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Moving in Colour Illuminated Space: An Exploration of Analyses

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Abstract

This paper presents statistical results of an experiment investigating how the body moves in four different colour spectra of light across a blindfolded and non-blindfolded condition. In a light lab, 26 participants were immersed in white, blue, amber and red illumination, and asked to move around while blindfolded and non-blindfolded. Video-data of their movements were retrieved and coded by two independent researchers into eight binary movement categories of: fast/slow, up/down, hard/soft, coherent/incoherent. Intercoder reliability analysis shows satisfactory (41%), slight to fair (47%) and no (12%) agreements between the encodings. The coding chosen for further statistical analysis shows that participants moved in significantly different manners within the four lighting scenarios. No significant differences between the two conditions of blindfolding and non-blindfolding were found. These findings are in line with an earlier analysis of this study and generally appear to support the hypothesis that visual spectra of light are perceived beyond vision.

Keywords: *Light, Colour, Perception, Blindfold, Body Movement*

INTRODUCTION

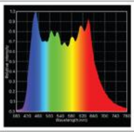
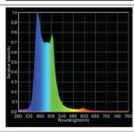
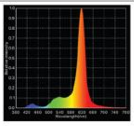
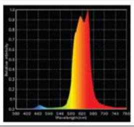
Contemporary technologies of programmable LED lighting open up new ways to integrate light as a multifunctional design element in our built environment. Now the spectral quality of so-called 'white' electrical light can be adjusted from a warm amber appearance (2200K), to a more neutral (3000-4000K), or a cool blue-white appearance (6500K) and beyond. Consequently, these new lighting technologies have enabled more saturated colours to enter our built public, urban and private spaces.

With the development of new lighting technologies, research on their effects on perception and well-being is expanding. Relatedly, studies show how different spectra of light have visual effects on our perception of space and non-visual effects on our psychophysiology such as circadian rhythm and mood (Besenecker et al. 2018; Boyce 2014; Li et al. 2017). Traditionally, these studies are based in the dominating belief that light is only to be perceived by the body via vision, where light is passing through the cornea of the eye to the retina, and photoreceptors process information to the visual cortex at the back of the brain (Boyce 2014: 43–57). However, recent studies within social science, neuroscience and biology point to that light within the visual spectrum is perceived beyond vision.

Within social science, a preliminary explorative study indicated that people experience different colour spectrums of light even when blindfolded, by for example describing experiences of floating in an infinite space (blue) or getting a soft hug (amber) both when being blindfolded and when having their eyes uncovered and open (Nielsen, Friberg and Hansen 2018). Moreover, a neuroscientific EEG-study detected distinctly different neurological variations in the brain of blindfolded subjects in response to three studied spectra of light (red, green and blue) (Wulff-Abramsson et al. 2019). Essentially, these results could be further supported by biological discoveries of photosensitive opsin proteins in the cells in the outer layer of our skin (epidermis), indicating that the retina is not the only bodily organ to detect visible radiation of light (Bennet et al. 2017; Haltaufderhyde et al. 2015; Tsutsumi et al. 2009).

EXPERIMENT AND INITIAL CODING

To further investigate the possible perceptual effects of different spectra of light beyond vision, an experiment was set up in a light lab, where 26 participants were immersed in four different colour spectra of light (white, blue, amber and red) and asked to move around in a blindfolded and non-blindfolded condition. The lighting scenarios and procedure of the experiment is shown in Figure 1.

Scenario	Photo	Fixture	Illuminance	CIE1931	SPD
			DIALux Evo	Spectrometer – AsenseTek alp-01	
White		iGuzzini Reflex Q263 Round spot-light Tuneable White + RGB LEDs	460 lx	x 0.3338 y 0.3267	
Blue			50 lx	x 0.1450 y 0.1608	
Amber			290 lx	x 0.5720 y 0.3785	
Red			180 lx	x 0.6168 y 0.3565	

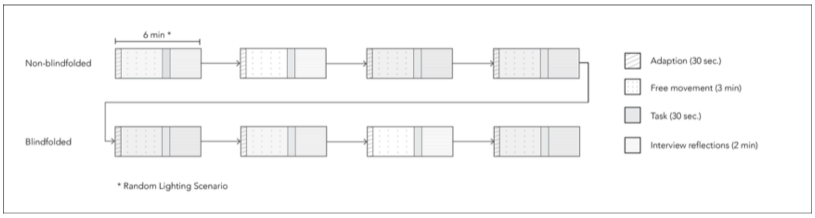


Figure 1: Lighting Scenarios and Procedure of Experiment.

