore, the study was conducted to assess colour preferences and perception, emotional responses towards colours and colours related to memory and cognition in different age groups in India.

## MATERIALS AND METHODS

A cross-sectional study was conducted on 300 subjects over a period of two months (January 2018 to February 2018), following approval by the Institutional Ethics Committee (DMCK/148/2018, 14/05/2018). The study was conducted among students from Shantiniketan School (CBSE), Kolhapur, Maharashtra and DY Patil Medical College, Kolhapur, Maharashtra, India. Assent was taken from students between the age of 13 to 18 years and consent from students between 19 and 25 years. Assent was signed by students along with the guardian teacher.

**Inclusion criteria:** Students between the age group of 13-25 years and willing to participate in the study were included.

**Exclusion criteria:** Students with learning or memory related disorders were excluded.

**Sample size calculation:** Participants were divided into two groups according to age (Group A-13 to 18 years, Group B-19 to 25 years;  $n = 150$  each). Considering  $\alpha = 5\%$ ,  $\beta = 20\%$ , power = 80% the sample size was calculated as 150 for each group.

Two groups of students were shown the same presentation at different session. In four consecutive days, both groups were exposed to the same power point slide some words highlighted with a red, blue, yellow and green colours respectively. Different colours, red: material related to discovery of earth's polarity, blue: material related to arbovirus, yellow: material related to pathophysiology of diabetes mellitus, or green: material related to Mangalyan were used for the slides and were displayed for 15 minutes. At the end of the fourth session, a validated questionnaire was used to collect the data (Annexure). The sessions were conducted in the morning for two hours; to maintain uniformity in both groups and to avoid any kind of cognitive bias.

## Study Tool

The questionnaire tool was validated by six experts from various departments of the tertiary care hospital. The final questionnaire consisted of 20 questions regarding colour preference, perception, emotional responses as well as memory and cognition related questions. The colour black was also given as an option apart from red, blue, yellow, and green. The questionnaire included both close-ended and open-ended questions.

## STATISTICAL ANALYSIS

The data were analysed using R software version 3.6.1. Colour preferences, perception, emotional response as well as memory and cognition related colours were represented using frequency distribution. A minimum Content Validity Ratio (CVR) value of 0.99 was considered the cut-off value to retain an item in the proforma [9]. Colour preference based on age group was represented using mean $\pm$ SD. The Kruskal-Wallis test was used to find significant differences among colours within the group. The p-value <0.05 was considered statistically significant.

## RESULTS

The mean age of students in group A and group B were 15.2 $\pm$ 2.5 years, 21.5 $\pm$ 3.0 years, respectively. In Group A, red appeared to be the most attention-grabbing colour (26.0%). Yellow was the colour that helped in better recollection of facts in 29.33% of the study sample [Table/Fig-1].

| Questions                                   | Colour preferences |            |            |            |            |
|---|--------------------|------------|------------|------------|------------|
|   | Red                | Blue       | Green      | Yellow     | Black      |
|   | n (%)              |            |            |            |            |
| Colour you like more                        | 8 (5.33)           | 70 (46.67) | 13 (8.67)  | 43 (28.67) | 16 (10.67) |
| Bedroom wall colour                         | 33 (22.0)          | 46 (30.67) | 18 (12.0)  | 41 (27.33) | 12 (8.0)   |
| Attention grabbing colour                   | 39 (26.0)          | 38 (25.33) | 15 (10)    | 32 (21.33) | 26 (17.33) |
| More soothing colour                        | 11 (7.33)          | 76 (50.66) | 19 (12.66) | 19 (12.66) | 25 (16.66) |
| Colour which increases appetite             | 46 (30.67)         | 26 (17.33) | 26 (17.33) | 34 (22.67) | 18 (12)    |
| Colour which better defines personality     | 18 (12.0)          | 60 (40.0)  | 15 (10.0)  | 35 (23.33) | 22 (14.67) |
| Clothing colour                             | 25 (16.67)         | 38 (25.33) | 21 (14)    | 33 (22)    | 33 (22)    |
| Colour which makes feeling calm and relaxed | 26 (17.33)         | 47 (31.33) | 26 (17.33) | 39 (26)    | 12 (8)     |
| Captivating colour                          | 28 (18.67)         | 47 (31.33) | 20 (13.33) | 30 (20)    | 25 (16.67) |
| Colour which helps in better recall         | 16 (10.67)         | 36 (24.0)  | 16 (10.67) | 44 (29.33) | 38 (25.33) |

