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Context-Moderated Effect of Color on Physiological and Self-Report Measures of Emotional Response

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Abstract

Color psychology refers to the study of color and its effect on emotion and behavior. Elliot & colleagues[1] have proposed a "color-in-context theory," arguing that the effect of color on psychological functioning is modulated by the situational context. Specifically, it is claimed that red facilitates sexual attraction in romantic or sexual contexts, but can have a negative impact on mental and physical performance by increasing the perception of threat in achievement contexts. Past research has focused mainly on behavioral and self-report measures. The present study adds to this work by further collecting participants' physiological data in response to color. As a measure of arousal and valence, facial electromyography and skin conductance were recorded as both male and female participants viewed pictures of either attractive individuals of the opposite sex or threatening images presented on a background of either blue or red. Self-reported ratings of arousal, valence, attraction and threat of the images (arousing/unarousing, happy/unhappy, attractive/unattractive, threatening/nonthreatening) were also collected. It was hypothesized that images on a red background would evoke higher physiological and self-reported arousal in all conditions (including threat and romantic), and that physiological and self-report measures of valence would be dependent on the context of the images. It was found that males viewing females gave significantly higher attraction ratings when the images were displayed on a blue, rather than red background. No other significant effects of color were found. These results fail to support the red effect theory, and suggest a need for greater standardization of colors and images used in color-in-context research.

1. Introduction

Color has a powerful effect on emotion and behavior, for biological as well as cultural reasons[2]. Humans associate specific meaning or significance with different colors, and these different associations lead to varied emotional reactions[3, 4]. It has also been suggested that different colors can consistently lead to distinct behavioral responses, including in social interactions[1]. The color red is known to be especially arousing or exciting, and past research suggests an evolutionary reason. Trichromatic vision in primates - essentially, the ability to differentiate reds, rather than only green and blue - likely evolved for enhanced detection of edible food resources[5]. This is supported by findings that the young leaves of many tropical plants emit a strong "red-green signal" when they undergo chloroplast development that makes them more edible and nutritious to primates; trichromatic vision may be used to distinguish these leaves against a background of darker green foliage[6]. Discrimination of reds may also have been selected to improve detection of ripe fruits, but likely to a lesser extent than for finding edible leaf patches – although many tropical fruits exhibit a more pronounced red pigment when ripe, it is also common for primates to eat fruits that are green or yellow when ripe[7]. Once trichromatic vision evolved, these primates exhibited a "bias" for red that facilitated the evolution of red as a social signal, such as red skin coloration to indicate sexual

receptivity. This is supported by the finding that, in chimpanzees and many monkey species, females exhibit hormone-dependent red "sexual skin" coloration in the genitals, rump, and face during times of high fertility[8]. This indicator is used even in primate species that engage in sexual behavior for social, rather than reproductive purposes, such as the Bonobo apes. Although Bonobos engage in socio-sexual behavior (i.e. genital rubbing and oral sex) regardless of sexual receptivity level, the majority of actual mating occurs during female estrous[9], which is characterized by red genital swelling[10]. This suggests that, although red coloration is not necessary in order for sexual activity to occur, it may be a strong indicator of a female's likelihood to produce offspring. Trichromatic vision may also have been recruited to signal dominance, as some male primates exhibit status-dependent red coloration on the face, rump, and genitalia[11]. In mandrills, for example, the extent and brightness of this coloration is reliably linked with measures of dominance, such as testosterone level, and past research does not suggest that subordinate male primates exhibit "deceptive" skin coloration to signal higher status than their true ranking[12]. This likely reflects the costs associated with higher status (greater inter-male competition and injury risk), which may be too costly for males that do not genuinely have a high fitness level**.** The use of red coloration as a genuine dominance signal may also facilitate coexistence between members of a community[11, 13]. Skin color may be used to infer a potential rival's respective fighting ability and choose the appropriate reaction, and thereby act as a conflict management mechanism by preventing unnecessary injuries, as well as saving time and energy. These findings provide a possible evolutionary explanation for the emotional significance of red and its use as a social signal in humans.

