
The Effect of Red on Avoidance Behavior in Achievement Contexts

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This research tests whether the perception of red in an achievement context evokes avoidance behavior without conscious awareness and also examines the context specificity of the hypothesized red effect. In Experiment 1, participants were briefly shown red or green on the cover of an analogies test that they would ostensibly take (a achievement context) or rate on likability of (a nonachievement context) in an adjacent lab. Those shown red, relative to those shown green, knocked fewer times on the door of the adjacent lab in the achievement context; no red-green difference in knocking was observed in the nonachievement context. In Experiment 2, participants were briefly shown red, green, or gray on the cover of an IQ test that they would ostensibly take. Those shown red moved their body away from the test cover to a greater degree than did those shown green or gray. This research contributes to incipient work on color psychology and to the more established literature on the automatic link between evaluation and behavior.

Keywords: *color; red; movement; avoidance; evaluation*

Each and every physical stimulus that individuals encounter in their daily life contains information about color. Nevertheless, psychologists have conducted little research on and know little about the influence that perceiving color has on motivation and behavior (Fehrman & Fehrman, 2004; Whitfield & Wiltshire, 1990). Color typically represents the ground rather than

the figure of the stimuli that individuals perceive, thus, any effect of color on psychological functioning is likely to take place in subtle fashion. In the present research, we conducted two experiments designed to test the overlooked issue of the influence of color on behavior. Specifically, we examined the hypothesis that a brief glimpse of the color red evokes physically enacted avoidance behavior and does so without conscious awareness. In addition, we examined the context specificity of the hypothesized red effect.

Color and Psychological Functioning

In response to the dearth of conceptual and empirical work on color psychology, Elliot, Maier, Moller, Friedman, and Meinhardt (2007) recently proposed a

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general model of color and psychological functioning. In the model, Elliot and colleagues contended that color can carry psychologically relevant meaning. Individuals are exposed to many different pairings of colors and specific messages, concepts, and experiences throughout their lifetime. With repeated exposure, these pairings produce strong color associations, such that the mere perception of a color in a particular situation can activate the paired associate. Some color meanings are undoubtedly based in learning alone, but others may be grounded, in part, in biologically based predispositions to interpret and respond to color stimuli in particular ways. Regardless of the origin of color meanings, when a color carries a specific meaning it is presumed to function as a subtle prime, exerting a direct influence on motivation and behavior without individuals' conscious awareness.

In addition to this general model, Elliot et al. (2007) offered a specific proposal regarding the color red in achievement contexts (i.e., situations in which competence is evaluated and both success and failure are possible). They posited that red carries the meaning of danger in achievement contexts, specifically, the psychological danger of failure. This red–danger link is presumed to be the product of several sources. One source is likely schoolteachers' use of red ink to mark mistakes and failures. This specific association is undoubtedly grounded in a broader societal association between red and danger in situations where negative possibilities are salient, such as stop signs, fire alarms, and warning signals. These learned associations may themselves be embedded in a biologically based predisposition across species to interpret red as a danger signal in competitive situations (e.g., the high status of an opponent; Setchell & Wickings, 2005). Thus, through both specific and general associative processes, and perhaps even evolutionarily ingrained proclivities, red carries the meaning of failure in achievement contexts, serving as a warning that a dangerous possibility is at hand. This warning signal is presumed to evoke avoidance motivation and behavior and to do so without conscious awareness.

Elliot et al. (2007) conducted two experiments to examine the link between red and avoidance motivation in an achievement context. In one experiment, participants viewed red or another color prior to ostensibly taking an IQ test, and their preference for easy or moderately difficult test items was assessed; in a second experiment, participants viewed red or another color prior to ostensibly taking an IQ test, and their prefrontal cortical activity was assessed. In these experiments, participants in the red condition showed a preference for easier test items and evidenced more right prefrontal cortical activity, both of which indicate avoidance motivation (Atkinson & Litwin, 1960;

Davidson, 1992). In subsequent research, Maier, Elliot, and Lichtenfeld (2008) demonstrated that viewing red prior to an ostensible achievement task evoked perceptual processes (i.e., a local focus) commonly associated with avoidance motivation (Derryberry & Reed, 1994).

