Article

Personality and Social Psychology Bulletin
38(6) 784–797

DOI: 10.1177/0146167212436611
http://pspb.sagepub.com
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Fertile Green: Green Facilitates Creative Performance

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Abstract

The present research sought to extend the nascent literature on color and psychological functioning by examining whether perception of the color *green* facilitates creativity. In four experiments, we demonstrated that a brief glimpse of green prior to a creativity task enhances creative performance. This green effect was observed using both achromatic (white, gray) and chromatic (red, blue) contrast colors that were carefully matched on nonhue properties, and using both picture-based and word-based assessments of creativity. Participants were not aware of the purpose of the experiment, and null effects were obtained on participants' self-reported mood and positive activation. These findings indicate that green has implications beyond aesthetics and suggest the need for sustained empirical work on the functional meaning of green.

Keywords

green, creativity, performance, color, hue

Received April 6, 2011; revision accepted December 11, 2011

Color is a ubiquitous stimulus in our perceptional world. Given this ubiquity, one might anticipate that a large body of systematic research would be present on the influence of color perception on affect, cognition, and behavior. Surprisingly, research on color effects is sparse, especially relative to empirical work on color physics and color physiology (Fehrman & Fehrman, 2004; Whitfield & Wiltshire, 1990). More surprising still is that until quite recently, the research conducted in this area has lacked conceptual depth (e.g., being atheoretical or based on broad statements regarding wavelength and arousal) and methodological rigor (e.g., failing to control for lightness and chroma in testing the influence of hue; see Elliot & Maier, 2007; Valdez & Mehrabian, 1994).

In the past few years, however, there has been a surge of research activity on the influence of color, specifically hue, on psychological functioning, and this work has attended to the aforementioned weaknesses. That is, recent research has begun to offer precise conceptual statements linking color to meaning and associated affect, cognition, and behavior, and has used carefully controlled experimental designs and materials. A few studies have examined color preferences (Franklin, Bevis, Ling, & Hurlbert, 2010; Hurlbert & Ling, 2007; Maier, Barchfeld, Elliot, & Pekrun, 2009), focusing on a variety of different color stimuli. Other research has shown that color can function as a meaning-laden prime in certain contexts, influencing perceivers' motivation and action without awareness. This research has focused on the color red, using other colors such as white, gray, blue, and green as achromatic or chromatic controls. For example, red has been shown to carry the meaning of sex and romance in heterosexual person perception, leading men and women to view members of the opposite sex as more attractive and sexually desirable (Elliot et al., 2010; Elliot & Niesta, 2008; Niesta Kayser, Elliot, & Feltman, 2010). A pressing question, at present, is whether color effects of this nature are restricted to red or whether other hues also have implications for psychological functioning.

In the present research, we focus on the color green and examine its influence on creativity. Our central hypothesis is that perceiving green prior to a creativity task fosters creative performance, and we put this hypothesis to test in a series of four experiments. Our hypothesis is grounded in a broad analysis of the meaning of green.

The Meaning of Green

Green is an additive primary color with strong associations across time and culture. In English, and many other languages

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across the globe, the etymological root of green is "grow," especially "tangibly growing things" ("Green"; *Oxford English Dictionary*, 1989; Hutchings, 2004). Scholars believe that this widespread linguistic connection between green and grow emerged from the universal experience of observing the green of grass, herbs, and fresh vegetation that grows out of the ground (Wierzbicka, 1990).

Historically, green has been used to symbolize concepts closely related to growth, such as fertility, life, and hope. In ancient Egypt, Greece, Rome, and India, green was the color of several god figures representing vegetation, fertility, and rebirth (Chamberlin, 1968; Matthews, 2001), and green emerged in each of the major monotheistic religions as a symbol of life, hope, and resurrection (Allen, 1936; Mahnke, 1996; Jacobs & Jacobs, 1958). In northern and central Europe, green gowns were commonly worn in pagan ceremonies and festivals during springtime to convey the coming renewal and emergence of life (Chamberlin, 1968; Peterson & Cullen, 2000). Likewise, until the Middle Ages, for women in Europe, Anatolia, India, and many other areas of the world, green was commonly used as the color of wedding dresses and adornments (e.g., belts, ribbons) to symbolize the hope of fertility (Becker, 2000; Wasserfall, 1999). In the art, literature, and folklore of the Middle Ages, green was linked to characters representing life, fertility, and renewal (Basford, 1978; Cameron, 1936; Gage, 1999). In contemporary times, many languages link green to vegetation and the environment. A "green thumb," for instance, is an excellent gardener, "going green" means becoming more environmentally aware, and "greener pastures" are (perceived as) a new and better place.

Quality empirical research on green associations is sparse. A few studies have presented participants with color words and/or adjectives and had participants provide free associations. In these studies, green has been linked to nature, restfulness, peace, and positive evaluation (Adams & Osgood, 1973; Clarke & Costall, 2008; Grieve, 1991). Studies that have presented participants with color samples and had participants provide free associations have invariably been flawed, due to a failure to properly control for lightness and chroma in examining associations to hue. This methodological problem renders this work uninterpretable (see D'Andrade & Egan, 1974; Valdez & Mehrabian, 1994). Moller, Elliot, and Maier (2009) used a reaction time methodology to examine implicit links between red, competence-relevant words, and general positive and negative words, with green serving as a control color. The lightness and chroma properties of color were held constant; only hue was allowed to vary. The data linked green to success-relevant, but not general positive, words. Elliot, Feltman, and Maier (2011) used this same reaction time methodology and rigorous control of nonhue color properties but focused on green per se and its associations with growth-relevant words, both concrete (e.g., sprout, bud) and abstract (e.g., flourish, develop). The data revealed an implicit link between green and both types of growth-relevant words, indicating that green is associated with psychological growth and mastery, as well as physical growth.