Past research has not been able to explain with certainty the specific mechanisms by which color effects emotion and behavior. Goldstein[14], followed by subsequent researchers who built on his theory[15], claimed that longer wavelength colors (i.e. red, orange) are arousing, whereas shorter wavelength colors (i.e. green, blue) are calming. According to Elliot[1], there has been limited empirical research investigating this theory, and the majority has been inconsistent, unsupportive, or fraught with methodological flaws. In particular, most studies have failed to account for the psychological effects of each of the three attributes of color - hue (wavelength), lightness, and chroma.

To account for this lack of rigorous, systematic investigation, Elliot and colleagues propose a "color-in-context theory"[1, 16] in order to provide a framework for explanation and prediction of the relationship between color and affect, cognition, and behavior. This theory focuses on the interaction between top-down and bottom-up perception of color, emphasizing that particular colors elicit characteristic emotional responses, but that these responses are modulated by the psychological context in which they are viewed. Specifically, Elliot et al. ground their theory on six fundamental claims about color: 1) color carries meaning, 2) viewing color influences psychological functioning according to the specific meaning of the color, 3) this process is automatic, 4) the meaning of a color and an individual's response to it are derived from learning and biology, 5) visual perception is influenced by the psychological state of the viewer, and 6) color meanings and effects are context-specific. This last premise is most important in setting the color-in-context theory apart from past research - the majority of past research has failed to account for the importance of context in the psychology of color. Elliot[1] claims that this is largely responsible for the lack of consistent data in this area.

In a series of studies designed to explore the context-based effect of color, Elliot et al. focused on the color red in both achievement (performance) contexts and affiliation (sexual attraction) contexts. As mentioned previously, red can serve as both a threat cue and as a sexual signal, depending on the situation. This has been found in primate studies, suggesting an evolutionary basis, and analogous processes have been suggested in humans. It was therefore hypothesized that red would negatively impact performance in achievement contexts, and facilitate sexual attraction of participants to a target individual in affiliation contexts. Both of these hypotheses were supported, as detailed further below.

Pazda et al.[17] found that male participants rated women as more attractive, sexually desirable, and sexually receptive when wearing red rather than green. In another study, Kayser et al.[18] compared the responses of men to pictures of a woman in which the shirt color of the woman was manipulated to be red or green. The men were more likely to ask the woman in red intimate questions compared to the woman in green, as well as sit closer to females wearing red rather than blue. Additional studies focused on the effect of red in achievement contexts, in which competence and performance were to be evaluated. These studies found that, compared with blue or green, red impaired performance on intelligence tests, and impaired some measures of physical performance on strength tests[1].

The present experiment is derived largely from one previous color-in-context study[19], chosen because it incorporates both achievement and affiliation contexts into one study. In addition, it introduces the elements of approach (toward-stimulus) motivation and avoidance (away-from-stimulus) motivation as factors that are differentially impacted by the color red, depending on context. This past experiment compared walking speeds of participants primed with either red or blue in an affiliation (romantic) or achievement-related context. Participants in the affiliation condition were told that they would be interviewed about dating by an attractive member of the

opposite sex, and were shown an image of the prospective interviewer. It was found that participants walked faster towards the interview room if shown a picture of the interviewer wearing a red shirt than if they were shown a picture of the interviewer wearing a blue shirt. In the achievement condition, in which participants were told that they would be interviewed about their intelligence, walking speeds were slower when participants were shown a picture of their interviewer wearing red than if they were shown a picture of their interviewer wearing blue[19]. This is evidence that red increases approach motivation in an affiliation context, but increase avoidance motivation in an achievement context.

The present study examines, in part, the effect of red on threat. The majority of the color-in-context studies of red in an achievement context focused on performance on tasks of mental or physical ability, rather than directly on perception of threat. However, Feltman & Elliot[20] conducted a study in which participants were told to imagine competing in a Taekwondo match against a same-sex opponent. Participants were shown an image of their imaginary opponent wearing either red or blue, and asked to complete measures of how dominant or threatening they perceived themselves or their opponent to be. It was found that individuals perceived their opponents as more dominant and threatening if said opponents were wearing red rather than blue, suggesting that red does in fact serve as a threat cue.

Past research on color-in-context and the red effect has focused mostly on behavioral and self-report measures, with some exceptions. Elliot et al.[2] used EEG to investigate the red effect on frontal cortical asymmetry, which is indicative of avoidance-based emotional processing, and found that priming participants with red before an IQ test led to greater frontal asymmetry during the anticipation phase than priming them with green or gray. In addition, a later study[21] used ECG and high-frequency heart rate variability (HF-HRV), a low level of which indicates anxiety. They found that priming with red in an achievement context led to lower HF-HRV than priming with blue or gray.

