Pertanika J. Soc. Sci. & Hum. 24 (2): 811 – 824 (2016)

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

Colour Effect on Physiology in a Stimulating Environment

Ab. Jalil, N.[1]*, Yunus, R.[2], Sheik Said, N.[3] and Iqbal, M. I.[4]

[1]*Kulliyyah of Architecture & Environmental Design, International Islamic University Malaysia, Kuala Lumpur, 50728, Malaysia*
[2]*Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Shah Alam, Malaysia*
[3]*Faculty of Modern Languages & Communication, Universiti Putra Malaysia, Serdang, Malaysia*
[4]*Kulliyyah of Islamic Revealed Knowledge and Human Sciences, International Islamic University Malaysia, Kuala Lumpur, Malaysia*

ABSTRACT

Colour is an environmental stimulus that exerts an influence on human beings in a multitude of ways. The effect of colours has been abundantly and unequivocally demonstrated in previous research on the integration of multimodal approaches such as the psychological, performance and non-performance and preferences assessments. Nevertheless, little research has been conducted locally on the integration of physiological assessment and consideration of subjects' living ecology. This is particularly true in the field of design. The objective of this paper is to propose an optimal colour for the hostel environment of female university students based on their heart-rate response. Four determined colours, namely strong red, bluish-green, pink and white, were painted in their rooms and divided according to exposures. In the experiment, a test and re-test method of assignment was conducted. The results show that subjects in the strong-red environment were stimulated after a short exposure, while subjects in the bluish-green environment were stimulated after long and sustained periods of exposure. In summary, the significance of a coloured environment is discussed with suggestions for a short, longer and sustainable period of exposure from a physiological perspective, aim of which being engagement.

ARTICLE INFO

Article history:
Received: 2 April 2015
Accepted: 30 July 2015

E-mail addresses:
nurlelawati@iium.edu.my (Ab. Jalil, N.),
rodzy859@salam.uitm.edu.my (Yunus, R.),
norma@fbmk.upm.edu.my (Sheik Said, N.),
iznita@iium.edu.my (Iqbal, M. I.)
* Corresponding author

ISSN: 0128-7702

Keywords: Environmental stimulus, colour exposure, colour effect, heart rate responses, arousal

INTRODUCTION

Colour is used to give a form, add character and define space for the purpose of identifying surroundings and providing meaningful information that is useful for environment adaptation. People function more optimally when there is adequate stimulation from the environment (Wohlwill, 1974; Evans & Cohen, 1987). An environment with either a dearth of or exorbitant stimulation invariably results in such detrimental effects as depression and withdrawal due to stress, impairment of attention and the ability to process information and stifled performance, as reported in a review by Jalil, Yunus and Said (2012). The physical comfort and tranquility engendered by colour in an environment manifestly encourages creative thinking in performance (Lichtenfeld *et al*., 2012; Bisadi, Mozaffar, & Hosseini, 2013) and communication (Bisadi, Mozaffar, & Hosseini, 2013). Conversely, a lack of colour could lead to accidents in the workplace and work fatigue, as highlighted by Yi *et al*. (2012) and Küller *et al*. (2006).

The fact that colour is conditioning response makes it difficult to find the appropriate colour for a particular purpose. Colour conditioning is where the effects depends on the context of the situation and the perceiver's condition (Fehrman & Fehrman, 2003). In this regard, the integration of physiological assessment is another option in finding an explanation for the effect and influences of colour. This is because physiology is one of the important channels in understanding the nature of humans' responses to their environments and, in this context, an environment of colour. Due to this and various other factors, some emotional responses are virtually ineffable in words and can, therefore, be determined solely through physiological means. For example, an unrecognised sign to a pleasant environment was detected from the increased volume of regional cerebral blood flow (rCBF), as observed by Tsunetsugu, Miyazaki and Sato (2005). They assumed that the identified effect was showing an interested response to the tested interior even though the sensory evaluation was indicating the opposite.

There have been a surprisingly limited number of studies conducted on the effects of coloured in environments on university students. In fact, most of the previous colour-effect studies were conducted abroad, some of which being from other fields such as psychology, engineering and neural science, the studies were carried out under various research contexts. Indeed, environmental stimulation is important for a sense of self-attachment (Hassanian, 2008) and to encourage the intellectual abilities as well as the level of productivity among university students (Adewunmi *et al*., 2011; Najib *et al*., 2011). Drawing from the limited studies and existing findings, this research attempted to fill the gap. It aimed to identify the effects of colour on students according to four coloured environments (white, strong red, bluish-green and pink) from their heart-rate assessments across three types of exposure. The central hypothesis is that colour effects change over time from positive to negative and vice versa, contrary to the previous findings that were based on a short-term of exposure. Specifically, strong red and pink are expected to produce positive stimulation in short-term exposure only. In contrast, bluish-green is expected to be more profound in the longer and sustained terms of exposure, while white is expected to reveal an adverse effects for a longer time of exposure.