Stimulus Evaluation and Behavior

Although the prior experiments have documented a link between red and avoidance motivation, they have not examined the influence of red on physically enacted avoidance behavior, and the primary aim of the present research was to determine whether perceiving red affects actual bodily movement. Several theorists over the years have posited that exposure to positive or negative stimuli automatically produces approach or avoidance behavior (Lewin, 1935; Osgood, 1953), presumably by activating basic approach or avoidance motivational systems (Lang, 1995). This link between stimulus evaluation and action has been empirically documented in several experiments reported in the past decade. Chen and Bargh (1999; see also Solarz, 1960) had participants pull a lever toward themselves (an approach-related action) or push a lever away from themselves (an avoidance-related action) as they viewed valenced words. Results indicated that participants moved the lever faster when the valence of the stimulus word matched the presumed valence of the behavior. Similar findings have been obtained in subsequent research that has used valenced objects or persons as stimuli (Duckworth, Bargh, Garcia, & Chaiken, 2002; Neumann, Hülsebeck, & Seibt, 2004; Rotteveel & Phaf, 2004) or that has had participants respond by moving their arm toward/away from a computer screen or by flexing/extending their arm to press or release a button (Neumann et al., 2004; Pucca, Rinkeauer, & Breidenstein, 2006; Rotteveel & Phaf, 2004; see also Markman & Brendl, 2005; Maxwell & Davidson, 2007; Seibt, Neumann, Nussinson, & Strack, 2008; Wentura, Rothermund, & Bak, 2000; Willowski & Robinson, 2006).

In the present research, red is posited to carry the negative meaning of failure in achievement situations, and given the close connection between negative stimuli and avoidance behavior demonstrated in existing work, we hypothesized that perceiving red prior to an achievement task would evoke avoidance behavior. Also following existing work on evaluation and behavior, we anticipated that this red effect would occur without conscious awareness. Establishing a link between red and implicit, physically enacted avoidance behavior would provide the most direct and compelling evidence to date for the existence of a deeply embedded red–danger link. It would also suggest that the posited red effect

may represent embodied or grounded cognition (Barsalou, 2008; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005), a possibility we will revisit in the General Discussion.

Importantly, in testing the link between red and avoidance behavior, we not only sought to advance the nascent research on color and psychological functioning, but also sought to extend the literature on evaluation and behavior with regard to both the evaluative stimulus and the behavioral response. In our research, we briefly showed participants red (or a contrast color) on the cover of a test that they would ostensibly take and then assessed avoidance behavior. With regard to the evaluative stimulus, the color red differs from stimuli used in prior work on evaluation and behavior in two primary ways. First, it is a background feature of a more focal target, and attention is not explicitly directed to color during task presentation. As such, red represents a more subtle stimulus cue than is typically used in the evaluation-behavior literature. Second, red is presented only once for a brief period, rather than multiple times over the course of several trials (and, often, blocks of trials). Again, this highlights the minimalist nature of red as a stimulus cue. With regard to the behavioral response, avoidance behavior may take on many different forms, including withdrawal, freezing, inhibition, and escape (Atkinson, 1964; Faneslaw, 1991; Lewin, 1935). In our first experiment, we utilized an indicator of avoidance behavior that is novel to the evaluation-behavior literature—inhibited motor action when required to approach a potentially dangerous situation (see Geen, 1987; Gray & McNaughton, 1997).¹ In our second experiment, we utilized withdrawal upon presentation of a negative stimulus as our indicator of avoidance behavior; withdrawal is commonly used to test the evaluation-behavior link, but we used a unique manifestation of withdrawal in the form of freely enacted bodily movement away from the stimulus (rather than a constrained, dictated action, such as extension of one's arm away from the stimulus; see Hillman, Rosengren, & Smith, 2004). Thus, if we could indeed document the hypothesized red effect using these novel, naturalistic indicators of avoidance behavior, it would represent a particularly provocative and ecologically valid demonstration of the evaluation-behavior link.

Finally, our research afforded an opportunity to attend to an important issue that has recently arisen in the evaluation-behavior literature: Rotteveel and Phaf (2004) questioned whether the relation between the processing of valenced stimuli and approach-avoidance behavior is really automatic. Their argument is that repeated exposure to explicitly valenced stimuli in the existing research could lead participants to engage in conscious evaluative processing. We would add that

explicitly dictating the need for a precise response to the encountered stimuli would undoubtedly increase the likelihood of conscious evaluation. Our use of a subtle, briefly presented, background stimulus in the present research, coupled with our assessment of naturally occurring (i.e., goal-independent; Klauer & Musch, 2003) behavior, should provide a more stringent test of the automaticity of the evaluation-behavior relation (see also Alexopoulos & Ric, 2007).