The purpose of the present study is to complement the existing body of knowledge by adding the measures of skin conductance response (SCR), an indicator of autonomic arousal, as well as facial electromyography (EMG) as a measure of positive versus negative valence. Contraction of the zygomaticus muscles, located in the cheeks, indicates positive emotion, whereas negative emotions are indicated by contraction of the corrugator muscles, located above the eyebrows[22]. Participants were presented either photos of individuals of the opposite sex or threatening images, and each photo was presented against a background of either red or blue. Physiological data and self-reported ratings of valence, arousal, and attraction or threat were collected during presentation of these images. For participants viewing threatening images, it was hypothesized that physiological and self-report measures would indicate higher arousal and lower valence (indicating heightened avoidance motivation) in the red versus blue condition. For attraction images, these measures were hypothesized to show higher arousal and higher valence (indicating greater approach motivation) for red versus blue.

2. Methods

2.1 Participants

38 participants (26 females, 12 males) were recruited from undergraduate psychology courses at UNC Asheville. Participants were grouped into the following image conditions: threatening (8 red, 8 blue), female models (4 red, 4 blue), and male models (7 red, 7 blue). Condition assignment was pseudo-random: due to the low number of male participants, most males were assigned to view and rate attractiveness of female faces, resulting in under-representation in the threatening photo condition. Female participants were randomly assigned to one of the four possible conditions for females (red threat, blue threat, red males, and blue males), keeping the number of subjects in each of these four conditions balanced throughout the course of the experiment.

2.2 Stimuli

Every image condition was comprised of 15 images. To make up the threatening condition, images from the International Affective Picture System were used[23]. The images were all low valence, with a valence rating below 5 on an ordinal scale from 1 to 9, and high arousal, with an arousal rating of above 5 on an ordinal scale from 1 to 9. The two attraction conditions were comprised of images from professional online profiles of individuals that were not locally identifiable. All photos were headshots, with subjects facing the camera posing with a neutral or happy expression. The individuals in the images were dressed in professional clothing. The images were edited to be black and white, and only photos with a neutral background were used. Males who participated in the study were

presented only images of 15 females. Females who participated in the study were presented only images of 15 males. (For both males and females who viewed the attraction condition, they were asked to rank their sexual attraction to both men and women on an ordinal scale from 1 to 9 to control for sexuality.)

A second factor of the experiment manipulated the background color images were presented on. For each image type condition, subjects viewed images on either a red or blue background. Using an i1 Display Pro colorimeter (X Rite, Grand Rapids, MI, USA), the L*a*b* values of the displayed red color were measured at (37.43/59.24/47.63) and the values of the displayed blue were (36.68/34.86/87.99). The two colors were equated for measured lightness. Each image that was presented on the background was scaled to be 800 pixels in width.

2.3 Procedure

Each trial began with the presentation of a fixation cross presented for 1000 ms, followed by an image for 6000 ms. The background color of either blue or red was displayed throughout the experimental period. After this sequence, participants were prompted with 2 IAPS SAM rating images[23] in sequence to rate their valence and arousal in response to the image on an ordinal scale from 1-9. In the threat condition, participants would rate how threatening they found the subject of the image on an ordinal scale from 1-9 after rating their valence and arousal in response to the image. In the attraction condition, participants would rate how attractive they found the subject of the image on an ordinal scale from 1-9 after rating their valence and arousal in response to the image. Participants indicated their ratings via a wireless numerical keypad (Targus Inc., Anaheim, CA, USA). After completing the 3 ratings, participants viewed a 5000-9000 ms blank screen in the experimental color to allow physiological measures to return to baseline before the start of the next trial.

In the two attraction conditions, the participant rated how sexually appealing they found both men and women on a scale from 1 to 9 after being presented all 15 images of the opposite gender. In the threat condition, the participants were not asked any control questions after viewing the images.

