Self-chosen Colored Light Induces Relaxation

A. Johnson, & P. Toffanin

University of Groningen, Groningen, The Netherlands

Introduction

New technologies, in particular the availability of light emitting diodes (LEDs) in different colors, make it increasingly possible to integrate light into products and the environment. Moreover, research inspired by the discovery of short-wavelength sensitive retinal ganglion cells that are not involved in vision, but that do directly influence circadian rhythms, has shown that lights of different color temperature differentially affect circadian physiology and cognitive performance (e.g., Chellappa et al., 2011; Figueiro, Bierman, Plitnick, & Rea, 2009). In short, "color therapy" has taken on new meaning since the heyday of interest in its possibilities (e.g., Birren, 1950).

Psychological research on color, as such, has concentrated on color preference (e.g., Eysenck, 1941; Meerum Terwogt & Hoeksma, 1995) or the relation between color and emotion or mood (Levy, 1984; Meerum Terwogt & Hoeksma). Research on the relations between color and performance and color and mood has yielded mixed results. For example, whereas Knez (2001) and Boray, Gifford, and Rosenblood (1989) found no main effects of the color of environmental light on mood or performance, Knez and Niedenthal (2008) found that performance in a video game was better when the game world was lit by warm (reddish) as opposed to cool (bluish) light. In Knez and Niedenthal's study the reddish light was rated as more pleasant, leading the authors to suggest that the difference in performance between the conditions may have been mediated by pleasantness.

Our particular interest was whether exposure to colored light can induce a state of relaxation. To maximize any effects of color, participants were exposed to a near-Ganzfeld of color and were allowed to choose for themselves a color which they deemed relaxing. Relaxation was operationalized as alpha synchronization. Alpha activity is regular rhythmical activity of the brain in the frequency range from 8-12 Hz. Measured at the scalp using electroencephalography, alpha activity is usually associated with a no-task, no-stimulation relaxed state, and is most evident when the eyes are closed. Alpha activity is reduced or eliminated when feeling anxious, when unfamiliar sounds are heard, or when concentration is high, and is interpreted as a state of relaxed awakeness without concentration or application of attention (Niedermeyer, 1997).

The possibility of inducing a relaxed state with colored light is an interesting one because of the proliferation of products that can be used to introduce colored light into the environment. To date, most of these products have been marketed as "mood lighting" rather than as a proven means of relaxation. A finding that some colors of light lead to more relaxation than others (and that observers are capable of determining which colors lead to a more relaxed state) would suggest that mood lighting could have therapeutic value.

Materials and Method

Twenty-three students and members of the University of Groningen community between 18 and 32 years old (mean = 21.1 years; 10 females and 13 males) volunteered to participate in the study. The study was approved by the local ethics committee and all participants gave their informed consent. The effects of colored light on relaxation and mood were assessed using the "Light Shower™" (Rozema, http://www.monartworks.nl/ thepalace.html; see Figure 1), a domed construction onto which light is projected while participants are seated on a chair with their heads and shoulders in the dome so that they experience what is essentially a Ganzfeld (a visual field without edges or contours; see Avant, 1965).

The Light Shower is 2.60 m high, and consists of a chair which can be raised into a cylinder with a diameter of about 1.5 m. The inside of the cylinder is lined with a dome made of opaque Plexiglas and extending 80 cm into the cylinder. The dome is provided with a "floor" of the same material as the dome, with a 35-cm hole cut into it through which the head can pass. Illumination is provided by RGB LEDs placed above and below the dome to create a uniform field of light. The brightness of the light depends on the color and intensity chosen by the observer, with a maximum of 500 lux. A computer program was used to present the full spectrum of colors. The intensity of the color could be changed by the observer using a computer mouse.

Fig. 1: The Light Shower

Mood was measured with the Positive Affect Negative Affect scale (PANAS; Watson, Clark, & Tellegen, 1988), a questionnaire with 10 items (adjectives) measuring negative affect and 10 items measuring positive affect. Participants were instructed to rate the degree to which each adjective described them at that moment in time using a scale of 1 (very slightly or not at all) to 5 (extremely). The experience of being in the Light Shower was assessed using an evaluation form with eight attributes (e.g., nice—unpleasant), each rated on a 7-point scale ranging from +3 to -3.

