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Basic Hue-Meaning Associations

Arlen C. Moller
Gettysburg College and Northwestern University

Andrew J. Elliot
University of Rochester

Markus A. Maier
State University of New York at Stony Brook

Color may not only be pleasing to the eye, but may also carry important associations relevant for psychological functioning. Two experiments were conducted to test for basic hue-meaning associations, controlling for lightness and chroma. Specifically, we used a reaction time paradigm to test for links between red and green, and words that varied in achievement content (failure and success) or valence more generally. Results revealed that red was positively associated with failure and general negative words, and was negatively associated with success and general positive words, whereas green was positively associated with success words only. These findings directly document that hue carries psychologically relevant meaning. Implications both within and beyond the achievement domain are discussed.

Keywords: color, hue, red, green, valence, associations

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Color is usually considered in terms of aesthetics alone. However, it is possible that the reds, greens, blues, and yellows that we perceive on a daily basis are not only pleasing to the eye, but also carry meaningful associations that have direct implications for psychological functioning. Surprisingly, little research has examined color associations and the work that has been done has invariably had participants self-report associations to colors, and/or has presented hues without adequately controlling for the two additional properties of color, lightness and chroma. Few consistent patterns have emerged from these self-report investigations, and even clear patterns would be difficult to interpret given the confounding of hue, lightness, and chroma (Whitfield & Wiltshire, 1990).

In the present research, we used a reaction time paradigm to investigate basic color associations, and did so focusing on hue while systematically controlling for lightness and chroma. This is the first research to examine basic associations to hue (see Meier, Robinson, & Clore, 2004, for related research on lightness) and is also the first to examine associations to one color parameter with the other parameters directly controlled (see Valdez & Mehrabian, 1994, for the closest approximation). Our specific aim was to test for associations between red and negative valence, and green and positive valence. In doing so, we sought to link an ubiquitous nonlexical stimulus (i.e., hue) to a construct central to the psychological literature (i.e., evaluative valence).

We posit that red is associated with the danger of failure in achievement settings. Such a link could develop through classical conditioning, for example, teachers' repeated use of red ink to mark students' mistakes (Elliot & Maier, 2007). Complementary, another possibility is that humans share with other primates a biologically based tendency to interpret red as a danger signal in competitive (i.e., failure-relevant) contexts (Setchell & Wickings, 2005). From an empirical standpoint, Elliot, Maier, Moller, Friedman, and Meinhardt's (2007) recent finding that participants who view red before taking a challenging test exhibit avoidance motivation may be interpreted as indirect support for the posited red-failure association.

If a red-failure association exists, it may represent a link between red and negative valence specific to the achievement domain, but there are reasons to think it may be more general. In everyday life, red is used to convey negative information, usually danger, in a variety of contexts (e.g., alarms, sirens, traffic lights, warning signals, terrorist alerts, financial statements), and it objectively conveys danger in the form of fire, exposed blood, and an angry face. Furthermore, red's negative connotation is expressed in diverse phrases such as "in the red," "see red," "red tape," "red herring," "code red," "red flag," and "red handed." Certainly, red is not exclusively associated with negativity, as there are some instances in which it undoubtedly carries appetitive meaning (e.g., ripeness in fruit, Mollon, 2000; sexual readiness, Elliot & Niesta, 2008; Setchell, 2005; Waitt et al., 2003). However, given both the commonness that red is paired with danger in daily life, and the relative importance of avoiding negative possibilities (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001), red may carry negative meaning unless explicitly directed otherwise (i.e., in frugivory or sexual contexts).

Green is an optimal chromatic contrast to red, because red and green are opposing colors in well-established color models (Fehrman & Fehrman, 2004). Moreover, it is possible that green itself carries psychologically meaningful associations. In the U.S., green may be associated with success, given the link between green and

Arlen C. Moller, Gettysburg College and Northwestern University; Andrew J. Elliot, University of Rochester; Markus A. Maier, State University of New York at Stony Brook.

