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THE GAMUT OF HUES
A STUDY ON THE INFLUENCE OF COLORS ON TYPICALLY DEVELOPING CHILDREN

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Abstract
Colours are an inevitable part of life and may even have a deep, lesser-explored impact on individuals. They alter the way we see, attend to, and perceive stimuli in our surroundings. They enable us to express and understand, thus comprising an integral part of Art Therapy.
All of the above intrigued us to carry out an investigation within 3 age groups of typically developing children (7-9 years, 12-14 years and 16-18 years) to study their sensitivity to colours and additionally the impact of them on their learning and recall patterns.
For this purpose, the objective of the research has been split into two studies:
Study 1- Colour overlays were used to investigate learning and recall.
Study 2- Sample was assessed on how sensitive they were to the variations in a single hue. In all, 4 universal colours i.e. Red, Blue, Green and Yellow were used. For this purpose, colour grids based on the Munsell's colour system were formed.
A baseline is established using a recall of words on neutral background- white i.e. without the overlays. Results were analyzed using 3-way ANOVA and Pearson's Product Moment Correlation.
The findings showed significant impact of Age on Recall with Overlays. Correlation of Sensitivity on the grid and Recall on overlays was significant only for 'Green' color.
Keywords- color, color overlays, learning and recall, sensitivity

Aim
To study the sensitivity and the impact of colours on learning and recall in typically developing children of 3 age groups (7-9 years, 12-14 years and 16-18 years) with the use of coloured overlays.

Objective
1. To study the difference in the level of recall of the 3 age groups with the use of colored overlays.
2. To study the relationship between sensitivity and the recall on colored overlays of a particular color.
3. To study the influence of 'Age' and 'Gender' of the subject on the recall with and without the use of colored overlays.

Introduction
Colors
The Oxford dictionary defines colors as the property possessed by an object of producing different sensations on the eye as a result of the way it reflects or emits light.
Color is the element of art that is produced when light, striking an object, is reflected back to the eye.
There are three properties to color. First is hue, which simply means the name we give to a color (red, yellow, blue, etc.). The second property is intensity, which refers to the strength and vividness of the color. For example, we may describe the color blue as "royal" (bright, rich, vibrant) or "dull" (grayed). The third and final property of color is its value, meaning its lightness or darkness. The terms shade and tint are in reference to value changes in colors.
Colors are used since early years of an individual's life and can have a lasting impact on them. They help a person to see and perceive things better in the environment. They also add aesthetically and enhance the beauty of the world around us.
Recognition of colors in early childhood, and the activities of coloring a picture forms and integral part of the early years of life. Individuals tend to have a 'favorite' color or a color of preference that they like better than others and are attracted towards it. This

attraction creates a vulnerability of them to be impacted by these colors in multiple ways.

Sensitivity

Based on the various sensory systems, i.e. Interception, Proprioception, Vestibular, and Exteroception; sensitivity is the strength of the capacity to detect and discriminate stimuli by the sensory systems. It is how strong the perception of a stimulus is in an individual. A person who has higher sensitivity will perceive a stimulus more strongly at a lower level than someone who is less sensitive to the stimulus. If two people are looking at a light that is increasing in brightness the one who is more sensitive will squint and close their eye sooner than the person who is less sensitive.

People have variations in sensitivities to different stimuli. The variations in sensitivity can be broadly categorized into two kinds:

Hyposensitivity

It occurs when a child is underwhelmed by the world around him or her and needs to seek out additional sensory information to feel content. Signs of this behavior could include a need to touch things excessively, always turning the volume very loud, or constantly putting objects in his or her mouth. Those who struggle with staying still for any extended period could be hyposensitive, trying to constantly seek movement stimulation.

Hypersensitivity

Hypersensitivity (also known as sensory defectiveness) is characterized by those who become uncomfortable when experiencing minor encounters with environmental stimuli. A person with hypersensitivity may smell scents others cannot detect get distracted by common sounds, such as a humming refrigerator, or avoid using playground equipment in fear of different movements.

