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ASLI QoL 2017

E-B Environment - Behaviour Proceedings Journal

AQoL2017Kuching

http://www.amerabra.org; *https://fspu.uitm.edu.my/cebs*
3rd ABRA International Conference on Quality of Life
"Quality of Life 3"
Riverside Majestic Hotel, Kuching, Malaysia, 14-16 Oct 2017

e-IPH e-International Publishing House Ltd., United Kingdom

Effects of Colour, Area, and Height on Space Perception

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Abstract
Colours and the spatial properties of the workplace are primarily visually conveyed. The aim of this study determines how colour, area and height influence space perception. 80 interior designers participated in this experiment to evaluate the sixteen workspace images on the internet-based questionnaires. Four factors of space perception; spaciousness, openness, complexity, and order, were assessed using a semantic differential scale. The outcomes revealed that variations in space perception were significantly associated with the difference in colour, area, and height. Neutral colour in all area and height obtained the highest rating of the overall factors, followed by cool colours.

Keywords: Effect of colour, Colour combination, Work environment, Space perception

https://doi.org/10.21834/e-bpj.v2i6.978

1.0 Introduction

The physical work environment that can affect human perception is well documented. Certain attributes of the workplace such as room configuration, office planning, ergonomics, colour or lighting have been conducted. In term of colour, which is one of the interior design elements that also play a crucial role in influencing either large or small space. However, little research investigates the interaction effect of colours and spatial-architectural dimension in the work environment on human space perception. Most of them conducted in the experimental room and focused on examining the effect of each factor separately. Many studies have studied on colours only at the walls but lack of concentration in the whole space. It should determine the spatial effects with all three planes such as the horizontal plane, vertical plane, and overhead plane. Moreover, there is a limited amount of research in a wide range of color. There were almost examined a few prominent colour such as red, blue, green, and particular research have attempted to compare the effect of one colour with other colour. Therefore, this study aimed to explore the various colour schemes and room proportion in the real design work environments in Thailand, and then examine how colour, area and height influence space perception. It's necessary to understand how the different colour in the various room proportion can affect human perceptions to create a positive workplace. The findings will provide the essential variables, set of effective colour, implication, and recommendation for further study.

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https://doi.org/10.21834/e-bpj.v2i6.978

2.0 Literature review

In this study, the perception of space and the work environment were interested in investigating the interaction effect of colours, area, and height of the workplace on human space perception. The following review aims to establish the theoretical basis, research framework of relevant variables and their relationships is developed (Fig. 1).

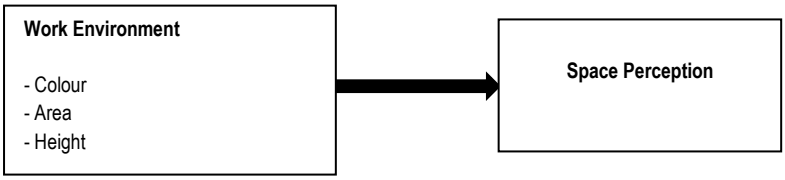

Fig.1. Research Framework

2.1. Colour

Colours and spatial dimensions of the physical environment are primarily visually conveyed. Numerous studies indicate that colour can have a profound effect on perceived room dimensions. For instance, warm colours, such as red, yellow and orange, tend to make space seem smaller than it actually is (Yildirim et al., 2012). Warm deep colours on the end walls with a lighter colour wall can make a long narrow room seem close and appear more evenly proportioned (Pile, 1997). On the other hand, cool colours, such as blue and green, and lighter colour tend to make space much more spacious (Yildirim et al., 2011). The cool colour space was perceived as somewhat more openness than the warm colour space.

Neutral colours, such as white, beige, black and gray, are the most commonly used colours for workplace environments. The office with white painted walls was perceived as more spacious than the monochromatic red and green painted walls (Kwallek, 1996). Moreover, the mean rating for spaciousness for white lighting was higher than that of green and red as well (Odabaşioğlu & Olguntürk, 2015). A low ceiling will seem less oppressive by a light colour, and the perceived room height tend to increase with wall lightness (Oberfeld & Hecht, 2010). While a high ceiling can be made to seem lower by a dark blue and black (Pile, 1997). The multicolour room was found to have a very high complexity and non-unity, whereas the neutral room obtained an opposite effect (Küller et al., 2009). The achromatic scheme was perceived more harmonious, and the chromatic scheme was indicated a more complex (Öztürk, Yılmaze & Ural, 2012).