Correspondence concerning this article should be addressed to Arlen C. Moller, 680 N. Lake Shore Drive, Suite 1220, Chicago, IL 60611. E-mail: a-moller@northwestern.edu

U.S. currency (i.e., "greenbacks"), and green may even have more general positive associations given its meaning of "go" in traffic lights and its connection to growth in nature. It is difficult to imagine any possible biologically based source for a green-success or a green-positive link and, in general, it is more difficult to marshal evidence for such links than for the analogous links to red. Nevertheless, such associations seem plausible, and are explored herein.[1]

Overview of the Present Research

Research on evaluation clearly shows that valence is extracted quickly and unintentionally from lexical stimuli (Zajonc, 1980), and research on color indicates that hue is processed at a very early, rudimentary stage of perception (Gegenfurtner & Kiper, 2003). If hue is associated with valence, then a colored word that means the same thing based on both evaluative processing and color processing should be easier to categorize than a colored word that conveys different meanings based on evaluative and color processing. Based on this response competition logic (Klinger, Burton, & Pitts, 2000), we used a modified Stroop word evaluation task to test for basic hue-valence associations. In a first experiment, we examined associations between red/green and failure/success. In a subsequent experiment, we sought to replicate the Experiment 1 findings, and to extend them to questions regarding the direction of the observed effects (facilitation vs. inhibition) and the generality of the observed effects (achievement specific vs. general).

Experiment 1

In this experiment, failure and success words were presented in red and green, and participants categorized them as failure-related or success-related. Of most interest was whether failure words in red and success words in green would be categorized most quickly.

Method

Participants. Fifteen (7 women, 8 men) undergraduates (mean age = 20.6 years) participated for extra credit. Participants in each experiment were native English speakers, had no language-related disabilities, and were not red-green colorblind.

Stimuli and pilot test. Ten adjectives were used as lexical stimuli, five denoting failure (wrong, worse, worst, incorrect, inaccurate) and five denoting success (excellent, better, best, correct, accurate). The failure (M = 6.8, SD = 1.92) and success words (M = 6.8, SD = 2.29) did not differ in word length, $t < 1$.

The words were rated by 78 (45 women, 33 men) pilot participants for the degree to which they were failure-related, success-related, and familiar (1 = not at all, 6 = extremely). The failure words were rated as more failure-related than were the success words, and the success words were rated as more success-related than were the failure words, ts > 3.98, ps $< .01$. Participants' ratings of the failure and success words were equal in extremity, and these words were rated as equal in familiarity, $t < 1$.

A spectrophotometer was used to select colors equated on lightness and chroma (red: LCh[65.30/76.18/33.76], green: LCh[65.96/75.77/145.56]); equated means functionally equivalent (within 2.0 units; Stokes, Fairchild, & Berns, 1992).

Design and procedure. The experiment had a 2 (Valence: failure vs. success) × 2 (Color: red vs. green) repeated measures design. It consisted of 80 trials divided into two blocks. Within block, each failure and success word was presented four times (twice in each color) in random order on a black computer screen. Participants' task was to press a key labeled to indicate whether the word was failure-related or success-related. Label position was alternated across participants. For each trial, a fixation cross appeared for 500 ms, then a word appeared until a response was made or 5,000 ms elapsed. The intertrial interval was 1,000 ms. Inaccurate (2.3%) and untimely (<200 or >5,000 ms; 1.2%) responses were omitted (Kazén & Kuhl, 2005). Twenty practice trials preceded the experiment.

Results and Discussion

Label Position had no main or interactive effects, so it was not considered further. There were no main effects of sex, nor did sex moderate the theoretically central interaction, so sex was not considered further. A 2 (Valence) × 2 (Color) repeated measures ANOVA on reactions times revealed a significant main effect of Valence, but not Color. More importantly, a significant Valence × Color interaction, $F(1, 14) = 14.41$, $p < .01$, $\eta_p^2 = .51$ (Figure 1), indicated that participants were faster categorizing failure words presented in red (M = 631.36 ms, SD = 57.60) versus green (M = 674.68 ms, SD = 86.07), $t(14) = 2.57$, $p < .05$, and were faster categorizing success words presented in green (M = 603.20 ms, SD = 52.95) versus red (M = 647.80 ms, SD = 77.19), $t(14) = 2.74$, $p < .05$. These results suggest that red is associated with failure, whereas green is associated with success.

Experiment 2

Experiment 2 sought to replicate Experiment 1 using a different set and type (nouns rather than adjectives) of words. More importantly, we examined the precise directionality of the effects. From Experiment 1, it was impossible to determine whether red facilitates or green inhibits reactions to failure words, whether green facilitates or red inhibits reactions to success words, or some combination therein. To address this issue, we added white as a control color, and anchored the red and green effects to this achromatic baseline. An additional aim of Experiment 2 was to examine the generality of the effects. We did so by including general positive or negative words to see if the effects would extend beyond achievement words to valenced words per se. Finally, we included a condition that downplayed the achievement-relevance of the setting to act as a contrast to the standard experimental context (which may, by default, be perceived as evaluative in nature). This allowed us to test whether word content alone is sufficient to produce the observed associations or whether they depend on an achievement-oriented context.