**[Table/Fig-1]:** Distribution of colour preferences based on age group (Group A: 13 to 18 years).

In group B, Blue appeared to be the most attention grabbing colour (30.67%) and was also considered as a captivating colour by 43.33% of the subjects. Black was the colour that helped in better recollection of facts (27.33%) [Table/Fig-2].

| Questions                               | Colour preferences |            |            |            |            |
|---|--------------------|------------|------------|------------|------------|
|   | Red                | Blue       | Green      | Yellow     | Black      |
|   | n (%)              |            |            |            |            |
| Colour you like more                    | 35 (23.33)         | 44 (29.33) | 8 (5.33)   | 31 (20.67) | 32 (21.33) |
| Bedroom wall colour                     | 11 (7.33)          | 63 (42.0)  | 22 (14.67) | 43 (28.67) | 11 (7.33)  |
| Attention grabbing colour               | 33 (22)            | 46 (30.67) | 10 (6.67)  | 25 (16.67) | 36 (24)    |
| More soothing colour                    | 29 (19.33)         | 41 (27.33) | 23 (15.33) | 43 (28.67) | 14 (9.33)  |
| Colour which increases appetite         | 21 (14)            | 53 (35.33) | 22 (14.67) | 43 (28.67) | 11 (7.33)  |
| Colour which better defines personality | 25 (16.67)         | 47 (31.33) | 9 (6)      | 27 (18)    | 42 (28)    |
| Clothing colour                         | 22 (14.67)         | 42 (28.0)  | 40 (26.67) | 30 (20)    | 16 (10.67) |

|   |            |            |            |            |            |
|---|------------|------------|------------|------------|------------|
| Colour which makes feeling calm and relaxed | 22 (14.67) | 48 (32.0)  | 12 (8.0)   | 30 (20)    | 38 (25.33) |
| Captivating colour                          | 7 (4.67)   | 65 (43.33) | 22 (14.67) | 40 (26.67) | 16 (10.67) |
| Colour which helps in better recall         | 33 (22.0)  | 35 (23.33) | 9 (6.0)    | 32 (21.33) | 41 (27.33) |

**[Table/Fig-2]:** Distribution of colour preferences based on age group (Group B: 19 to 25 years).

Among group A participants, most of the students felt that colour was related to mood and emotions (78%). Maximum students felt that colour plays an important role in memorising things (67%). Colours were found to be the most memorable aspect in advertisements or commercials among group A study subjects (89%) [Table/Fig-3].

| Questions  | Agree |     | Disagree |    |
|--|-------|-----|----------|----|
|  | n     | %   | n        | %  |
| Do you think children love to read from the books that are coloured and have illustrations and diagrams? | 150   | 100 | 0        | 0  |
| Do you think coloured diagrams drawn in exams fetch more marks than students who don't draw diagrams?    | 83    | 55  | 67       | 45 |
| Do you think colour affect your mood?  | 114   | 76  | 36       | 24 |
| Does the colour of the cloths of the person talking to you affect your mood or attitude towards them?    | 86    | 57  | 64       | 43 |
| Do you think the colour of the question paper affect student's ability to think?                         | 71    | 47  | 79       | 53 |
| Do you think colours are gender oriented?  | 37    | 25  | 113      | 75 |
| Do you think colour affects taste or appetite?   | 66    | 44  | 84       | 56 |
| Do you think colour is related to mood and emotions?   | 117   | 78  | 33       | 22 |
| Do you think colour plays an important role in memorising things?  | 101   | 67  | 49       | 33 |
| Do you think the most memorable thing in advertisement or commercials is colour?                         | 133   | 89  | 17       | 11 |

**[Table/Fig-3]:** Proportion of agree and disagree according to different questions (Group A: 13 to 18 years)

Among group B participants, most of the students felt that colour was related to mood and emotions (96%). Many students felt that Colours play an important role in memorising things (69%). Colours were found to be the most memorable aspect of advertisements or commercials among group B study subjects (71%) [Table/Fig-4].

