Original Article

Impact of Visual Imagery of Coloured Rose Flower on Heart Rate Variability

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Abstract

Background: Viewing of visual imagery of forest or nature is known for producing physiological and psychological relaxation of mind and body**.** Nature surroundings are colourful and vary from green of plants, blue of water and red, orange, yellow and violet of flowers. These coloured imageries also known to affect our emotion; may lead to joy, sorrow, happiness grief etc. Heart Rate Variability (HRV) indexes through vagal activity the autonomic responses and thereby affects our emotions and behavioural outcome. This study is planned to assess the colour effects of visual imagery of coloured rose flowers on HRV in males and females for red, blue, green, indigo, yellow, orange and violet colours.

Methodology: The Heart Rate Variability analysis was conducted on Power Lab AD Instruments, Australia in thirty healthy individuals (15 males and 15 females), aged between 20 to 40 years

Results: We observed variation in autonomic response to different colours in males and females on Heart Rate Variability assessment. There was augmentation of sympathetic drive on viewing of red, orange and violet colour roses in males and that of blue and violet colours in females. The visual imagery of blue, green, indigo and yellow coloured roses in males and red, green, indigo, yellow and orange coloured in females produced a parasympathetic influence on Heart Rate Variability.

Conclusion: Colours affects HRV and thereby can influence our emotional and behavioural responses in our daily life. Adapting to coloured surrounding of choice at workplace and at home may influence our work output and productivity as well produce physical and mental wellbeing.

Keywords: Heart Rate Variability; Autonomic; Roses; Colours; Sympathetic; Parasympathetic.

Introduction

Viewing of visual imagery stimulates the activity of our autonomic nervous system as well as Central Nervous System. Viewing of imagery of nature, forest and roses have been shown to produce physiological and psychological relaxation.[1,2] Mental imagery are also found to be motivational. [3]Nature composes of skies, plants, rivers, mountains, birds and animal and not only they are beautiful but are colourful too. Colours influence our emotions and behaviours and may produce feelings of joy, sorrow, grief, happiness etc.[4]The colours in nature are numerous and beautiful and vary from green of that of plants, to blue of skies and red, purple, orange and yellow colours of flowers. These colours not only beautify the environment but also have soothing effect over human's physical health and mental wellbeing. The colours influences human health and may lead to

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elation of emotions and mood stability or may produce anxiety, uneasiness and behavioural aggressiveness depending on colour type[4,5]The photoelectric energy produce by various colours stimulates the functioning of the pituitary gland and hypothalamus; thereby regulating the hormonal mechanism and helping in coping with emotional stress.[4, 5] The colour effects are exhibited through cones visual functional efficacy as well as the patency of the retino-hypothalamic tract which traverse from the retinaand relays to the hypothalamus, thus linking vision and colour perception with the autonomic nervous system.[6]The autonomic nervous system response to colour may either be parasympathetic or sympathetic; as observed in research studies which opined that the red colour enhances sympathetic activity; blue colour enhances parasympathetic activity, while green mediates autonomic effects varying between sympathetic and parasympathetic.[7,8]

The heart rate variability indexes through vagal activity, the activity of the prefrontal cortex which is integrated within the brainstem nuclei and thus influences emotion, mental state of mind and cognition. Colours may have a varied impact on our physiological and psychological health and that may also differ along sexes.[1,2]

Though many studies have been conducted in study of coloured light on HRV, but there is paucity of data of colour effects of visual imagery of the primary (red, blue, green) and complimentary colours (yellow, orange, indigo and violet)on autonomic responses such as heart rate variability in males and females. Moreover the effects of impact of visual coloured imagery and coloured lights are different as colour perception and visual impact vary in above two conditions. These facts gave us an impetus to explore the effects of viewing rose imagery having red, blue, green colours (primary colours) and indigo, yellow, orange and violet colours (complimentary colours) on heart rate variability. Our Proposed research work shall be novelty as it will be exploring coloured visual imagery impact rather than effect of coloured light effects.