2.4 Data Analysis

Facial EMG (corrugator and zygomaticus) and skin conductance level (SCL) were recorded using Biopac MP36 unit (Biopac, Goleta, CA). The corrugator and zygomaticus measurements were taken only on the left side of the participant's face, as the left side of the face has been shown to be generally more expressive than the right in response to emotionally arousing stimuli[24]. Recorded SCL measurements were filtered with high (0.1 Hz) and low pass (1 Hz) filters using BSL 3.7.7 Analysis software (Biopac, etc.), windowed into 9s epochs around each picture presentation (1s pre-stimulus to 8s post-stimulus), baseline corrected, and averaged across all 15 trials. Averaged SCRs were then log transformed to reduce skewness. Peak values of the averaged SCRs in the 8ms post-stimulus time window were extracted for each subject and submitted to statistical analysis.

EMG signals were bandpass filtered (30-500Hz) during acquisition and separated into epochs (-1 to 5s post-stimulus). Root mean squared of EMG signals were calculated 1-4 seconds post-stimulus and baseline-corrected before averaging across image trials for further statistical analysis.

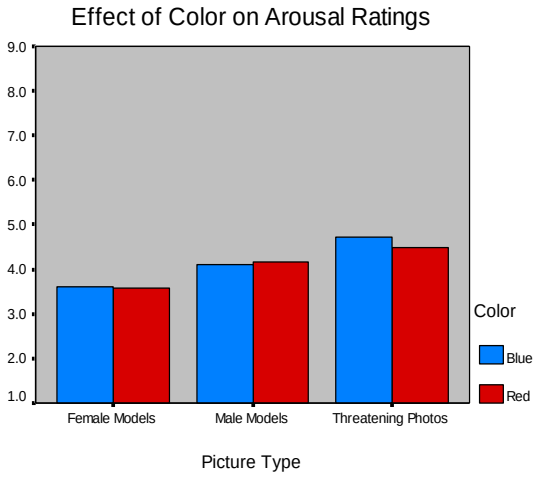
3. Results

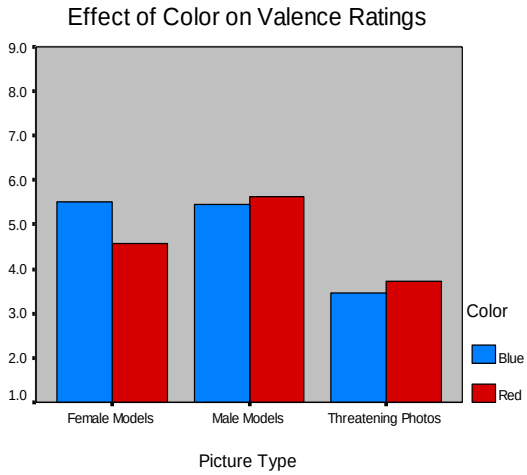
Statistical analysis was conducted to determine the effects of image type and background color on ratings (valence, arousal, attraction/threat) as well as physiological responses collected (zygomaticus EMG, corrugator EMG, SCR). This analysis yielded a main effect of image type on valence ratings ($p<.01$). Specifically, valence ratings were lower in response to threatening images than to photos of the opposite sex. This is an unsurprising result, as threatening images were selected specifically to be unpleasant. Contrary to expectations, however, there was no main effect of image type on reported arousal or physiological measures, nor was there a main effect of color on any dependent variable.

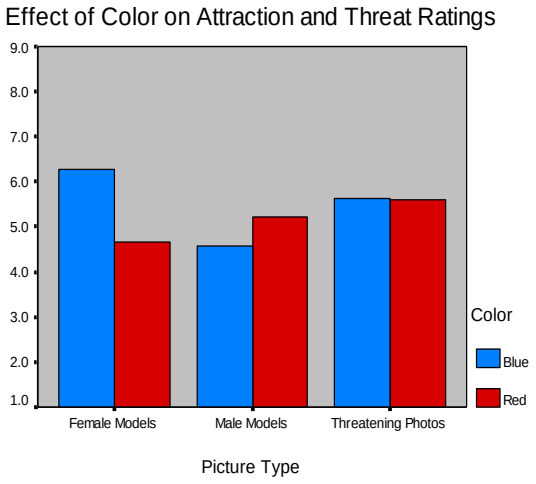
Further analysis yielded a significant color x image type interaction. In the attraction condition, males viewing female models rated them as significantly more attractive ($p<.05$) when presented against a blue background than a red background. No other significant interaction was found between color and any other self-report rating. In threat and attraction conditions, it was expected that threat and attraction ratings would be higher when viewed on a red

background. However, threat ratings were not significantly different between the red and blue conditions. No significant effect of color was found for attraction ratings of females viewing males.

