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FlashReport

# The semantic red effect: Processing the word red undermines intellectual performance

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ABSTRACT

Recent research has shown that a two second glimpse of color can have an important influence on affect, cognition, and behavior. The present research examined whether perceiving color is necessary to produce an effect on psychological functioning or whether the mere act of processing a color word might be sufficient. Specifically, four experiments tested the hypothesis that processing the word red undermines intellectual performance, much like actually perceiving the color red. Supportive data were obtained with three different types of subtle manipulation, with three different types of control words, and on two different types of IQ test performance. Worry, but not mood or general arousal, was shown to mediate the semantic red effect, which appears to take place outside of individuals' awareness. The theoretical and practical implications of the results are discussed.

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Recent research has demonstrated that perceiving color stimuli can have an important influence on psychological functioning. Indeed, even a two second glimpse of color has been shown to influence affect, cognition, and behavior (Elliot, Maier, Binser, Friedman, & Pekrun, 2009; Elliot, Maier, Moller, Friedman, & Meinhardt, 2007; Maier, Elliot, & Lichtenfeld, 2008). These findings are provocative, and naturally lead to an equally provocative question: is perceiving color necessary to produce an effect on psychological functioning or might the mere act of processing a color word be sufficient?

Several lines of empirical work suggest a close connection between processing color words and actually perceiving color. Research on the Stroop effect clearly indicates that color words and colors themselves share a common representational format (De Houwer, 2003: Schmidt & Cheesman, 2005). Research on color associations has found that the associations generated by color words share considerable overlap with those generated by color samples (Hupka, Zaleski, Otto, Reidl, & Tarabrina, 1997; Pecjak, 1970). Two recent neurophysiological investigations have found that processing color words activates the same brain regions that are activated when color is actually perceived (Moscoso del Prado Martín, Hauk, & Pulvermüller, 2006; Simmons, Ramjee, Beauchamp, McRae, Martin, & Barsalou, 2007). These data indicating shared representation, association, and activation for color word processing and color perception, suggest that processing color words, in and of itself, can influence psychological functioning. However, such an influence has yet to be documented.

Elliot et al. (2007) recently proposed that the perception of red signals the danger of failure in achievement situations based on learned associations (e.g., teachers' use of red to mark mistakes, red on alarms) and perhaps even our biological heritage (e.g., in many primates, red signals an opponent's dominance; Setchell & Wickings, 2005). This danger signal is presumed to prompt avoidance motivational processes (e.g., self-protection, worry) known to undermine performance on challenging intellectual tasks. Supportive evidence has now been obtained for each aspect of this proposal: perceiving red undermines intellectual performance (Elliot et al., 2007), perceiving red activates thoughts about failure and prompts avoidance motivational processes in achievement settings (Elliot et al., 2009; Metha & Zhu, 2009; Moller, Elliot, & Maier, submitted for publication), and avoidance processes mediate the red effect (Maier et al., 2008).

Like the color red, the word red often carries the meaning of danger or negative event, both in general (e.g., "code red", "red flag") and with regard to achievement-relevant outcomes (e.g., "in the red", "red herring"). This linguistic connotation of red, coupled with the aforementioned findings suggesting a close link between processing color words and perceiving color, lead us to expect that the word red alone is sufficient to undermine performance on challenging intellectual tasks. We examined this semantic red hypothesis herein with four experiments focused on IQ test performance. We put the hypothesis to increasingly stringent test by using word manipulations of an increasingly subtle nature in our sequence of experiments.

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## Experiment 1

Experiment 1 examined the effect of the word red, compared to a neutral word with the same letters, on IQ test performance.

### Method

Forty-nine (16 female) participants (15–19 years old) were randomly assigned to a red or neutral condition, instantiated using the words "ROT" (red) or "ORT" (place), respectively. Analogy IQ test performance was the dependent variable. In this and all subsequent experiments, participants were German high school student volunteers run in small groups by an experimenter blind to condition and hypotheses.

Participants were informed that they would take an IQ test and were given a description of the test (the 20-item analogy subtest of the Intelligence Structure Test [IST]; Amthauer, Brocke, Liepmann, & Beauducel, 1999). For each item, a word pair is provided, along with the first word of a second pair (e.g., Dark:Bright = -Wet:_____); five response options are given, one of which best completes the pairing (Rain, Day, Damp, Wind, Dry; solution: Dry).

Following the test description, participants completed two sample items. Then, they were asked to read the directions on the following page. Participants were informed that they would be randomly assigned to one of two groups to facilitate data entry, the "red group" or the "place group". Participants were then given 5 min to complete the test. Next, they completed demographics items and a funnel debriefing that probed for awareness (e.g., "What do you think we were trying to test?").