| Questions  | Agree |     | Disagree |    |
|--|-------|-----|----------|----|
|  | n     | %   | n        | %  |
| Do you think children love to read from the books that are coloured and have illustrations and diagrams? | 150   | 100 | 0        | 0  |
| Do you think coloured diagrams drawn in exams fetch more marks than students who don't draw diagrams?    | 83    | 55  | 67       | 45 |
| Do you think colour affect your mood?  | 114   | 76  | 36       | 24 |
| Does the colour of the cloths of the person talking to you affect your mood or attitude towards them?    | 86    | 57  | 64       | 43 |
| Do you think the colour of the question paper affect student's ability to think?                         | 54    | 36  | 96       | 64 |
| Do you think colours are gender oriented?  | 15    | 10  | 135      | 90 |
| Do you think colour affects taste or appetite?   | 96    | 64  | 54       | 36 |
| Do you think colour is related to mood and emotions?   | 144   | 96  | 6        | 4  |
| Do you think colour plays an important role in memorising things?  | 104   | 69  | 46       | 31 |
| Do you think the most memorable thing in advertisement or commercials is colour?                         | 106   | 71  | 44       | 29 |

**[Table/Fig-4]:** Proportion of agree and disagree according to different questions (Group B: 19 to 25 years).

There was a statistically significant difference among Cognition/Recall Memory of Colour Preference in group A, with the highest mean value for red colour (mean=8.02±2.83;  $p=2.20e^{-16}$ ) [Table/Fig-5].

There was a statistically significant difference among Cognition/Recall Memory of Colour Preference in group B, with the highest mean value for blue colour (mean=8.35±3.59;  $p=5.90e^{-16}$ ) [Table/Fig-6].

| Colour | Mean±SD   | p-value |
|--------|-----------|---------|
| Blue   | 6.62±2.81 | <0.0001 |
| Green  | 6.43±3.02 |         |
| Yellow | 3.5±2.45  |         |
| Red    | 8.02±2.83 |         |

**[Table/Fig-5]:** Cognition/Recall Memory of Colour preference based on age group (13-18 years).

\* $p \leq 0.05$  was considered statistically significant, Kruskal-Wallis Test used

| Colour | Mean±SD   | p-value |
|--------|-----------|---------|
| Blue   | 8.35±3.59 | <0.0001 |
| Green  | 7.24±2.9  |         |
| Yellow | 5.39±2.8  |         |
| Red    | 6.07±3.13 |         |

**[Table/Fig-6]:** Cognition/Recall Memory of Colour preference based on age group (19-25 years).

\* $p \leq 0.05$  was considered statistically significant; Kruskal-Wallis test used

## DISCUSSION

Colour has a profound effect on our mood and behaviour. It impacts our emotional state, cognition, memory, and general disposition and has an impact on almost every aspect of our being. Given the powerful influence of colour on an individual and on the community, it would be prudent to utilise the impact of colour on the human mind, especially in an educational set-up where the human mind is trained and tuned. In the educational setting, the utilisation of cognitive abilities by students is very important and may contribute to better academic achievement [10]. Hence, it is important to understand the influences of colour on learning and what colours are best for specific age groups [7]. Thus, the study aimed to evaluate the perception and effect of colour on cognition in various age groups.

Variations in the preferences and perceptions were observed in both the groups. Differences could be explained by the fact that as the individual gets older, his/her preferences change based on their life experiences [11].

In the 13-18 years age group highest mean was observed for the colour red. This can be ascribed to the longer wavelength of red; and hence is perceived to be stimulating, lively and friendly [12,13]. In contrast, in the 19-25 years age group, the highest mean was observed for the colour blue. This can be ascribed to different amounts of irradiance from 440 nm to 490 nm [14]. Hence, blue colour is perceived to stimulate intellectual activity, reason and logical thought that develops as the individual grows older [12].

In group A, blue was perceived as a soothing colour. In the state of relaxation, blue stimulates the alpha band in the occipital areas [14]. It is often associated with openness, peace and tranquility [15]. On the contrary, in group B, yellow was perceived as the more soothing colour. This can be attributed to changes in the oxygenated haemoglobin ( $O_2Hb$ ) and deoxygenated haemoglobin ( $Hb$ ) concentrations in the Left Prefrontal Cortices (L-PFC) [16]. It is often perceived as the colour that lets the sunshine in [5].

The colour that increased appetite was red in group A. In contrast, in group B, blue colour was found to be appetite stimulating. Students in group B agreed that colour affected taste/appetite and this has been studied in previous literature as well [17,18]. This can be ascribed to hormones that are released in the brain, when colour perception is transmitted from the eye to the brain. In turn, colours are used to "level out" emotions or to create different moods [5]. Colours could thus be used to stimulate or reduce appetite and

could play a significant role in weight management issues among adolescents. Blue is the colour of intellect and stimulates clear thoughts [19]. It was perceived as the colour which defines the participants' personality among both the groups.