LITERATURE REVIEW

Colour Effects in Performance

Having an attractively coloured environment boasting an attractive colour may not necessarily have a positive effect on emotions and productivity. A colour may possess different attributes of negative and positive influence at the same time. From the review, the positive and negative effects of red colours red are equally prominent, in comparison to green. The color white, on the other hand, exhibits more negative influences than positive qualities. Perhaps one question that needs to be asked is just how much of a negative or positive effect of a colour would there be. Several researchers have postulated that red is the most arousing colour of all (Jacobs & Hustmyer, 1974; Kwallek & Lewis, 1990; Küller, Mikellides, & Janssens, 2009). It therefore results in enhanced performance with fewer mistakes, as mentioned by Kwallek and associates, Küller and associates and Stone (2003). A recent study by Knez (2011) discovered that red lighting is recommended for short-term memory tasks and problem-solving tasks. The adverse effect of red, however, are worrying about its salient and subtle negative effects on performance in many ways. The avoidance behaviour, reducing the attention and moderating of the perception of the activity that is cognitively challenging (Stone & English, 1998; Stone, 2003; Maier, Elliot, & Lichtenfeld, 2008; Elliot *et al*., 2009).

On the contrary, green is usually associated with positive traits such as calmness, relaxation, peace and reduction of stress levels (Kaya & Epps, 2004; Chebat & Morrin, 2007; Dijkstraa, Pieterseb, & Pruyn, 2008; Yi *et al*., 2012). Moreover, Lichtenfeld *et al*. (2012) recommended the colour green for improving creativity in performance in preference to other colours. As for white, several studies by Kwallek *et al*. (1997) and Stone (2001) have pointed out that the colour causes dysphoria or emotional distress. Despite these findings, many people have preferred white in their environment, including working environment; this is perhaps due to having adapted to the colour after long periods of exposure. Hence, it seems reasonable to raise the possibility that the same outcome would be found in other colours among people who have been exposed to the colour for a sustained period and adapted to the environment. Furthermore, all of the effects are based on the sensory evaluation, which at some point would be different or could be detected by the physiological devices (Tsunetsugu, Miyazaki, & Sato, 2005).

Actual Experiment Setting

Apropos the type of research setting and assessment methods, there are inadequate colour effect researches from the physiological evidence in design area with the use of subjects actual environment. Currently, there exist only six empirical studies that integrated the physiological assessment in identifying the colour effects (Jalil, Yunus, & Said, 2012). Only three of them involved space, in the research as found in Kuller, Mikellides and Janssens (2009), Tsunetsugu, Miyazaki and Sato (2005) and Jin *et al*. (2005). Instead, the rest of them make use of colour slides (Libby, Lacey, & Lacey, 1973; Jacobs & Frank, 1974); coloured objects (Clifford *et al*., 2009) and coloured paper (Elliot *et al*., 2011) as the stimuli. In terms of physiological aspects, they included the galvanic skin response (GSR), heart rate variables, blood pressure, respiration and brain activity. However, not all of the assessment methods were found suitable for all the experimental conditions, especially between the performance and non-performance contexts of the studies. In the performance context, the arousal effect, emotions and motivation are variables that are found to be correlated (Elliot *et al*., 2009). The non-performance context, on the other hand, merely concentrated on the arousal effect of the stimuli. Among the many physiological assessments, the use of heart rate variability was preferred in a performance context, as found by Libby, Lacey and Lacey (1973), Küller *et al*. (2006) and Elliot *et al*. (2011). Due to portable, non-invasiveness and no interference reasons the use of heart rate is appropriate for this study.

EXPERIMENT METHOD

Participants

In order to avoid excessive noise and a paucity of findings, factors such as the specific age range, defined gender, similarities in cultural backgrounds and the health conditions of the potential subjects were strongly taken into consideration. Consequently, the experiment consisted of 22 female undergraduates from courses of various background at the Universiti Teknologi MARA, namely Fine Arts, Mass Communication in Public Relations, Industrial Design, Legal Studies and Culinary Arts Management. Their ages ranged from 19 to 26 years, with a median age of 22. With the limitation of the target group, it was assumed that the findings would reflect the actual patterns of response, as the experiment was conducted in their environment (ecology) over a one-month period of observation. In regards to the cultural and course differences, it was acceptable that the differences were reduced, as the commonly perceived meanings of the colours among the target population were consequently reduced by the fact that a majority of the population lived in hostels. In the hostel, they performed similar activities such as learning, socialising, eating, sleeping, attending classes and relaxing as daily routines (Adewunmi *et al*., 2011).

