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Mediation of the Negative Effect of Red on Intellectual Performance

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This research examines the hypothesis that an attentional process grounded in avoidance motivation—local relative to global processing—mediates the negative effect of red on intellectual performance. This hypothesis was tested in a series of experiments using two approaches to documenting mediation. Experiment 1 established that the perception of red undermines IQ test performance. Experiments 2a and 2b documented mediation via the experimental causal chain approach, and Experiment 3 documented mediation via the measurement of mediation approach. This represents the first demonstration of a mediational process in the domain of color psychology. A call is made to broaden priming research to include color stimuli.

Keywords: *red; avoidance; focus of attention; performance; mediation*

Research on priming has clearly demonstrated that the perception of subtle, even subliminal cues can have an important impact on motivated behavior (Bargh, 1997; Dijksterhuis, Chartrand, & Aarts, 2007; Moskowitz, Li, & Kirk, 2004). A substantial number of studies have now shown that lexical (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001), contextual (Aarts & Dijksterhuis, 2003), and relational (Shah, 2003) stimuli can activate motivation and guide behavior in implicit fashion.¹ Furthermore, research on “grounded cognition” (see Barsalou, 2008) has shown that perception of a stimulus activates memory traces that mentally simulate actions associated with the stimulus and that these simulations prepare thoughts, feelings, and

behaviors related to the stimulus. Thus, the mere perception of a stimulus can have a subtle influence on approach and avoidance-related affect, cognition, and behavior (see Markman & Brendl, 2005; Neumann, Förster, & Strack, 2003). However, there has been a dearth of attention to the critical issue of the mediational mechanisms responsible for such perception–action links (Aarts, Custers, & Holland, 2007; Bargh, 2006). In the present research, we examine color as a priming stimulus that can have subtle affects on motivation and behavior. We focus on avoidance motivation and explicitly attend to mediation.

In recent work, Elliot, Maier, Moller, Friedman, and Meinhardt (2007) demonstrated that the perception of red in an achievement situation can undermine performance and prompt psychological functioning (e.g., self-protective task choice) associated with avoidance motivation.² In the present research, we seek to extend these provocative findings by examining avoidance motivation as a mediator of the negative effect of red on

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performance attainment. Specifically, in a series of experiments we seek to demonstrate that the brief perception of red in achievement settings evokes an attentional process grounded in avoidance motivation—local relative to global processing—and that this in turn has a negative influence on intellectual performance and accounts for the link between red and performance attainment.

Color and Psychological Functioning

Despite the ubiquity with which color stimuli are encountered in daily life, relatively little conceptual or empirical work has been done on color psychology (Fehrman & Fehrman, 2004; Whitfield & Wiltshire, 1990). To address this lacuna, Elliot et al. (2007) recently proffered a general model of the influence of color on psychological functioning. The three core premises of this model may be stated in brief.

The first premise is that color can carry specific meaning and convey specific information. Color meanings are grounded in two basic sources: One is learned associations that develop from repeated pairings of color and particular messages, concepts, or experiences, and the other is the biologically based signal function of color that is part of our evolutionary heritage. The second premise is that the perception of color can implicitly evoke motivational processes that produce behavior. Color stimuli that carry a positive meaning evoke approach motivation and produce appetitive behavior, whereas color stimuli that carry a negative meaning evoke avoidance motivation and produce aversive behavior. The third premise is that color meanings are contextual. Color carries different meanings in different contexts (e.g., achievement contexts, relational contexts), therefore, color has different implications for motivation and behavior in different contexts.

Red, Avoidance Motivation, and Performance

In achievement situations, success and failure are at stake, and individuals can be motivated to approach success or avoid failure. We posit that in such situations, red is linked to the psychological danger of failure (Elliot et al., 2007). In many cultures, teachers use red to mark students' mistakes and errors, and over time this repeated pairing is presumed to create a learned association between red and failure. This specific pairing is likely bolstered by the more general use of red to signal danger in other contexts in which negative outcomes are salient (e.g., traffic lights, warning signals). These specific and general learned associations may themselves be bolstered by or even derived from an evolutionarily ingrained predisposition to interpret red as a signal of danger in competitive contexts where negative outcomes are salient (e.g., in several species of ape, red

signals the dominance or attack readiness of an opponent; Pryke, Andersson, Lawes, & Piper, 2001; Setchell & Wickings, 2005).

Given the link between red and failure or danger in achievement contexts, red is posited to implicitly evoke avoidance-based processes in such contexts. This follows directly from the literature on evaluative processes that clearly shows that avoidance processes are activated implicitly when encountering a negative object, event, or possibility (Bargh & Chartrand, 1999; Cacioppo, Gardner, & Berntson, 1997).

