DOI: 10.7860/JCDR/2021/46349.15042

Original Article

Psychiatry/Mental Health Section

Effect of White and Yellow Background Colour on Short Term Memory: A Cross-over Study

MITHUN S ACHARYA[1], NARAYANA KEERTISH[2], HARSHA T GOWDA[3], SS KRITHISHREE[4]

ABSTRACT

Introduction: Colour has a potential influence on learning by improving Short Term Memory (STM) in different settings. Background colours of study materials can have an impact on STM in healthy student population. Enhanced memory can improve academic performance in students. In this study background colour between chromatic/yellow and achromatic/white colours were compared.

Aim: To compare the effect of white background black text with yellow (preferential colour chosen via voting by students) background black text of study materials on STM.

Materials and Methods: A cross-over study design was conducted in a tertiary care hospital of southern India with an interval of two weeks in October 2018. Two groups of 27 students each were assessed for visual STM using word list recall in a cross-over design study with an interval of two weeks duration. Data was collected as number of words and correct number of words recalled, from the word list. The obtained data was then put to statistical analysis using statistical software IBM Statistical Package for the Social Sciences (SPSS) version 25.0.

Results: Out of total sample of 54 students, 13 were males and 41 were females. The males and females were comparable with age with p-value of 0.25 which was not statistically significant. The analysis showed that there was no statistically significant difference in the number of words and number of correct words recalled between white and yellow colour backgrounds in both the sessions. There was an overall improvement in the recall of words in both test materials from first session to second session.

Conclusion: Chromatic/yellow background colour was no better than the standard achromatic/white background colour. Improvement in the number of words recalled from first session to second session with both colours appeared to be due to carry over effects.

Keywords: Achromatic, Chromatic, Colour blindness

INTRODUCTION

Colour as a visual experience, has been shown to have a significant impact on memory [1,2]. Colour has been used as an influencer in marketing, sports and communication [3]. In clinical settings, the use of colour has been found to be beneficial in elderly patients with dementia [4] and in children with dyslexia, autism spectrum disorders [5,6]. Colour is known to enhance memory performances as it has a significant influence on the level of attention, emotional arousal [7,8]. Few studies done in educational settings by manipulation of colour have enhanced memory and classroom learning [9,10], thus improving academic performances [11]. Impact of colour on STM of students has shown positive results in colour studies predominantly done on foreground aspects like colours of words/shapes of pictures [12-15]. Background colours when in right combination with foreground colours have significant impact on memory retention [16,17]. Studies on colour can bring about changes in the routine curriculum of imparting education, thus making this study on colour important.

Memory being a psychological construct when measured under similar conditions maximises its reliability and validity [18]. In a cross-over study design each subject act as his/her own control and thus minimising variability and outside confounders such as varying intelligent quotients, language barriers etc., [19]. Previously, done studies have not explored this study design and hence such an attempt has been done in this study.

White background colour is the most common background colour used in online/offline materials and thus was chosen as the first colour for comparison. Nextly, colours such as yellow, orange and peach are the most beneficial background colours on reading abilities [20]. The aim of this study was to compare the effect of white background black text with yellow (preferential colour chosen via voting by students) background black text of study materials on STM.

MATERIALS AND METHODS

A cross-over study design was conducted in a tertiary care hospital of southern India with an interval of two weeks in October 2018. Study was started after obtaining Srinivas Institutional Ethics Committee clearance (reference number 2018/10/10/8). Informed consent for participation in the study was obtained from the students.

Inclusion and Exclusion criteria: In this study, 54 undergraduate students of physiotherapy in the age range of 20 to 22 years were recruited. Consented students were screened for colour blindness using Ishihara 14-plate colour plates and none were found to be colour blind. Those students who were diagnosed with epilepsy or who were on antiepileptic/psychotrophic medications were excluded from the study.

Sample size calculation: The sample size was calculated to be 56 with the parameters of power of study at 0.08, alpha error at 0.05 and effect size at 0.32 [21].