It is possible that the historical uses and current associations with green are entirely due to societal learning. However, it is also possible that the link between green, growth, and associated concepts is grounded, in part, in our biological heritage. Specifically, for our early ancestors living on the Savanna, a distant patch of green would represent fresh vegetation and, implicitly, a water source. Those who oriented and engaged in approach behavior toward green would have had greater access to the nutrition and sustenance needed for survival, and would thus have been more likely to procreate (for related arguments regarding natural landscapes in general, see Hartmann & Apaolaza-Ibáñez, 2010; Orians & Heerwagen, 1992; Ulrich, 1993). As such, selection processes may have set in place a predisposition to perceive green as an appetitive signal of growth.

Of course, societal and biological accounts of the green-growth link need not be mutually exclusive but may operate in a joint fashion (for similar reasoning regarding *red*, see Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). That is, the societal uses of green may not be random but may derive from a biologically based predisposition to perceive green as a signal of growth. These societal uses of green may not only reinforce a biologically engrained meaning of green but may also extend it from the concrete notion of vegetative growth and life to the more abstract, psychological notions of development and mastery.[1]

In sum, both historically and currently, green appears to carry the meaning of growth, in both concrete (physical growth) and abstract (psychological growth) manifestations. This green-growth link is undoubtedly rooted in societal learning that may itself be grounded in an evolutionarily engrained predisposition.

The Influence of Green

The controlled experimental research on color effects that has included green has tended to use it as a chromatic control in examining red effects. This research has focused primarily on analytical performance and heterosexual attraction, and has not revealed any influence of viewing green on these (and related) variables. That is, green has consistently been shown to yield null effects relative to other chromatic and achromatic controls (e.g., Elliot et al., 2007; Elliot & Niesta, 2008). Research on green and creativity, our focal interest herein, has yet to be conducted.

Creativity is consensually defined as the generation of ideas or products that are both novel and of value (Amabile, 1983; Sternberg & Lubart, 1999). Creativity is critical to both survival and prosperity; it advances science and technology, provides pleasure in arts and entertainment, and facilitates the effective and enjoyable navigation of daily life (Nijstad, De Dreu, Rietzschel, & Baas, 2010; Runco, 2005). Research on creativity has documented many different situational and person-based factors that contribute to creative output (for reviews, see Baas, De Dreu, & Nijstad, 2008; Hennessey & Amabile, 2010; Ma, 2009; Mumford, 2003; Runco, 2004; Simonton, 2003). In the present research, we examine green as a situational prime that influences creative performance.

A well-established finding in the creativity literature is that positive, approach-based motivational states are beneficial for creative performance. Research has shown that experiencing positive affect (Hirt, Melton, McDonald, & Harackiewicz, 1996; Isen, Daubman, & Nowicki, 1987), focusing on potential positive outcomes (Friedman & Förster, 2001; 2005), engaging in approach-relevant motor actions (e.g., arm flexion; Cretenet & Dru, 2009; Friedman & Förster, 2000, 2002), and possessing approach-oriented traits (e.g., extraversion; De Dreu, Nijstad, & Baas, 2011; Feist, 1998; Furnham & Bachtiar, 2008) facilitates creative output. Appetitive states signal a benign, safe environment in which perceptional and cognitive processing is open, inclusive, and risk tolerant, and one can freely explore procedures and alternatives in an unconstrained manner (Friedman & Förster, 2010; Schwarz & Bless, 1991). Such states are known to stimulate and support creativity (Ashby, Isen, & Turken, 1999; Carson, Peterson, & Higgins, 2005; Friedman & Förster, 2005; Mednick, 1962; Nijstad et al., 2010; Winkielman, Schwarz, Fazendeiro, & Reber, 2003).

As noted earlier, green is associated with growth, not only physical growth but also psychological growth such as development and mastery. Accordingly, green may serve as a particular type of appetitive cue that evokes mastery-approach striving (i.e., striving for improvement and task mastery; Elliot, 1999) in creativity contexts; mastery-approach striving has been shown to foster innovation and creative performance in prior research (Gong, Huang, & Farh, 2009; Hirst, Van Knippenberg, & Zhou, 2009; Janssen & Van Yperen, 2004).

Performance on creativity tasks may be distinguished in terms of quantity and quality (De Dreu, Baas, & Nijstad, 2008; Hirt, Levine, McDonald, Melton, & Martin, 1997). Quantity refers to the number of responses generated, regardless of their creativity, whereas quality refers to the divergence and uniqueness of the responses that are generated, that is, creativity per se (Friedman & Förster, 2002; Hirt et al., 1997). Research has repeatedly shown that appetitive cues in performance contexts foster creativity per se without necessarily influencing the number of responses generated (Friedman & Förster, 2002; Roskes, De Dreu, & Nijstad, 2011). Likewise, we have no reason to expect that green will influence the number of responses generated per se, so we posit that green will enhance the creativity, but not necessarily the amount, of response output.

In addition, we predict that any influence of green on creativity observed in our experiments will take place subtly, outside of conscious awareness. Friedman and Förster (2010) recently coined the term *implicit affective cue* to refer to stimuli that activate hospitable or hostile appraisals of the current environment (and accompanying appetitive or aversive perceptual-cognitive processes) and do so without producing any explicit, conscious feeling state. Such cues are presumed to exert an influence on behavior without the perceiver's awareness. One of three programs of research reviewed by Friedman and Förster (2010) to illustrate the concept of the implicit affective cue is the aforementioned research on the color red. In the present research, we posit that green, like red, can serve as an implicit affective cue. Specifically, we predict that perceiving the color green facilitates creativity and does so without the perceivers' awareness.

Experiment 1

Experiment 1 examined the effect of green, relative to white, on creative task performance. We predicted that participants in the green condition would exhibit more creativity than those in the white condition.