Context

An additional aim of the present research was to test the context specificity of the hypothesized red effect. In the sparse literature on color and psychological functioning in humans, context has been largely ignored by theorists and researchers alike. For example, on the theoretical front, Goldstein (1942) offered the general proposal that colors such as red and yellow are experienced as stimulating, focus people on the outward environment, and produce forceful behavior, whereas colors such as green and blue are experienced as quieting, focus people inward, and produce reserved behavior. Although Goldstein made passing reference to inter- and intraindividual variation in people's responses to color stimuli, he emphasized the pervasiveness of the hypothesized patterns across situations. On the empirical front, Frank and Gilovich (1988) conducted several studies in which they documented a link between black uniforms and malevolence and showed that individuals competing in black uniforms engage in more aggressive behavior than those competing in white uniforms. Frank and Gilovich acknowledged that black might not produce aggressiveness in all situations, but did not test the context specificity of their effect. Indeed, we are not aware of any empirical research with human participants that has examined the contextual nature of a color effect (for a discussion of research regarding the contextual nature of automatic evaluation more generally, see Ferguson & Bargh, 2008).

The contextual nature of color effects has received a bit more attention in the nonhuman animal literature, although here too very little empirical work has been conducted. Theorists have observed that the same color can convey distinct messages to the same organism under different conditions. For example, for some species of birds, red displayed on the back of an insect indicates that the insect is poisonous and to be passed over, but red displayed on a piece of fruit indicates that it is ripe and ready for consumption (Schmidt & Schaefer, 2004; Schuler & Roper, 1992). Surprisingly, the observation that color carries different meanings under different conditions has not translated into sustained research activity. In fact, we are aware of only two articles that have demonstrated a color context effect. Gamberale-Stille and Tullberg

(2001) presented male chicks with insects or similarly sized pastry spheres in red or green colors and found that the chicks displayed greater consumption of the green insects than the red (ostensibly poisonous) insects, whereas no color difference was observed in consumption of the pastry spheres. Zachar, Schrott, and Kabai (2008) conceptually replicated these findings using decerebrated chicks. It should be noted that in these experiments, context was manipulated by varying the object on which color was presented. Perhaps the most stringent test of color-context moderation would be to present color on the same object, with variation in the psychological meaning of the situation alone.

In the present research, we examined the hypothesis that red evokes avoidance behavior in achievement contexts but has no impact on avoidance behavior in nonachievement contexts. That is, we think that the influence of red on avoidance behavior is due to the signal value of red—the meaning that it conveys to the perceiver in the specific situation. In an achievement situation, red is presumed to carry the meaning of failure and therefore is expected to prompt avoidance behavior, whereas in a situation in which achievement is not made salient, red is presumed to carry no specific meaning and is not expected to have any particular influence on avoidance behavior. Thus, our proposal may be contrasted with that espoused by Goldstein (1942), in that we view red as operating via meaning structures rather than operating directly as a function of stimulus properties that are invariant across situations.

Overview of Present Research and Hypotheses

The present research is comprised of two experiments. In Experiment 1, we focused on the influence of red on one form of avoidance behavior, behavioral inhibition, and also examined the issue of context. Participants were briefly shown red or green on the cover page of an analogies test that they would ostensibly take (achievement context) or rate the likability of (nonachievement context) in an adjacent lab. The door to the adjacent lab was closed, and we predicted that participants shown red, relative to those shown green, would manifest avoidance behavior by knocking fewer times on this door when they anticipated taking the test but that no effect on knocking behavior would be exhibited when they anticipated merely rating the likability of the test. Green was selected as the contrast to red because red and green are opposite colors in well-established color models (Fehrman & Fehrman, 2004) and because green, like red, is a chromatic color that would allow nonhue properties of color (lightness and chroma) to be controlled. Having addressed the context issue in Experiment 1, in Experiment 2 we focused on the influence of red on a second form of avoidance

behavior, behavioral withdrawal. Participants were briefly shown red, green, or gray on the cover page of an IQ test that they would ostensibly take. A sensor was placed on participants to assess their body movement upon presentation of the colored test cover, and we predicted that those shown red, relative to those shown green or gray, would manifest avoidance behavior by moving away from the test cover when it was presented. Gray is an achromatic color and thus served as an additional baseline control; gray is an optimal control color because it allows lightness to be controlled (achromatic colors have no chroma, so this property of color is irrelevant for neutral hues). The effect of red in these experiments was expected to occur without participants' awareness.

EXPERIMENT 1

Method

Participants. A total of 67 (20 male and 47 female) U.S. undergraduates participated in the experiment for extra course credit. Participation was restricted to individuals who were not red–green color–blind. The mean age of participants was 19.97 years old with a range of 18 to 54.

Design and procedure. Participants were randomly assigned to condition in a Color (red vs. green) × Achievement Context (achievement context vs. nonachievement context) between-subjects experiment. The number of times that participants knocked on the door of the lab was the dependent measure.