Participation was on a voluntary basis, with subjects free from visual impairment as detected by the Ishihara test; additionally, subjects were healthy and not on medication, as per ethical requirements. All participants lived in the hostels for the reason of convenience sampling, seeing as how the investigation required naturally formed groups and settings (Creswell, 2009). Since the experiment involved heart-rate recording, approval and consent from the Research Ethics Committee (REC) of the Universiti Teknologi MARA (UiTM), as well as from subjects' parents, were obtained. All participants were given a token and thanked at the end of the experiment.

Experiment Setting

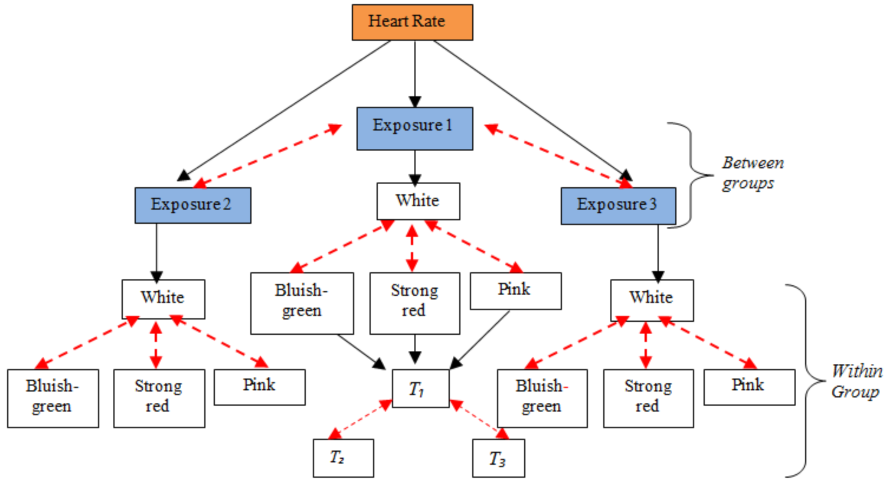
There were only 12 units of twin type rooms available at Block 1 of Kolej Seroja for the experiment. They had floor areas (21 metres square), lighting and furniture. Each of the rooms was painted with one of the four colours, namely strong red, bluish-green, pink and white, as the existing colour. The bluish-green and strong red colours selection were based on the Munsell Colour System as used in the ICI Dulux paint colour system. The strong red was selected from research by Stone and English (1998) and Stone (2003), while the bluish-green was from research by Kwallek *et al*. (1997) and Kwallek, Soon and Lewis (2007). The intention behind using both colours was to retest the colour effect to this context. In their studies, there were several types of greens and reds tested. According to Stone and Stone and English, the red environment has caused more error and lower performance for high-demand tasks, as the colour is distracting. The opposite effects were found for low-demand tasks. For blue-green in Kwallek *et al*., the colour had less influence on the performance than did red. Although this study used only two colours adapted from them, the similar effects were predicted for a short term of exposure and eventually changes over time due to the dominant attribute of the colours as highlighted in the literature. The stands were made as many of reviews had postulated the similar pattern of effects (Jalil, Yunus, & Said, 2012). They are an intense bluish-green (5BG 5/8 Munsell Book of Colour, 1929 or Dulux Real Teal 50GG 30/467) and a strong red (5R 5/8 Munsell Book of Colour, 1929 or Dulux Chorus Rouge 10YR 28/361). The pink (Dulux Peppermint Candy 32RR 50/280) was selected based on a survey conducted earlier in this study that reflected the colour as students' most preferred colour with the white environment as a reference point. In their rooms, the wall at the study area is painted with a dimension of 3 metres wide by 3 metres high for the purpose of this study as recommended by the university. During the experiment, subjects were equipped with the Omron Automatic Blood Pressure Monitor and the portable Polar FT4 to record their heart-rate fluctuations. The selection of the devices for this purpose was approved by the Research Ethics Committee of the university.

Stimuli

The coloured walls and paper-based test were the two types of stimuli used in the experiment. Students' performance was recorded based on their attention level and alertness while they were involved in activities in the coloured environment. There were four tasks in total, named Task 1 through Task 4. Two tasks were given consecutively with a five-minute break in between; them this was done each for two weeks. The break was predicted to affect their performance. However, the score and performance of the experiment is not included in this paper; only heart-rate responses are revealed for all intents and purposes of this study.