Nevertheless, there is some contradiction in previous studies. For instance, the influence of colour on perceived spaciousness was reported smaller effect when the amount of light is controlled (Stamp, 2011). There was no difference between colourful and gray workspace in term of enclosedness (Küller et al., 2009). The floor lightness has no significant effect on perceived height and that the total brightness of the room is not the critical factor influencing the perceived height (Oberfeld & Hecht, 2010).

The colour combination in the workplace will consider as good because the colours blend nicely between the wall, furniture, and floor finish. An office has a multicolour scheme where the colours do not mix up together completely, causing conflict between the colours used (Kamaruzzaman & Zawawi, 2010). However, the previous studies in physical workplace environment have mostly focused on colours only at the walls but lacking in concentration as a whole space and have some conflicts between the results. For example, a study found that employee preferred the combination of cool and warm colours than the combination of cool or warm colours (Poursafar et al., 2016). And another research found that neutral colour with a mixture of cool colour could help enliven perception. (Kamaruzzaman & Zawawi, 2010). Thus, more research relating to the relation of colour and space perception is needed to be done to understand differences in effectiveness.

2.2 Horizontal area

Horizontal area or floor area is the most crucial factor that influences perceived spaciousness (Franz and Wiener, 2005; Franz; Stamps, 2007; Stamps, 2011). The amount visible edges also had a strong effect on judged spaciousness (Benedikt and Burnham, 1985; Franz & Wiener, 2005). The larger area was perceived more positively than, the smaller one (Barucha-Reid and Kiyak, 1982), and was judged as being more spacious than it seems to be (Stamps, 2009; Stamps, 2011). Primary affective dimensions of spaces are probably their size (Joedicke, 1985) and rate of the enclosure (Franz et al., 2005; Stamps, 2005).

2.3 Height

There are the influences of boundary height and space perception of the physical environment. The ceiling height might extend beyond the upper limit of room to increase the perception of its size. Double high space can enhance the volume of space and create a sense of spaciousness. It appears that people tend to prefer ceilings that are higher than standard and the preference of ceiling height varied as a function of occupant's activity in the room (Baird, Cassidy and Kurr, 1978). The lower boundaries could increase the perception of spaciousness (Stamps, 2011). However, the findings and theories are still not sufficiently empirically backed and integrated, especially in the context of the work environment. More research has to be investigated.

2.4 Space perception

Many environmental factors are effective in the evaluation and space perception. Appropriate and proper use of physical features can enhance human satisfaction. Regarding empirical aesthetics, the environmental factors were classified into three categories: complexity, order and spatial perception (Nasar, 1997). Complexity includes visual richness, decoration accessories, and information

ratio. The order comprises unity, order, and clarity. Spatial perception provides openness, spatial arrangement, and density. This study focus on the work environment context and four factors are mainly considered: spaciousness, openness, complexity, and order.

Spaciousness can influence the properties of the physical environment (Stamps, 2007). The potency dimension linked to the size and spaciousness such as spacious-cramped, low-high. Openness related with the rate of the enclosure. Rectangular architectural space seems to predict from room proportions, area, and openness ratio (Franz et al., 2005). In term of complexity and order, the theories suggest that they are essential fundamental factors of architecture (Weber, 1995). The high level of plan complexity is another factor that influences spatial perception. Complex spaces are perceived darker and confined (Hidayetoglu et al., 2010). Complexity is represented by the variable simple-complex. Overall building shape, patterns, and compositional elements can enhance a sense of order. The dependent variables linked to order are harmonious-inharmonious, fit-contrast. The factors and semantic differential rating scale variables related to space perception are shown in table 1.

Table 1. Factor and dependent variables of the construct space perception

Factor	Dependent variables
Spaciousness	spacious-cramped
	high-low
Openness	openness-enclosure
Complexity	simple-complex
Order	harmonious-inharmonious
	fit-contrast

Several research tools are used to explore the space perception in previous studies such as photo, experimental room, existing workplace and virtual reality. Using image as a measure tools instead of real on-site evaluation can predict respondent's similar response and can go through the various environment in a short period (Kaplan & Kaplan, 1989; Liu & Chuang, 2014). Due to this experiment aim to explore and examine the effect of different colour in the difference workspace. Therefore, the photograph was a tool that suited for this research.

3. Methods

This experimental research was carried out in two stages: a pilot study and main study. A pilot study was conducted to explore colour in the work environment with the different room proportion, and to come up with the representative stimuli using for the main study. The sorting task was used to select out workplace images with the primary three attributes: colour, area, and height.