The EEG signal was recorded from Cz, Fz and Pz (the standard electrodes for measuring alpha activity) using a 19-Ag-AgCl electrode cap (Electro-cap International Inc., Eaton, Ohio, USA) and standard recording and filtering procedures.

After the EEG cap was fitted, participants (1) filled in the PANAS; (2) were subjected to measurement of baseline alpha (1 min with eyes open and 1 min with eyes closed); (3) entered the Light Shower to choose the colors that they found relaxing and energizing/not relaxing, respectively; (4) filled in the evaluation of the Light Shower and light quality questionnaires; (5) reentered the Light Shower where EEG was measured during 2.5 min exposure to the self-chosen relaxing color; (6) filled in the PANAS once more; (7) reentered the Light Shower where EEG was measured during 2.5 min exposure to the energizing/not relaxing color; and (8) were once more subjected to measurement of baseline alpha (1 min with eyes open and 1 min with eyes closed).

Results

Fifteen of the 23 participants chose a blue or green hue as relaxing; the remaining participants chose pink, purple, orange, or a neutral color. Only four participants chose green as energizing/not relaxing; the rest chose colors close to red/pink in the color spectrum. Three of the participants who chose red/pink colors as relaxing chose blue/green colors as energizing/not relaxing.

A repeated measures ANOVA with light condition (relaxing vs. energizing/not relaxing color) and electrode position (Fz, Cz, or Pz) as factors was conducted on alpha amplitude (see Figure 2). Alpha amplitude was consistently higher in the relaxing color condition than in the energizing/not relaxing color condition ($F(1, 22) = 5.68$, $p = .02$, $\eta^2_{partial} = .21$). Alpha amplitude depended on

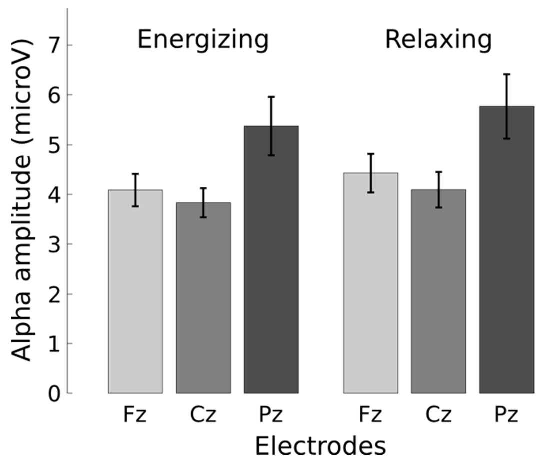

Fig. 2: Alpha amplitude (in μV) as a function of electrode position (Fz, Cz, or Pz) and light condition (energizing/not relaxing or relaxing color). Error bars are standard error of the means.

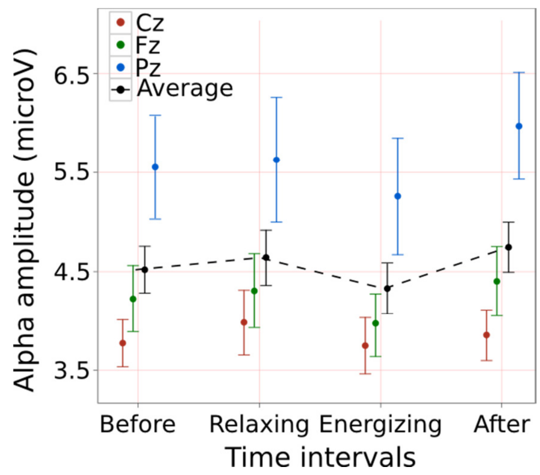

Fig. 3: Alpha amplitude as a function of electrode position (Fz, Cz, or Pz) and time interval during which alpha amplitude was measured. The dashed line is the average alpha amplitude across the three electrodes. Error bars are standard error of the means.

electrode position ($F(2, 44) = 16.76$, $p < 0.01$, $\eta^2_{partial} = .43$), but there was no significant interaction between electrode position and light condition.