[1] Green-negative links do exist (e.g., "green with envy", the green of moldy food), but these links are less salient for individuals (in both speech and everyday life) and, therefore, undoubtedly less accessible, than the positive links highlighted in the text.

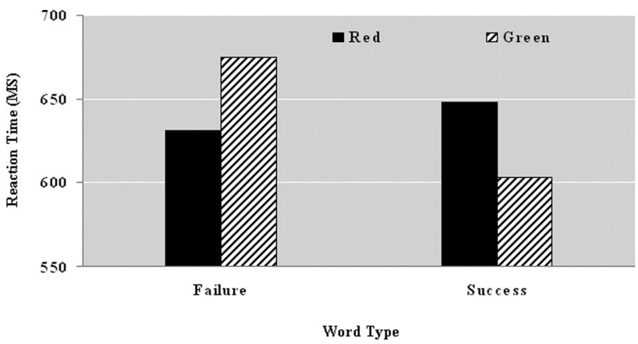

Figure 1. Mean response latencies for failure and success words presented in red and green. See online supplementary material for color version of Figure 1.

Method

Participants. Seventy-two (45 women, 27 men) undergraduates (mean age = 19.87 years) participated for extra credit.

Stimuli and pilot test. Thirty-two nouns were used as lexical stimuli, eight failure words (inaccuracy, blunder, loser, error, stupidity, failure, incompetence, mistake), eight success words (winner, triumph, accuracy, success, competence, brilliance, champion, victor), eight negative but not failure (general negative) words (hangover, ugliness, boredom, prejudice, feces, blindness, garbage, chore), and eight positive but not success (general positive) words (angel, giggle, truth, entertainment, toys, bravery, blessing, birthday). The failure and success words, and the general negative and general positive words did not differ in word length, $t(14)$s < 1.

The chromatic colors were equated on lightness and chroma (red: LCh[51.70/71.30/25.70], green: LCh[53.60/69.80/141.00]); the achromatic color (white) has maximum lightness and no chroma.

The words were rated by 116 (72 women) pilot participants for the degree to which they were failure-related, success-related, unpleasant, pleasant, and familiar (1 = not at all, 6 = extremely). The failure words were rated as more failure-related than were the success words, and the success words were rated as more success-related than were the failure words, $t(14)$s > 10.10, $p < .01$. The general negative words were rated as more unpleasant than were the general positive words, and the general positive words were rated as more pleasant than were the general negative words, $t(14)$s > 14.92, $p < .001$.

In addition, the unpleasantness rating of the failure words did not differ from the unpleasantness rating of the general negative words, $t(14) < 1$, but the failure words were rated as significantly more failure-related than the general negative words $t(14) = 6.46$, $p < .01$. The pleasantness rating of the success words did not differ from the pleasantness rating of the general positive words, $t(14) < 1$, but the success words were rated as significantly more success-related than the general positive words, $t(14) = 5.55$, $p < .01$. Participants' ratings of the failure and success words were equal in extremity, as were their ratings of the general negative and general positive words; the failure and success words, as well as the general negative and general positive words, were also rated as equal in familiarity, $t(14)$s < 1.

Design and procedure. The experiment had a 2 (Valence: negative vs. positive) $\times$ 3 (Color: red vs. green vs. white) $\times$ 2 (Word Type: achievement vs. nonachievement) $\times$ 2 (Achievement Context: standard vs. de-emphasized) mixed model design, with Valence and Color as within-subjects factors and Word Type and Achievement Context as between-subjects factors. It consisted of 96 trials divided into two blocks. Within block, each valenced word was presented three times (once in each color). Participants in the achievement word type condition categorized the words as failure related or success related; those in the nonachievement word type condition categorized the words as negative or positive. Participants in the standard achievement context condition were given the same instructions provided in Experiment 1; those in the de-emphasized achievement context condition were informed that the task was simple and was just a preliminary activity to select words for future experiments. All other procedures were the same as Experiment 1. Inaccurate (3.1%) and untimely (1.1%) responses were omitted. Twenty-four practice trials preceded the experiment.