Heart-Rate Assessment Procedure and Recording

There were three types of colour exposure in the experiment. The Exposure 1 was for subjects that were exposed to the colours for less than 1 hour (short time), meanwhile, the Exposure 2 was for subjects who lived in the coloured environment for one to two weeks (longer period). Finally, the Exposure 3 was where the subjects lived in the coloured rooms for three to four weeks (sustained period). As for Exposure 1, the experiment was performed one time only, with two tasks given for completion (Task 1 and Task 2) and a short 5-minute break between them. For Exposure 2 and Exposure 3, on the other hand, two experiments were conducted in different weeks consecutively. During the first week of the experiment, Task 1 and Task 2 were given while Task 3 and Task 4 were given for the following week. Just as was the case with Experiment 1, a short break was given between the tasks. Subjects' heart rates were recorded at three different points in time for comparison. The particular times were pre-test for rest or normal condition as a reference point; mid-test for the first 5 minutes during the test; and post-test upon completion of the test. Each group consisted of all four environments with white as its reference point. Below is the diagram of the test and review of data for analysis.



Legend:
Test
T_1 - Time point 1 / Pre-test / Normal or resting condition
T_2 - Time point 2 / Mid-test
T_3 - Time point 3 / Post-test

Fig.1: Diagram of the Heart Rate Test

RESULTS

From the Friedman Test, every task from Exposure 1 to Exposure 3 revealed that there were no significant differences in the overall heart rates in all coloured environments across the three-time points (pre-test, middle of test and post-test) with $p>.05$ due to the small number of participants. However, the changes in patterns of the median values (*Md*) of the heart rate from the three time points were comparable to the analysis. From the observation, there were four types of movement pattern found, namely, increasing (affected), decreasing (affected), consistently unaffected or at a resting level and constantly affected. These movement patterns were found from comparisons of heart rates at the time point 2 and time point 3 against the heart rate of resting level at time point 1 (refer Appendix A.1 to A.3). The patterns were eventually turned into a score and used in explaining the arousal level from its total scores (refer to Table 1 to Table 3). In line with the findings of Elliot *et al*. (2011), the decreasing heart rate indicates negative emotional states such as stress, anxiety, fear and worry. The increasing heart rate relates to positive interest and expressiveness in the performance context.

Colour Effects from the Heart Rate in Exposure 1

Among the colours in Exposure 1, only heart rate from the strong-red environment was identified by showing several positive patterns and high scores through the heart-rate reactions. Subjects were aroused, as shown from the increased and sustained heart-rate levels after the break in Task 2 (Table 1), although most subjects either experienced calmness or were not stimulated consistently at first. The short exposure during the break was powerful enough to increase and positively sustain the arousal level up until the end of the experiment. The heart responses from the bluish-green rooms were also identified by showing positive patterns similar to those of the white environment. Most subjects were described as unattached or apathetic to the stimuli) at the beginning of the test or while they were in Task 1. However, a short exposure served to rejuvenate their arousal levels with an increase in heart rate in Task 2, but did not last until the end of the test. The heart rates of those in the white rooms, on the other hand, showed a short arousal effect, which gradually dissipated. Although the pink rooms showed a pattern of effect akin to those of the white rooms, it also served to undermine or draw away their attention from the activity. The entire positive or negative pattern exhibited from the heart rate fluctuations was converted to a score to identify its potential character of the colour (see Appendix A.1 for detail of heart-rate pattern in the graph). The table below recorded the score of each colour for Exposure 1.

TABLE 1
Pattern of the Heart Rate Fluctuations According to Tasks of Exposure 1

Colour	Task 1			Score (S1)	Rest / Break	Task 2			Score (S2)	TOTAL SCORE (S1 +S2)
	TP 1	TP2	TP3			TP1	TP2	TP3		
White	R (0)	I (+1)	D (-1)	0		R (0)	I (+1)	D (-1)	0	0
Bluish-green	R (0)	D (-1)	I (+1)	0		R (0)	I (+1)	D (-1)	0	0
Strong red	R (0)	C (0)	C (0)	0		R (0)	I (+1)	C (+1)	2	*2
Pink	R (0)	I (+1)	D (-1)	0		R (0)	D (-1)	C (-1)	-2	-2

* Colour with the highest score for the week of observation.
Legend:
R – Average Resting Level / Calm State (0); I – Increase (+1)
D – Decrease (-1); C – Consistently Unaffected / Affected (0 / +1 / -1)
TP (1/2/3) – Time Point 1/2/3

Colour Effects from the Heart Rate in Exposure 2

In Exposure 2, judging from the total scores of the tables below, there are two colours that stands stood out as having significantly more advantage points or arousal effects on heart rate. The strong red, scored highly in Week 1 together with the bluish-green colour, but not in Week 2. The high score indicated that after longer duration of exposure, the positive effects of strong red, as found in Exposure 1, lessened over time compared to those of bluish-green. Instead, the heart rates from the bluish-green environment were high in both weeks and were consistently high (arousal) after a short break during the tests. Even though towards the end of the tasks subjects were less aroused than before, the fact that their heart rates were elevated after the short break indirectly shows the rejuvenating effects of bluish-green. The white environment, on the other hand, exhibited more negative heart-rate patterns, as shown in Week 2 (after two weeks of exposure). In contrast, subjects in the pink environment were more aroused or positively stimulated in the second week than they were before.