To determine whether the difference between the relaxing light condition (which was measured first) and the energizing/not relaxing light condition might be attributable to order of administration, an additional analysis was carried out in which the pre- and post-exposure measures of alpha baseline and the alpha measured during the relaxing and the energizing/not relaxing light condition were compared (see Figure 3). Due to missing data two participants were excluded from this analysis. A repeated measures ANOVA with time interval (before exposure, relaxing light condition, energizing/not relaxing light condition, or after exposure) and electrode position (Fz, Cz, or Pz) as factors conducted on alpha amplitude showed a main effect of electrode ($F(2, 40) = 23.29$, $p < .01$, $\eta^2_{partial} = .54$), a main effect of order ($\underline{F}(3, 60) = 3.39$, $\underline{p} = .02$, $\eta^2_{partial} = .16$), and no interaction. As shown in Figure 3, alpha tended to increase across the session, except in the energizing/not relaxing condition.

Both positive ($t(22) = 7.52$, $p < .001$) and negative ($t(22) = 3.22$, $p = .004$) affect as measured by the PANAS decreased after exposure to the Light Shower. Scores on the PANAS were somewhat higher on the positive items (2.88 vs. 2.22 for the first and second measurements, respectively) than on the negative items (1.22 vs. 1.09, for the first and second measurements, respectively).

The ratings given to the adjectives used to evaluate the experience of the Light Shower were analyzed using separate two-tailed t tests. The Light Shower was evaluated as nice (mean = 1.38; $t(22) = 5.41$, $p < 0.001$), stimulating (mean = 0.71; t(22) = 2.38, p < 0.026), comforting (mean = 1.46; $t(22) = 5.42$, $p < 0.001$), pleasant (mean = 1.38; $t(22) = 6.15$, $p < 0.001$), relaxing (mean = 1.38; $t(22) = 4.78$, $p < 0.001$) and calming (mean = 1.33; $t(22) = 4.55$, $p < 0.001$). No other differences were significant.

Discussion

This study focused on the intersection between entertainment and well-being in examining whether exposure to a pleasant, self-chosen light in the unique environment of a near-Ganzfeld could induce a relaxed state. The participants in this study were enthusiastic about the experience of being in the Light Shower used to administer the Ganzfeld of colored light, rating it as nice, stimulating, comforting, pleasant, relaxing, and calming. Evidence that people are able to select a color that relaxes them was found in the comparison of the alpha rhythm while in the relaxing light versus in the energizing/non-relaxing light: Alpha rhythm was higher in the self-chosen relaxing color as compared to a self-chosen energizing/not relaxing color.

Effects on alpha rhythm manifested quickly: Two and one-half min of exposure to the light was sufficient to see a significant difference in alpha amplitude for the relaxing and energizing/not relaxing color conditions. In itself, it is not surprising that alpha differences emerged quickly, as changes in alpha amplitude due to opening or closing the eyes typically emerge within 5 seconds (Niedermeyer, 1997). It might be argued that participants chose a preferred color as their relaxing color and a non-preferred color as the energizing/not relaxing color and that effects on alpha activity are mediated by color preference. However, Kawasaki and Yamaguchi (2011) recently showed that no asymmetries in alpha activity are found in a task of selecting a preferred color from one of two colors. To date, thus, there is no evidence that preference alone increases alpha amplitude.

One limitation of the study is that alpha for the relaxing color was always measured first. However, the fact that the pre- and post-exposure measures of baseline alpha did not significantly differ suggests that order effects did not occur. Another limitation is that we cannot rule out that people's expectation that they would feel more relaxed when viewing the relaxing color than the energizing/not relaxing color may have influenced alpha activity. Current work being carried out in our laboratory will address this issue.

The research reported here suggests that people "know what's good for them" in that they were able to select a color which induces a relaxed state. This finding lends support to the idea that environmental light can be not only fun, but therapeutic.

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