Method

Participants. A total of 69 (36 male, 28 female, 5 unspecified) individuals participated in the experiment. Participant ethnicity was as follows: 6 Caucasian, 1 African American, 54 Asian, 3 Hispanic, and 5 unspecified. In this and all subsequent experiments, we were careful to exclude any color-deficient individual who participated in a chromatic condition. The mean age of participants was 27.84 years with a range of 19 to 43. Individuals received US$0.20 for their participation.

Design, procedure, and materials. Participants were randomly assigned to one of two between-subjects conditions: the green condition or the white condition. Sex and age effects are sometimes evident in creativity research (for reviews see, Baer, 2008; Ma, 2009). Accordingly, in this and all subsequent experiments, we tested for sex and age differences in preliminary analyses and retained these variables as covariates in final analyses when they were significant or marginally significant (see Judd & Kenny, 1981).

Experiment 1 was conducted over the World Wide Web using Amazon's popular crowdsourcing platform, Mechanical Turk (http://www.mturk.com). Participants were informed that they would take part in several different studies. On the first screen of the focal study herein, participants were presented with a black study number placed in a rectangle in the middle of the screen. The rectangle was either colored green or left uncolored (i.e., white); a standard green was selected for the color manipulation (it was not possible to establish the precise parameters of the green color, given that each participant viewed it on a different computer screen).

After viewing the cover page, participants were asked to complete a creativity task for 2 min. Following the creativity task, participants were given a short questionnaire that contained demographic items, as well as questions that asked participants to report the color they saw on the first page of the experiment and that probed for participants' awareness of the purpose of the experiment.[2]

Creativity task. Participants completed the unusual uses task (Guilford, 1967), which has been used in prior research to assess creativity (Baas, De Dreu, & Nijstad, 2011; Friedman & Förster, 2001). In the task, participants write down as many different creative ways to use an object as possible, in this case a tin can. They are told that their ideas should be neither typical nor impossible.

Two coders rated each idea generated by participants for creativity, with creativity being defined as an idea that is uncommon, remote, and clever (1 = *not creative at all*, 5 = *very creative*), following Guilford's classic criteria of originality (Wilson, Guilford, & Christensen, 1953). One person coded all responses, and the other coded 30% of the responses (De Dreu & Nijstad, 2008: Kohn, Paulus, & Choi, 2011); both coders were blind to participants' experimental condition. Interrater agreement was good following criteria as per Cicchetti & Sparrow (1981; intraclass correlation, ICC[1] > .62).

Results and Discussion

Preliminary analyses revealed no sex or age effects on creativity or the number of responses generated (Fs < 0.23, ps >.63). Therefore, we did not include sex or age in the final analyses.

An independent-samples t test examining the influence of color condition on creativity revealed a significant color effect, $t(67) = 2.12$, $p < .05$, $d = .52$. Participants in the green condition exhibited more creativity than did those in the white condition (see Figure 1 for means by color condition). An independent-samples t test examining the influence of color condition on the number of responses yielded a null effect ($t = 0.10$, $p = .92$).

A chi-square test of independence was calculated to determine whether participants' color reports corresponded to their color condition. The analysis yielded a significant effect, $\chi^2(1, N = 66) = 10.95$, $p < .01$, indicating that participants were indeed cognizant of the color on the first screen of the experiment. In the awareness probe, however, not a single participant correctly guessed the purpose of the experiment.

In sum, the results supported our predictions. Participants who viewed the color green prior to engaging in a creativity task exhibited more creativity than did those who viewed white. No differences were observed for overall response output. Participants were able to correctly report the color they saw, but remained unaware of the purpose of the experiment.

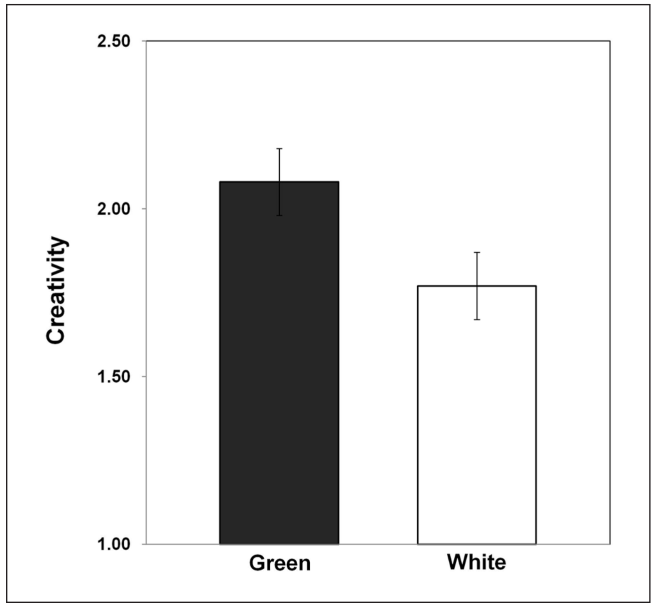

Figure 1. Creativity as a function of color in Experiment 1
Note: Standard errors are indicated by vertical lines.

Experiment 2

In Experiment 2, we changed several features of the experimental procedure. First, we changed the control color from white to gray. We used gray as the contrast to green because gray is the only achromatic control that can be equated to green on lightness. Moreover, we changed the venue of the experiment from an online setting to a real-world classroom setting. Finally, we changed the manipulation in that we presented the word *Ideas* on the cover page of the task.

Method

Participants. A total of 35 (5 male, 30 female) college students in Germany voluntarily participated in the experiment. All participants were Caucasian. The mean age of participants was 19.94 years with a range of 17 to 26.

Design, procedure, and materials. Participants were randomly assigned to one of two between-subjects conditions: the green condition or the gray condition. Participants were tested in small groups by an experimenter blind to participants' condition and the experimental hypothesis. At the beginning of the experiment, the experimenter provided participants with a description and illustration of the creativity task. To minimize any threat or pressure that participants might experience, the experimenter sought to create a relaxing atmosphere with no mention of creativity, testing, or performance.