In both groups, blue was the preferred colour for dressing and made them feel calm. Participants in both groups agreed that their mood was affected by colour, as observed in previous literature [20]. Their attitude was also affected by the clothes' colour of other people. This can be ascribed to the fact that colour is an essential part of our lives and its existence is seen in everything that we perceive. Hence, colour has a profound effect on our feelings and expressions [21].

Among group A students, red was the most attention-grabbing colour. In contrast, in group B, blue was considered the most attention-grabbing colour. The most captivating colour among both the groups was the colour blue. Among group A students, the colour yellow helped in better recollection of facts. In contrast, in group B, the colour black helped in better recollection. Participants in both the groups agreed that children love to read from coloured books and also felt that coloured diagrams fetched more marks in exams. Students in both the groups agreed that colours helped in memorising better as observed in previous studies [22]. This could be explained by the fact that colour draws on cognitive powers to influence learning, facilitating memorisation and identification of concepts. It also affects the way we perceive and process information and can upgrade our ability to recall both words and pictures [23-25].

Students also felt that the most memorable aspect of advertisement and commercials are colours as seen in previous studies as well [26,27]. This can be attributed to the fact that colours can evoke perceptual and emotional responses in consumers and influence their behaviour [28,29].

## Limitation(s)

Limitations of the study include the fact that colour perception based on gender, age wise stratification within the group was not assessed and provides scope for further research in the arena.

## CONCLUSION(S)

Colour perceptions/cognition varies among different age groups of students. Colour has the potential to transmit the stimuli to a more permanent state in the memory of students. Colour is perceived to help in memorisation of facts and its integration in papers, books and presentations can improve cognition and learning outcomes among students of all age groups.

**Authors contribution:** Design and conception: SGL, ARG; Collection and gathering of data: SGL, ARG; Clinical monitoring and laboratory detection: SGL, ARG; Data analysis and interpretation: SGL, ARG; Manuscript preparation: SGL ARG; Approval of Manuscript: All authors.

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## QUESTIONNAIRE

### D.Y. PATIL MEDICAL COLLEGE, KOLHAPUR

#### Annexure

Effect of Colours on Perception and Cognition of Students belonging to two different age groups 13-18 and 19-25 years.

This study provides us meaningful insight to the use of Colour in increasing retention rate of learners, especially adult learners. The questions are to introspect the Effect of Colours on Perception and Cognition of Students belonging to two different age groups 13-18 and 19-25 years.

| Sr. No. | Questions   | Red | Blue | Green | Yellow | Black |
|---------|---|-----|------|-------|--------|-------|
| 1       | Which colour out of these do you like more?   |     |      |       |        |       |
| 2       | What colour out of these would you like the walls of your bedroom to be?  |     |      |       |        |       |
| 3       | Which colour out of these according to you attracts or grabs more attention?  |     |      |       |        |       |
| 4       | Which out of these colour is the most soothing colour according to you?   |     |      |       |        |       |
| 5       | Which colour out of these do you think increases appetite?  |     |      |       |        |       |
| 6       | If you were asked to relate yourself to the colours, which colours out of these do you think suits you or describes you the best? |     |      |       |        |       |
| 7       | What colour of cloths out of these do you generally like to wear?   |     |      |       |        |       |

|    |  |  |  |  |  |  |
|----|--|--|--|--|--|--|
| 8  | Which colour out of these makes you feel calm and relaxed?   |  |  |  |  |  |
| 9  | Which colour out of these do you think is captivating?   |  |  |  |  |  |
| 10 | Which colours out of these helps you for better recall?  |  |  |  |  |  |
| 11 | Do you think children love to read from the books that are coloured and have illustrations and diagrams? |  |  |  |  |  |
| 12 | Do you think coloured diagrams drawn in exams fetch more marks than students who don't draw diagrams?    |  |  |  |  |  |
| 13 | Do you think colour affect your mood?  |  |  |  |  |  |
| 14 | Does the colour of the cloths of the person talking to you affect your mood or attitude towards them?    |  |  |  |  |  |
| 15 | Do you think the colour of the question paper affect student's ability to think?                         |  |  |  |  |  |
| 16 | Do you think colours are gender oriented?  |  |  |  |  |  |
| 17 | Do you think colour affects taste or appetite?   |  |  |  |  |  |
| 18 | Do you think colour is related to mood and emotions?   |  |  |  |  |  |
| 19 | Do you think colour plays an important role in memorising things?  |  |  |  |  |  |
| 20 | Do you think the most memorable thing in advertisement or commercials is colour?                         |  |  |  |  |  |