Once activated, avoidance-based processes are presumed to undermine performance attainment. A great deal of research has documented that avoidance processes (e.g., anxiety, effort withdrawal) have a negative influence on performance (Elliot & McGregor, 1999; Hembree, 1988). Nearly all of this research has examined the impact of self-reported avoidance processes; what is less clear is whether implicit avoidance processes also influence performance. A few studies have shown that avoidance motivation (specifically, fear of failure and evaluation anxiety) has an inimical influence on performance (Birney, Burdick, & Teevan, 1969; Bosson, Haymovitz, & Pinel, 2004; Egloff & Schmukle, 2002), but with one exception (discussed in the following paragraph) this research has focused on dispositions rather than on psychological processes.

Considered together, the aforementioned propositions raise the possibility that implicit processes grounded in avoidance motivation may account for (i.e., mediate) the inimical influence of the perception of red on performance attainment. This possibility has received no empirical attention, and to the best of our knowledge, only a single study has examined the more general question of whether an implicit avoidance-based process can mediate a negative performance effect. Bosson et al. (2004) showed that stereotype-threatened gay males exhibited more nonverbal anxiety while interacting with preschool children in a child care context and that this anxiety mediated the negative effect of stereotype threat on child care performance. By the authors' own admission, however, anxiety and performance were confounded in this study because both variables were coded from the same set of videotaped behavior.

Local Processing as a Mediator Variable

Over the years, several theorists have contended that motivational systems and states have important implications for perceptual and attentional processes (Derryberry & Tucker, 1994; Easterbrook, 1959; Eysenck & Eysenck, 1985; Gray, 1999; Lang, Bradley, & Cuthbert, 1997). Most relevant to the present research, Derryberry and Tucker (1994) have proposed that avoidance

motivational states constrict the scope of attention. That is, when aversively motivated, individuals are posited to focus on more concrete, detailed aspects of the environment and to attend to a narrower, more constrained set of mental constructs. Several lines of research have provided support for this proposal (Derryberry & Reed, 1998; Förster, Friedman, Özsel, & Denzler, 2006; Mikulincer, Kedem, & Paz, 1990).

In the present research, the mediator variable of central interest was attentional focus, as assessed by a visual matching task that differentiates local from global information processing. Empirical work has demonstrated that variation in the scope of visual attention can take place independently of visual awareness, indicating that local–global discriminations can reflect basic, implicit attentional processes (Koivisto & Revonsuo, 2004; Koivisto, Revonsuo, & Lehtonen, 2006). Therefore, we used local relative to global processing as our implicit indicator of avoidance motivation. We predicted that the perception of red, relative to gray, in an achievement context would lead to more local processing but would not lead to greater self-reported test anxiety or negative mood.

Local processing represents an avoidance-based narrowing of attention that is accompanied by rigid, inflexible cognition (Derryberry & Reed, 1998; Mikulincer et al., 1990). This constrained form of processing is ill suited for many achievement activities such as IQ tests that require flexible access to a broad range of information and fluid and efficient mental operations (Geen, 1980; Spielberger & Vagg, 1995). As such, local processing is predicted to undermine performance attainment. Furthermore, local processing is presumed to be the reason that the perception of red impairs performance. That is, the inimical effect of red is not viewed as an ideomotor phenomenon driven by the direct activation of behavioral representations (Dijksterhuis, 2001; Wheeler & Petty, 2001). Rather, it is viewed as a motivational phenomenon in which the perception of red activates an avoidance-based process, which in turn impairs intellectual performance.

Documenting Mediation and the Present Research

The aim of the present research was to examine whether the negative influence of the perception of red on intellectual performance is mediated by avoidance motivation as indicated by local relative to global processing. In a recent conceptual analysis of mediation, Spencer, Zanna, and Fong (2005) proposed that there are several different ways in which mediation may be documented. Each of the available approaches has strengths and limitations, and in the present research we used two approaches that complement each other in this regard.

Specifically, in the experiments presented here, we used both the measurement-of-mediation approach (for details, see Baron and Kenny, 1986) and the experimental-causal-chain approach (for details, see Spencer et al., 2005) to documenting mediation. The measurement-of-mediation approach has the strength of testing the full mediational model within a single study but is limited in that it is inherently correlational in nature (and, furthermore, measurement of the mediator variable can interfere with the hypothesized effect or even produce an effect that would not otherwise exist). The experimental-causal-chain approach has the strength of testing all aspects of the mediational model using experimental manipulation but is limited in that it can only test the model in piecemeal fashion.

