INTERIOR DESIGN: HOW COLOR AND LIGHTING AFFECT MOOD AND COGNITIVE PERFORMANCE

Megan Afifi, Dr. Elizabeth Krumrei-Mancuso, Dr. Janet Trammell

Pepperdine University

ABSTRACT

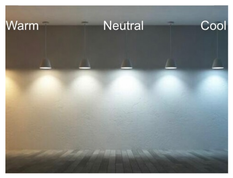
The current study examined the effects of a space's background color and lighting temperatures and their interaction effects on mood, cognitive performance, and arousal in young adults. Previous studies have examined the effects of color and lighting independently of one another, but to our knowledge, none have analyzed the interaction of color and lighting on our outcomes. Positive mood was found to be higher in the cool color/warm lighting condition, and negative mood was also higher in warm lighting. In terms of cognitive performance, creative problem-solving scores were better in cool lighting, and reaction times on a cognitive interference task were faster in warm lighting. The effects of color and lighting on heart rates, and the interaction effects on all factors except positive affect, were not significant. This research demonstrates the psychological and cognitive reactions people have to certain design elements and may provide a foundation for more purposeful design.

INTRODUCTION

- **Cool colors like blue are shorter in wavelength, and warm colors like red are longer in wavelength. Cool lighting is more blue-white light, and warm is more orange-white light.**

Figure 1
Color Temperature Scale

Figure 2
Lighting Temperature Scale



- **Generally, warm colors like red and yellow are more stimulating and arousing than cool colors like blue and green, which are more relaxing and calming[1,2,3,4,5]**
- **Warm colors can also be distracting while cool colors help promote focus[5,6]**
- **Conversely, warm (orange-white) lighting positively influences mood more than cool (blue-white) lighting, but cool lighting can better promote productivity[7,8]**
- **No study thus far has analyzed the interaction of background color and lighting temperature on mood and cognitive performance.**
- **Hypotheses:**
- **(1) Cool color and warm lighting conditions would elicit more positive mood than warm color and cool lighting conditions**
- **(2) Warm color as well as cool lighting conditions would be more arousing than cool color and warm lighting conditions as measured by heart rates**
- **(3) Cognitive performance would be better in cool color and cool lighting conditions than warm color and warm lighting conditions**
- **(4) Generally, the four color and lighting combinations would have different effects from one another on mood and cognitive performance.**

METHOD

- **Data were collected from 78 undergraduate students in a 2 (between subjects: warm vs cool color) X 2 (within-subjects: warm vs cool lighting) mixed experimental design**
- **Our outcomes included:**
  - **Affect (as measured by the PANAS)**
  - **Cognitive performance (as measured by reaction times and accuracy scores on the Stroop task and creative intelligence scores on the RAT)**
  - **Arousal (as measured by forearm heart rate monitors).**
- **Two 2 (warm color, cool color) x 2 (warm lighting, cool lighting) mixed MANOVAs were used to measure color and lighting interactions on positive and negative affect scores, and reaction times and accuracy scores.**
- **Two 2 (warm color, cool color) x 2 (warm lighting, cool lighting) mixed ANOVAs were used to measure color and lighting interactions on creative intelligence sum scores and heart rate scores.**
- **On the right are images of what the cool color condition looked like with both warm and cool lighting as used in the experiment. (Warm color not pictured)**