Colour: (C1) Warm colour, (C2) Cool colour, (C3) Colourful, (C4) Neutral colour
Area : (A1) Small open plan (4-9 persons), (A2) Medium-sized open plan (10-24 persons)
Height: (H1) Low ceiling, (H2) High ceiling

3.1 A Pilot study

The first step, four interior design graduate students worked together to select 200 colour photographs of real design workplace. The selection based on the following criteria:

- The workplaces are locating in Thailand.
- Interior space that can be viewed as a three-dimensional: floor plan, wall, and ceiling plane.
- Images from most popular digital magazine and website for architecture and design domestic and international (archdaily, designboom, retaildesignblog, dezeen, art4d, etc.)
- Between the year 2000 and 2017

All the inclusion images were standardized in term of size and resolution and printed on A4 Paper. Photographs with poor printing quality were excluded. Importantly, the stimuli were not controlled by other variables such as light and furniture.

The second step, six experts with year-long practical working experience, three professional interior designers and three lecturers from interior design departments, were gathered at the expert meeting and picked out the photos that best suit to measure three attributes in 8 component. Finally, 16 colour images were fit the inclusion criteria and then were used in the main study. See the sample of workplace images with three attributes below.

Fig. 2. C1- A1- H1.

Fig. 3. C1- A1- H2.

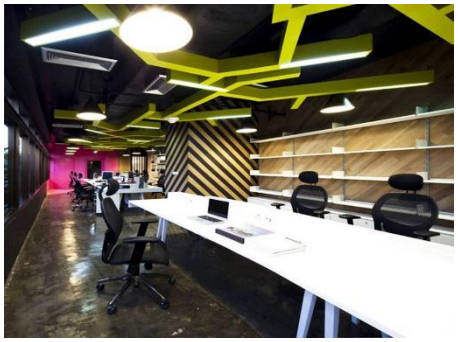

Fig. 4. C3- A1- H1.

Fig. 5. C2- A1- H1.

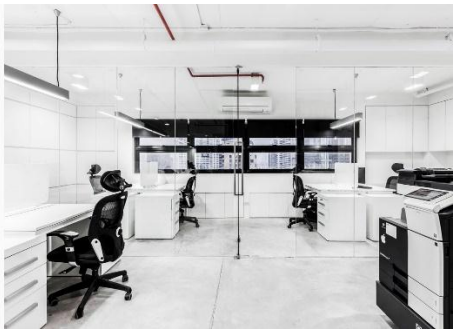

Fig. 6. C4- A1- H1.

Fig. 7. C4- A1- H2.

Source of each representative image:
Fig.2 https://www.archdaily.com/office/studio-of-design-and-architecture, Fig.3 https://supermachine.co/2016/09/28/hubba-to/, Fig.4 https://www.archdaily.com/232514/rebirth-of-saatchi-saatchi-thailand-supermachine-studio, Fig.5 https://www10.aeccafe.com/blogs/arch-show case/2017/04/13/kbtg-kasikorn-business-technology-group-building-in-chaengwattana-thailand-by-pbm-progressive-building-management-co-ltd/, Fig.6 https://www.archdaily.com/558152/rabbit-s-tale-t-dtangstudio, Fig.7 https://www.archdaily.com/641200/zonic-vision-office-stu-d-o-architects.

3.2 The main study

Participants

A total of 80 interior designers (41 females, 39 males) with normal or corrected to normal vision participated in the experiment. The average age was 25.8 years with a range of 21 to 35 years. All participants were randomly assigned to one of the internet-based questionnaires and were briefly introduced to the experiment at the beginning. They took approximately 10 minutes to complete each of the questionnaires. The data were obtained during 2-weeks period

Materials

The two questionnaires were prepared for the experiments consisting of two parts: the first part was composed of question about general information of the participants relating to the age, education level, and work experience; the second part consisted of 7-point semantic differential scale about the perception of the work environment. Each questionnaire contained eight workplace photographs so that it could be completed in an appropriate time frame. The participants were asked to evaluate the differently colour workspace on each of 6 bipolar adjective pairs on a 7-point semantic differential scale as follows: spacious-cramped, high-low, openness-enclosure, simple-complex, harmonious-inharmonious and fits-contrast. The differences between participant's space perceptions in 4 different spaces (small area-low ceiling, medium area-low ceiling, small area-high ceiling and medium area-high ceiling) with four colour schemes (warm colour, cool colour, colourful, neutral) were tested using three-way ANOVA.