In a first experiment, we sought to establish what both approaches to mediation consider a necessary precondition for an examination of mediation—the presence of an independent variable effect on the dependent variable (Baron & Kenny, 1986; cf. Shrout & Bolger, 2002). Specifically, we tested whether perception of red undermines intellectual performance. In the next two experiments, we sought to establish mediation via the experimental-causal-chain approach. Specifically, in Experiment 2a we tested whether the perception of red leads to greater local processing, and in Experiment 2b we tested whether local processing undermines intellectual performance. In the final experiment, we sought to establish mediation using the measurement-of-mediation approach. Specifically, we tested whether the perception of red leads to greater local processing, which in turn is a negative predictor of intellectual performance, and whether this greater local processing accounts for the effect of red on intellectual performance.

EXPERIMENT 1

Experiment 1 focused on demonstrating a relation between the perception of red and intellectual performance. This finding was established in prior work (Elliot et al., 2007) that showed that red undermines intellectual performance relative to black, white, gray, and green. Here, we seek to document this relation again to set the stage for examination of the two different approaches to mediation in our subsequent experiments. In this and all subsequent experiments, we use gray as the achromatic, neutral contrast to red.

Method

Twenty (11 males, 9 females) German high school students participated in the experiment. Participation was restricted to individuals who were not red–green color blind. Participants were randomly assigned to one

of two between-subjects conditions: the red condition or the gray condition. Numeric IQ test performance was the dependent variable.

Participants were tested in a group in a high school classroom by an experimenter blind to participants' condition and the experimental hypotheses. On arrival for the experiment, participants were informed that they would take an IQ test and were given a verbal description of the test. The test was the 20-item numeric subtest of the Intelligence Structure Test (IST), a German IQ test (Amthauer, Brocke, Liepmann, & Beauducel, 1999). For each item, a sequence of numbers is listed with a final number unspecified (e.g., 18, 16, 19, 15, 20, 14, 21, ?); the task is to determine the number that completes the sequence (solution: 13). The challenge in this task—as in many IQ tests—is to find a mathematical rule that is represented in a sequence of several numbers and in combinations of sequences (the rule in the sample item above is: $-2, +3, -4, +5, -6, +7$). To find the correct solution the participant must attend to the full sequence of numbers and be able to flexibly engage in abstract mental operations.

Following the description of the test, participants completed two sample items. Then participants were given a white two-ring binder that contained the experimental manipulation and the test and were informed that they would receive feedback on their test performance.

The first page within the binder was the cover page of the test. The experimental conditions were instantiated by printing a colored rectangle on the cover page. For both conditions, "Items" was placed in black ink in 34-point font on a red or gray rectangle $5 \times 7\frac{1}{4}$ in. in the middle of the white page. The colors for 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 (Fairchild, 2005). The red, LCh(48.9, 52.2, 27.9), and gray, LCh(48.8, -, 106.5), colors were equated on lightness; chroma is not a relevant parameter because gray is an achromatic color (equated here means functionally equivalent, which in this and the subsequent experiments is defined as within one unit; see Stokes, Fairchild, & Berns, 1992). The red and gray hues were standard representations of each color.

The experimenter informed participants that the first page within the binder contained the word *Items*, and instructed them to open the binder to this page. The experimenter waited for 2 s and then told participants to turn the page and begin the test. After 7 min, the experimenter announced that time had expired.

Following the test, participants completed a brief demographics questionnaire, received a funnel debriefing that queried for awareness of the hypothesis, and were asked to name the color on the test cover. Participants

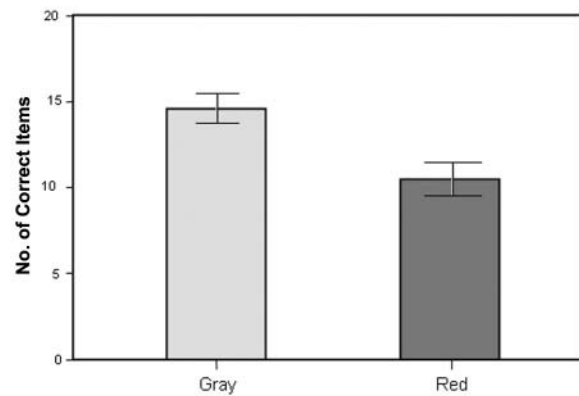


Figure 1 The effect of color on IQ test (numeric subtest) performance in Experiment 1.

NOTE: Mean and standard error of the number of correctly solved items by color on the cover of the test.

were then informed that they would receive feedback via e-mail and were dismissed.