Participants were run individually by two experimenters in two adjacent laboratories. The experimenters were blind to color condition and the experimental hypotheses. Upon arrival at Lab A, participants were instructed to put their belongings in a designated place (this was done to ensure that their dominant hand would be free for knocking). Participants were then told that they would be going to another room to get instructions and complete a consent form. They were informed that this was done to keep their name separate from the materials that they would complete during the experiment. The experimenter then showed participants the location of Lab B, which was approximately 40 feet from Lab A.

At Lab B, participants signed a consent form and were told one of two things about what they would be doing in the other room. In the achievement context condition, participants were told that they would be taking one of two types of tests—an analogies test or a vocabulary test—whereas in the nonachievement context condition, participants were told that they would be rating one of two types of tests—an analogies test or

a vocabulary test—for how much students tend to like or dislike that type of test. Thus, in the achievement context participants' competence would ostensibly be evaluated, but in the nonachievement context no competence evaluation would be anticipated. The experimenter indicated that she was not allowed to know which type of test participants would be taking/rating and would therefore provide a sample item from each. The sample items were as follows:

Analogy Test:

Forest: Trees = Meadow: _____
 a) Grass b) Hay c) Feed d) Nature e) Pasture

Vocabulary Test:

The opposite of Predisposed is _____
 a) Directed b) Stubborn c) Disinclined d) Nostalgic e) Tranquil

After reading the sample items, participants in the achievement context condition were informed: "When you have finished with your test, the experimenter will give you feedback on your performance," whereas those in the nonachievement context were told: "We won't ask you to take a test; we just want you to look one over and rate how much you think [students] would like or dislike it."

Next, participants were given a white two-ring binder and told that the word on the front of the test inside the binder indicated the type of test that they would be taking/rating. The experimenter then stated: "You can open the binder now to see which test you will take/rate," paused briefly, and continued "and then close the binder and leave it there, and go ahead to the other room to take/rate the test." *Analogy* was placed in black ink in 34-pitch font on a colored rectangle 5" long × 7¼" wide. The colored rectangle was on a white page, centered horizontally, and began 2" from the top of the page (see Figure 1). The colors in the manipulation were selected using the CIELCh color model, which defines color in terms of three parameters: lightness, chroma, and hue (LCh; Fairchild, 2005). Using this model, the red and green colors were equated on lightness and chroma, namely, red LCh(44.00, 48.29, 24.34) and green LCh(47.00, 45.00, 161.61); equated in this context means functionally equivalent (i.e., within 5 units on each relevant parameter; M. Fairchild, personal communication, June 9, 2005).² Pilot testing with a separate sample documented that the colors in the manipulations were clearly recognized as the designated colors.³ As the experimenter delivered the instructions about opening the binder, she turned to open the door to the lab to avoid seeing the color manipulation. Participants were exposed to the color on the test cover for approximately 2 seconds.

Immediately after the color manipulation, participants returned to Lab A. The door to Lab A was closed,



Figure 1 The test cover for the red condition in Experiment 1. NOTE: To view this figure in color, log on to <http://pspb.sagepub.com> and search for this article.

and a white sign on the door stated "Please knock" in black letters. While participants were in Lab B, the Lab A experimenter turned on a tape recorder to record the sound of the participant knocking on the door. A research assistant blind to color condition and the experimental hypotheses counted the number of knocks for each participant from the audiotapes (see Robinson, Wilkowsky, & Meier, in press, for use of a similar measure). After participants stopped knocking, the experimenter opened the door to the lab. At this point the experiment was over as participants were not actually asked to take/rate a test. The experimenter had participants complete a few other materials unrelated to the present experiment and then gave participants a verbal funnel debriefing that probed for awareness of the purpose of the experiment and if color was mentioned, queried for specifics (e.g., "Do you have any guesses about what the purpose of color in this study might have been?"). Finally, participants were asked to name the color on the cover of the test that they were shown in the other lab. Participants were then debriefed, given extra credit, and dismissed.

Results and Discussion

A between-groups analysis of variance (ANOVA) was used to examine the effect of color and achievement context on the number of knocks. A preliminary analysis examined the main and interactive effects of gender; no significant results were obtained, so gender was not considered further.