### Results

In this and all subsequent experiments, initial analyses included the main and interactive effects of sex (men = −1, women = 1); significant or marginally significant sex effects were retained in the final analyses. An ANOVA revealed a significant effect of experimental condition on performance, $F(1, 47) = 3.91$, $P \leqslant 0.05$, $\eta_p^2 = 0.08$; participants in the red group performed worse ($M = 11.91$, $SD = 2.33$) than those in the neutral group ($M = 13.42$, $SD = 2.93$). No participant correctly guessed the purpose of the experiment.

## Experiment 2

Experiment 2 sought to replicate the semantic red effect using a different, more subtle manipulation. In addition, the word in the control condition was changed to another color, gray.

### Method

Forty-four female participants (16–19 years old) from an all girls school were randomly assigned to a red or gray condition. Analogy IQ test performance was the dependent variable. The procedure was the same as that of Experiment 1, with two exceptions. First, the manipulation was instantiated with two different color words, red and gray, rather than a color word and a word composed of the same letters. Second, the manipulation was instantiated by varying the second sample item on the analogy test. For this sample item, a word pair was provided, along with the first word of a second pair: Animal:Hound = Plant:_____. Five response options were given; in the red condition, they were Branch, Red-Alder, Root, Tree, and Organism, whereas in the gray condition Gray-Alder replaced Red-Alder (solution: Red-/Gray-Alder).

### Results

An ANOVA revealed a significant effect of experimental condition on performance, $F(1, 42) = 5.95$, $P < 0.05$, $\eta_p^2 = 0.12$; participants in the red condition performed worse ($M = 11.13$, $SD = 2.65$) than those in the gray condition ($M = 13.24$, $SD = 3.08$). No participant correctly guessed the purpose of the experiment.

## Experiment 3

Experiment 3 sought to replicate the semantic red effect using another, even more subtle manipulation. In addition, the dependent measure was changed to numeric IQ test performance.

### Method

Forty (26 female) participants (15–18 years old) were randomly assigned to a red or gray condition. Numeric IQ test performance was the dependent variable.

Participants were informed that they would take an IQ test and were given a description of the test (the 20-item numeric subtest of the IST). For each item, a sequence of numbers is listed with a final number unspecified (sample item: 18, 16, 19, 15, 20, 14, 21, ?); the task is to determine the number that completes the sequence (solution: 13).

The manipulation was instantiated by slightly altering the copyright label in the bottom right corner of the three introductory pages of the test. Page one contained assurance that the results would be confidential, page two provided sample items, and page three instructed participants to wait for the signal to begin the test. In the red condition, the copyright label was written as "© by Hogrefe Series of Tests Red, 1978" in 10 point Arial font, whereas in the gray condition, Gray replaced Red. Participants were then given seven minutes to complete the test. Then, they completed demographics items and a funnel debriefing.

### Results

An ANOVA revealed a significant effect of experimental condition on performance, $F(1, 38) = 4.14$, $P < 0.05$, $\eta_p^2 = 0.10$; participants in the red condition performed worse ($M = 9.26$, $SD = 3.30$) than those in the gray condition ($M = 11.72$, $SD = 4.33$). No participant correctly guessed the purpose of the experiment.

## Experiment 4

Experiment 4 sought to replicate the semantic red effect using a chromatic color, green, as the control word. In addition, the aim of Experiment 4 was to examine whether the negative influence of semantic red on intellectual performance is mediated by avoidance motivation.

Worry, an avoidance motivational process shown to mediate performance effects in other research (e.g., a stereotype threat effect, Brodish & Devine, 2009; an avoidance goal effect, Elliot & McGregor, 1999), was used as the focal mediator variable. Alternative mediator candidates, mood and general arousal, were also examined.

### Method

Twenty (6 female) participants (17–19 years old) were randomly assigned to a red or green condition. Numeric IQ test performance was the dependent variable.

The procedure was the same as that of Experiment 3 with two exceptions. First, the chromatic color green was used as the control word, rather than the achromatic color gray. Second, immediately after completing the IQ test, participants completed worry, mood, and general arousal measures with regard to their experience during the test. Morris, Davis, and Hutchings (1981) 5-item scale was

used to assess worry (e.g., "I felt that I may not do as well on this test as I could"; 1 = does not describe my condition to 7 = describes my condition very well). Seibt and Foerster's (2004) 1-item mood measure was used to assess mood ("How did you feel?"; 1 = very bad to 7 = very good). Thayer's (1986) 5-item scale was used to assess general arousal (e.g., "How energetic did you feel?"; 1 = not at all to 5 = very).

*Results*

Multiple regression was used to analyze the data, because the mediator candidates represented continuous variables. Three regression analyses were conducted to test for mediation (see Baron & Kenny, 1986 for the steps required to document mediation).

First, regressing numeric IQ test performance on color (red = +1, green = −1) revealed a significant effect of color, $F(1, 17) = 10.32$, $p < 0.01$, $\eta_p^2 = 0.38$ ($\beta = -0.62$); participants in the red condition performed worse ($M = 10.20$, $SD = 3.58$) than those in the green condition ($M = 14.70$, $SD = 4.30$). Sex was also a marginally significant predictor of performance, $F(1, 17) = 4.16$, $p < 0.10$, $\eta_p^2 = 0.20$ ($\beta = -0.40$), indicating that males performed better than females.