Results and Discussion

A unifactorial (color condition: red vs. gray) between-subjects ANOVA on numeric performance revealed a significant effect of color, $F(1, 19) = 10.16, p < .01, \eta^2_p = .36$. As seen in Figure 1, participants in the red condition solved fewer items correctly than those in the gray condition. An additional analysis revealed neither a main effect nor an interactive effect of sex of participant on numeric performance ($F_s < 1$).

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, $\chi^2(1, N = 19) = 19.00, p < .001$, indicating that participants were cognizant of the color on the cover page of the test. In the funnel debriefing, however, only one participant guessed that the experiment focused on color, and this individual had no awareness of the specific hypothesis being tested (the results remain the same with this participant excluded).

In sum, the results from this experiment support our predictions. Participants who viewed red before an IQ test solved fewer items correctly than those who viewed gray. Participants were able to report the correct color on their test but were unaware of the purpose of the study. These results, together with those of Elliot et al. (2007), clearly demonstrate the effect in question and establish the need to attend to mediation.

EXPERIMENT 2A

Experiment 1 satisfied the first requirement for documenting mediation via the experimental-causal-chain

approach, and Experiment 2a focused on the second requirement by testing whether the perception of red, relative to gray, in an achievement context has an effect on our candidate mediator variable. Elliot et al. (2007) recently demonstrated that the perception of red in achievement settings can influence behavioral choice (lead to selection of easy relative to moderately difficult test items) and physiological activity (evoke right relative to left prefrontal cortical activity) associated with avoidance motivation. In the present experiment, we sought to extend these findings by linking red to a different indicator of avoidance motivation—local relative to global processing. Local processing was deemed an optimal mediator variable because it can be readily manipulated in testing the next part of the proposed mediational model in Experiment 2b. Local processing is thought to reflect an implicit process; indicators of explicit processes—namely, self-reported state test anxiety and self-reported mood—were also examined, with null results anticipated.

Method

Twenty-one (10 males, 11 females) German high school students participated in the experiment. Participation was restricted to individuals who were not red–green color blind. Participants were randomly assigned to one of two between-subjects conditions: the red condition or the gray condition. Local relative to global processing, self-reported state test anxiety, and self-reported mood were the dependent variables.

Participants were tested in a group in a high school classroom by an experimenter blind to participants' condition and the experimental hypotheses. The initial part of the procedure was identical to that of Experiment 1. Participants were informed that they would take an IQ test (the numeric subtest of the IST), were given a verbal description of the test, completed two sample items, were presented with a white binder containing the manipulation and (ostensibly) the test, and were told that they would receive feedback on their performance. The color manipulation was presented on the cover page of the test, as in Experiment 1; the LCh values were slightly different: red, LCh(49.2, 52.0, 27.5), and gray, LCh(49.0, –, 98.1). After participants viewed the cover page for 2 s, they turned the page to find a "filler task." They were told that this filler task and a few other questions were to be completed before the test would start.

The filler task was a 12-item visual matching task (see Kimchi & Palmer, 1982) that yielded the focal mediator variable. Each item on this task presents a target figure and two comparison figures, and the participant judges which comparison figure is most similar to the target figure. Each figure is composed of several elements, and the similarity judgment may be based on either the local

elements composing the figure or the global figure itself. For example, if the target is a triangle composed of square elements, selection of a square composed of squares represents local processing, whereas selection of a triangle composed of triangles represents global processing. The more constricted participants' attentional focus, the more their selections will exhibit local processing (Gasper, 2004). A local processing score was computed by assigning 1 for each local selection and 0 for each global selection and summing the total.

Following the visual matching task, participants completed a brief questionnaire containing the state form of Spielberger's (1978) 20-item State-Trait Anxiety Inventory (sample item: "I feel anxious"; 1 = *strongly disagree*, 7 = *strongly agree*; $\alpha = .90$; see Elliot & McGregor, 1999, on the correspondence between test anxiety and avoidance motivation) and Seibt and Förster's (2004) one-item mood measure ("How do you feel right now?" 1 = *very bad*, 9 = *very good*). When participants had completed the questionnaire, they were informed that they did not actually have to take the test. Participants then filled out a brief demographics questionnaire, received the same funnel debriefing used in Experiment 1, and were asked to name the color on the test cover.

Results and Discussion

A unifactorial (color condition: red vs. gray) between-subjects ANOVA on local processing revealed a significant effect of color, $F(1, 19) = 4.48, p < .05, \eta_p^2 = .19$. As seen in Figure 2, participants in the red condition made more local selections than those in the gray condition. Additional ANOVAs on state test anxiety and general mood yielded no significant color effects ($F_s < 1$). Additional analyses revealed neither a main effect nor an interactive effect of sex of participant on any outcome variable ($F_s < 1$).