The analysis revealed no main effects, but a significant Color × Achievement Context interaction, $F(1, 63) = 5.51$,

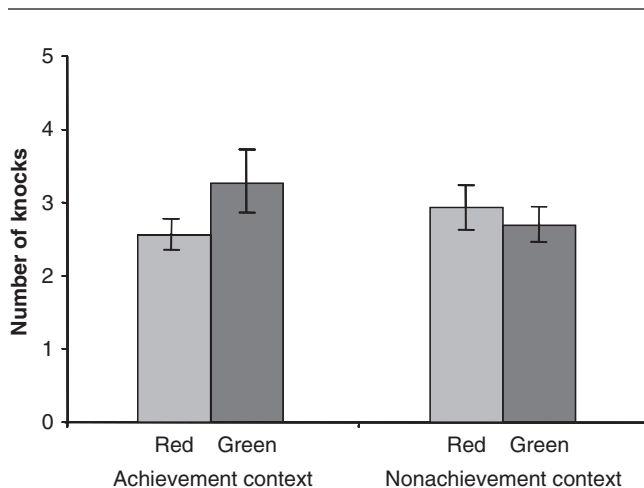


Figure 2 The effect of color condition and achievement context condition on mean number of knocks in Experiment 1. NOTE: Confidence intervals (95%) are indicated by vertical lines. To view this figure in color, log on to <http://pspb.sagepub.com> and search for this article.

$p < .05$ (see Figure 2). As predicted, planned comparisons revealed that in the achievement context, participants in the red condition knocked less than those in the green condition, $t(35) = 2.25$, $p < .05$, whereas in the nonachievement context, no difference in knocking was observed between the red and green conditions ($t < 1.18$).

A chi-square test of independence was calculated to determine whether participants' color reports corresponded to their color condition. The analysis was significant, $\chi^2(1) = 48.49$, $p < .001$, indicating that participants were indeed cognizant of the color on the test. In the funnel debriefing, one participant mentioned color and another participant mentioned knocking, but no participant mentioned the two together.⁴

In sum, the results from this experiment supported our hypothesis. Participants shown red prior to an ostensible analogies test, relative to those shown green, exhibited avoidance behavior by knocking fewer times on the lab door; color had no influence on knocking when participants thought they simply had to rate a test on likeability. Participants were able to report the color on the test cover but were unaware of the purpose of the study.

The indicator of avoidance behavior in Experiment 1 was more naturalistic than is the norm in research on the evaluation-behavior link. However, knocking was an action that was required of participants, and inhibited motor action is only one of many forms of avoidance behavior. In addition, although inhibited knocking seems a rather clear representation of avoidance behavior, at the most concrete level of action identification, it is possible to construe it as restrained approach behavior. The

indicator of avoidance behavior that we used in Experiment 2 was a naturalistic action that was not dictated by the experimenter and that unequivocally represents avoidance behavior—physical movement backward in response to the color stimulus. Furthermore, Experiment 1 documented the hypothesized red effect but did not anchor this effect to an achromatic baseline control; we used the achromatic color gray for this purpose in Experiment 2. Having demonstrated that the red effect is limited to an achievement context in Experiment 1, we focused on an achievement context only in Experiment 2.

EXPERIMENT 2

Method

Participants. A total of 30 (6 male and 24 female) German undergraduate and graduate students participated in the experiment for extra course credit. Participation was restricted to individuals who were not red-green color-blind. The mean age of participants was 33.23 years old with a range of 17 to 55.

Design and procedure. Participants were randomly assigned to one of three between-subjects conditions: the red condition, the green condition, or the gray condition. Time (specifically, the 5 seconds following onset of the color manipulation) was a within-subjects factor, and body movement was the dependent measure.

Participants were run individually by an experimenter blind to color condition and the experimental hypotheses. Upon arrival for the experiment, participants were seated in front of a computer monitor. The experimenter provided a brief overview of the session while a movement sensor was placed on the participant. The participant was told that the sensor was perfectly safe and that information about the reason for the sensor would be provided after the experiment. The experimenter then stepped behind a partition to remain blind to color condition.

The experimenter informed participants that they would be taking an IQ test. When participants indicated their readiness to begin, the experimenter started the program. First, participants were presented with two sample items from the test. The first sample item was the same as the analogies test sample item in Experiment 1; the second was in the same format as the first. Then, participants were instructed to look at the fixation cross in the center of the computer screen until the test began. The fixation cross was presented for 10 seconds, and then the IQ test cover page was presented for 2 seconds.

The IQ test cover page was formatted in similar fashion to the cover page used in Experiment 1. *Analogies* was placed in black ink in 34-pitch font on a colored rectangle 5.2" long \times 7.6" wide. The colored rectangle was on a white screen, centered horizontally, and began 2.1" from the top of the screen. The colors in the manipulation were selected using the CIELCh color model used in Experiment 1. The chromatic colors were equated on lightness and chroma, namely, red LCh(39.92, 52.81, 29.25) and green: LCh(40.08, 51.63, 152.78); and the achromatic color, which has no chroma, was equated on lightness, LCh(39.41, —, 251.25). Pilot testing with a separate sample documented that the colors in the manipulations were clearly recognized as the designated colors.⁵

The 2-second color presentation was followed by presentation of the fixation cross. Movement data were extracted from the periods 5 seconds prior to onset of the color manipulation and 5 seconds following onset of the color manipulation. This extraction of data immediately prior to and immediately after stimulus onset is common in analogous research (e.g., Bradley & Lang, 2000).