TABLE 2
Pattern of Heart Rate Fluctuations According to Tasks in Week 1 (Top) and Week 2 (Below) of Exposure 2

Colour	Task 1 TP1	Task 1 TP2	Task 1 TP3	Score (S1)	Rest / Break	Task 2 TP1	Task 2 TP2	Task 2 TP3	Score (S2)	TOTAL SCORE *(S1 +S2)*
White	R (0)	I (+1)	D (-1)	0		R (0)	D (-1)	I (+1)	0	0
Bluish-green	R (0)	I (+1)	I (+1)	2		R (0)	I (+1)	D (-1)	0	*2
Strong red	R (0)	I (+1)	D (-1)	0		R (0)	I (+1)	I (+1)	2	*2
Pink	R (0)	D (-1)	D (-1)	-2		R (0)	D (-1)	C (-1)	-2	-2

Colour	Task 3 TP1	Task 3 TP2	Task 3 TP3	Score (S1)	Rest / Break	Task 4 TP1	Task 4 TP2	Task 4 TP3	Score (S2)	TOTAL SCORE *(S1 +S2)*
White	R (0)	C (0)	D (-1)	-1		R (0)	D (-1)	D (-1)	-2	-3
Bluish-green	R (0)	I (+1)	I (+1)	2		R (0)	I (+1)	D (-1)	0	*2
Strong red	R (0)	I (+1)	D (-1)	0		R (0)	I (+1)	D (-1)	0	0
Pink	R (0)	I (+1)	D (-1)	0		R (0)	I (+1)	D (-1)	0	0

* Colour with the highest score for the week of observation.
Legend:
R – Average Resting Level / Calm State (0); I – Increase (+1)
D – Decrease (-1); C – Consistently Unaffected / Affected (0 / +1 / -1)
TP (1/2/3) – Time Point 1/2/3

Colour Effects from the Heart Rate in Exposure 3

As predicted, in Exposure 3, the bluish-green environment was consistently found to stimulate the heart rate in both weeks, as stated in the total scores of Table 3 and Table 4. However, the positive influence was more profound in Week 1, indicating that the stimulating and rejuvenating effects of the bluish-green colour eventually diminished, but was still more significant than the others after four weeks of living in the coloured rooms. As expected, strong red and pink environments are the colours that have the lowest scores in terms of decreased heart rate. This suggested that the pink environment affected the subjects negatively even though pink was rated as the most preferred colour by the female students found from the survey. Surprisingly, the white colour had a positive stimulating effect on the subjects after three weeks of living in the coloured rooms, although the effect is eventually lessened, thereby contradicting the prediction.

TABLE 3
Pattern of the Heart Rate Fluctuations According to Tasks in Week 1 (Top) and Week 2 (Below) of Exposure 3

Colour	Task 1			Score *(ST1)*	Rest / Break	Task 2			Score *(ST2)*	TOTAL SCORE *(ST1 +ST2)*
	TP1	TP2	TP3			TP1	TP2	TP3		
White	R (0)	I (+1)	I (+1)	2		R (0)	I (+1)	D (-1)	0	2
Bluish-green	R (0)	I (+1)	I (+1)	2		R (0)	I (+1)	I (+1)	2	*4
Strong red	R (0)	D (-1)	D (-1)	-2		R (0)	D (-1)	D (-1)	-2	-4
Pink	R (0)	D (-1)	I (+1)	0		R (0)	I (+1)	D (-1)	0	0

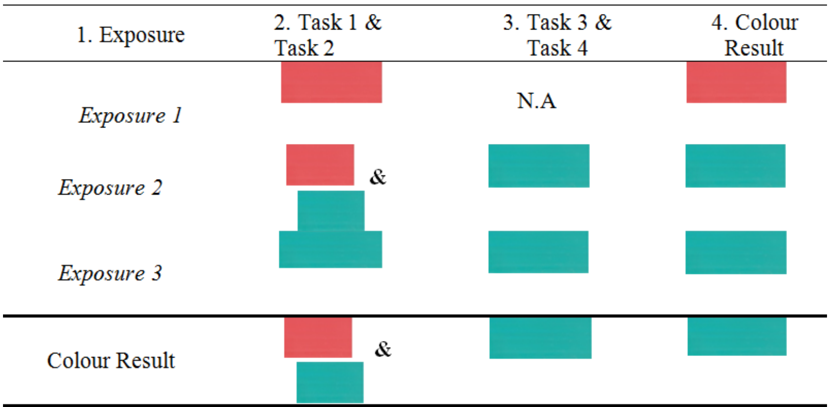
Colour	Task 3			Score *(ST3)*	Rest / Break	Task 4			Score *(ST4)*	TOTAL SCORE *(ST3 +ST4)*
	TP1	TP2	TP3			TP1	TP2	TP3		
White	R (0)	I (+1)	D (-1)	0		R (0)	D (-1)	I (+1)	0	0
Bluish-green	R (0)	I (+1)	D (-1)	0		R (0)	D (+1)	I (+1)	2	*2
Strong red	R (0)	C (0)	I (+1)	1		R (0)	I (+1)	D (-1)	0	1
Pink	R (0)	D (-1)	D (-1)	-2		R (0)	C (0)	D (-1)	-1	-3