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, $\chi^2(1, N = 20) = 20.00, p < .001$, indicating that participants were cognizant of the color on the cover page of the test. In the funnel debriefing, however, not a single participant guessed that the experiment focused on color.

In sum, the results from this experiment support our predictions. Participants who viewed red before an (ostensible) IQ test exhibited more local processing than those who viewed gray. The effect of red was only found on the implicit indicator of avoidance motivation; null results were obtained on self-reported state test anxiety and general mood. Participants were able to report the correct color on their test but were unaware of the purpose of the study. These results extend earlier findings on the link between red and avoidance motivation

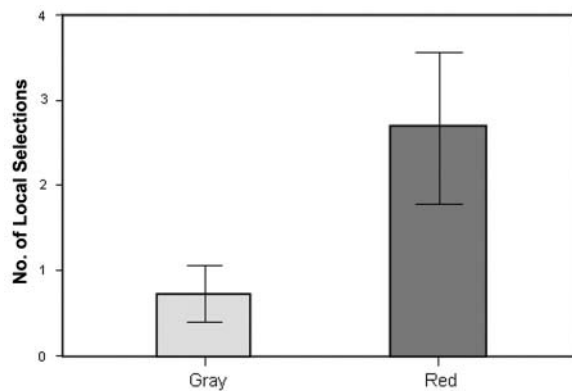


Figure 2 The effect of color on local processing in Experiment 2a. NOTE: Mean and standard error of the number of local selections by color on the cover of the test.

to the realm of attentional processing and satisfy the second requirement for documenting the proposed mediational model.

EXPERIMENT 2B

Experiment 2b focused on the third and final requirement for documenting mediation via the experimental-causal-chain approach. Experiment 1 demonstrated an effect of red on intellectual performance, Experiment 2a demonstrated a link between red and local processing, and in this experiment we sought to demonstrate a link between local processing and intellectual performance. It is important to note that the mediator variable we manipulated in this experiment maps directly onto the mediator variable we measured in Experiment 2a, and the outcome variable we used in this study is the same outcome variable we used in Experiment 1 to document the effect of red on performance (see Spencer et al., 2005, on the importance of attending to these issues in the experimental-causal-chain approach to mediation).

Method

Twenty-two (18 males, 4 female) German high school students participated in the experiment. Participants were randomly assigned to one of two between-subjects conditions: the local processing condition or the global processing condition. Numeric IQ test performance was the dependent variable.

Participants were tested in a group in a high school classroom by an experimenter blind to participants' condition and the experimental hypotheses. The initial part of the procedure was identical to that of Experiment 1. Participants were informed that they would take an IQ

test (the numeric subtest of the IST), were given a verbal description of the test, completed two sample items, and were told that they would receive feedback on their performance. The attentional focus manipulation was presented on additional pages that ostensibly preceded the test.

The attentional focus manipulation was based on the 12-item visual matching task that was used in Experiment 2a as the dependent variable. Each item on this task presents a target figure and two comparison figures; one comparison figure corresponds to the local details of the target figure, and the other comparison figure corresponds to the global details of the target figure. In the local processing condition, participants were instructed to select which of the two comparison figures corresponded to the local details of the target figure, and in the global processing condition participants were instructed to select which of the two comparison figures corresponded to the global details of the target figure. The instructions were written on a sheet of paper and were illustrated with a sample item. Following the attentional focus manipulation, participants completed the numeric IQ test, and after the test they completed a brief demographics questionnaire.

Results and Discussion

First we checked to make sure that participants followed the instructions in the attentional focus manipulation. Each of the selections made by participants indeed correctly corresponded to their attentional focus condition.

Next we tested our central prediction. A unifactorial (attentional focus condition: local vs. global) between-subjects ANOVA on numeric performance revealed a significant effect of attention condition, $F(1, 20) = 4.20$, $p < .05$, $\eta^2_p = .17$. As seen in Figure 3, participants in the local processing condition did worse than those in the global processing condition. An additional analysis revealed neither a main effect nor an interactive effect of sex of participant on numeric performance ($F_s < 1$).

In sum, the results from this experiment support our predictions. Participants with a local focus of attention performed worse on the IQ test than did those with a global focus of attention. This finding satisfies the third requirement for documenting the proposed mediational model, and together Experiments 1, 2a, and 2b provide clear evidence for mediation of the negative effect of red on performance using the experimental-causal-chain approach.