Building on studies of the atmospheric potential of light to attune sensory experiences and body movements in space (Nielsen et al. 2018; Nielsen et al. 2020), the movements of the participants were observed and video recorded.

A qualitative, thematic and statistical analysis of the entire dataset was then carried out by the 1st and 3rd author of this paper (Nielsen et al. 2021). This analysis found that participants moved in significantly different manners in accordance with the surrounding hue of light. Moreover, statistical analyses generally showed no significant differences between the two conditions of blindfolding and non-blindfolding (ibid.).

SCOPE AND AIM

In the following section, we present the statistical results of an additional coding of the video-data on movement, subsequently carried out by two independent researchers, one of which is the 2nd author of this paper. This paper thus presents new results that qualify the validity and reliability of the initial analysis (Nielsen et al. 2021). As a means to this, the paper explores the following research questions:

1. How do four chosen light spectra illuminating a space affect observed body movements?
2. Are these observed effects apparent only when the light is visible to the eye, or also when people are blindfolded?

METHODS

Thematic Analysis

Transferring the coding strategy of the initial coding, the additional encodings of video-data were informed by an overall methodological framework to grasp body movement – that of Laban Movement Analysis (Bartenieff 2002). This framework enables detailed findings by allowing for an in-depth coding of body movements from categories of, for example, ***pace, position*** and ***dynamics***, plus the body's location or ***level*** in space (ibid.). Accordingly, all video-data on movement was coded into eight binary movement categories of: fast/slow (pace), coherent/incoherent (position), hard/soft (dynamics) and up/down (level), as shown in Figure 2. The one of the two movements that occurred most frequently was coded (e.g. fast), whereas the initial encoding was based on detection of both (Nielsen et al. 2021).

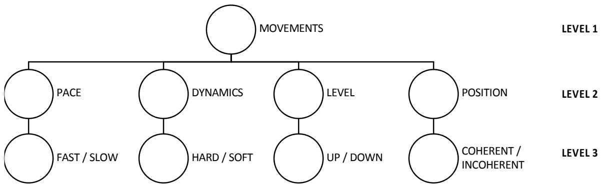


Figure 2: Levels and Categories of Encoding.

Descriptive Statistical Analysis

Based on the two coders' encodings, a descriptive analysis was conducted, with the purpose of getting an overview of frequency of movements for each colour. Figure 3 shows a visualization of the 1st and 2nd coders' encodings sorted by movement category, lighting scenario and condition.