* Colour with the highest score for the week of observation.
Legend:
R – Average Resting Level / Calm State (0), I – Increase (+1)
D – Decrease (-1); C – Consistently Unaffected / Affected (0 / +1 / -1)
TP (1/2/3) – Time Point 1/2/3

FINDINGS AND DISCUSSION

From the physiological responses it has been revealed that bluish-green, followed by strong red, were the colours with the most significant implications on subjects' levels of stimulation based on the type of exposures (Table 4). For a short duration of exposure, strong red environment is recommended for the students, as it is capable of positively stimulating their interest (arousal) in the activities. This notion is aligned with the findings of Kwallek and Lewis (1990) and Küller, Mikellides and Janssens (2009) on the red effects for a short-term of exposure. As for a longer and sustained period of exposures, bluish-green is recommended for the environment for its calming, stimulating and rejuvenating effects on the subjects' emotions, as explained in the literature review. The experiment did not provide statistical evidence of the relationship between colour effects and the heart rate due to its sample size. Therefore, it is reasonable to ascertain the results from the average of median values that reflect the actual responses of this small group of residential female students. In addition, the results have proven that all of colours' effects change over time, with the effects not being static. Referring to the central hypothesis, only findings from the strong red and bluish-green environments are parallel to the expectations, while the others showed inconsistent patterns.

TABLE 4
Summary of Colour Results According to Tasks and Type of Exposure from Heart-Rate Responses



CONCLUSION

In conclusion, bluish-green is recommended for a better degree of activity engagement if the activity involves a longer time spent in the coloured space, such as in the case of a hostel room. Conversely, strong red is recommended for better engagement when the activity involves a short term of colour exposure. As the colour is conditioning, and the findings have proven that the change in colour effects depends on the length of colour exposure (Fehrman & Fehrman, 2004; Kwallek, Soon, & Lewis, 2007). The impact will be more outstanding, however, if the colours are used together, although this has yet to be discovered. Notwithstanding the recommendation, the result does not warrant any performance or emotional improvement *per say* as the objective is to identify the colour effect physiologically. In the experiment, the physiological assessment that involved physical contact contributed to a small number of volunteers, which rendered the data unsuitable for statistical analysis. With such a limitation, the research merely focussed on the intricacies of the colour effects instead of making a generalisation about the population. However, it is believed that a larger sample size may give a statistically significant result and could, therefore, be useful for actual applications. Despite the limitation, the results provide a new perspective to design area by providing a significant application with potential pragmatic applications. Another factor to ponder here is that a green environment does not necessarily require that the backdrop be a bluish-green wall; instead, the same result could probably be obtained by the use of green plants or any other random green decorative item.

ACKNOWLEDGEMENT

This paper and the research were sponsored by the Ministry of Higher Education of Malaysia with support from the International Islamic University Malaysia and Universiti Teknologi MARA, Malaysia.

Appendix A

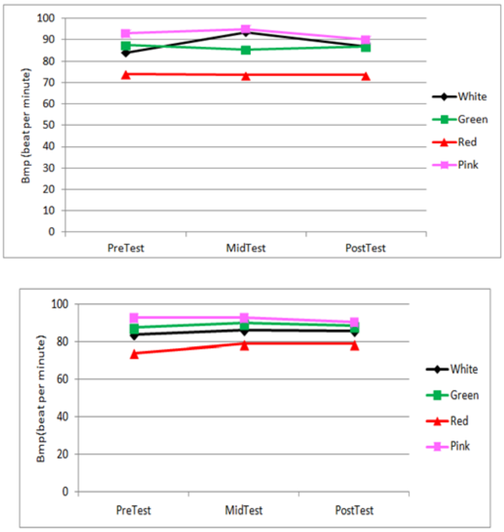


Fig.2: Graph of heart rate fluctuations of Task 1 (top) and Task 2 (below) from all environments of colour in Exposure 1.