Visual STM was tested using a word list obtained from online source Briangle.com [22,23]. The word list had single 40 words, each word had five letters, which were not in synchrony nor related to syllabus of physiotherapy. The word list in black texts with times new roman font 20 size, were printed on A4 (8.27×11.69 inches), 75 Grams per Square Meter (GSM) white and yellow papers. A total of 54 students were randomly divided into two groups of 27 each and test materials were administered separately in the morning around 11 am. One group of 27 students were given word list recall in white background black text papers and other group of 27 students were given same word list recall in yellow background black text papers. After five minutes of handing over word list, papers were taken back. A time of five minutes was given to read the word-list recall on lines of previous studies where in time duration varied from one minute [21], three minutes [23] up to ten minutes [24]. Immediately, later a

mathematical work termed as 'Math Play' taken from Braingle.com [25] was given for five minutes to avoid mental rehearsal of words [24] and to enhance complexity of attention span in order of higher cognition [26,27]. Based on context dependent memory [17,28], those who were given white background were given white paper and yellow background were given yellow paper to write down recalled words. Students could write down the list of words which need not be in the same order given in the word-list.

After two weeks/14 days with cross-over design the same procedure with same word-list recall was repeated at 11 am [11,29]. The second session was not informed to the students to avoid probable rehearsal of words [7]. Words were analysed for number of words and number of correct words because in our study the test materials were of incongruent colours and hence the recall response should exclude inaccurate words [27,30]. Scores after both the sessions were not revealed to prevent the bias of regression to mean [31].

STATISTICAL ANALYSIS

The obtained data was then put to statistical analysis using statistical software IBM SPSS version 25.0. Data were analysed with descriptive frequencies and the p-value was computed using independent t-test statistics, Chi-square, General Linear Model (GLM), multivariate paired analysis along with t-test carry over effect.

RESULTS

In this study sample of 54 students, 13 were males and 41 were females. The mean age of students in the total sample was 20.87±0.83 years. The students were comparable with respect to age [Table/Fig-1] and sex [Table/Fig-2]. All of the students were studying in the same grade/class/semester of physiotherapy. The number of words and number of correct words recalled were analysed from the written recall list. The descriptives for each test material is shown in [Table/Fig-3]. The analysis showed that there was an improvement in the number of words and number of correct words recalled from first session to second session in both test materials i.e., white background black text (15.11±4.14; 9.59±2.515) to (20.07±3.583; 14.37±2.96), yellow background black text (12.22±4.66; 7.52±2.66) to (17.56±4.65; 13.67±4.14).

Groups	N	Mean	Standard deviation	p-value
Test material: 1 White background black text	27	21.00	0.679	0.25
Test Material: 2 Yellow background black text	27	20.74	0.944	

[Table/Fig-1]: Independent t-test statistics of age between the two groups.
p-value set at <0.05 as statistically significant; Independent t-test statistics

Groups	N	Male	Female	p-value
Test material: 1 White background black text	27	6	21	0.7
Test material: 2 Yellow background black text	27	7	20	

[Table/Fig-2]: Chi-square test of sex between the two groups gender comparison.
p-value set at <0.05 as statistically significant

Infact the white background black text had better recall than yellow background black text but not statistically significant. [Table/Fig-4] shows the results of GLM for treatment and period effects. This analysis showed that there was no statistical difference of the background colour of test material on the recall of number of words and number of correct words before and after cross-over design (-1.28 to 0.91, 0.74 and -1.62 to 0.25, 0.15) ("p<0.05"). Also, the analysis showed that the overall improvement in the number of words and correct words appears due to the period effects/carry over effects between the two cross-over design sessions (4.05 to 6.24, p-value <0.001 and 4.52 to 6.41, p-value <0.001) ("p<0.05").