No significant interaction was found between background color and any of the physiological measures recorded. No significant differences in zygomaticus, corrugator, or skin conductance responses were found between red and blue in any image condition. However, a marginal effect was found (p=.10) for increased corrugator activity in the threat condition when viewing images on a red background.







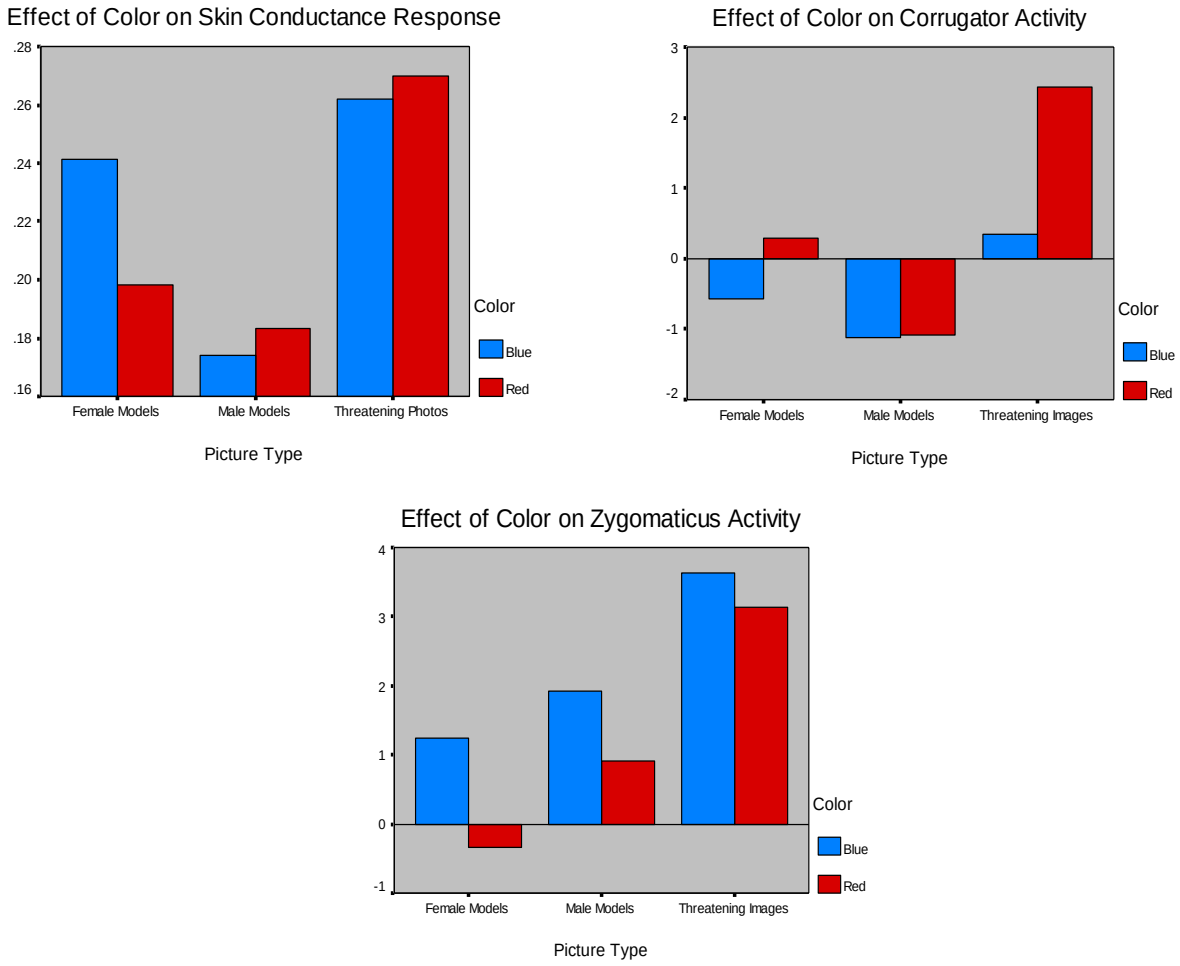


Figure 1. Effect of color on self-report ratings and physiological measures.