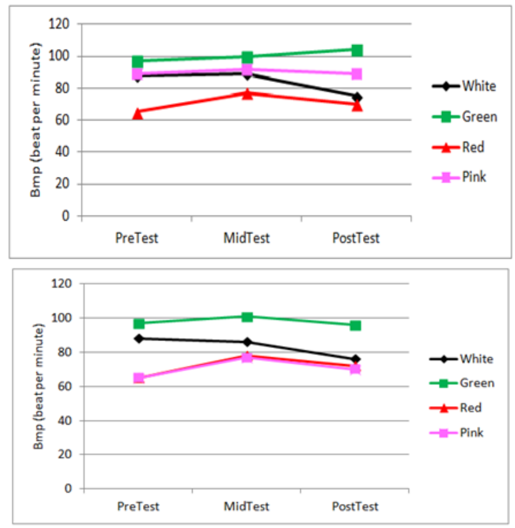


Fig.4: Graph of heart rate fluctuations of Task 1 (top) and Task 2 (below) in week 2 from all environments of colour in Exposure 2.

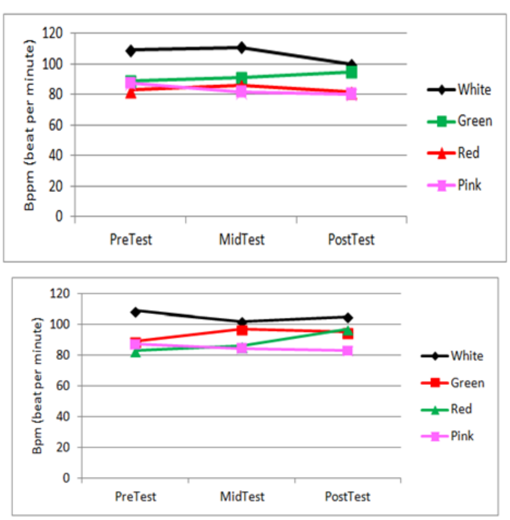


Fig.3: Graph of heart rate fluctuations of Task 1 (top) and Task 2 (below) in week 1 from all coloured environments in Exposure 2.

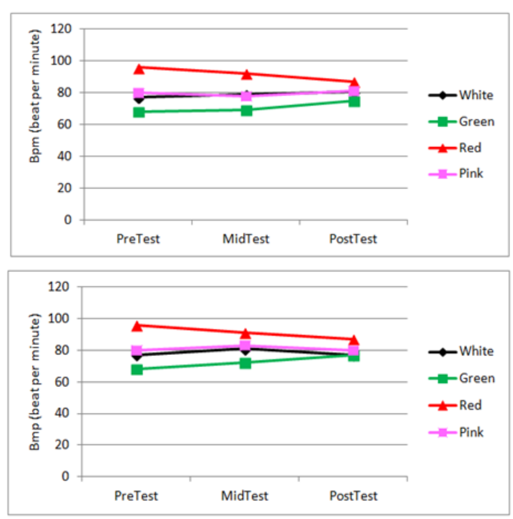
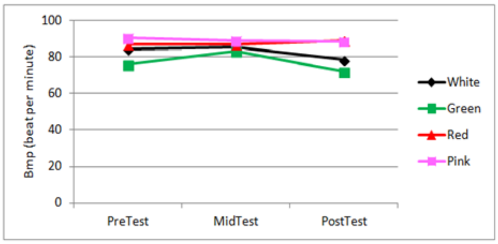


Fig.5: Graph of heart rate fluctuations of Task 1 (top) and Task 2 (below) in week 1 from all coloured environments in Exposure 3.



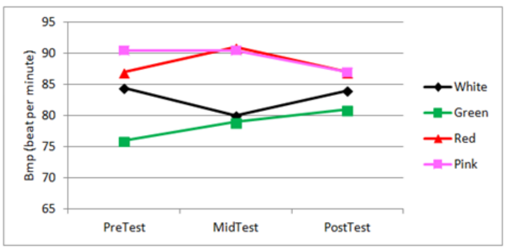


Fig.6: Graph of heart rate fluctuations of Task 1 (top) and Task 2 (below) in week 2 from all coloured environments in Exposure 3.

REFERENCES

Bisadi, M., Mozaffar, F., & Hosseini, S. B. (2013). *Appropriate Architecture and Urban Design Research Centre for Creative Thinking and Communication*.

Chebat, J.-C. & Morrin, M. (2007). Colors and Cultures: Exploring the Effects of Mall Décor on Consumer Perceptions. *Journal of Business Research, 60*(3), 189-196. doi: 10.1016/j.jbusres.2006.11.003

Cresswell, J. W. & Clark, V. L. P. (2011). *Designing and Conducting Mix Methods Research* (2nd Ed.). Thousand Oaks, California: SAGE Publications, Inc.