EXPERIMENT 3

Experiment 3 focused on documenting mediation using a different approach than that used in the prior experiments, namely, the measurement-of-mediation

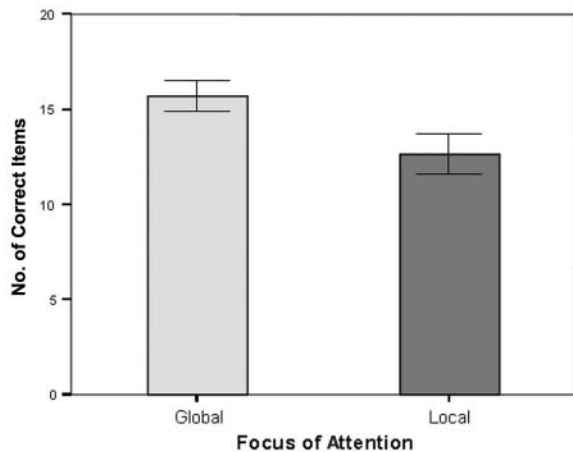


Figure 3 The effect of focus of attention on IQ test (numeric subtest) performance in Experiment 2b.

NOTE: Mean and standard error of the number of correctly solved items by local versus global focus of attention.

approach. In this approach, all three required steps for documenting mediation can be examined in a single experiment. We predicted that the perception of red would have a negative effect on performance, thereby replicating Experiment 1 (and satisfying the first requirement for mediation). We also predicted that the perception of red would lead to more local processing (satisfying the second requirement for mediation), which in turn would negatively predict IQ test performance and account for the relation between red and IQ test performance (satisfying the third requirement for mediation).

Method

Twenty-two (13 males, 9 female) German high school students participated in the experiment. Participation was restricted to individuals who were not red-green color blind. The design, measures, and procedure for the experiment were the same as those in Experiment 2a with two exceptions: Participants completed the visual matching task following the manipulation but did not complete the self-report measures, and participants were not stopped after the mediator variable assessment but actually completed the test. The LCh values used in the color manipulation were identical to those used in Experiment 2a.

Results and Discussion

Regression analysis was used to analyze the results because the focal mediator is a continuous variable. First, a regression analysis (color: *red* = -1, *gray* = +1) was

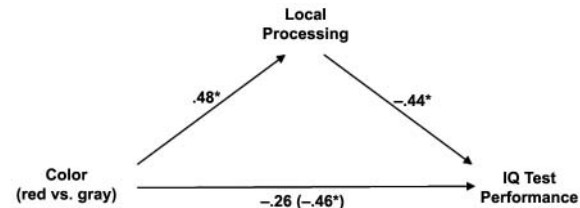


Figure 4 The effect of color on IQ test (numeric subtest) performance mediated by local processing in Experiment 3.

NOTE: The values in the figure represent standardized regression coefficients from the regression analyses; the value in parentheses is from the analysis of the effect without local processing in the equation. * $p < .05$.

conducted on numeric performance to examine whether an effect was present. The analysis revealed a significant effect of color, $F(1, 20) = 5.48$, $p < .05$, $\eta_p^2 = .22$ ($\beta = -.46$). Participants in the red condition solved fewer items correctly ($M = 9.91$, $SD = 3.21$) than did those in the gray condition ($M = 13.27$, $SD = 3.52$).

Second, a regression analysis was conducted on local processing to examine whether color had an effect on the mediator variable. The analysis revealed a significant effect of color, $F(1, 20) = 5.87$, $p < .05$, $\eta_p^2 = .23$ ($\beta = .48$). Participants in the red condition made more local selections ($M = 1.45$, $SD = 1.70$) than did those in the gray condition ($M = 0.18$, $SD = 0.41$).

Third, the first regression analysis was repeated with local processing included as an independent variable to examine whether local processing mediated the effect of color on performance. The analysis revealed a significant influence of local processing on performance, $F(1, 19) = 4.43$, $p < .05$, $\eta_p^2 = .19$ ($\beta = -.44$). Inclusion of local processing into the equation reduced the coefficient for the effect from $-.46$ to $-.26$ ($F < 1.51$, $p > .24$), a decrease of 43.5%. MacKinnon, Lockwood, Hoffman, West, and Sheets's (2002) z' test further validated the mediational role of local processing ($z' = 1.59$, $p < .01$; see Figure 4).

Additional analyses revealed neither a main effect nor an interactive effect of sex of participant on any of the outcome variables ($F_s < 1$).