Figure 1 Participants rated images as lower in valence ($p<.01$) in the threatening vs. attraction condition. In addition, males rated female models as more attractive ($p<.05$) against a blue background than a red background. There was also a marginal effect ($p=.10$) of color on corrugator response between image conditions, as threatening images elicited greater corrugator activity when presented against a red vs. a blue background.

4. Discussion

The red effect theory states that the color red has a differential effect on emotion and behavior depending on the context in which the color is presented. In the present study, it was hypothesized that red would affect self-report ratings and physiological activity differently when presented as a background to images in the threat versus attraction condition. Specifically, we hypothesized that red would increase SCR and self-report arousal in both image conditions, and increase threat and attraction ratings in their respective image conditions. In the attraction condition, it was expected that red would lead to higher valence ratings and greater zygomaticus activity than blue. For threatening images, it was expected that red would lead to lower valence ratings and greater corrugator activity than blue. In general, the results of this study do not confirm these hypotheses, and fail to support the theory of the red effect.

Males viewing females rated them as significantly more attractive in the blue condition as compared to red. This trend was not reflected in any physiological measures. The ratings alone suggest that blue increases the perceived

attractiveness of women to men, contrary to what the red effect suggests. Valence ratings were significantly higher for attraction conditions compared to threat conditions, as would be expected. There were no other significant results of color on ratings or physiological measures within any condition; however, there was a marginal effect of red on corrugator activity within the threat condition, which would support the red effect. It's somewhat surprising that this effect was found only in the threat condition. Previous research does not indicate that red elicits an overall stronger response in either the threat or attraction condition, but rather a qualitatively different response. Attraction conditions would evoke stronger zygomaticus response and threat conditions would evoke stronger corrugator responses, but a significantly different overall SCR response between conditions would not be expected. The underpowered nature of this study could be the reason for the lack of significant results. There were only four males in each female attraction condition, which could skew the results into having the opposite effect of what was expected. More participants would also increase the likelihood of finding more significant results in general.

In the future, standardization of the images should be done to ensure the proper responses to images and an increased probability of finding significant results. In this study, some threatening images elicited zygomaticus responses, indicating a positive reaction instead of a negative one. The attraction ratings were averaged as desired so as to examine the effect of color on attractiveness, rather than attractiveness alone. It may be helpful to conduct a preliminary trial, in which subjects' self-report ratings and physiological measures would be collected in response to images in the absence of color. This would help to find the most effective images for the actual experiment for a new set of participants. In addition to controlling for actual attractiveness of models, it may be helpful to control for race. Pazda et al.[15] did not incorporate such a control, but it may be an important factor, as Tarr et al.[25] have found that red-green hue balance may be different in African/African-American faces than in Caucasian faces.

Another modification that could be made in the future would be the addition of two more threat conditions. Based on evidence that color-moderated approach/avoid reactions are seen in the context of dominance fights[7], a condition in which males view males and females view females and are asked to self-report threat-could be added. More knowledge could be gained about the effect of red on perceived dominance of other humans, as opposed to when viewing threatening situations.

There is also the question of which red is the best red to study. Elliot et al. used various LCH values for their "red" throughout different studies, ranging from 40.6/40.4/20.1 to 50.3/47.0/25.0. In the present study, the LAB value for red was 37.43/59.24/47.63, which approximates[26] to an LCH value of 37.43/76.01/38.80. Because these values are different across previous research, it is difficult to compare results. There may be specific hues of red that produce certain effects. In future studies, the possible differential effects of various hues of red should be analyzed, to facilitate more effective comparison.

This study found a slight discrepancy between explicit self-ratings and implicit physiological measures. Two examples are the presence of a color effect on males' self-report ratings in the absence of physiological correlates that would indicate said effect, and the marginal effect of color on corrugator activity in threat, which was not even remotely reflected in threat ratings. These inconsistencies may be resolved by making the aforementioned changes in future research. One explanation for the discrepancies and opposite findings could be the foreign, "strange" environment in which participants were tested, as subjects sat alone in a dark environment with electrodes placed on their face and fingers. A previous color study[27] found similar discrepancies between explicit and implicit measures of emotional response, and the possible explanation for their occurrence was similar. In conclusion, the red effect was not supported by the present study. The observed effect of blue on attraction ratings of females by males opposes the red effect, but could be due to many factors. Future research should emphasize the standardization of images and colors used for research in the color-in-context theory.

5. References

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