Material and Methods

The present research work was conducted in department of Physiology, Dr Ram Manohar Lohia Institute of Medical Sciences, Lucknow, India after approval of the Institutional Research Committee and Institutional Ethical Committee. Thirty healthy individuals (15 males and 15 females), aged between 20 to 40 years were recruited in our study. These individuals selected in our research protocol were healthy, non-smoker, non-alcoholic, and were not on any drug or therapy. The participants were informed about the aims, procedure and scope of our research work. A written consent was obtained from all the participants. The Heart Rate Variability analysis was conducted on Power Lab AD Instruments, Australia.[7,8]

Procedure Protocol for Recording Observation: The participants were comfortably seated in relaxed position in the autonomic lab of the department. The room temperature was maintained at 24 degree Celsius and room illumination was 50 lux. The participants were made to relax for 10 (ten) minutes and thereafter HRV was recorded. The flowers imagery for visual stimulation was displayed on a liquid crystal display computer screen of 24 inches and it had 3840 x 2160 pixel resolutions (Lenovo Company Computer).[8,9] The HRV was a continuous recording for about five minutes duration for every stimulus as detailed below.

The individual was asked to occupy the examination couch and relax. The leads and electrodes were properly placed on chest of participants for HRV recording. Then after sixty seconds (rest period) the resting state HRV was recorded for a minute as part of five minutes HRV recording. This was followed by HRV recording on exposure of individual to red coloured rose flowers for 90 seconds, further followed by again resting state HRV recording with closed eyes for 60 seconds.[9]Successively, following the same protocol HRV was recorded for exposure to blue, green, indigo, orange, yellow and violet colorsflower imagery on display.

The change (variation) of heart rate during short term (5 minutes) was analysed with the method of frequency domain to provide the degree of balance and activity of autonomic nervous system. The SA-3000P Software was employed for conducting the measurement and physiological interpretation of bio-signal processing algorithms as recommended by 'The European Society of Cardiology and The

North American Society of Pacing and Electrophysiology 1996'.[10] The HRV analysis was assessed by noting the cardiac autonomic modulation which was quantified using frequency domain analysis.[10, 11]The HRV analysis in the frequency domain were recorded for low frequency (LF: 0.04–0.15 Hz) and high frequency (HF: 0.15–0.40 Hz) spectral components and measurements were reported in ms^2. The spectral analysis was calculated using the Fast Fourier Transform algorithm. The changes in values of LF/HF (Low Frequency / High Frequency) and LF / HF ration every 30s were noted during 90s of stimulation to respective stimuli and Total Power (TP) were calculated. (Note: The LF band represents the modulation of vagal and sympathetic tone by baroreflex activity. HF power represents vagal modulation of heart rate while the ratio of LF to HF power (LF/HF ratio) represents the sympatho-vagal balance. Total power is the sum of the energy in the VLF, LF, and HF bands for short-term recordings.) [10,11]

All data were calculated from differences from average of 30 seconds rest period. The mean values of heart rate variability parameters over the 90 seconds stimulation were analysed using ANOVA for comparison among the various stimuli. The P value less than 0.05 was considered to be statistically significant. Post Hoc analysis was carried out to find out the significance difference amongst mean value of Heart Rate Variability for various colours in individual sexes.