4.0 Results

According to the three-way ANOVA results, the difference between variables; colour and height, were found to be statistically significant at the level of $p<0.05$ for all of the semantic differential items (spacious-cramped, high-low, openness-enclosure, simple-complex, harmonious-inharmonious and fit-contrast). Room area did not reach statistical significance regarding some perceptions.

As shown in table 2, a three-way between groups analysis of variance was conducted to explore the impact of colour, area, and height on the perception of spaciousness. The interaction effect between colour, area, and height was statistically significant,

F(3, 624)=10.55, p=.00. There was a statistically significant main effect for colour, F(3, 624)=17.72, p=.00; area, F(1, 624)=39.05, p=.00; and height, F(1, 624)=96.44, p=.00.

The difference colour, area, and height had significant relation effects and were perceived entirely different in spaciousness. Neutral colour workplaces tended to create more spacious in the medium area with the low ceiling as well as in the small and medium area with high ceiling. In small room area with the low ceiling, cool colour evoked a feeling of spaciousness while colourful perceived in the opposite direction.

Table 2. Results of the between-subjects effects test for the perception of spaciousness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	381.494a	15	25.433	19.191	.000	.316
Intercept	1775.556	1	1775.556	1339.799	.000	.682
Col	70.456	3	23.485	17.722	.000	.079
Area	51.756	1	51.756	39.054	.000	.059
Height	127.806	1	127.806	96.440	.000	.134
Col * Area	35.131	3	11.710	8.836	.000	.041
Col * Height	52.606	3	17.535	13.232	.000	.060
Area * Height	1.806	1	1.806	1.363	.243	.002
Col * Area * Height	41.931	3	13.977	10.547	.000	.048
Error	826.950	624	1.325			
Total	2984.000	640				
Corrected Total	1208.444	639				

a. R Squared = .316 (Adjusted R Squared = .299)

According to the result shown in table 3, a three-way between groups analysis of variance was conducted to explore the impact of colour, area, and height on the perception of height. The interaction effect between colour, area, and height was statistically significant, F(3, 624)=4.65, p=.03. There was a statistically significant main effect for colour, F(3, 624)=12.15, p=.00, and height, F(1, 624)=362.12, p=.00. The main effect for the area, F(1, 624)=.80, p=.37, did not reach statistical significance.

The difference colour, area, and height had significant relation effects and were perceived completely different in the perception of height. In the medium area with both low and high ceiling, neutral colours workplace perceived much higher ceiling than other colour schemes. In the small area, colourful work environment obtained the high score in a high ceiling workplace but got a low score in a low ceiling space. Cool colours room were rated to appear higher ceiling than others in the small area.

Table 3. Results of the between-subjects effects test for the perception of height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	590.686a	15	39.379	32.367	.000	.438
Intercept	1553.139	1	1553.139	1276.595	.000	.672
Col	44.330	3	14.777	12.146	.000	.055
Area	.977	1	.977	.803	.371	.001
Height	440.564	1	440.564	362.119	.000	.367
Col * Area	22.692	3	7.564	6.217	.000	.029
Col * Height	63.655	3	21.218	17.440	.000	.077
Area * Height	1.502	1	1.502	1.234	.267	.002
Col * Area * Height	16.967	3	5.656	4.649	.003	.022
Error	759.175	624	1.217			
Total	2903.000	640				
Corrected Total	1349.861	639				

a. R Squared = .438 (Adjusted R Squared = .424)

The results as shown in table 4, a three-way between groups analysis of variance was conducted to explore the impact of colour, area, and height on the perception of openness. The interaction effect between colour, area, and height was statistically significant, F(3, 624)=5.55, p=.00. There was a statistically significant main effect for colour, F(3, 624)=10.20, p=.00; area, F(1, 624)=31.45, p=.00; and height, F(1, 624)=251.21, p=.00.

The difference colour, area, and height had significant relation effects and were found completely different in openness. In the medium area with both low and high ceiling, neutral colour workplaces perceived higher score in openness than others. Warm colours in both small and medium area with low ceiling workplace tend to provide the feeling of enclosure. In small room area with the low ceiling, the cool colour was perceived as being higher in openness than other schemes.