Results and Discussion

Label Position and Achievement Context had no main or interactive effects, so they were not considered further. There were no main effects of sex, nor did sex moderate any of the theoretically central interactions, so sex was not considered further. A 2 (Valence) $\times$ 3 (Color) $\times$ 2 (Word Type) mixed model ANOVA on reaction times revealed a significant main effect of Valence, but not Color or Word Type, and a significant Valence $\times$ Word Type interaction. More importantly, a significant Valence $\times$ Color interaction, $F(2, 70) = 32.92$, $p < .01$, $\eta_p^2 = .32$, indicated that participants were faster categorizing negative words presented in red ($M = 622.36$ ms, $SD = 121.11$) versus green ($M = 670.37$ ms, $SD = 132.11$), $t(71) = -5.50$, $p < .01$, or white ($M = 662.21$ ms, $SD = 120.15$), $t(71) = -5.50$, $p < .01$. Latencies for negative words presented in green and white did not differ ($t < 1.01$). Participants were faster categorizing positive words presented in green ($M = 599.99$ ms, $SD = 104.69$) versus red ($M = 639.09$ ms, $SD = 123.73$), $t(71) = 4.78$, $p < .01$, but not green versus white ($M = 608.55$ ms, $SD = 97.99$; $t < 1.22$). Participants were slower categorizing positive words presented in red versus white $t(71) = 3.83$, $p < .01$.

Furthermore, the Valence $\times$ Color interaction was moderated by Word Type, $F(2, 69) = 3.20$, $p < .05$, $\eta_p^2 = .04$ (see Figure 2).

For achievement words, participants were faster categorizing failure words presented in red ($M = 604.70$ ms, $SD = 117.43$) versus green ($M = 656.75$ ms, $SD = 139.26$), $t(36) = -3.86$, $p < .05$, or white ($M = 640.09$ ms, $SD = 113.09$), $t(36) = -3.67$, $p < .01$. Latencies for failure words presented in green and white did not differ ($t < 1.82$). Participants were faster categorizing success words presented in green ($M = 582.30$ ms, $SD = 95.47$) versus red ($M = 639.33$ ms, $SD = 127.57$), $t(36) = 5.17$, $p < .01$, or white ($M = 608.28$ ms, $SD = 109.96$), $t(36) = -2.72$, $p < .01$, and participants were slower categorizing success words presented in red versus white, $t(36) = 2.99$, $p < .01$.

For nonachievement words, participants were faster categorizing general negative words presented in red ($M = 641.02$ ms, $SD = 125.85$) versus green ($M = 684.78$ ms, $SD = 124.48$), $t(34) = -3.94$, $p < .01$, or white ($M = 685.60$ ms, $SD = 124.52$), $t(34) = -4.07$, $p < .01$. Latencies for general negative words presented in green and white did not differ ($t < 1$). Reaction times for general positive words presented in green ($M = 618.68$ ms,

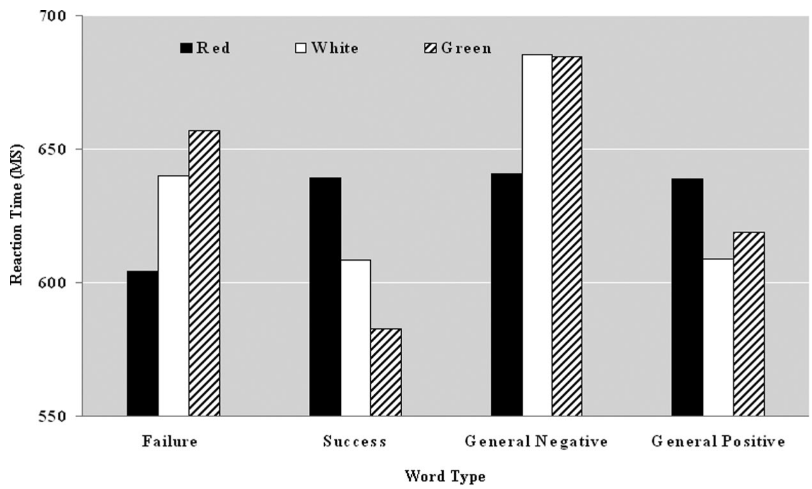

Figure 2. Mean response latencies for failure, success, general negative, and general positive words presented in red, white, and green. See online supplementary material for color version of Figure 2.

SD = 111.96) and red (*M* = 638.84 ms, *SD* = 121.40; t < 1.77), and green and white (*M* = 608.84 ms, *SD* = 85.15; $t < 1.04$), did not differ, but participants were slower categorizing general positive words presented in red versus white, $t(34) = 2.43$, $p < .05$.

These results perfectly replicate those from Experiment 1 and pinpoint the directionality of the associations: Red is positively associated with failure and negatively associated with success, whereas green is only positively associated with success. The results also document the generality of the associations: The red associations extend to valence in general, but the green associations do not. These patterns were observed whether achievement was deemphasized or not, suggesting that word content is sufficient to produce the effects.