Results

Table 1: Effect of red, blue, green, indigo, orange, yellow and violet colors on Heart Rate Variability in Males

HRV indices	Red Colour	Blue Colour	Green Colour	Indigo colour	Yellow Colour	Orange Colour	Violet Colour	ANOVA	Post Hoc
Low frequency (%)	35.545 ± 23.12067	41.835 ± 15.36174	32.94813 ± 23.00359	36.77125 ± 14.13012	29.46625 ± 18.39109	36.43375 ± 20.54233	32.76138 ± 19.85702	0.477166	NS
High frequency (%)	46.1375 ± 25.69558	42.24125 ± 14.55444	43.37 ± 21.28648	47.5625 ± 17.40502	45.865 ± 22.4901	39.86325 ± 23.7456	43.998 ± 28.340	0.248639	k
Very Lowfrequency (%)	17.71775 ± 18.45786	15.07213 ± 10.15777	22.4205 ± 21.81838	15.036 ± 11.86976	24.11775 ± 17.53675	22.89925 ± 22.2721	29.0605 ± 25.33797	0.013 0358	a, g, i-l, q, r
LF/HF ration	1.462225 ± 2.0168705	1.207675 ± 0.787978	1.038188 ± 0.986776	1.06225 ± 1.060733	0.953788 ± 0.944416	2.113288 ± 3.538124	1.411053 ± 1.389623	0.000 0000 0073 857	a-e, j, k, m, q, s, u
Total Power (ms^2)	1084.09 ± 853.5	1132.413 ± 986.9491	1074.025 ± 653.89	1218.1 ± 961.3494	1207.8 ± 1084.155	1394.725 ± 1381.4	1364.45 ± 976.5051	0.223 26	n

Table 2: Post-hoc analysis of all color groups in males showing comparison between the color groups (p-value)

	LF	HF	VLF	LF/HF	Total Power
Red Vs Blue: a	0.1381	0.07313	0.03269	0.001176	0.5940
Red Vs Green: b	0.9851	0.4903	0.5396	0.01145	0.3303
Red Vs Indigo: c	0.07576	0.1572	0.1101	0.02210	0.6622
Red Vs Yellow: d	0.4022	0.6248	0.8508	0.007538	0.3815
Red Vs Orange: e	0.6642	0.7719	0.4912	0.04381	0.08224
Red Vs Violet: f	0.5767	0.7190	0.2481	0.1757	0.6212
Blue Vs Green: g	0.1429	0.1672	0.007127	0.4102	0.1355
Blue Vs Indigo: h	0.7589	0.5120	0.5678	0.2780	0.9231
Blue Vs Yellow: i	0.5094	0.1151	0.04987	0.5068	0.7301
Blue Vs Orange: j	0.2887	0.07745	0.005827	0.000001403	0.2207
Blue Vs Violet: k	0.3480	0.01787	0.001550	0.04196	0.9688
Green Vs Indigo: l	0.07872	0.4608	0.02965	0.7906	0.1616
Green Vs Yellow: m	0.4127	0.8398	0.4238	0.8719	0.06851
Green Vs Orange: n	0.6778	0.6881	0.9397	0.00002369	0.008367
Green Vs Violet: o	0.5894	0.2960	0.5832	0.2126	0.1456
Indigo Vs Yellow: p	0.3354	0.3487	0.1564	0.6698	0.6590
Indigo Vs Orange: q	0.1738	0.2572	0.02482	0.00005689	0.1873
Indigo Vs Violet: r	0.2153	0.07860	0.007569	0.3237	0.9542
Yellow Vs Orange: s	0.6846	0.8418	0.3818	0.00001380	0.3754
Yellow Vs Violet: t	0.7781	0.3975	0.1809	0.1607	0.7010
Orange Vs Violet: u	0.9008	0.5166	0.6359	0.001244	0.2067

Table 3: Effect of red, blue, green, indigo, orange, yellow and violet colors on Heart Rate Variability in Females