After the description of the task, participants were provided with the experimental materials in a white two-ring binder. The manipulation was similar to that used by Elliot et al. (2007). The first page in the binder was a cover page, which was a piece of white paper with the word *Ideas* in black ink in 48-point font placed on a 5.15 in. long × 7.33 in. wide rectangle in the middle of the page. The rectangle was colored either green or gray; the colors in the manipulation were selected using the International Commission on Illumination

LCh color model. This model defines color space in terms of three parameters: lightness, chroma, and hue (LCh; Fairchild, 2005). A spectrophotometer was used to select colors equated on lightness (green: LCh[52.4/60.2/155.9], gray: LCh[52.8/–/289.5])—"Equated" in this context means functionally equivalent (within 1.0 unit; Stokes, Fairchild, & Berns, 1992). As gray is an achromatic color, chroma is not a relevant parameter in this experiment.

The experimenter informed participants that the first page in the binder should contain the word *Ideas* and then instructed them to open the binder to this page. The experimenter remained blind to color condition by turning away from participants as they checked the page. Participants were exposed to the color for approximately 2 s, and then they were asked to turn the page and complete the task. When 2.5 min had elapsed (time was monitored surreptitiously with a stopwatch to avoid evoking evaluative pressure), the experimenter told participants to turn the page and answer a brief questionnaire. This questionnaire contained demographic items as well as questions that asked participants to report the color they saw on the first page and that probed for participants' awareness of the purpose of the experiment. At the end of the experiment, participants were debriefed, thanked, and dismissed.

Creativity task. We administered a subtest of the Berlin Intelligence Structure (BIS) test (Jäger, Süß, & Beauducel, 1997), which has been used in prior research to assess creativity (Reuter et al., 2005; Weis & Süß, 2007). In this task, participants draw as many different objects as they can from a geometric figure during the allotted time period.

The creativity of participants' responses was independently coded by two individuals who rated the number of distinct categories that were generated (Jäger et al., 1997). One person coded all responses, and the other coded 30% of the responses; both coders were blind to participants' experimental condition. Interrater agreement was ICC[1] > .90, which is good to excellent according to Cicchetti and Sparrow's (1981) criteria.

Results and Discussion

Preliminary analyses revealed no sex or age effects on creativity or the number of responses generated (Fs < 0.54, ps > .46). Therefore, we did not include sex or age in the final analyses.

An independent-samples t test examining the influence of color condition on creativity revealed a significant color effect, $t(33) = 2.00$, $p = .05$, $d = .70$. Participants in the green condition exhibited more creativity than did those in the gray condition (see Figure 2 for means by color condition). An independent-samples t test examining the influence of color condition on the number of responses yielded a null effect ($t = 0.81$, $p = .42$).

A chi-square test of independence was calculated to determine whether participants' color reports corresponded to their color condition. The analysis yielded a significant effect, $\chi^2(1, N = 35) = 10.21$, $p < .01$, indicating that participants were indeed cognizant of the color on the first page of the task. In the awareness probe, however, not a single participant correctly guessed the purpose of the experiment.

In sum, the results supported our predictions. Participants who viewed the color green prior to engaging in a creativity task exhibited more creativity than did those who viewed gray. No differences were observed for overall response output. Participants were able to correctly report the color they saw, but remained unaware of the purpose of the experiment.

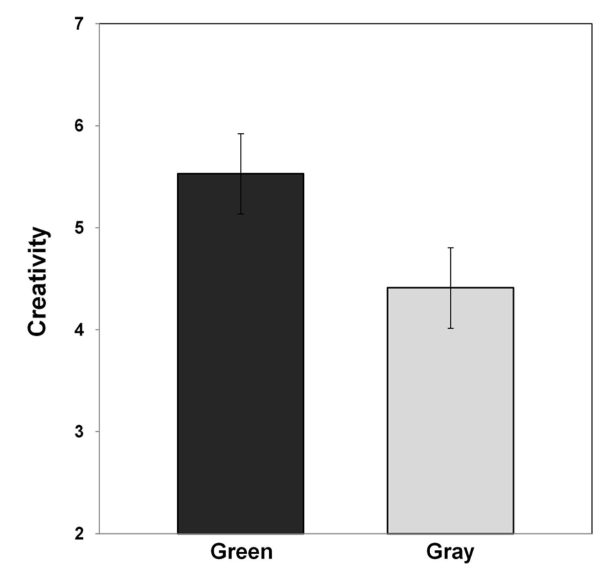

Figure 2. Creativity as a function of color in Experiment 2
Note: Standard errors are indicated by vertical lines.

Experiment 3

In Experiment 3, we added two features to the Experiment 2 methodology. First, we included a chromatic color, red, as well as an achromatic color, gray, as a contrast for green. Gray affords control of the lightness property of color, whereas red (or any other chromatic color) affords control of both the lightness and chroma properties of color in examining the effect of hue. We selected red as the chromatic contrast because red, like green, is an additive primary color, and red and green are opposite colors in several well-established color models (Fehrman & Fehrman, 2004). Furthermore, red is an interesting contrast color because it has been shown to be an aversive cue that has negative implications for analytical performance (Elliot, Maier, Binser, Friedman, & Pekrun, 2009; Maier, Elliot, & Lichtenfeld, 2008). Aversive cues have also been shown to have negative implications for creativity, presumably because they produce narrow, rigid perceptual-cognitive processing that is antithetical to creative performance (Friedman & Förster, 2000, 2001, 2002). Accordingly, we predicted that green would facilitate creativity relative to red and gray, and that red would undermine creativity relative to gray.