Attention-Colour-Learning

"Learning is the relatively permanent change in a person's knowledge or behavior due to experience. This definition has three components:

1) The duration of the change is long-term rather than short-term;

2) The locus of the change is the content and structure of knowledge in memory or the behavior of the learner

3) The cause of the change is the learner's experience in the environment rather than fatigue, motivation, drugs, physical condition or physiologic intervention."

–From Learning in Encyclopedia of Educational Research, Richard E. Mayer

Attention which is concentrating on/or selecting a piece of information, can facilitate learning(D). Rosegard and Wilson (2013) in their research pointed out the work of Posner & Peterson (1996) who opinionated that attention consists of processes which "help in orienting to a sensory event, detecting signals for focal conscious processing and maintaining a vigilant and an alert state[2][3]".

In a research by Kim(2010), it has been noted that vivid information and color presumably attract and hold people's attention because it is concrete, imagery-provoking, or proximal in a sensory, temporal, or spatial way (Nisbett & Ross, 1980)[4][5]. Before this, Farley & Grant (1976) concluded that colour affects attention more[6]. They compared the performance of individuals who were administered black-and-while multimedia presentations with those who received coloured presentations.

Anatomically, it is the visual cortex located in the medial occipital lobe which is primarily responsible for processing colour signals. The ventral stream which is an important part of the brain in colour recognition, lies in the visual cortex. The perception of colour further activates the fusiform gyrus[7], which makes us capable to process faces or recognition in general[8]. fMRI studies have also proved that colour activates the lingual gyrus [9]. The lingual gyrus playes a crucial role in identification and recognition of words [10].

The direct link between colour, recognition, and word processing, should be capable of manifesting results that colour can improve learning,

FOUNDATION THEORIES OF RESEARCH

Helen Irlen's Colored Overlays

Helen L. Irlen is an internationally recognized educator, researcher, therapist, scholar, and expert in the area of visual-perceptual problems.

Over 20 years ago, research directed by Helen Irlen under a federal research grant studied methods of

helping children and adults with reading and learning disabilities. She discovered that a subgroup of individuals showed a marked improvement in their reading ability when colored acetate sheets called the 'Overlays' covered reading material[11]. For thenext five years, Ms. Irlen worked on refining her discovery, developing diagnostic testing instruments, and patenting a set of colored filters.

Munsell's Color System

Created by Professor Albert H. Munsell in the first decade of the 20th century, the Munsell color system is a color space that specifies colors based on three color dimensions: hue, value (lightness), and chroma (color purity).

Hue - Each horizontal circle Munsell divided into five principal hues: Red, Yellow, Green, Blue, and Purple, along with 5 intermediate hues (e.g., YR) halfway between adjacent principal hues. Each of these 10 steps, with the named hue given number 5, is then broken into 10 sub-steps, so that 100 hues are given integer values. In practice, color charts conventionally specify 40 hues, in increments of 2.5, progressing as for example 10R to 2.5YR.

Value - Value, or lightness, varies vertically along the color solid, from black (value 0) at the bottom, to white (value 10) at the top. Neutral grays lie along the vertical axis between black and white**.**

Chroma - Chroma, measured radially from the center of each slice, represents the "purity" of a color (related to saturation), with lower chroma being less pure (more washed out, as in pastels). Note that there is no intrinsic upper limit to chroma. Different areas of the color space have different maximal chroma coordinates. For instance light yellow colors have considerably more potential chroma than light purples, due to the nature of the eye and the physics of color stimuli.

Hypotheses

2.1 There may or may not be a significant difference in the recall of the 3 age groups with the use of colored overlays.

2.2 There may or may not be a significant correlation between the scores on sensitivity grids and the recall on colored overlays of a particular color.

2.3 Age and Gender of the subject may or may not have a significant impact on the recall with and without the use of colored overlays.

Review Of Literature

Different colors enhance different achievement motivations, which can then affect the performance on different types of cognitive tasks[12]. The influence of color on psychological functioning is implicit and automatic. The activation of the motivation behavior takes place without awareness [13].