HRV indices	Red Colour	Blue Colour	Green Colour	Indigo colour	Yellow Colour	Orange Colour	Violet Colour	ANOVA	Post Hoc
Low frequency (%)	24.960 ± 12.87475	37.8835 ± 25.16041	36.175 ± 17.10432	21.392 ± 10.85297	25.6375 ± 8.838644	32.60325 ± 21.93088	43.5525 ± 9.725281	0.00013308	a, h, i, k, m, o, q, s, u
High frequency (%)	41.6575 ± 21.92517	49.915 ± 31.0739	53.28 ± 15.17245	46.175 ± 17.12636	52.895 ± 20.58083	53.9425 ± 27.39201	43.8675 ± 21.0569	0.119736	g, h, n
Very Low Power frequency (%)	33.3125 ± 23.20653 123	11.863 ± 11.89763	9.2663 ± 13.84817	31.8775 ± 19.92751	21.3575 ± 14.3469	12.6862 ± 9.508898	12.53525 ± 12.76321	0.0151722	a, e, f, q
LF/HF ratio	0.778433 ± 0.528081	1.63772 ± 2.159577	0.748475 ± 0.429054	0.53135 ± 0.434336	0.964425 ± 1.021289	0.940405 ± 1.032557	1.612725 ± 1.743767	0.00000000 00733704	a, d-j, m-r
Total Power (ms^2)	719.5057 ± 595.6612	1433.195 ± 607.912	728.8225 ± 518.4158	1128.928 ± 776.4508	827.1308 ± 789.7337	2987.8 ± 1158.87	3114.5 ± 1106.768	0.0142885	a, e, f, j, k, n, o

Table 4: Post-hoc analysis of all color groups in females showing comparison between the color groups (p-value)

	LF	HF	VLF	LF/HF	Total Power
Red Vs Blue: a	0.01730	0.2043	0.01714	0.000004613	0.0006571
Red Vs Green: b	0.2996	0.1807	0.06310	0.4469	0.9404
Red Vs Indigo: c	0.5311	0.3663	0.5763	0.4739	0.3327
Red Vs Yellow: d	0.1716	0.8162	0.08261	0.01900	0.3030
Red Vs Orange: e	0.05550	0.4151	0.001954	0.01722	0.01801
Red Vs Violet: f	0.3056	0.8820	0.03252	0.00006419	0.02703
Blue Vs Green: g	0.1610	0.01123	0.5776	0.000000319	0.5591
Blue Vs Indigo: h	0.003330	0.03311	0.06335	0.000000374	0.3708
Blue Vs Yellow: i	0.000362	0.1352	0.4927	0.008293	0.3388
Blue Vs Orange: j	0.6142	0.6434	0.4120	0.009211	0.02160
Blue Vs Violet: k	0.001047	0.1576	0.7964	0.4335	0.03217
Green Vs Indigo: l	0.09999	0.6565	0.1856	0.9641	0.1428
Green Vs Yellow: m	0.01889	0.2660	0.8965	0.002537	0.1271
Green Vs Orange: n	0.3633	0.03453	0.1719	0.002263	0.004810
Green Vs Violet: o	0.04290	0.2324	0.7644	0.000004988	0.007561
Indigo Vs Yellow: p	0.4520	0.5006	0.2312	0.002879	0.9503
Indigo Vs Orange: q	0.01273	0.08980	0.009037	0.002570	0.1461
Indigo Vs Violet: r	0.6871	0.4492	0.1069	0.000005819	0.1971
Yellow Vs Orange: s	0.001640	0.2965	0.1358	0.9678	0.1636
Yellow Vs Violet: t	0.7255	0.9330	0.6676	0.05448	0.2190
Orange Vs Violet: u	0.004407	0.3364	0.2827	0.05940	0.8658

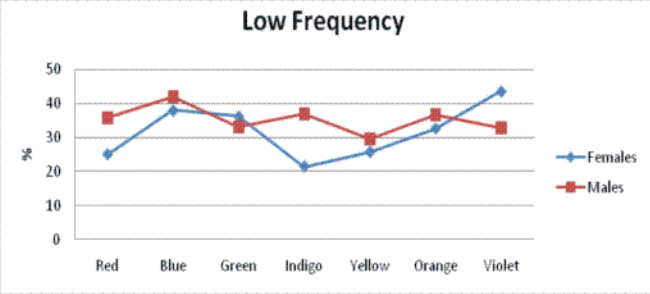

Figure 1: HRV analysis in the frequency domain of low frequency spectral component for red, blue, green, Indigo, yellow, orange, violet colors in males and females.