Variables		First session (before cross-over)		Second session (before cross-over)	
		Number of words	Number of correct words	Number of words	Number of correct words
Test material: 1 White background black text	Mean	15.11	9.59	20.07	14.37
	Std. deviation	4.145	2.515	3.583	2.963
	Minimum	8	5	13	6
	Maximum	22	15	25	20
Test material: 2 Yellow background black text	Mean	12.22	7.52	17.56	13.67
	Std. deviation	4.660	2.666	4.652	4.142
	Minimum	6	4	11	8
	Maximum	22	14	25	22

[Table/Fig-3]: Descriptive frequencies of number of words and number of correct words recalled.
a) S1: Number of words recalled in the first session before cross-over; b) S2: Number of words recalled in the second session after cross-over; c) S1: Number of words correctly recalled without spelling mistakes before cross-over; d) S2: Number of words correctly recalled without spelling mistakes after cross-over

Number of words	Period		95% CI; p-value	
	1	2	Treatment effect	Period effect
A then B			-1.28 to 0.91 0.74	4.05 to 6.24 p-value <0.001
Mean (SD)	15.11 (4.15)	20.07 (3.58)		
B then A				
Mean (SD)	12.22 (4.66)	17.56 (4.65)		
Number of correct words				
A then B			-1.62 to 0.25 0.15	4.52 to 6.41 p-value <0.001
Mean (SD)	9.59 (2.52)	14.37 (2.96)		
B then A				
Mean (SD)	7.52 (2.66)	13.67 (4.14)		

[Table/Fig-4]: General Linear Model (GLM): Multivariate paired analysis along with t-test carry over effect.
A: Test Material 1 (White background black text); B: Test material 2 (Yellow background black text); SD: Standard deviation; CI: Confidence Interval; p-value set at <0.05 as statistically significant

DISCUSSION

This study is a modest attempt to compare the effect of different background colours (with black text) on STM [24]. A cross-over design study was done which is different from the methodological approaches of previous studies [7,11,24,32,21]. Yellow background was chosen because of being a warm colour, it is known to have a greater impact on attention [17,32]. Based on voting between yellow, orange and peach; majority of the students chose the yellow colour as the preferential background colour. Effects of preferential colours on memory are known to be important in classroom settings and thus yellow colour was the second colour chosen [21]. White background and black text were compared as it is conventionally used in most study materials [32].

The study analysis shows that there was no statistically significant difference between the outcome (STM) when white and yellow background were compared. This rejects the alternative hypothesis of yellow background being better than white background. Amongst the reasons for this finding; incongruent colours have lesser impact on STM than congruent colours [24] and warm colours like blue/red have better impacts on memory than yellow [33-35]. Good colour contrast combinations have better impact on STM/retention rates [17] like yellow with blue and white with black [36]. Such a finding was also seen in this study wherein STM was better with white and black contrast over yellow and black contrast, though this was not statistically significant. Another reason being that STM/recall is better in colour unitary conditions due to the theory of contiguity [32], in comparision to non unitary study materials used in our study.

This finding of achromatic colours like white and black having a better recall than yellow colour is different but not in contrast from previous studies [15,21,37]. in this study, the focus was on background colours in text materials on lines of previous studies on preferential colours [10], photographic prints [15,21], natural scenes [37] or object colours [38].

Although there was a definitive improvement seen in the number of words and number of correct words from first session to second session seen in both the colours, this appears to be due to the period effects of two weeks duration leading to carry over effects. Another probable reason for carry over effects could be that the same list of words in first session was repeated in the second session. Also, the instrumentation effects of repetition of a test might change cognitive constructs [27] along with hawthorne effects [39].

Limitation(s)

The hue and brightness of test paper materials could not be testified and hence could not be manipulated. Good colour contrast combinations like yellow and blue over yellow and black would be an interesting combination. Carry over effects due to various reasons need to be dealt in future studies by altering the interval gap between sessions and/or changing word lists between the sessions.

CONCLUSION(S)

The chromatic yellow background colour with black text did not have better recall/visual STM in comparison to achromatic white background colour black text. Improvement was seen in the recall rates/STM in both test materials due to the carry over effects. Future studies can be planned by varying colour combinations of background and text colours.