Cool color, cool lighting condition

Cool color, warm lighting condition

RESULTS

- **Positive Affect (PA)**
  - **Significant main effect of lighting: $F(1,76) = 95.55$, $p < .001$, $\eta^2_p = .56$, with higher scores in warm lighting ($n = 78$, $M = 21.79$, $SD = 8.08$) than cool lighting ($M = 21.12$, $SD = 7.94$).**
  - **Marginally Significant interaction effect: $F(1,76) = 3.97$, $p = .050$, $\eta^2_p = .05$, as in the warm color condition, the difference between scores in the warm lighting ($n = 37$, $M = 20.30$, $SD = 6.07$) and cool lighting ($M = 19.11$, $SD = 6.47$) conditions were greater than the difference between the cool color condition scores in the warm lighting ($n = 41$, $M = 23.15$, $SD = 9.42$) and cool lighting ($M = 22.93$, $SD = 8.75$) conditions.**
  - **Main effect of color was not significant**
- **Negative Affect (NA)**
  - **Significant main effect of lighting: $F(1,76) = 4.15$, $p = .045$, $\eta^2_p = .05$], with higher scores in warm lighting ($n = 78$, $M = 13.64$, $SD = 4.23$) than cool lighting ($M = 12.97$, $SD = 4.58$).**
  - **Main effect of color and interaction effects were not significant**
- **Reaction Times**
  - **Significant main effect of lighting: $F(1,73) = 105.57$, $p < .001$, $\eta^2_p = .59$, with faster reaction times in the warm ($n = 75$, $M = -300.90$, $SD = 326.48$) than cool ($M = -309.98$, $SD = 286.59$) lighting condition. Negative scores reflect how much slower reaction times were on color incongruent vs. color congruent trials on the Stroop task.**
  - **Main effect of color and interaction effects were not significant**
- **Accuracy**
  - **Neither color nor lighting had any main or interaction effects on accuracy scores.**
- **Creative Intelligence**
  - **Marginally significant main effect of lighting: $F(1,75) = 3.95$, $p = .050$, $\eta^2_p = .05$, with lower scores in warm lighting ($n = 77$, $M = 7.35$, $SD = 3.97$) than cool lighting ($n = 77$, $M = 8.13$, $SD = 4.24$).**
  - **Main effect of color and interaction effects were not significant.**
- **Arousal**
  - **Neither color nor lighting had any main or interaction effects on heart rates.**
  - **An exploratory analysis of Arousal (high PA and NA vs. low PA and NA) and Pleasantness (high PA and low NA vs. low PA and high NA) using the PANAS scores showed:**
  - **Significant main effect of lighting on arousal: F(1,76) = 4.15, p = .045, $\eta^2_p = .05$. Arousal scores were higher in warm lighting (n = 78, M = 35.44, SD = 10.36), than in cool lighting (M = 34.09, SD = 10.20)**
  - **Significant main effect of color on Pleasantness: F(1,76) = 4.50, p = .037, $\eta^2_p = .06$. Pleasantness scores were higher in the cool color condition (n = 41, M = 63.70, SD = 8.30) than in the warm color condition (n = 37, M = 60.203, SD = 5.91)**

CONCLUSIONS

Cool colors and warm lighting are more favorable for promoting a positive mood than warm colors and cool lighting. Warm lighting may affect one's mood more, and perhaps amplify it, and cool lighting may either reduce mood intensity or distract from our ability to perceive it.

These elements may not influence physiological arousal, but feelings of arousal in terms of affect were influenced by lighting. The effects of color and lighting on arousal could be explored in future research.

As reaction times were faster in the warm lighting condition than the cool lighting condition but creative intelligence was higher in cool than warm light, it seems that the effects of lighting on cognitive performance seem to be task dependent.

Cognitive performance and mood are key aspects of functioning in offices, residences, and many other spaces. These results can inform individuals and designers on how to optimize such areas of psychological functioning using these elements of a space.

Future studies should continue and solidify research on the interactions of multiple background colors (including achromatic) and lighting temperatures and illuminance levels on different areas of psychological and physiological functioning.

FOOTNOTES

[1] AL-Ayash, A., Kane, R. T., Smith, D., & Green-Armytage, P. (2015). The influence of color on student emotion, heart rate, and performance in learning environments. Color Research & Application, 41(2), 196–205. https://doi.org/10.1002/col.21949

[2] Costa, M., Frumento, S., Nese, M., & Predieri, I. (2018). Interior color and psychological functioning in a university residence hall. Frontiers in Psychology, 9. https://doi.org/10.3389/fpsyg.2018.01580

[3] Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. Journal of Experimental Psychology: General, 136(1), 154–168. https://doi.org/10.1037/0096-3445.136.1.154

[4] Roy, S., Banerjee, A., Roy, C., Nag, S., Sanyal, S., Sengupta, R., & Ghosh, D. (2021). Brain response to color stimuli: an EEG study with nonlinear approach. Cognitive Neurodynamics, 15(6), 1023–1053. https://doi.org/10.1007/s11571-021-09692-z

[5] Wilms, L., & Oberfeld, D. (2017). Color and emotion: effects of hue, saturation, and brightness. Psychological Research, 82(5), 896–914. https://doi.org/10.1007/s00426-017-0880-8

[6] Kaya, N., & Epps, H. H. (2004). Relationship between color and emotion: A study of college students. College Student Journal, 38(3), 396–405.

[7] Knez, I., & Kers, C. (2000). Effects of indoor lighting, gender, and age on mood and cognitive performance. Environment and Behavior, 32(6), 817–831. https://doi.org/10.1177/0013916500326005

[8] Zhu, Y., Yang, M., Yao, Y., Xiong, X., Li, X., Zhou, G., & Ma, N. (2019). Effects of illuminance and correlated color temperature on daytime cognitive performance, subjective mood, and alertness in healthy adults. Environment and Behavior, 51(2), 199–230. https://doi.org/10.1177/0013916517738077

FURTHER INFORMATION

Contact: Meganafifi@gmail.com