Table 4. Results of the between-subjects effects test for the perception of openness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	757.986a	15	50.532	26.760	.000	.391
Intercept	972.689	1	972.689	515.102	.000	.452
Col	57.755	3	19.252	10.195	.000	.047
Area	59.414	1	59.414	31.464	.000	.048
Height	474.377	1	474.377	251.213	.000	.287
Col * Area	39.805	3	13.268	7.026	.000	.033
Col * Height	84.442	3	28.147	14.906	.000	.067
Area * Height	10.764	1	10.764	5.700	.017	.009
Col * Area * Height	31.430	3	10.477	5.548	.001	.026
Error	1178.325	624	1.888			
Total	2909.000	640				
Corrected Total	1936.311	639				

a. R Squared = .391 (Adjusted R Squared = .377)

According to the result shown in table 5, a three-way between groups analysis of variance was conducted to explore the impact of colour, area, and height on the perception of complexity. The interaction effect between colour, area, and height was statistically significant, F(3, 624)=6.84, p=.00. There was a statistically significant main effect for colour, F(3, 624)=89.54, p=.00, and height, F(1, 624)=5.86, p=.02. The main effect for area, F(1, 624)=2.60, p=.11, did not reach statistical significance.

Colour, area, and height had significant relation effects on perception. The difference between colour and height factors were perceived completely different in complexity. The neutral workplaces in all proportion of space were perceived as the most simplicity. Warm colour in the medium workplace area with low ceiling perceived to be more complex than small area and other colour schemes. Colourful space perceived high complexity in all workplace except in the medium area with high ceiling.

Table 5. Results of the between-subjects effects test for the perception of complexity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	896.850a	15	59.790	36.825	.000	.470
Intercept	810.000	1	810.000	498.880	.000	.444
Col	436.138	3	145.379	89.539	.000	.301
Area	4.225	1	4.225	2.602	.107	.004
Height	9.506	1	9.506	5.855	.016	.009
Col * Area	270.113	3	90.038	55.454	.000	.210
Col * Height	133.056	3	44.352	27.316	.000	.116
Area * Height	10.506	1	10.506	6.471	.011	.010
Col * Area * Height	33.306	3	11.102	6.838	.000	.032
Error	1013.150	624	1.624			
Total	2720.000	640				
Corrected Total	1910.000	639				

a. R Squared = .470 (Adjusted R Squared = .457)

As shown in table 6, a three-way between groups analysis of variance was conducted to explore the impact of colour, area, and height on the perception of harmony. The interaction effect between colour, area, and height was not statistically significant, F(3, 624)=1.70, p=.17. There was a statistically significant main effect for colour, F(3, 624)=139.40, p=.00, and height, F(1, 624)=9.86, p=.02. The main effect for area, F(1, 624)=3.36, p=.07, did not reach statistical significance.

Colour, area, and height had no statistically significant relation effects on perception. However, the difference between colour and height factors were perceived completely different in harmony. Neutral colour in small area both low and high ceiling workplace got the high score in harmony. Cool colour in the small area with high ceiling perceived upper harmony similar to the neutral environment, while colourful and warm colour tended to create a more non-harmony perception.

Table 6. Results of the between-subjects effects test for the perception of harmony

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	876.275a	15	58.418	40.010	.000	.490
Intercept	950.625	1	950.625	651.070	.000	.511
Col	610.588	3	203.529	139.394	.000	.401
Area	4.900	1	4.900	3.356	.067	.005
Height	14.400	1	14.400	9.862	.002	.016
Col * Area	141.463	3	47.154	32.295	.000	.134
Col * Height	80.588	3	26.863	18.398	.000	.081
Area * Height	16.900	1	16.900	11.575	.001	.018

Col * Area * Height	7.438	3	2.479	1.698	.166	.008
Error	911.100	624	1.460			
Total	2738.000	640				
Corrected Total	1787.375	639				

a. R Squared = .490 (Adjusted R Squared = .478)

According to the result shown in table 7, a three-way between groups analysis of variance was conducted to explore the impact of colour, area, and height on the perception of contrast. The interaction effect between colour, area, and height was not statistically significant, F(3, 624)=2.38, p=.07. There was a statistically significant main effect for colour, F(3, 624)=65.45, p=.00, and height, F(1, 624)=19.12, p=.00. The main effect for area, F(1, 624)=.25, p=.62, did not reach statistical significance.

Colour, area, and height had no statistically significant relation effects on perception. However, the difference between colour and height factors were perceived completely different in contrast variable. All of the neutral workplaces were rated as more fit in space except the small area with the low ceiling. Cool, provide more fit small space. The colourful workplace in small area both low and high ceiling tended to perceive spatial contrast.