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, $\chi^2(1, N = 22) = 18.33$, $p < .001$, indicating that participants were cognizant of the color on the cover page of the test. In the funnel debriefing, however, not a single participant guessed that the experiment focused on color.

In sum, the results from this experiment support our predictions. Participants who viewed red before an IQ test solved fewer items correctly than those who viewed

gray. In addition, those in the red condition evidenced more local processing than those in the gray condition, and this local processing in turn predicted worse performance. Local processing was shown to account for the effect of red on performance. Participants were able to report the correct color on their test but were unaware of the purpose of the study. This experiment provides clear evidence for mediation of the negative effect of red on performance using the measurement-of-mediation approach.

GENERAL DISCUSSION

The present research firmly establishes the inimical influence of red on intellectual performance and documents how this effect occurs. The perception of red evokes an avoidance-based constricting of attentional focus, which in turn undermines performance attainment. Our experiments provide evidence for mediation obtained with two very different empirical approaches: the experimental-causal-chain approach and the measurement-of-mediation approach (Spencer et al., 2005). To the best of our knowledge, these results represent the first demonstration of any form of mediation in the domain of color psychology. In addition, our research represents one of the first demonstrations of an avoidance-based mediational process in the now burgeoning literature on "auto-motivation" (Bargh, 1990, 1997; Ferguson, Hassin, & Bargh, 2007).

The use of two mediational approaches is a noteworthy strength of our research, but we hasten to add that we do not wish to hold up this dual documentation of mediation as a new empirical standard. In our research, we sought to emphatically document the proposed mediational process because it is both novel and highly provocative. An ancillary reason for using both approaches was to illustrate the utility of Spencer et al.'s (2005) analysis of mediation by showing that the same psychological process can be empirically validated in two very different ways. Nevertheless, we do not think that investigators as a general rule should be asked to use more than one approach when testing mediation. Rather, we concur with Spencer et al.'s conclusion: "Although using multiple methods to test a theoretical account would be ideal, we feel that in most situations requiring such multiple methods would be setting such a high standard that progress in the field might well be impeded" (p. 847).

In addition to highlighting this strength, we would like to note some potential limitations of our research. First, we used the same contrast color, gray, across our sequence of experiments, because each of the experiments was linked to the next as we attempted to document

mediation. Gray was equated with red on lightness, but as an achromatic color, it could not be equated with red on chroma. We do not consider this a major concern because prior work (Elliot et al., 2007) has shown that gray produces the same results on intellectual performance and avoidance motivation as those produced by a green that has been matched to red on chroma. Second, each of our experiments used German participants only, leaving open the question of generalization to individuals from other countries. This concern is mitigated by the fact that prior research (Elliot et al., 2007) has shown that red impairs performance and evokes avoidance motivation in U.S. participants, but extending the work to other countries, including non-Western cultures, would help address questions regarding generalizability. Third, recent research has demonstrated that approach-based desire, like avoidance-based fear, can lead to a narrowing of attentional focus (Gable & Harmon-Jones, 2008). This raises the question of whether our results are mediated by an appetitive, rather than an aversive, psychological process. We think that this is highly unlikely given that prior research has linked viewing red in achievement settings to other indicators of avoidance motivation, such as self-protective task choice and greater right relative to left prefrontal cortical activation (Elliot et al., 2007). Nevertheless, given the new work by Gable and Harmon-Jones (2008), it would be optimal in subsequent research to replicate the present findings using other indicators of avoidance motivation or related processes such as reduced cognitive flexibility or disrupted working memory due to task-irrelevant thoughts.

In our research, we have demonstrated that the perception of red in achievement contexts impairs performance, and an interesting question for future research is whether the perception of red impairs any and all types of performance. We think the answer is likely "no." Achievement tasks that require narrow, rigid processing (e.g., copyediting) may not be undermined and may even be facilitated by red and the avoidance-based processes that it evokes. Other, simple tasks that require minimal cognitive capacity or mental manipulation (e.g., strength tasks such as weightlifting) may be affected in like manner (Elliot & Conroy, 2005). The broad take-home message from our research is that red and its accompanying avoidance motivation may not be problematic for all tasks but is likely to impair any sort of performance that requires more than a modicum of cognitive capacity, mental manipulation, or flexible and efficient processing. The fact that most achievement tasks encountered in the classroom and the workplace entail such cognition and the fact that our research took place within real-world achievement contexts highlights the importance of our findings.