Dalke, H., Little, J., Niemann, E., Camgoz, N., Steadman, G., Hill, S., *et al*. (2005). Colour and Lighting in Hospital Design. *Optics & Laser Technology, 38*(4-6), 343-365. doi: 10.1016/j.optlastec.2005.06.040

Dijkstra, K., Pieterseb, M. E., & Pruyn, A. T. H. (2008). Individual Differences in Reactions towards Colour in Simulated Healthcare Environments: The Role of Stimulus Screening Ability. *Environmental Psychology, 28*, 268-277. doi:10.1016/j.jenvp.2008.02.007.

Elliot, A. J., Maier, M. A., Binser, M. J., Friedman, R., & Pekrun, R. (2009). The Effect of Red on Avoidance Behavior in Achievement Contexts. *Personality and Social Psychology Bulletin, 35*(3), 365-375

Fehrman, K. R. & Fehrman, C. (2004). *Color: The Secret Influence* (2nd Ed.). Upper Saddle River, NJ: Prentice Hall.

Jacobs, K. W. & Hustmyer Jr, F. E. (1974). Effects of four psychological primary colors on GSR, heart rate and respiration rate. *Perceptual and motor skills, 38*(3), 763-766.

Jalil, N. A., Yunus, R. M., & Said, N. S. (2013). Students' Colour Perception and Preference: An Empirical Analysis of Its Relationship. *Procedia-Social and Behavioral Sciences*, *90*, 575-582.

Jalil, N. A., Yunus, R. M., & Said, N. S. (2012). Environmental colour impact upon human behaviour: A review. *Procedia-Social and Behavioral Sciences*, *35*, 54-62.

Kaya, N. & Epps, H. H. (2004). Relationship between Color and Emotion: A Study of College Students. *Journal of College Student, 38*(3), 396-405.

Knez, I. (2001). Effects of Colour of Light on Nonvisual Psychological Processes. *Journal of Environmental Psychology, 21*(2), 201-208. doi: 10.1006/jevp.2000.0198.

Küller, R., Ballal, S., Laike, T., Mikellides, B., & Tonello, G. (2006). The Impact of Light and Colour on Psychological Mood: A Cross-Cultural Study of Indoor Work Environments. *Ergonomics, 49*(14), 1496-1507.

Küller, R., Mikellides, B., & Janssens, J. (2009). Color, Arousal, and Performance. A Comparison of Three Experiments. *Journal of Colour Research and Application, 34*(2), 141-152. doi: 10.1002/col.20476

Kwallek, N. (1996). Office Wall Color: An Assessment of Spaciousness and Preference. *Journal of Perceptual and Motor Skills, 83*, 49-50.

Kwallek, N. & Lewis, C. M. (1990). Effects of Environmental Colour on Males and Females: A Red or White or Green Office. *Applied Ergonomics, 21*(4), 275-278. doi: 10.1016/0003-6870(90)90197-6.

Kwallek, N., Soon, K., & Lewis, C. M. (2007). Work Week Productivity, Visual Complexity, and Individual Environmental Sensitivity in Three Offices of Different Color Interiors. *Journal of Colour Research and Application, 32*(2), 130 - 143. doi: 10.1002/col.20298

Kwallek, N., Lewis, C. M., Lin-Hsiao, J. W. D., & Woodson, H. (1996). Effects of Nine Monochromatic Office Interior Colors on Clerical Tasks and Worker Mood. *Journal of Colour Research and Application, 21*(6), 448 – 458.

Lichtenfeld, S., Elliot, A. J., Maier, M. A., & Pekrun, R. (2012). Fertile Green Facilitates Creative Performance. *Personality and Social Psychology Bulletin, 38*(6), 784-797.

Maier, M. A., Elliot, A. J., & Lichtenfeld, S. (2008). Mediation of the Negative Effect of Red on Intellectual Performance. *Personality and Social Psychology Bulletin, 34*(11), 1530-1540.

Stone, N. J. (2001). Designing Effective Study Environments. *Journal of Environmental Psychology, 21*(2), 179-190.

Stone, N. J. (2003). Environmental View and Colour for a Simulated Telemarketing Task. *Journal of Environmental Psychology, 23*(1), 63-78. doi: 10.1016/S0272-4944(02)00107-X.

Stone, N. J., & English, A. J. (1998). Task Type, Posters, and Workspace Color on Mood, Satisfaction, and Performance. *Journal of Environmental Psychology, 18*(2), 175-185. doi: 10.1006/jevp.1998.0084.

Yi, J.-s., Kim, Y.-w., Kim, K.-a., & Koo, B. (2012). A suggested color scheme for reducing perception-related accidents on construction work sites. *Accident Analysis & Prevention, 48*, 185-192.