Second, in Experiment 3 we included assessments of participants' mood and positive activation to see if color influenced variation on these explicit measures. In line with prior color research (see Elliot & Maier, 2007) and consistent with the view of color as an implicit affective cue (Friedman & Förster, 2010), we anticipated that the predicted effects of color on creativity would emerge without showing any influence on participants' conscious affective states.

Method

Participants. In all, 33 (29 male, 4 female) high school students in Germany voluntarily participated in the experiment. All participants were Caucasian. The mean age of participants was 16.82 years with a range of 16 to 18.

Design, procedure, and materials. Participants were randomly assigned to one of three between-subjects conditions: the green condition, the red condition, or the gray condition. The general procedure for the experiment was the same as that used in Experiment 2. The experiment differed from Experiment 2 in that an additional, chromatic contrast color was used and additional items were included on the post-task questionnaire to assess conscious affective experience.

The colors for the manipulation were selected using the same procedure used in Experiment 2. The chromatic colors were equated on lightness and chroma, and the chromatic and achromatic colors were equated on lightness (green: LCh[52.4/60.2/155.9], red: LCh[53.4/60.2/22.5], gray: LCh[52.8/–/289.5]).

Creativity task. As in Experiment 2, we used a subtest of the BIS test (Jäger et al., 1997) to assess creativity. Again, the creativity of responses was independently coded by two individuals blind to participants' experimental condition. Interrater agreement was good to excellent based on Cicchetti and Sparrow's (1981) criteria (ICC[1] > .80).

Mood. Mood was assessed with Friedman and Förster's (2001) single-item measure ("How do you feel right now?") using a 1 = *very bad* to 9 = *very good* scale.

Positive activation. Positive activation was assessed with the five-item General Activation subscale (e.g., "How vigorous did you feel while solving the creativity task?") of Thayer's (1986) Activation–Deactivation Adjective Check List. Participants responded on a 1 = *not at all* to 5 = *very strongly* scale ($\alpha = .76$).

Results and Discussion

Preliminary analyses did not reveal age effects on any dependent variable (Fs < 0.57, ps > .45), so age was not included in the final analyses. Preliminary analyses indicated that sex was a marginally significant or significant predictor of creativity ($F = 3.43$, $p < .10$) and number of responses ($F = 4.52$, $p < .05$; women exhibited higher values in each instance); therefore, sex was included as a covariate in the final analyses with these variables.

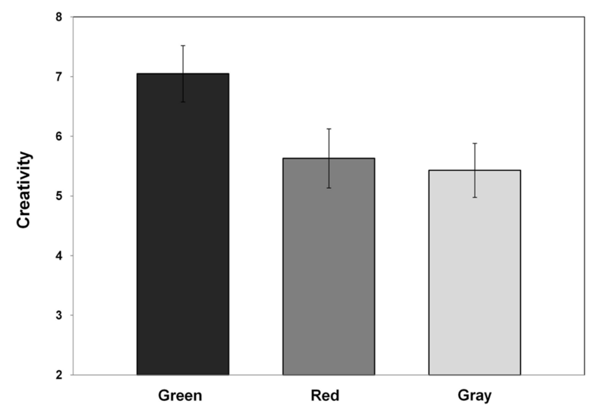

Figure 3. Creativity as a function of color in Experiment 3 (means are adjusted for sex)
Note: Standard errors are indicated by vertical lines.

A unifactorial (color condition: green vs. red vs. gray) between-subjects ANCOVA was conducted on creativity. The analysis revealed a significant effect of color condition on creativity, $F(2, 29) = 3.51$, $p < .05$, $\eta^2_p = .20$ (see Figure 3 for means by color condition). Planned comparisons were then conducted to determine the precise nature of the effect. The analyses revealed that participants in the green condition exhibited more creativity than did those in the red condition, $t(29) = 2.07$, $p < .05$, $d = .77$, and the gray condition, $t(29) = 2.47$, $p < .05$. $d = .92$. Participants in the red and gray conditions displayed comparable levels of creativity, $t(29) = 0.30$; $p > .76$.

The same ANCOVA was then conducted on the number of responses generated. This analysis indicated that color condition did not have a significant effect on the overall number of responses ($F = 2.34$; $p = .11$). ANOVAs on mood and positive activation also failed to yield significant effects of color condition (Fs < 0.38, ps > .68).

A chi-square test of independence was calculated to determine whether participants' color reports corresponded to their color condition. The analysis yielded a significant effect, $\chi^2(4, N = 33) = 60.27$, $p < .01$, indicating that participants were indeed cognizant of the color on the first page of the task. In the awareness probe, however, not a single participant correctly guessed the purpose of the experiment.

In sum, the results for green supported our predictions. Participants who viewed the color green prior to engaging in a creativity task exhibited more creativity than did those who viewed red or gray. Surprisingly, red did not undermine creativity, relative to gray; possible reasons for this null effect will be considered in the general discussion section. No differences were observed for participants' overall number of responses. Participants were able to correctly report the color they saw, but remained unaware of the purpose of the experiment. Furthermore, null effects on mood and positive activation suggest that color had no influence on participants' conscious affective experience.