The experimenter then emerged from behind the partition, informed participants that they would not have to take the test, and gave them the funnel debriefing and color naming question used in Experiment 1. Participants were then debriefed, given extra credit, and dismissed.

Movement apparatus and measurement. Participants were seated on a stool in front of a 19" color monitor. The stool was firmly attached to the ground and did not restrict movement of the upper body in any direction. Movement toward or away from the monitor was measured with an inclinometer sensor taped to the left bare shoulder of the participant. An inclinometer sensor assesses alteration of the angle of an object with respect to gravity (Mathie, Coster, Lovell, & Celler, 2004). A SCA 100T-D01 sensor from VTI Technologies was used; the range of the sensor is $\pm 30^\circ$ with a resolution of 0.003° . The angular error of the sensor is small (1.3°), its reproducibility is high (0.2°), and its inherent angular noise is small (0.04°) and independent of the orientation of the device. The session was videotaped to ensure that movement was measured properly for each participant; data for one participant was excluded because the person stood during the assessment period.

The analog signal from the inclinometer sensor was digitized with a sample rate of 64 measurements per second. These data were reduced to 1 Hz sampling by computing the mean value of the 64 measurements for each second. This mean value over 1 second is the average score for object position relative to 90° (Hansson,

Asterland, Holmer, & Skerfving, 2001). All data were represented in the decimal measurement unit milli g (*mg*), with 1000 mg equal to 90° ; this allowed the use of parametric statistical procedures (see Mathie et al., 2004). Negative and positive *mg* values indicate angle alteration backward and forward, respectively.

Results and Discussion

A mixed-model analysis of covariance (ANCOVA) was used to test for color and time effects on body movement. A set of orthogonal contrasts was used to represent the between-subjects effect of color condition: A red–green contrast tested the red condition (-1) versus the green condition ($+1$), and a color–no color contrast tested the red (-1) and green (-1) conditions versus the gray condition ($+2$). When analyses with these orthogonal contrasts revealed a significant red–green effect, two planned contrasts were used to anchor the red and green conditions to the gray control: a red–gray contrast (red -1 , gray $+1$) and a green–gray contrast (green $+1$, gray -1 ; see Elliot & Harackiewicz, 1996, for a comparable data-analytic procedure).

The within-subjects effect of time was represented by the linear, quadratic, cubic, and quartic trends across the 5 seconds following onset of the color manipulation (Cohen & Cohen, 1983). Participants' body position 1 second prior to onset of the manipulation was used as a covariate to establish a reference point for body movement following manipulation onset (see Harmon-Jones, Vaughn-Scott, Mohr, Sigelman, & Harmon-Jones, 2004). Variance in body movement during the 5-second premanipulation period was used as an additional covariate to minimize noise due to general fluctuations in body position (see Mathiak, Hertrich, Lutzenberger, & Ackermann, 2002).

All variables were centered to enable the simultaneous interpretation of main and interactive effects. Preliminary analyses examined main and interactive effects of gender; no significant results were obtained, so gender was not considered further.

The analysis with the set of orthogonal contrasts revealed a significant Red-Green \times Linear Trend interaction, $F(1, 25) = 4.92$, $p < .05$, indicating that the linear pattern of body movement differed in the red and green conditions. As seen in Figure 3, participants in the red condition, relative to those in the green condition, moved their body away from the monitor when the test cover was presented. None of the Red-Green \times Higher Order Trend interactions were significant ($F_s < 1.85$), nor were there any significant effects involving the color–no color contrast ($F_s < 1.67$). A few results of peripheral interest (i.e., not involving color) also emerged; these results may be obtained from the first author upon request.