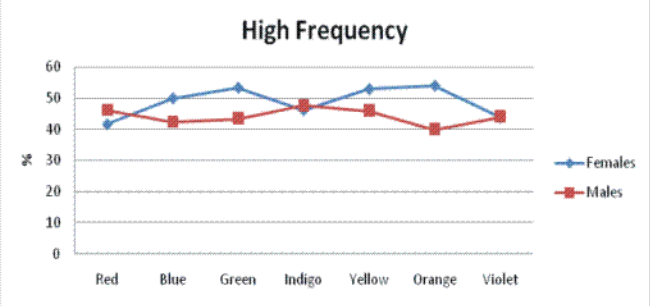

Figure 2: HRV analysis in the frequency domain of high frequency spectral component for red, blue, green, Indigo, yellow, orange, violet colors in males and females.

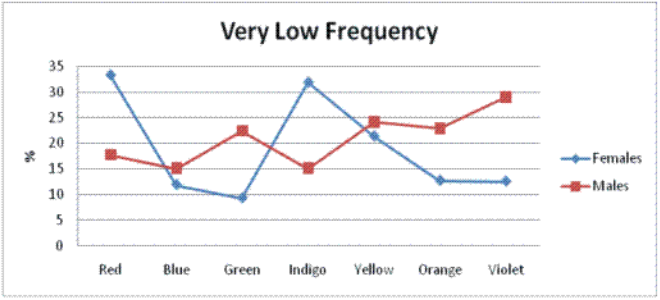

Figure 3: HRV analysis in the frequency domain of very low frequency spectral component for red, blue, green, Indigo, yellow, orange, violet colors in males and females.

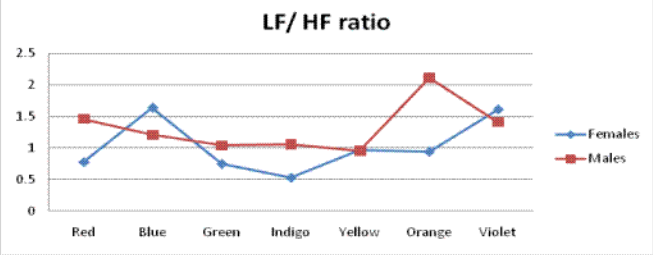

Figure 4: LF/HF Ration for red, blue, green, Indigo, yellow, orange, violet colors in males and females.

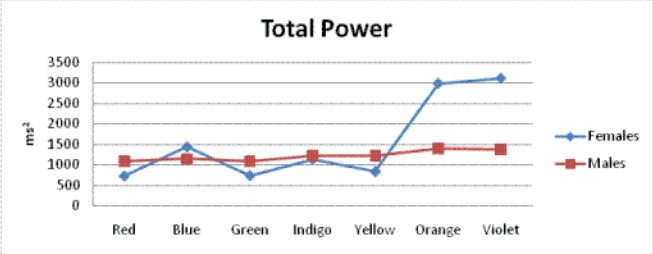

Figure 5: Total Power of HRV of red, blue, green, Indigo, yellow, orange, violet colors in males and females.