Experiment 4

In Experiment 4, we made two changes to the Experiment 3 methodology. First, we included a different chromatic color, blue, as a contrast to green. Like red, blue affords control of both the lightness and chroma properties of color in examining the affect of hue, and, like green and red, blue is an additive primary color. However, in contrast to green and red, blue does not have a rich, consistent symbolic history (Pastoureau, 2001; Wolf, 2007). Furthermore, although the primary etymological root for blue in English, sky, carries positive connotations (De Vries, 2004; Gage, 1999; Wierzbicka, 1990), the figurative and colloquial meanings of blue across languages are decidedly mixed in valence (e.g., faithful, dependable, high quality, but also sad, obscene, drunk; Allan, 2009; "Blue"; *Oxford English Dictionary*; Heller, 2004). The few available studies on blue associations that have either properly controlled for nonhue properties or used semantic stimuli have likewise revealed a mix of positive and negative connotations (pleasant, calm, but also sad, cold; Adams & Osgood, 1973; Clarke & Costall, 2008; Valdez & Mehrabian, 1994). Psychological theorizing on blue shows a similar divide, with some positing that blue carries a negative meaning (sadness) that prompts careful, aversive processing (Soldat & Sinclair, 2001), and others positing that blue carries a positive meaning (openness) that prompts exploratory, appetitive processing (Mehta & Zhu, 2009). Empirical support for both of these opposing proposals has been reported (including research linking blue to enhanced creativity; see Mehta & Zhu, 2009), but nonhue properties of color were not properly controlled in this work.[3] In light of this mixed portrait for blue, it seems wise to take a conservative stance (i.e., to posit neither a positive nor a negative effect). Accordingly, we predicted that green would facilitate creativity relative to blue and gray, and that blue and gray would exhibit no difference.

Second, in Experiment 4 we used a different creativity task, the instances task of Wallach and Kogan (1965). Conceptually replicating the prior experiments with another approach to creativity assessment would help demonstrate the generalizability of the green effect.

Method

Participants. A total of 65 (30 male, 35 female) high school students in Germany voluntarily participated in the experiment. All participants were Caucasian. The mean age of participants was 16.48 years with a range of 15 to 18.

Design, procedure, and materials. Participants were randomly assigned to one of three between-subjects conditions: the green condition, the blue condition, or the gray condition. The general procedure for the experiment was the same as that used in Experiments 2 and 3. The experiment differed from the prior experiments in that a different chromatic contrast color was used and a different creativity task was used.

The colors for the manipulation were selected using the same procedure used in the prior experiments. The chromatic colors were equated on lightness and chroma; the chromatic and achromatic colors were equated on lightness (green: LCh[57.8/50.3/153.1], blue: LCh[57.1/50.9/285.3], gray: LCh[57.7/–/273.4]).

Creativity task. We administered Wallach and Kogan's (1965) instances task, which has been used in prior research to assess creativity (Hattie, 1980; Runco & Charles, 1993). In this task, participants are asked to generate as many instances as they can for four different categories (e.g., things that are round). Participants are given 2 min to respond for each category.

The creativity of participants' responses was independently coded by two individuals who rated each response ("How creative is this response?") on a 1 = *not creative* to 5 = *very creative* scale (for a similar rating procedure, see Bechtoldt, De Dreu, Nijstad, & Choi, 2010). One person coded all responses, and the other coded 30% of the responses; both coders were blind to participants' experimental condition. Interrater agreement was good to excellent based on Cicchetti and Sparrow's (1981) criteria (ICC[1] > .74). The ratings were used to calculate an average creativity score for each participant (i.e., the summed ratings divided by the total number of ratings).

Mood. As in Experiment 3, mood was assessed with Friedman and Förster's (2001) single-item measure ("How do you feel right now?") using a 1 = *very bad* to 9 = *very good* scale.

Positive activation. Positive activation was assessed with Elliot et al.'s (2007) single-item short form ("How energetic did you feel while solving the creativity task?") of the General Activation subscale of Thayer's (1986) Activation–Deactivation Adjective Check List. This item is the highest loader on the General Activation subscale. Participants responded on a 1 = *not at all* to 5 = *very strongly* scale.

Results and Discussion

Preliminary analyses did not reveal sex effects on any dependent variable (Fs < 0.74, ps > .39), so sex was not included in the final analyses. Preliminary analyses indicated that age was a marginally significant or significant positive predictor of creativity ($F = 3.32$, $p < .10$) and number of responses ($F = 4.81$, $p < .05$); therefore, age was included as a covariate in the final analyses with these variables.

A unifactorial (color condition: green vs. blue vs. gray) between-subjects ANCOVA was conducted on creativity. The analysis revealed a significant effect of color condition on creativity, $F(2, 61) = 3.18$, $p < .05$, $\eta^2_p = .09$ (see Figure 4 for means by color condition). Planned comparisons were then conducted to determine the precise nature of the effect. The analyses revealed that participants in the green condition exhibited more creativity than did those in the blue condition, $t(61) = 2.46$, $p < .05$, $d = .63$, and tended to exhibit more creativity than did those in the gray condition, $t(61) = 1.77$, $p = .08$, $d = .45$. Participants in the blue and gray conditions displayed comparable levels of creativity, $t = 0.78$; $p = .44$.

The same ANCOVA was then conducted on the number of responses generated. This analysis indicated that color condition did not have a significant effect on the overall number of responses ($F = 1.08$; $p = .35$). ANOVAs on mood and positive activation also failed to yield significant effects of color condition (*F*s < 0.98, *p*s > .38).

A chi-square test of independence was calculated to determine whether participants' color reports corresponded to their color condition.

The analysis yielded a significant effect, $\chi^2(4, N = 52) = 20.58$, $p < .01$, indicating that participants were indeed cognizant of the color on the first page of the task. In the awareness probe, however, not a single participant correctly guessed the purpose of the experiment.

In sum, the results again supported our predictions. Participants who viewed the color green prior to engaging in a creativity task exhibited more creativity than did those who viewed blue or gray. Blue neither facilitated nor undermined creativity relative to gray. No differences were observed for participants' overall number of responses. Participants correctly reported the color they saw, but could not correctly guess the purpose of the experiment. Furthermore, null effects were observed on mood and positive activation, suggesting color had no influence on participants' conscious affective experience.