A study was carried out to investigate the influence of colour on memory performance[14]. They used digit numbers with four different conditions; black, white, congruent, and incongruent colour conditions. They utilized the undergraduate students as their participants in the study. Three minutes were given to the participants to study the stimuli and another three minutes for them to recall the stimuli. The stimuli were exposed to the participants through a computer screen. Significant differences were found between recall conditions. The memory performance of the participants was found to be better in the congruent colour condition compared to the other conditions.

Additionally, in an increasingly interesting research led by Ludlow et.al., (2012), color overlays did have a substantial impact on the reading speed and enhance visual perception among children with Autism Spectrum Disorder (ASD) [15].

Variables & Sample

Independent Variables - Age, Gender and The Use of Overlays

Dependent Variables - Learning and Recall

The sampling technique used was purposive in nature. A sample of 58 students including both boys and girls was taken from age groups 7-9, 12-14 and 16-18 from different schools of Chandigarh and Ludhiana.

V.DESIGN

The experiment was conducted in three phases:

Phase 1 - a learning and recall task of 20 words with the neutral stimulus.

Phase 2 - assessing color sensitivity of the subjects using the color grids derived on the basis of Munsell's color system.

Phase 3 - a learning and recall task of 20 words using the color overlays (translucent colored plastic sheets

used to change the background color of the learning material).

Note: Phases 1 and 3 were reversed for half of the sample to counterbalance the design and nullify the impact of Interference in learning and fatigue.

Procedure

The present study was conducted on a sample of 58 students of age group 7-9, 12-14, 16-18 obtained randomly from the schools of the Tri-city. To study the effect of colors on learning a list of 40 commonly used, unrelated, meaningful words was prepared. The 40 words were printed on 10 sheets of paper such that each sheet contained 4 words in 2x2 pattern. 20 of them were presented on a neutral background i.e. black text on a white background. Rest of the 20 words were presented with the colored overlay (plastic translucent sheets). Colored overlays of four colors – red, blue, green and yellow were used. These colors were chosen as they represent psychological primary colors and belong to the limited number of basic colors which can be internally represented and uniquely identified across different cultures [16]. Also, previous research has shown that primary color categories are organized around universally shared focal points in color space [17][18]. The colored overlays of each of the four colors wereattached together as in the same pattern in which the words were presented i.e. 2x2 such that each word was overlayed by one specific color.

This was used to create scientific color grids (25 each) of increasing levels of difficulty for 4 colors- Blue, Red, Green and Yellow; as a measure of an individual's sensitivity to a particular color.

For the sensitivity task color grids of each of the colors used were prepared using the Munsell's color system. The 25 grids in increasing order of difficulty from 4x4 to 12x12 were formed.

Administration

The experiment was divided into 3 phases. The first phase involved the presentation of 20 words on a neutral background. The subject was asked to try and learn the words while the 10 seconds presentation of each sheet (containing 4 words). Presentation of 20 words was followed by a gap of 1 minute after which the subject was asked to recall/write the words in no specific order and under no time limitation. The second phase involved the presentation of the color grids on the laptop screen. The resolution and the angle of the screen was kept constant at 1080 x 540 and 110 degree respectively. The subject was asked to point out the different color hue from the grid. The time limit for the presentation of each grid was 10 seconds. The presentation of the grids of that particular color was terminated following the commission of three consecutive errors i.e. selection of the wrong hue. The total time taken for the completion of each color was noted along with the no. of errors made. This helped to determine the sensitivity to that color and the most and the least sensitive color. The third phase comprised of the presentation of the 20 color overlayed words. The placement of each color over the sheet of words was counter balanced by rotating the overlay sheet. Similar to the first task, learning and recall was checked. In order to nullify the fatigue effect the presentation of the first and last task was interchanged alternatively.

Method Of Analysis Of Data

Analysis Of Variance - Three-way ANOVA was conducted to determine the effect of the three nominal predictor variables (age, gender & overlays) on the outcome variable (learning & recall)

Correlation - Correlation between the sensitivity and recall score of the respective colors were computed to trace whether or not a relationship exists. This was also used to validate the sensitivity grids.