Discussion

We analyzed the effect of viewing of visual imagery of roses on HRV. The other studies conducted on viewing of forest imagery or roses found a significant reduction in concentration of oxy-Hb in the right prefrontal cortex and opine that visual imagery promotes perceptions of feeling "comfortable," "relaxed," and "natural."[1,2,12] Research evidences also proved that imagery reduces blood pressure, and strengthen immune response as well as allay anxiety and depression.[13,14] Colours influence our physical and psychological health and these effects are mediated via the autonomic responses[4,5] The known warm colours are red, orange, indigo and yellow and they evoke emotional responses which vary from feelings of warmth, comfort, joy and energetic to aggressiveness and revengeful attitude. The cool colours include blue, violet, green and purple colours and their effects induces calmness and relaxed state of mind but may also evoke feelings of sorrow, uneasiness and grieved state.[15]

In our study the healthy participant males and females were exposed to flower imagery of red, blue, green, indigo, yellow, orange and violet colours and their sympatho-vagal responses were by heart rate variability analysis of LF, HF, LF/HF ratio and Total Power. There HRV analysis of LF, HF, LF/HF ratio revealed increased sympathetic drive on exposure to red, orange and violet colours in males and that of blue and violet colours in females. Our findings were in concurrence with those of Aseel AL-Ayash et al[16] and Abbas N etal[17] for red and blue colour in males while contrary for blue colours in females. In a study conducted by Aseel AL-Ayash et al, the six colours which included vivid red, vivid blue, vivid yellow, pale red, pale blue and pale

yellow were analyzed for their impact on performance, heart rate and emotion of students. It was observed that students were relaxed in pale coloured environment than vivid colour. There was increase in heart rate with red and yellow colour while blue colour produced relaxation and calmness of mind.[16] Similarly Abbas N et al in their study assessed the impact of colours and light on physiological states and found an increase in heart rate after exposure to red while with blue colour, there was found to be calming and decrease in heart rate.

As we searched the literature to analyze effect of colours in red spectrum of light wave length such as yellow, orange on HRV, we found that our findings for yellow and orange colours was in concurrence with those of S. Sakakibara et al[12] and Choi CJ et al[13]in males but contrary in females for red and red spectrum of light as their study opined that the red colour and colours in red spectrum of light wave length such as yellow, orange or reddish orange exerts a sympathetic stimulation effects as they experimentally are proven to simulate the posterior hypothalamus.[18,19]

The LF / HF ratio for colours blue, green, indigo and yellow in males and red, green, indigo, yellow and orange in females in our study reflected a parasympathetic influence on Heart Rate Variability. It was found that the blue colour enhances the parasympathetic response in males while blue and violet colour enhances sympathetic response in females. The findings in reference to blue colour were controversial in various studies. The few studies opined that the blue colour stimuli or with bluish spectrum of colour such as blue/green, blue and violet produce sleep, produce drowsy state or enhances digestive process.[20,21,22]While studies by Prathiba Modi et all[23]could not infer any conclusive result on exposure to blue light. The sympathetic influence of blue and violet colour in females can be attributed to suppression of vagal balance by blue light and these findings are in concurrence with Yuda E et al[20,] Lehrl S et al[21] and Sahin et al [22].

Our findings about parasympathetic response of green colour in males and female is in concurrence with studies of Hurbelt A eta al [24] Briki et al[25] and Briki and Hue[26] as green colour enhances positive affective and cognitive outcomes (like joy, self esteem and motivation) and reduces negative outcome (mood disturbances and anxiety).

There is paucity of data for influence of indigo and violet colour on autonomic functions. But our study reveals parasympathetic response of indigo colour and this may be attributed to the fact that indigo colour has a wavelength between 445 and 464 nm and as observed in other studies that colour of shorter wavelength exert parasympathetic influence.