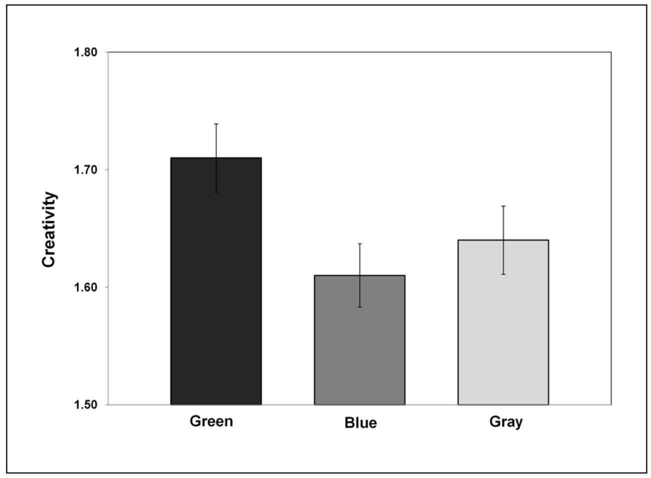

Figure 4. Creativity as a function of color in Experiment 4 (means are adjusted for age)
Note: Standard errors are indicated by vertical lines.

General Discussion

The results of the present research provide strong support for the hypothesized influence of green on creativity. In four experiments we demonstrated that a brief glimpse of green prior to engaging in a creativity task facilitates the creativity (but not overall amount) of response output. This green effect was observed using achromatic (white, gray) and chromatic (red, blue) contrast colors and using picture-based and word-based assessments of creativity. Critically, the effect was documented using hues matched at the spectral level on lightness and chroma. Participants were not aware of the purpose of the experiment, and null effects were obtained on measures of participants' conscious, self-reported, experiential states.

Our documentation of a green effect in this research nicely extends the extant empirical work on color and psychological functioning. Prior work has focused on the color red, showing links to analytical performance and attraction-relevant behavior (e.g., Elliot & Niesta, 2008; Maier et al., 2008). Here, we show that another color, green, has a systematic influence on another important outcome, creativity performance. Other recent work has reported that blue enhances creativity performance (Mehta & Zhu, 2009), but our research using carefully controlled color stimuli indicates that it is green, not blue, that facilitates creativity. Additional research is needed to further examine a possible link between blue and creativity, but at present, the data support green as the critical hue in this regard and hint that the prior findings attributed to blue may actually be due to lightness, chroma, or some sort of interaction among the three basic color properties (see Valdez & Mehrabian, 1994; Whitfield & Wiltshire, 1990).

Together, the emerging data on color and performance exhibit the following pattern: Green facilitates creativity performance, but has no influence on analytical performance, whereas red undermines analytical performance, but has no influence on creativity performance. This differentiated pattern suggests that broad and simple statements regarding color and performance are not warranted. Rather, it is necessary to consider factors such as the specific meaning/motivation associated with a particular color and the specific processing demands involved in performing a particular task in seeking to understand the link between color and performance outcomes. We do this in the following for green and red, respectively.

Regarding green, we do not view green as a general appetitive cue in performance contexts, but rather as a cue of growth-oriented mastery. In the achievement motivation literature, appetitive motivation is differentiated in terms of mastery-approach and performance-approach; mastery-approach motivation focuses on developing one's skills and improving one's performance, whereas performance-approach motivation focuses on demonstrating one's ability and outperforming others (Dweck, 1986; Elliot & Harackiewicz, 1996; Nicholls, 1984). Mastery-approach motivation is most similar to the growth-oriented appetitive state thought to be associated with green. Interestingly, mastery-approach motivation has been shown to facilitate deep processing, intrinsic interest, and creative performance, but has no clear relation to analytical performance (Elliot, McGregor, & Gable, 1999; Hirst et al., 2009; Hulleman, Schrager, Bodmann, & Harackiewicz, 2010; Janssen & Van Yperen, 2004; Shally, Gilson, & Blum, 2009). These findings are consistent with both the positive relation between green and creativity in the present research and the null relation between green and analytical performance in prior research. Thus, green appears to prompt a growth-oriented appetitive state akin to mastery-approach motivation that facilitates the type of pure, open processing required to do well on creativity tasks. Analytical tasks require a more constrained, outcome-based processing that is facilitated by performance-approach motivation (Elliot & McGregor, 2001; Moller & Elliot, 2006; Senko, Hulleman, & Harackiewicz, 2011), and we see no reason to believe that green would prompt this other form of appetitive motivation.

Regarding red, we view this color as a general aversive cue signaling danger and potential negative outcomes in performance contexts (Elliot & Maier, 2007; Moller et al., 2009). A substantial amount of research in the test anxiety and achievement motivation literatures has shown that aversive motivation prompts worry, distraction, perceptual-cognitive rigidity, and self-protective processes known to undermine performance on analytical tasks (Elliot & McGregor, 2001; Hembree, 1988; McCrea & Hirt, 2001; Urdan & Midgley, 2001). As such, it is not surprising that red has been linked to deleterious analytical performance in several experiments (e.g., Elliot, Payen, Brisswalter, Cury, & Thayer, 2011; Lichtenfeld, Maier, Elliot, & Pekrun, 2009; Maier et al., 2008). What is surprising is that red did not undermine creativity performance in Experiment 3. The traditional stance in the literature is that aversive states are antithetical to creativity (see Friedman & Förster, 2000, 2001), and we generated our Experiment 3 prediction for red accordingly. Why, then, did we obtain null results for red? One possibility is that an explicitly evaluative context is needed for red to serve as an aversive cue, and the nonthreatening, supportive environment that we established in our experiments to examine creative performance did not allow red to take on the meaning of danger and potential failure. Another possibility rests in recent research suggesting that aversive affective states can, in some instances, produce persistent effort that maintains or even facilitates creativity performance (De Dreu, Baas, & Giacomantonio, 2010; De Dreu et al., 2008; Roskes et al., 2011). It is possible that red in Experiment 3 prompted a combination of processes, some inimical for creativity and some beneficial for creativity, that together produced an overall null effect. Future research is needed to more thoroughly examine the link between red and creativity performance before a definitive statement on this relation is warranted.