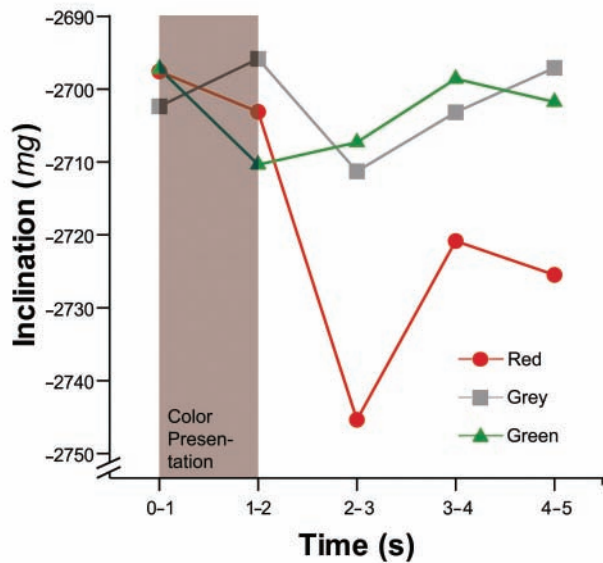


Figure 3 The effect of color condition on body movement (mean inclination of the upper body over time in milli g [mg] units) in Experiment 2.

NOTE: Negative mg values indicate angle alteration away from the test cover. To view this figure in color, log on to <http://pspb.sagepub.com> and search for this article.

The red–gray analysis revealed a significant Red–Gray \times Linear Trend interaction, $F(1, 25) = 4.65, p < .05$, indicating that the linear pattern of body movement differed in the red and gray conditions. As seen in Figure 3, participants in the red condition, relative to those in the gray condition, moved their body away from the monitor when the test cover was presented. None of the Red–Gray \times Higher Order Trend interactions were significant ($F_s < 1$). The peripheral results in this analysis were the same as those reported previously.

None of the green–gray effects attained significance ($F_s < 2.1$). Again, the peripheral results in this analysis were the same as those noted previously.

A chi-square test of independence was calculated to determine whether participants' color reports corresponded to their color condition. The analysis was significant, $\chi^2(4) = 38.93, p < .001$, indicating that participants were indeed cognizant of the color on the test. In the funnel debriefing however, not a single participant showed any awareness that the experiment focused on color and/or body movement.

In sum, the results from this experiment supported our hypothesis. Participants shown red prior to ostensibly taking an IQ test, relative to those shown green or gray, exhibited avoidance behavior by moving away

from the test cover when it was presented. Participants were able to report the color on the test cover but were unaware of the purpose of the study.

GENERAL DISCUSSION

The results of the experiments reported herein indicate that the brief perception of red in an achievement context evokes avoidance behavior and does so without conscious awareness. These findings help establish the provocative proposal that red serves as a danger signal in achievement contexts. Prior research examining this proposal (Elliot et al., 2007; Maier et al., 2008) documented a link between red and avoidance motivation; the present work extends this link to physically enacted avoidance behavior. The present work also extends existing research on evaluation and behavior more generally and documents the context specificity of the red effect.

The present research indicates that a minimalist, background presentation of red can evoke avoidance behavior. The apparent ease and subtlety with which red can trigger avoidance raises concerns about the way that red is currently used in experimental designs and assessment procedures. For example, red and green are often used in experiments as cues signaling loss/failure/bad and gain/success/good, respectively (e.g., Dijksterhuis & Smith, 2002; Förster, Higgins, & Idson, 1998; Guarnaschelli, McKelvey, & Palfrey, 2000; Rothermund, Wentura, & Bak, 2001; Trommershauser, Maloney, & Landy, 2003). Unfortunately, this use of red and green unwittingly confounds the effect of motivational framing with the effect of color. Likewise, red and other colors are sometimes used in IQ tests (e.g., Raven's Colored Progressive Matrices) to hold children's attention. Unfortunately, this use of color introduces unsystematic variance into the assessment and may influence some test takers more than others (e.g., red may be particularly likely to evoke avoidance in test-anxious individuals, for whom avoidance cues are highly accessible). In both of these examples, it is undoubtedly the case that color not only varies by hue but also by lightness and chroma, thereby adding further extraneous variance to the data. In short, our demonstration that red has a systematic influence on behavior in achievement contexts indicates that red, and color more generally, should be used with great care in experimental designs, assessment procedures, and beyond.

Color is processed at an early, rudimentary level within the perceptual system (Gegenfurtner & Kiper,

2003), and approach–avoidance are the most fundamental adaptive judgments that all organisms make in response to encountered stimuli (Kenrick & Shiota, 2008; Schneirla, 1959). As such, the present research linking the perception of red to avoidance behavior establishes a connection between two extremely basic aspects of psychological functioning. In so doing, our work provides additional support for Chen and Bargh's (1999) contention that the link between valenced stimuli and approach–avoidance behavior requires neither conscious evaluation nor behavioral intention. Admittedly, our contribution in this regard is limited to the avoidance component of the approach–avoidance distinction, and although we used a subtle, nonfocal stimulus and required no explicit evaluation in our experiments, the stimulus was presented in a way that *could* allow conscious processing. Future work would advance our understanding of the link between evaluation and behavior even further by focusing on approach-oriented, as well as avoidance-oriented, behavior and by presenting the valenced stimuli in subliminal fashion. In addition, future work would do well to examine the duration of the priming effects documented herein.