General Discussion

Our experiments yielded strong evidence for the presence of hue-meaning associations. Importantly, these associations were documented via reaction time behavior rather than self-report, using chromatic stimuli equated on nonfocal color parameters.

The observed associations were particularly strong for red, in two ways. First, red was both positively related to failure and negatively related to success. Reciprocal relations (i.e., those involving both valences simultaneously) are usually the product of primitive evaluative processes that prepare immediate responses to hostile/hospitable stimuli (Cacioppo, Gardner, & Berntson, 1997). As such, the present results add to the emerging idea that red serves a basic signal function in achievement contexts, warning the perceiver of imminent danger requiring the mobilization of resources for action (Elliot, Maier, Binser, Friedman, & Pekrun, 2009).[2] Second, these reciprocal relations were observed for red with both general words and achievement words. This is quite provocative, because it raises the possibility that the default (i.e., initial) evaluative response to red is negative. More research is needed, however, before definitive conclusions on this matter are warranted. Our results may reflect, at least in part, the subtlety with which achievement cues may be activated in experimental environments or even the chronic accessibility of achievement content for undergraduates or North Americans. Success and failure are broadly applicable (Elliot & McGregor, 2001), highly accessible (Stapel & Blanton, 2004) concepts, and to the extent that they are salient, they may taint the way that purportedly neutral words are processed. Thus, it seems prudent to continue to entertain the possibility that the red-negative association is achievement-specific, while also acknowledging the diversity and ubiquity of achievement concerns in daily life.

In contrast to the extensive associations documented for red, a single association was observed for green (it was positively related to success). The red-meaning links are presumed to be grounded in multiple sources, including context-specific conditioning, general conditioning, and perhaps even biologically based predispositions, whereas the lone green-meaning link perhaps emerges from a culturally constrained pairing of U.S. currency and financial success. Future research should not only focus on the cultural specificity-generality of these links, but also on whether these links vary within culture as a function of temporarily accessible pairings (e.g., the red-terrorism threat pairing currently prominent in the United States). It might also be helpful to compare and contrast findings obtained with behavioral and self-report assessment techniques.

In our experiments, participants made categorizations on the basis of valence (the focal stimulus feature), not hue (the irrelevant stimulus feature), yet hue produced effects. This not only suggests that hue was processed in obligatory fashion, but also that the meaning linked to hue was activated implicitly. Although this represents impressive evidence for the automaticity of the ob-

[2] Recent research in the sport domain has shown that individuals wearing red are perceived more positively (Greenlees, Leyland, Thelwell, & Filby, 2008) and are more likely to win competitive contests (Hill & Barton, 2005). Our interpretation of these findings is that perceiving red on an opponent is construed as a threat, activates avoidance motivation, and leads one to be more impressed with the opponent and to perform less competently against him/her (see Elliot et al., 2007; Maier, Elliot, & Lichtenfeld, 2008).

served associations (Meier et al., 2004), more impressive still would be documentation of these associations using nonconscious priming procedures (Schmidt, 2000).

Our findings would appear to have important implications for the use of color in achievement situations and beyond. For example, teachers interested in instilling a mastery focus in their students may want to reconsider the use of red to mark students' mistakes, and the use of red in IQ tests such as Raven's Colored Progressive Matrices may be questioned, as it may impact some (e.g., test-anxious) individuals more than others. In experimental paradigms, red and green are sometimes used as cues for potential losses or gains, respectively, and red and green are used as stimuli in Stroop(-like) tasks. Given that these hues carry subtle, psychologically relevant meaning, they likely represent confounding variables or, at minimum, produce extraneous variance in such paradigms. In light of the ubiquity of both achievement situations and hue-laden stimuli in daily life, the aforementioned implications likely represent the metaphorical tip of the iceberg. We should acknowledge, however, that the degree to which our findings generalize to everyday life, in which a variety of shades and combinations of hues are encountered in stimulus-rich environments, remains an open question.

The present research draws an integrative connection between social cognition and color, and fits nicely with recent inquiries extending priming effects beyond lexical stimuli (Aarts & Dijksterhuis, 2003; Ferguson & Hassin, 2007; Holland, Hendricks, & Aarts, 2004). Hue is a nonlexical stimulus that can communicate information quickly, subtly, and across barriers of language, age, and even species. Accordingly, we think that hue (and color more generally) is a dramatically understudied stimulus property in the psychological sciences.

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