Second, regressing worry on color revealed a significant effect of color, $F(1, 18) = 5.50$, $p < 0.05$, $\eta_p^2 = 0.23$ ($\beta = 0.48$); participants in the red condition worried more ($M = 2.88$, $SD = 0.98$) than those in the green condition ($M = 1.89$, $SD = 0.71$).

Third, repeating the first regression with worry included in the equation revealed a significant influence of worry on performance, $F(1, 16) = 8.21$, $p \leqslant 0.01$, $\eta_p^2 = 0.34$ ($\beta = -0.52$); participants who worried more performed worse on the test. Sex was also a significant predictor of performance, $F(1, 16) = 8.84$, $p < 0.01$, $\eta_p^2 = 0.36$ ($\beta = -0.49$); males performed better than females. Including worry in the equation reduced the β for the direct effect of color on performance from −0.62 to −0.40 ($p < 0.05$), a 58.4% decrease in variance accounted for (see Fig. 1). MacKinnon, Fritz, Williams, and Lockwood's (2007) bootstrapping procedure further validated the mediational role of worry, demonstrating that the 95% confidence interval for the indirect effect did not include zero (lower limit = −2.497, upper limit = −0.142).

Regressing mood and general arousal on color yielded null results ($Fs < 0.82$, $ps > 0.37$). Furthermore, all of the significant results reported above remained significant when the analyses were repeated with mood or general arousal in the equation. No participant correctly guessed the purpose of the experiment.

## Discussion

Our research clearly documents the semantic red effect: processing the word red undermined intellectual performance in four experiments. This effect was found with three different types of subtle manipulation, with three different types of control words, and on two different types of IQ test performance. Worry, but not mood or general arousal, was shown to mediate the effect.

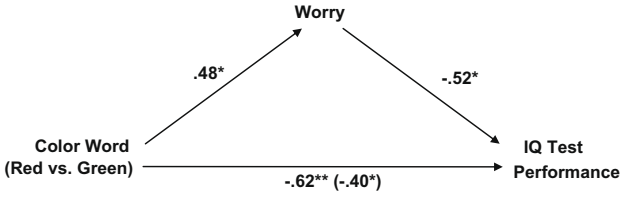


**Fig. 1.** The effect of color on IQ test (numeric subtest) performance mediated by worry in Experiment 4. The values in the figure represent standardized regression coefficients from the regression analyses; the value in parentheses is from the analysis with worry in the equation. $^{*}p < 0.05$; $^{**}p < 0.01$.

This research contributes to the psychological literature by extending the red effect (Elliot et al., 2007) beyond actual color to lexical representations of color. More generally, our work demonstrates, for the first time, that processing color words and perceiving color can influence psychological functioning in the same manner. Indeed, our work indicates that color words can have important effects even when presented in subtle fashion as peripheral, rather than central, stimuli. An additional noteworthy aspect of our research is that it draws on several areas of the psychological literature – color, cognition, motivation, intelligence – that are commonly studied in isolation.

Our findings are consistent with grounded theories of cognition (e.g., Barsalou, 1999) that portray conceptual knowledge as deeply intertwined with the perception, action, and introception systems of the brain. From this perspective, processing the word red not only activated the concept red, but may also have activated a multimodal representation of red that included the perceptual, affective, and motivational states commonly experienced in the presence of red. Simmons et al.'s (2007) finding that color word processing and color perception activate the same brain region certainly lends support to this interpretation. However, an account based in more traditional amodal theories of cognition (e.g., Smith, 1978), whereby red activated the concept failure and spread to its affective and motivational associates, cannot be ruled out by our experiments.

One impediment to progress in research on color psychology is that it is difficult to control for the lightness and chroma properties of color when examining hue effects, but failure to do so renders results uninterpretable (Valdez & Mehrabian, 1994). Our findings indicating that color words can produce the same processes and outcomes as actual color stimuli suggest a way to bypass this problem. However, we hasten to add that color words alone may not be sufficiently powerful in all instances. For example, it seems unlikely that a mere lexical description of a woman in red would evoke the same degree of sexual desire in males that an actual picture of a women in red has been shown to evoke (Elliot & Niesta, 2008). In addition, color words may evoke prototypic exemplars of colors that vary in lightness and chroma, as well as hue, and different people undoubtedly generate somewhat different color representations, leading to unsystematic variation that reduces the (statistical) power of the manipulation. Thus, color word manipulations hold promise as an efficient alternative in some instances, but should not be construed as an all-purpose panacea.

The semantic red effect appears to take place outside of individuals' awareness, in that not a single participant in our experiments was able to guess the purpose of the research. As such, the effect seems to be as subtle as it is provocative.

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