We observed variation in autonomic response to different colours in males and females on Heart Rate Variability assessment. Similarly the research conducted by Marco Costa et al [27]in four hundred and forty-three participants who were assessed for colour preference (hue and lightness) of the building interior, lightness preference, and the effects of colour on mood behaviour; it was observed that participants had preference for blue interiors, followed by green, violet, orange, yellow, and red. There were gender differences for the preference of blue and violet colours. Moreover the participants preference and mood elation effects was more for cool colours (blue, violet, and green) then warm colours (yellow, orange, and red). Similarly colour effect on heart rate variability in our study can be linked to the ecological valence theory pertaining to the positive health effects of colours and the individual's perception and preferences as pointed by Marco Costa et al.[24]

The newness of our study was that we compared the impact of coloured visual imagery (all seven primary and complimentary colours) on HRV while other studies mostly conducted effect of light or coloured light on HRV. Moreover the effects of colour imagery on HRV in males and females have not yet been discussed in literature considering all the seven colours. A detail understanding of the effect difference of colours and coloured light effect on HRV needs to be explored as the principle of colour perception varies in both situations. The colour of an object (that is flower imagery colour in our study) is determined by its surface, transmission and emission properties and all of them contribute towards the generated wavelengths in the light

leaving the surface of the imagery and perception of the observer. Lighting spectrum and viewing angle are other factors influencing the final appreciation of colours while the impact of coloured light on HRV; is influenced by the coloured light wavelength.

The limitations of our pilot study was the small sample size and we recommend that further studies with larger sample size should be conducted to see the impact of coloured imagery on health and diseased. These studies can help in giving deeper insight for understanding physiological impact of colours. Moreover, painting and decorating our surrounding with flowers and objects at home with colours which have positive effects on our physical and psychological health can be practiced for healthy living. Wearing clothes matching our choices as well as one which influences our emotions to make us feel happy and calm can be helpful in achieving physical and mental wellbeing.

Conclusion

Colours play a significant role in human perception and behaviour and are reflected by variation in both sympathetic or parasympathetic autonomic responses. The beneficial effects of parasympathetic outcome on human health are well documented. The increased risk of hypertension, cardiovascular and anxiety disorders occurs with enhanced sympathetic activity. Thus it is advocated that appropriate use of colours for clothing, painting and decorating of home and the workplace could have positive motivational effects over mood, emotion and behaviour.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Song C, Ikei H, Miyazaki Y. Physiological Effects of Visual Stimulation with Forest Imagery. *Int J Environ Res Public Health.* 2018;**15**: 213-223
2. Harumi Ikei, Misako Komatsu, Chorong Song, Eri Himoro and Yoshifumi Miyazaki. The physiological and psychological relaxing effects of viewing rose flowers in office workers. *J Physiol Anthropol*. 2014; **33**:6-10
3. Martin, K.A., Hall, C. R. Using Mental Imagery to Enhance Intrinsic Motivation *Journal of Sport and Exercise Psychology.* 1995; **17**: 54-69
4. Moharreri, S., Rezaei, S., Jafarnia Dabanloo, N., & Parvaneh, S. Study of induced emotion by color stimuli: power spectrum analysis of heart rate variability. *Computing in Cardiology*. 214; **41**: 977–980.
5. Palijan, T.; Kovacevic, D., and Kovac, M.. Chromotherapy in the regulation of neurohormonal balance in human brain – complementary application in modern psychiatric treatment. *Coll Antropol*. 2008; **32**:185-8.
6. Joseph N. Trachtman. Vision and the hypothalamus. Optometry - *Journal of the American Optometric Association*. 2010; **81**: 100-115
7. Ainsworth, R. A., Simpson, L., Cassell, D. Effects of three colors in an office interior on mood and performance. *Perceptual and Motor Skills*. 1993; **76**: 235–241.
8. Ou L, Luo MR, Woodcock A, Wright AA. Study of color emotion and color preference. Part I: Color emotions for single colors. *Color Res Appl* 2004; **29**: 232– 240.
9. Manav B. Color-emotion associations and color preferences: A case study for residences. *Color Res Appl* 2007; **32**:144– 151.
10. Camm A. J., Malik M., Bigger J. T., et al. Heart rate variability: standards of measurement, physiological interpretation, and clinical use. *Circulation*. 1996; **93**: 1043–1065.
11. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, "Heart rate variability: Standards of measurement, physiological interpretation and clinical use," *Circulation* 1996; **93**: 1043–1065.
12. Song C., Ikei H., Kobayashi M., Miura T., Taue M., Kagawa T., Li Q., Kumeda S., Imai M., Miyazaki Y. Effect of forest walking on autonomic nervous system activity in middle-aged hypertensive individuals. *Int. J. Environ. Res. Public Health*. 2015;**12**:2687–2699.