REFERENCES

[1] Adams FM, Osgood CE. A cross-cultural study of the affective meanings of colour. J Cross-Cult Psychol. 1973;4(2):135-56.
[2] Wichmann FA, Sharpe LT, Gegenfurtner KR. The contributions of colour to recognition memory for natural scenes. J Exp Psychol Learn Mem Cogn. 2002;28(3):509-20.
[3] Moore RS, Stammerjohan CA, Coulter RA. Banner advertiser-Web site context congruity and colour effects on attention and attitudes. J Advert. 2005;34(2):71-84.
[4] Cernin PA, Keller BK, Stoner JA. Colour vision in Alzheimer's patients: Can we improve object recognition with colour cues? Aging Neuropsychol Cogn. 2003;10(4):255-67.
[5] Ludlow AK, Wilkins AJ. Case report: Colour as a therapeutic intervention. J Autism Dev Disord. 2009;39(5):815-18.
[6] Ludlow AK, Taylor-Whiffen E, Wilkins AJ. Coloured filters enhance the visual perception of social cues in children with autism spectrum disorders. ISRN Neurol. 2012;2012:298098.
[7] Farley FH, Grant AP. Arousal and cognition: Memory for colour versus black and white multimedia presentation. J Psychol. 1976;94(1):147-50.
[8] MacKay DG, Ahmetzanov MV. Emotion, memory, and attention in the taboo Stroop paradigm: An experimental analogue of flashbulb memories. Psychol Sci. 2005;16(1):25-32.
[9] Neilsen EH, Winter M, Saatcioglu A. Building a learning community by aligning cognition and affect within and across members. J Manag Educ. 2005;29(2):301-18.
[10] Lechner A, Harrington L, Frattini E. A meta-analysis of colour effectiveness in designed environments. Óbuda University e-Bulletin. 2012;3(1):13.
[11] Stitt JL, Pula JJ. The impact of colour on vocabulary attainment with multi-ability seventh graders. Delta Kappa Gamma Bull. 2013;79(4):37.
[12] Asch SE. A reformulation of the problem of associations. Am Psychol. 1969;24(2):92.
[13] Ceraso J. Unit formation in perception and memory. In: Psychology of learning and motivation. Elsevier; 1985. Pp. 179-210.
[14] Judy M. The colour of learning: Enhance memory and retention with a splash of colour. Retrieved March. 2004;5:2010.
[15] Onasanya SA. The effect of colour on students' cognitive performance in instruction using photographic prints. Ilorin J Educ. 2002;21:156-66.
[16] Hall RH, Hanna P. The impact of web page text-background colour combinations on readability, retention, aesthetics and behavioural intention. Behav Inf Technol. 2004;23(3):183-95.
[17] Dzulkifli MA, Mustafar MF. The influence of colour on memory performance: A review. Malays J Med Sci MJMS. 2013;20(2):03-09.
[18] Chiang I-CA, Jhangiani RS, Price PC. Practical strategies for psychological measurement. Research Methods in Psychology [Internet]. BCcampus; 2015 [cited 2020 Dec 31]. Available from: https://opentextbc.ca/researchmethods/chapter/practical-strategies-for-psychological-measurement/.
[19] Cross-Over Study Design: Biostatistics Overview [Internet]. [cited 2020 Dec 31]. Available from: https://www.ebmconsult.com/articles/cross-over-study-design.
[20] Rello L, Bigham JP. Good background colours for readers: A study of people with and without dyslexia. In: Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility. 2017. Pp. 72-80.
[21] Fear AK. The Effects of Colour Preference on Word List Recall. 2016; 01-28.
[22] Braingle Mentalrobics: Memory Improvement Exercise [Internet]. [cited 2019 Jan 22]. Available from: https://www.braingle.com/mind/test_words.php.
[23] Smilek D, Dixon MJ, Cudahy C, Merikle PM. Synesthetic colour experiences influence memory. Psychol Sci. 2002;13(6):548-52.