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Figures and Tables

Table 1.1 Summary Table for 3-way ANOVA

SOURCE	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SUM OF SQUARES (MS)	F RATIO
SS_A	2.85	1	2.85	0.74
SS_B	220.28	2	110.14	28.68**
SS_C	5.39	1	5.39	1.40
SS_{AB}	47.14	2	23.57	6.14**
SS_{BC}	26.14	2	13.07	3.40*
SS_{AC}	1.14	1	1.14	0.29
SS_{ABC}	334.7	2	167.35	43.58**
SS_W	400.87	104	3.84	--
SS_T	1038.51	115	9.03	--

Here, Factor A is Gender, Factor B is the Age Group, and Factor C is the Conditions they've been exposed to i.e.Colored Overlays and Neutral Words.

** p>0.01 *p>0.05

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Table 1.2 Summary Table of Pearson's Product Moment Correlation

Color	Correlation Coefficient	Significance
Green	0.167*	Significant at 0.05
Yellow	0.063	Insignificant
Blue	0.061	Insignificant
Red	0.10	Insignificant

Discussion

A sample of 58 students including both boys and girls was taken from age groups 7-9, 12-14 and 16-18 from different schools of Chandigarh and Ludhiana, and were administered as per the design.

In order to check significance of the interaction of the three independent variables i.e. age groups, gender and two different conditions (neutral & overlay) on recall, statistical technique of Analysis Of Variance was used. Also, correlation was computed to measure the relationship between color sensitivity and recalls of the words on the respective colour overlays.

In reference to Table 1.1, it was found out that, SS_B i.e. Sum of Squares for variable of Age Group was significant at 0.01

level of significance [F (2,104)= 4.82 < F=28.68], and hence it can be understood that the age groups of the subjects had a significant impact on their learning and recall.

Additionally, SS_{AB} i.e. Sum of Squares for the interaction between gender and age group was significant at 0.01 level of

confidence [F(2,104)= 4.82 < F=6.14]- signifying that recall is significantly different among the gender and age group, together.

SS_{BC} i.e. Sum of Squares for the interaction between age group and use of color overlays turned out to be significant at

the 0.05 level of significance [F((2,104)= 4.82 < F=3.40]. Different age groups recall significantly differently on the overlayed task recall.

Thus, the two null hypotheses there may be a significant difference in the recall of the 3 age groups with the use of colored overlays, and Age and Gender of the subject may or may not have a significant impact on the recall with and without the use of colored overlays; are rejected to accept an alternate hypothesis that recall does have a significant difference on the three variables.

For the third hypothesis, stating there may or may not be a significant correlation between the scores on sensitivity grids and the recall on colored overlays of a particular color, it was found (referring to Table 1.2) that the Pearson Product Moment Correlation was positive and significant only for color 'Green' thus suggesting that the higher the scores of subjects on the sensitivity grids of Green color, the higher was the recall for them on the Green Overlays.

The most significant impact of overlays and performance was seen in the middle age group of 12-14 years. The less favorable results in the other two age groups can be reasoned by fatigue effect and practice effect which may be variable in either age groups. Presenting sensitivity grids followed by the overlayed task could have been too much for younger children (7-9 years). On the other hand, the subjects from the age group of 16-18, over the years, could have been accustomed to learning which involved a white ground and black figure- thus the practice effect.

Conclusion

It was found that all three factors- age, gender and treatment conditions contributed to a significant difference in the recall scores of the subjects. Certain limitations of the study were the data was unequally distributed, and the Sensitivity Grids

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could not clearly measure the variable recall, and thus are invalid.

For future research, freshly devised sensitivity grids may predict the recall on particular colors better, and a larger sample with equal distribution may be more reliable and easy to generalize.

This study along with prospective improvisations has the potential to act as baseline research. fMRI studies report a hypoactivation of the FG in ASD [19]. Given the anatomical relationship between colour and performance, such a research is a stepping stone towards countless fields. These findings can hopefully be expanded to the atypical population, especially children with Autism Spectrum Disorder (ASD).

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