Table 7. Results of the between-subjects effects test for the perception of contrast

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	560.100a	15	37.340	23.312	.000	.359
Intercept	960.400	1	960.400	599.589	.000	.490
Col	314.512	3	104.837	65.451	.000	.239
Area	.400	1	.400	.250	.617	.000
Height	30.625	1	30.625	19.120	.000	.030
Col * Area	106.587	3	35.529	22.181	.000	.096
Col * Height	83.337	3	27.779	17.343	.000	.077
Area * Height	13.225	1	13.225	8.257	.004	.013
Col * Area * Height	11.413	3	3.804	2.375	.069	.011
Error	999.500	624	1.602			
Total	2520.000	640				
Corrected Total	1559.600	639				

a. R Squared = .359 (Adjusted R Squared = .344)

In summary, the findings indicated that space perception of the sixteen work environments was different. The three physical work environment attributes had important effects on human space perception. However, the interaction effect of colour, area, and height was not significantly difference in two variables: harmony, and contrast. Moreover, room area did not reach statistical significance in some variables: height, complexity, harmony and contrast. Overall, it appeared that neutral colour in all of area and height obtained the higher positive score, followed by cool colours. Whereas warm and colourful received the lower rating. Expanding in horizontal area and ceiling height, the average mean of spatial effects in all variables increased as well.

5. Discussions

This study carried out the experimental research and tested the possible differences among the professional interior designers to explore the relation effects of colours and spatial-architectural dimension in the work environment. The results indicated that the variations in space perception were significantly associated with the difference in colour, area, and height. There were both consistency and contrary on the effects with previous research.

Regarding the colour factor, neutral was perceived the most positively in all factors of space perception. The workspace with neutral colours tended to perceive more spaciousness, openness, simplicity, and order than other colour schemes. These results support the previous study of Küller et al. (2009) that the neutral workspace obtained simplicity effect. The findings also support the studies that room with the achromatic scheme and the white workspace were perceived more harmonious (Kwallek, 1996; Öztürk et al., 2012). However, Küller et al. (2009) found that there is no difference between colourful and gray workspace in term of enclosedness, while this study revealed the contrary results. Although neutral seem to make an area appear more spacious than other colour scheme, it may not be the best colour to use in the workplace. There are several studies found the negative effect of neutral mainly white on emotional response and work performance. Workers performed worse in the white office space than in office with any of colours (Kwallek, 1996; Öztürk et al., 2012)

The perception of colourful workspaces accord with the previous studies of Küller et al. (2009) and Öztürk, et al. (2012) that there were high complexity and non-harmonious score in the colourful room. Additionally, this study has found that the small colourful room tended to create the negative perception in all variables.

As predicted, cool colours tended to make a space more spacious and openness, while warm colours seem to make space more cramp, encloses, and complex. This study also found that most of the colour schemes comparing in the small and medium area with low ceiling obtained a similar level in term of harmonious, complexity and contrast. Ranging from most positive to most negative as follows: neutral colours, cool colours and colourful. The spatial perception effects may not change between small and medium area.

The findings indicated the more positive effect in increasing horizontal area, and ceiling height also supports the previous research of Barucha-Reid and Kiyak (1982), Stamps (2009) and Stamps (2011).

The use of the image as the measurement tool was found both pros and cons. Images can be a useful technique to explore the various colour in the real work environment. However, the different levels of perspective distortion and various elements in those images might affect the perception. This limitation may explain why room area did not reach statistical significance regarding some perceptions contrast with the previous studies (Franz and Wiener, 2005; Franz; Stamps, 2007; Stamps, 2011).

6.0 Conclusions and Recommendations

In the work environment context, substantial evidence was established that using the difference colour in the various room proportion can affect human perception in the difference ways. An appropriate colour scheme in a suitable space can enhance the positive perception. The results of the study imply that neutral colour is suited to use in all proportion of workspace but should be considered the functional need and aesthetic response together. Cool colour and warm colour create the opposite perception.
Colourful is not suited to use in small space as those colours can lead to perceiving negative appraisal. In medium space, colourful can be used and must be careful in selecting of colour combination. Further research is required to examine the colour contradiction, how difference colour combination is associated with perception for various workplace settings.

A limitation of this study is that only interior designer participated in the experiment. Further studies could also explore the effect of the different colour scheme in the different work environment on the workers in other professions. Moreover, further research should be done on the development of measure tools considering three dimensional space.

Acknowledgements

The author would like to thank Ass. Prof Dr Chumporn Moorapun for his encouragement and advice. This study has been supported by Sripatum University and King Mongkut's Institute of Technology Ladkrabang.

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