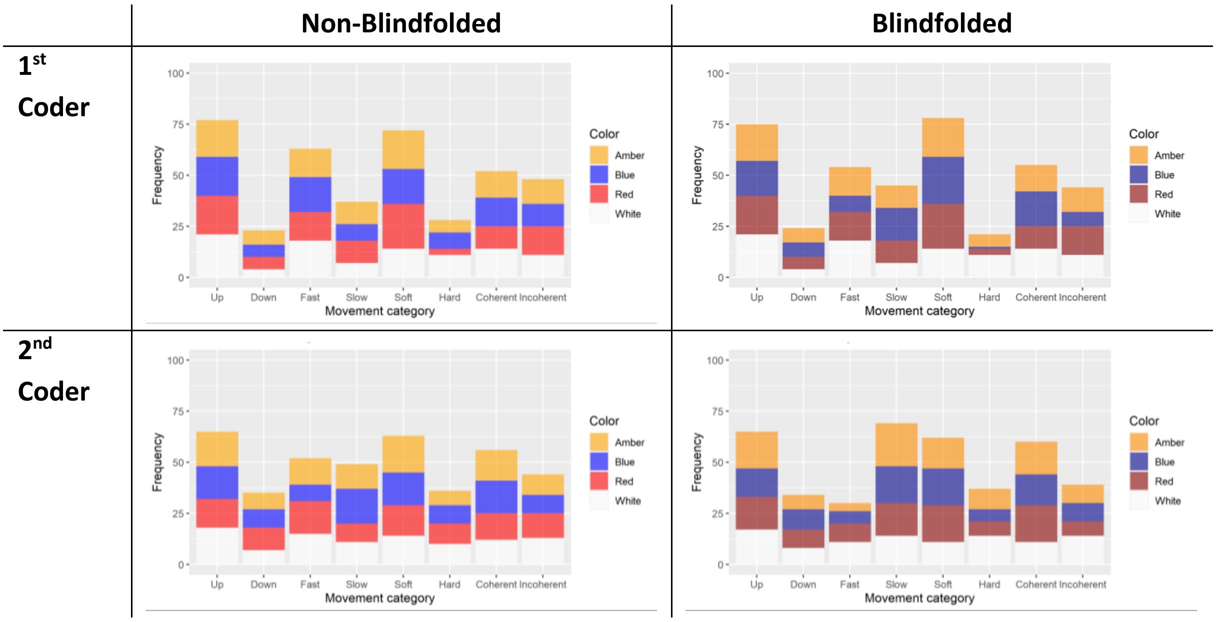


Figure 3: Descriptive Statistical Analyses.

Intercoder Reliability

In order to qualify the validity and reliability of the analyses (MacPhail et al. 2015), intercoder reliability was calculated using Cohen's Kappa for each of the general movement categories (8) across lighting scenarios (4) and conditions (2) for the two encodings – hence 32 kappa values in total. These ranged between -.325 and .905, of which 13 (41%) were above .40, which are considered as satisfactory agreement between the coders (ibid.). Except for four of the kappa values (12%), primarily within the coherence category, the rest (47%) showed slight to fair agreement (.0-.039) (Landis and Koch 1977).

Hence, despite the 88% satisfactory and slight to fair agreements between the encodings, the diversities of the two encodings generally point to the complexity of coding qualitative data, based on subjective interpretation and evaluation of data and codes. As such, personal, cultural and professional bias of the two coders inevitably affect the coding of data (Agar 1996). For contextual reference, both coders were females, around 30 years old and from Denmark. They were given the same explanatory introduction to the movement categories. However, only the 2nd coder held a background in academia and was a trained coder of qualitative data. In addition, the 1st coder carried out her encodings over 1½ months, compared to the 2nd coder spending two weeks, which assumedly heighten the consistency of data. On this basis, we have chosen to only address the encoding of the 2nd coder in further analyses.

Statistical analysis

To examine the first research question, i.e. whether there are differences in the movements within the four lighting scenarios, a Friedman's Two-Way Analysis of Variance (ANOVA) was conducted for each of the four movement categories in SPSS, as was done for the initial encoding, as described by Nielsen et al. (2021). Similarly, Wilcoxon Signed Rank Tests were repeated to answer the second research question of potential differences between the two conditions: non-blindfolded and blindfolded. To further explore the two research questions combined, Repeated Measures ANOVA were conducted, based on eight scales derived from adding the binary encodings from the four movement categories together. The scales ranged from 0-4, where a maximum score of 4 indicated expressive movements, as the participant had shown both upward, fast, hard and incoherent movements in the lighting scenario and condition in question. Contrarily, lower scores indicated that the participant had moved more calmly, by showing downward, slow, soft and/or coherent movements, with a minimum score of 0 representing the reverse pattern. Lastly, binomial tests were conducted to test whether one of the movements in the binary movement categories was chosen more than a change of 50%. All p-values were evaluated based on a 5% significance level.

ANALYSIS

The Repeated Measures ANOVA based on the 2nd coder's encodings showed significant differences between the four lighting scenarios ($F(3) = 4.282$, $p < .008$), indicating that participants moved differently depending on the colour of the light. The non-blindfolded and blindfolded conditions revealed no significant differences ($F(1) = 3.380$, $p < .080$), which indicates that the participants moved in the same way whether they could see or not. No interaction effects were found.

As seen in Figure 4, Wilcoxon's test showed, however, significant differences as regards fast/slow ($p = .004$). These results suggest that participants moved faster when non-blindfolded and slower when blindfolded but had similar movements across the two conditions when moving upward, hard or incoherently. Similarly, Friedman's ANOVA only revealed significant differences between the four lighting scenarios for the category of fast/slow movements ($p = .009$). Especially, participants seemed to move faster in the white light compared to blue and amber light ($p_{blue} = .012$, $p_{amber} = .039$).