[24] Olurinola O, Tayo O. Colour in learning: Its effect on the retention rate of graduate students. J Educ Pract. 2015;6(14):01-05.
[25] Braingle Math Brain Teasers [Internet]. [cited 2019 Jan 22]. Available from: https://www.braingle.com/brainteasers/Math.html.
[26] Turner ML, Engle RW. Is working memory capacity task dependent? J Mem Lang. 1989;28(2):127-54.
[27] Shipstead Z, Redick TS, Engle RW. Does working memory training generalize? Psychol Belg. 2010;50(3-4):245.
[28] Grant HM, Bredahl LC, Clay J, Ferrie J, Groves JE, McDorman TA, et al. Context-dependent memory for meaningful material: Information for students. Appl Cogn Psychol Off J Soc Appl Res Mem Cogn. 1998;12(6):617-23.
[29] Christianson SA, editor. The handbook of emotion and memory: Research and theory. Psychology Press; 2014 Feb 4.
[30] MacLeod CM, MacDonald PA. Interdimensional interference in the Stroop effect: Uncovering the cognitive and neural anatomy of attention. Trends Cogn Sci. 2000;4(10):383-91.
[31] Cohen J, Cohen P, West SG, Aiken LS. Applied multiple regression/correlation analysis for the behavioral sciences. Mahwah, NJ: erlbaum (3rd ed.); 2003.
[32] Wilton RN. The structure of memory: Evidence concerning the recall of surface and background colour of shapes. Q J Exp Psychol Sect A. 1989;41(3):579-98.
[33] Pan Y, Xu B, Soto D. Dimension-based working memory-driven capture of visual selection. Q J Exp Psychol. 2009;62(6):1123-31.
[34] Sahin L, Figueiro MG. Alerting effects of short-wavelength (blue) and long-wavelength (red) lights in the afternoon. Physiol Behav. 2013;116:01-07.
[35] Elliot AJ. Colour and psychological functioning: A review of theoretical and empirical work. Front Psychol [Internet]. 2015 Apr 2 [cited 2018 Dec 26];6. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4383146/.
[36] Westland S, Laycock K, Cheung V, Henry P, Mahyar F. Colour Harmony. JAIC-J Int Colour Assoc [Internet]. 2012 Feb 25 [cited 2018 Dec 31];1(0). Available from: http://jaic.jsitservices.co.uk/index.php/JAIC/article/view/70.
[37] Spence I, Wong P, Rusan M, Rastegar N. How colour enhances visual memory for natural scenes. Psychol Sci. 2006;17(1):01-06.
[38] Lloyd-Jones TJ, Nakabayashi K. Independent effects of colour on object identification and memory. Q J Exp Psychol. 2009;62(2):310-22.
[39] McCarney R, Warner J, Iliffe S, Van Haselen R, Griffin M, Fisher P. The Hawthorne Effect: A randomised, controlled trial. BMC Med Res Methodol. 2007;7(1):30.

PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Psychiatry, Srinivas Medical College and Research Centre, Suratkal, Karnataka, India.
2. Professor, Department of Psychiatry, BGS Global Institute of Medical Sciences, Bengaluru, Karnataka, India.
3. Associate Professor, Department of Psychiatry, BGS Global Institute of Medical Sciences, Bengaluru, Karnataka, India.
4. Assistant Professor, Department of Psychiatry, KVG Medical College and Hospital, Sullia, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. SS Krithishree,
House No. #403, Vijaya Apartment, Lobo Lane, Mallikatte, Mangalore, Karnataka, India.
E-mail: krithishree.somanna@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 22, 2021
- Manual Googling: Jan 11, 2021
- iThenticate Software: May 24, 2021 (22%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 18, 2020**
Date of Peer Review: **Nov 09, 2020**
Date of Acceptance: **Feb 04,2021**
Date of Publishing: **Jun 01, 2021**