13. Li Q, Morimoto K, Nakadai A, Inagaki H, Katsumata M, Shimizu T, Hirata Y, Hirata K, Suzuki H, Miyazaki Y, Kagawa T, Koyama Y, Ohira T, Takayama N, Krensky AM, Kawada T: Forest bathing enhances human natural killer activity and expression of anti-cancer proteins. *Int J Immunopathol Pharmacol.* 2007; **20**: 3-8.
14. Chun M.H., Chang M.C., Lee S. The effects of forest therapy on depression and anxiety in patients with chronic stroke. *Int. J. Neurosci.* 2017;**127**:199–203.
15. Hardin C. L. Red and yellow, green and blue, warm and cool: Explaining color appearance. *J. Conscious. Stud.* 2000; **7**:113–122.
16. Aseel AL-Ayash, Robert T Kane, Dianne Smith, Paul Green-Armytage.The influence of color on student emotion, heart rate, and performance in learning environments. *Col Res Appl.* 2016; **41**:196–205,
17. Abbas N, Kumar D, Mclachlan N. The Psychological and Physiological Effects of Light and Colour on Space Users, 27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Shanghai China; 2006
18. Sakakibara S, Honma H, Kohsaka M, Fukuda N, Kawai I, Kobayashi R, Koyama T. "Autonomic nervous function after evening bright light therapy: spectral analysis of heart rate variability," *Psychiatry and Clinical Neurosciences*. 2000; **54**: 363–364.
19. Choi CJ, Kim KS, Kim CM, Kim SH, Choi WS. Reactivity of heart rate variability after exposure to colored lights in healthy adults with symptoms of anxiety and depression. *Int J Psychophysiol.* 2011;**79**:83–8.
20. Yuda E, Ogasawara H, Yoshida Y, Hayano J. Enhancement of autonomic and psychomotor arousal by exposures to blue wavelength light: importance of both absolute and relative contents of melanopic component. *J Physiol Anthropol.* 2017; **36**:13-20
21. Lehrl S., Gerstmeyer K., Jacob J. H., Frieling H., Henkel A. W., Meyrer R., et al. Blue light improves cognitive performance. *J. Neural Trans*. 2007; **114**: 457–460.
22. Sahin L., Figuerio M. G. Alerting effects of short-wavelength (blue) and long-wavelength (red) lights in the afternoon. *Physiol. Behav.* 2013;116 – 117: 1-7.
23. Modi Pratibha ,Jha Kamlesh, Kumar, YogeshKumar, Tribhuwan kumar, Singh, Ramji, Mishra Abhilasha. The effect of short-term exposure to red and blue light on the autonomic tone of the individuals with newly diagnosed essential hypertension, *Journal of Family Medicine and Primary Care.* 2019 ; **8**: 1 :14-21
24. Hurlbert A. C., Ling Y. Biological components of sex differences in color preference. *Curr. Biol* 2007; **17**: 623–625.
25. Briki, W., Rinaldi, K., Riera, F., Than, T. T., and Hue, O. Perceiving red decreases motor performance over time: a pilot study. *Eur. Rev. Appl. Psychol.* 2015; **65**: 301–305.
26. Briki, W., and Hue, O. How red, blue and green are affectively judged. *Appl. Cogn. Psychol.* 2016; **30**: 301–304.
27. Marco Costa, Sergio Frumento, Mattia Nese, Iacopa Predieri. Interior Color and Psychological Functioning in a University Residence Hall. *Front Pschycol.* 2018; **9**:1580-1592.