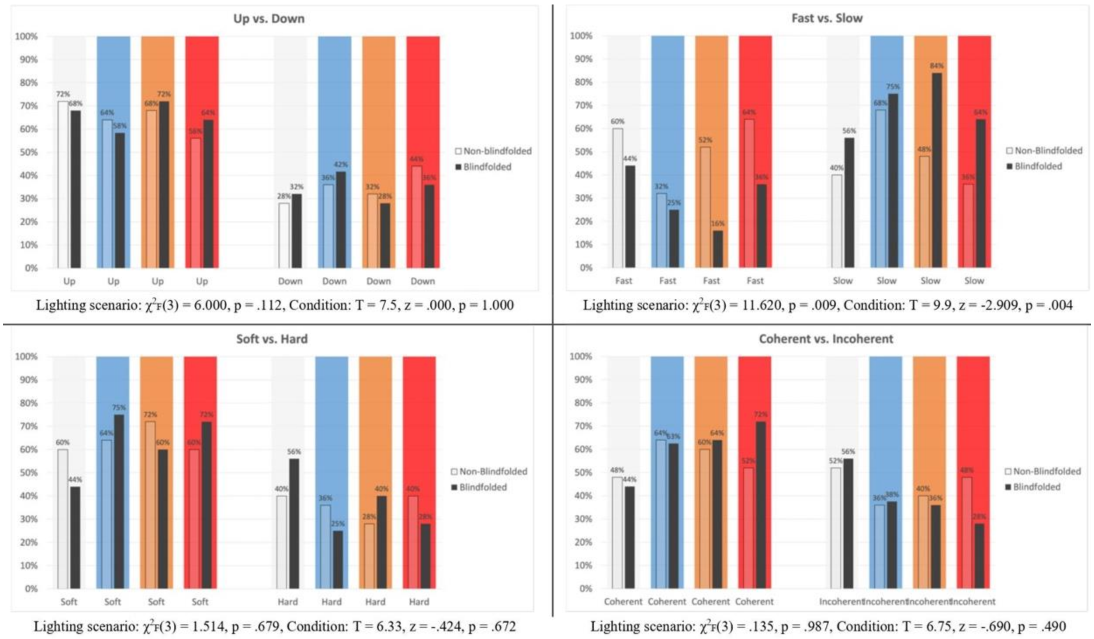


Figure 4: Distribution of assigned movement codes within each lighting scenario and condition.

The binomial tests showed that, when non-blindfolded, participants' movements were significantly more upwards in white light ($p = .043$), and more often soft in amber light ($p = .043$). Most of the significant p-values were, however, found in the blindfolded conditions. When blindfolded in amber light, participants were both moving more upward ($p = .043$) and slowly ($p < .001$). Conversely, blindfolded participants more often moved softly ($p = .043$) and coherently ($p = .043$) when exposed to red light. Also, when blindfolded in blue light, participants more often moved softly ($p = .023$).

DISCUSSION

In line with the general findings of the initial analysis presented in the original paper on the experiment (Nielsen et al. 2021), this study replicated significant differences in movements between the four lighting scenarios, but no significant differences between the two conditions of blindfolding and non-blindfolding. As such, our analyses generally appear to back up recent research, supporting the hypothesis that visual spectra of light are perceived beyond vision by the human skin (cf. Bennet et al. 2017; Haltaufderhyde et al. 2015; Tsutsumi et al. 2009).

Moreover, across our two analyses, participants were rated as moving faster in white light, compared to blue and amber light. Also, both analyses found that participants moved significantly slower in the blindfolded condition, compared to the non-blindfolded, possibly due to an assessment of caution (Nielsen et al. 2021). Despite similarities between the analyses, fewer significant differences were found in the present study. This may be due to the binary "either-or" encoding of the present study, which may be more subjective compared to the "both-and" encoding initially conducted.

In relation to participants rated by the 2nd coder, a binomial test showed that participants moved significantly more coherently than by chance in red light while blindfolded. Conversely, in the initial encoding, participants moved significantly more coherently in blue light across the conditions (ibid.). This discrepancy possibly points to the significance of bias when coding qualitative data, such as video-footage on body movements. As too reflected in the varying Kappa values between the two coders (cf. Method section). In this regard, it should be noted that the lowest intercoder reliability was primarily found within the coherence category.

CONCLUSION

This paper has shown that participants generally moved in significantly different manners within four different lighting scenarios in addition to finding no significant differences between the two conditions of blindfolding and non-blindfolding. Despite some differences, the results of this statistical analysis generally show in line with our initial analysis (Nielsen et al. 2021), which appear to back up recent research, supporting the hypothesis that visual spectra of light are perceived beyond vision.

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