The green effect observed in our research appears to be quite subtle in nature. In the experimental procedure in most of our experiments, green was presented briefly (for 2 s) as a mere background stimulus (on the first page of the task); no explicit attention was drawn to color at any time. In addition, participants showed no knowledge of the purpose of the experiment in a post-task awareness probe, and null effects were obtained across color condition on self-report measures of mood and positive activation. As such, green appears to serve as an implicit affective cue (Friedman & Förster, 2010) in influencing creativity performance.

As with other empirical work on implicit affective cues, including research on both creativity (Friedman & Förster, 2000, 2002) and color (Elliot et al., 2007; Elliot & Niesta, 2008), our focus in this initial examination of the green-creativity relation was on the presence or absence of a direct effect. Now that we have systematically documented that green facilitates creativity performance, subsequent research is needed to attend to the "second generation question" (Zanna & Fazio, 1982) of the mediational mechanism responsible for this direct effect. Such research is likely to be challenging, for two reasons. First, in general, testing mediation using implicit measures tends to be more difficult and precarious than testing mediation using explicit measures, as it requires the potentially disruptive assessment of an implicit process between the independent and dependent measures, rather than the mere addition of a few questionnaire items. Second, there is no implicit measure of mastery-approach motivation—our proposed mediational mechanism—available in the literature, meaning a preliminary step in testing mediation would be the development and validation of a new measure. Implicit measures of general appetitive motivation are available (see Bijleveld, Custers, & Aarts, 2009; Friedman & Förster, 2005; Robinson, Wilkowski, & Meier, 2008), but these undifferentiated assessments would not be sensitive enough to capture the more specific form of appetitive motivation posited to be involved in the green-creativity relation. Furthermore, the general appetitive mechanisms presumed to emerge from mastery-approach striving (e.g., open, flexible cognition) are downstream processes that proximally influence creativity; they may not be directly linked to green themselves. Despite these considerable challenges, we think that empirical examination of mediation is an important and necessary next step in this research program that promises to yield a more complete and precise understanding of the green effect documented herein.

Another issue worthy of exploration is the degree to which the meaning and influence of green are the same or different across cultures. Cross-cultural work may be particularly useful in determining whether the green-growth link (Elliot et al.,

2011) and the green effect observed in the present work are a product of social learning alone or have a biological basis. Definitive statements on such matters tend to be elusive, but acquiring data from different countries (e.g., East as well as West) and societies (e.g., remote tribes with little or no media contact) would be quite informative (see Davidoff, Fonteneau, & Goldstein, 2008; Elliot et al., 2010; Tracy & Robins, 2008). If the meaning and influence of green are indeed grounded in biology to some degree, relatively consistent data should be observed across these diverse groups.

In the present research, we showed that green facilitates creativity in a controlled experimental context, and an important question is whether this effect generalizes to real-world achievement settings in which creativity is highly valued. Thus, fieldwork could be conducted in which students or employees, for example, are regularly exposed to green (as well as other hues of equal lightness and chroma) in their work environment to see if this influences their creativity and innovation over time. On a related note, a number of theorists have posited that viewing nature or pictures of nature has beneficial implications for people's task engagement, emotional experience, and productivity (Kaplan & Kaplan, 1989; Orians & Heerwagen, 1992; Ulrich, 1993; Williams & Cary, 2002; Wilson, 1984), and research is starting to accumulate in support of this premise (Berman, Jonides, & Kaplan, 2008; Bringslimark, Hartig, & Patil, 2009; Hartmann & Apaolaza-Ibáñez, 2010; Ryan et al., 2010; Shibata & Suzuki, 2004; Ulrich, 1984). Interestingly, the nature manipulations used in these studies typically involve exposing subjects to live plants or to photos of natural settings replete with green trees and vegetation. In light of the results of the present experiments, it seems reasonable to raise the possibility that an (or even the) "active ingredient" in these nature manipulations is the color green. Green is also commonly used in other experimental paradigms as a cue to indicate "go," "potential gain," or "success," and as a potential distractor stimulus in Stroop-based procedures. The present results raise the possibility that these uses of green may be problematic, in that they may create confounds or, at minimum, produce extraneous variance.

In conclusion, careful, methodologically rigorous research on color and psychological functioning remains sparse and limited in scope. The present research extends this nascent literature by demonstrating that green, like red, can have a systematic influence on behavior. As such, green and red alike not only have aesthetic properties but also have functional properties, and clearly represent important perceptual stimuli in need of sustained empirical attention. We suspect that both green and red have a number of other influences on affect, cognition, and behavior beyond what has been documented in this and recent work. In other words, we believe that this is a fertile research area, destined for growth.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

1. We have emphasized the positive, appetitive meanings of green herein, because they are the most strong and prevalent, but green can also have negative, aversive connotations. For example, green can be linked to death and decay (Chamberlin, 1968), mold and poison (Mahnke, 1996), and youthful inexperience. Interestingly, each of these negative meanings may be seen as connected to the natural, cyclical progression of life, growth, death, and eventual renewal (Hutchings, 1997, 2004).
2. A correct guess was defined as stating something about color, something about creativity, and something about the direction of an effect.
3. Proper control of the nonhue properties of color requires measuring color stimuli at the spectral level using a spectrophotometer and equating the target hues on lightness and chroma. Soldat and Sinclair (2001) took no steps to equate their target hues on lightness and chroma. Mehta and Zhu (2009) sought to control nonhue color properties using a computer program to select comparable lightness and chroma values for their target hues. Unfortunately, color presentation is device dependent, and there is often considerable variation in color presentation across devices (Fairchild, 2005). As such, hue, lightness, and chroma were likely confounded in both instances, making clear interpretation of the results impossible (Elliot & Maier, 2007; Valdez & Mehrabian, 1994; Whitfield & Wiltshire, 1990) and, perhaps, explaining the divergent patterns obtained.

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