Another question worthy of consideration is whether the perception of red has avoidance-based effects in all contexts. Again, we think the answer is likely “no.” In relational contexts, red is commonly associated with love and romance and is often used to heighten interpersonal attraction (e.g., lipstick, rouge, lingerie) or indicate sexual readiness (e.g., red-light districts). In many nonhuman mammals, red is displayed by the female during estrus, presumably to attract mating partners (Barelli, Heistermann, Boesch, & Reichard, 2007; Dixson, 1983; Setchell, Wickings, & Knapp, 2006). As such, the perception of red may evoke approach motivation in relational contexts, with many positive consequences. Indeed, Elliot and Niesta (in press) recently conducted a series of experiments testing this hypothesis and found supportive evidence: Heterosexual men find the “lady in red” more attractive and sexually desirable. Thus, the influence of red on motivation and behavior is not invariant but is sensitive to context (see also Maier, Barchfeld, Elliot, & Pekrun, 2008).

At present, it is not known whether the red–avoidance link that we have documented in our research is grounded in associative learning, is biologically ingrained, or as we suspect, emerges from both sources. Cross-cultural research, developmental research, and primate research could all be helpful in revealing the precise origin of the meaning of red in achievement contexts. Such research could have implications beyond conceptual understanding. For example, if the red–avoidance link is based in specific associative processes alone, its eradication may be as simple as imploring teachers to be more judicious in their choice of pens or pencils to mark students’ mistakes. If, however, the red–avoidance link has a biological basis, the question of intervention becomes much more complex.

Our research shows that red can activate avoidance-based processes in a highly subtle fashion. Our color manipulation was presented briefly and was part of the ground (as opposed to the figure) of the focal stimulus. Querying (in the form of funnel debriefing) across Experiments 1, 2a, and 3 revealed that participants had no knowledge that color played a role in the experimental paradigm, and self-report measures of state test anxiety and mood were shown to be unrelated to the color manipulation. Furthermore, the mediator variable used in our research has been shown to reflect implicit processes (Andres & Fernandes, 2006; Koivisto & Revonsuo, 2004). Nevertheless, we acknowledge that we did not definitively demonstrate that the effects observed in our research were implicit in nature and that it remains possible that at least some explicit, deliberate processing was involved. Future work would do well to address this issue through the use of nonconscious priming procedures in

which color stimuli are presented below threshold (see Schmidt, 2000, 2002).

Research on color physics and color physiology is well developed, but research on color psychology has barely commenced. The minimal research that has been conducted has primarily been driven by applied concerns (e.g., what color do employees find most appealing in office settings?) and tends to be both atheoretical and less than methodologically rigorous (Fehrman & Fehrman, 2004; Valdez & Mehrabian, 1994; Whitfield & Wiltshire, 1990). Color is a pervasive stimulus in the everyday environment that likely exerts a powerful yet undetected influence on affect, cognition, and behavior. We believe that the time has come for the focus of priming research to be broadened beyond lexical, contextual, and relational stimuli to include color stimuli. This call fits nicely with the emerging theoretical and empirical work on grounded cognition, in which the perception of visual stimuli subtly prepares stimuli-relevant affect, cognition, and behavior (Barsalou, 2008; Barsalou, Niedenthal, Barbey, & Ruppert, 2003). For instance, a high vertical position is associated with and has been shown to activate positive affective valence (Meier & Robinson, 2004) and the concept of power (Schubert, 2005), and hand washing is associated with and has been shown to evoke moral emotions and behaviors (Zhong & Liljenquist, 2006). Color, in like fashion, may in some instances serve as a stimulus that is associated with and activates motivation and associated processes. In the present work, for example, red is a failure cue in achievement settings and appears to evoke failure-based cognitive processing. Color may be a particularly important stimulus to study, not only because it is so prevalent in the environment and is processed so quickly but also because color may represent something of a lingua franca—a common language capable of conveying information across the human life span and even across species.

NOTES

1. The term *implicit* is used here as defined by De Houwer and Moors (2007; see also De Houwer, 2006). From this perspective, a process measured by a task may be called implicit when the participant is not aware of the mechanism that is measured, and he or she does not realize that it is measured.

2. In addition to this work, other investigators have sought to examine links between color and performance; we are not aware of any past investigations of color and avoidance motivation. No consistent findings emerged from prior research on red and performance; most studies yielded null findings, although a few indicated worse (e.g., James & Domingos, 1953; Soldat, Sinclair, & Mark, 1997) or better (e.g., Hill & Barton, 2005) performance in red conditions. We believe that the likely reason for the lack of consistent findings is that the majority of the prior work was plagued by several weaknesses, including a failure to follow basic experimental procedures and confounds due to the unsystematic selection or presentation of color stimuli (see Elliot & Maier, 2007; Elliot et al., 2007).

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