The present work linking red to physically enacted avoidance behavior appears to fit nicely with recently articulated conceptualizations of embodied or grounded cognition (for reviews, see Barsalou, 2008; Niedenthal, 2007). One proposition set forth by such conceptualizations is that perceived stimuli not only automatically produce cognitive states but automatically produce bodily states as well (Barsalou, Niedenthal, Barbey, & Ruppert, 2003), and our findings, particularly those of Study 2, suggest that red in achievement contexts automatically evokes avoidance motor mechanisms. To the extent that the red effect documented herein is grounded in learning processes, an embodiment/grounding interpretation of our results certainly seems appropriate; indeed, even if the red effect is evolutionarily engrained, an embodiment/grounding account may still be possible (see Barsalou et al., 2003). Importantly, we view an embodiment/grounding explanation of our findings as complementary to, not in competition with, our conceptual model of color and psychological functioning.

An important feature of the present research was our attention to the issue of context, which has been almost entirely ignored, to date, in the nascent literature on color psychology. Herein we demonstrated that the effect of red on avoidance behavior is not invariant but instead differs according to the psychological meaning of the situation. This demonstration of color-context moderation nicely establishes a boundary condition for the link between red and avoidance behavior and more

generally illustrates the need for more nuanced statements about color and psychological functioning than are typically found in both the popular media and the scientific literature.

Once the issue of context is raised and its importance empirically established, a host of other interesting research questions come to the fore. One such question is whether the effect of red on avoidance behavior documented herein is limited to achievement contexts per se. We view achievement contexts as one of many types of situations in which danger is a salient possibility, and we view the red–danger link as the linchpin of the red effect. As such, we strongly suspect that red would have a similar impact on avoidance behavior in a broader class of dangerous situations, and we encourage subsequent research examining this issue.

Another interesting question is whether the influence of red on psychological functioning is limited to avoidance motivation (Elliot et al., 2007; Maier et al., 2008) and behavior (the present research) or whether red can evoke approach motivation and behavior in some contexts. We think that red can indeed have appetitive implications in some situations, such as those involving sex and romance. Red is often used by humans to facilitate attraction (e.g., with lipstick, rouge, or lingerie) or to indicate sexual availability (e.g., in red light districts), and in many nonhuman mammals, red is displayed by the female during estrus as a signal of sexual readiness (Barelli, Heistermann, Boesch, & Reichard, 2007; Dixson, 1998; Setchell, Wickings, & Knapp, 2006). Thus, in contexts in which sexual attraction is relevant, red may serve as an appetitive cue and evoke approach, rather than avoidance, motivation, and behavior. Indeed, empirical evidence supporting this red–approach link in romantic contexts has recently been obtained in our laboratory (Elliot & Niesta, 2008).

A third interesting question is whether the influence of red on motivation and behavior varies as a function of cultural context. The apparent similarity across species in the signal function of red in achievement and sexual contexts tempts us to posit that red would evoke similar types of motivation and behavior across the globe in these contexts. However, societal emphases are not always concordant with biologically based tendencies (Edgerton, 1992; Triandis, 2007), and any discrepancy between the two may produce cross-cultural differences in color meanings and accordingly the influence of color on motivation and behavior. Clearly “color in cultural context” is a fascinating area for future research endeavors. Future research would also do well to focus on other colors beyond red in empirical investigations of motivation, behavior, and context.

In light of the ubiquity of color in the everyday environment, it is surprising how little research has been done on color psychology. The research that has been conducted has, in the main, been applied and atheoretical, focusing on questions such as "What colors influence worker mood and productivity?" and "What colors influence food preference?" Within social psychology, color has primarily been used in stereotyping and prejudice research, where the effect of black and white stimuli on various responses has been examined (Chen & Bargh, 1997; Frank & Gilovich, 1988; Payne, 2001). This work has exclusively used achromatic stimuli that inherently confound hue with lightness (i.e., white is inherently lighter than black), making definitive statements regarding hue per se somewhat tenuous. Furthermore, and more critically, nearly all of the existing research within and beyond social psychology that has used chromatic stimuli has failed to control either lightness or chroma when examining hue effects (Elliot et al., 2007; Fehrman & Fehrman, 2004). As a consequence, some view any findings from such research as virtually uninterpretable (Valdez & Mehrabian, 1994; Whitfield & Wiltshire, 1990). In short, the literature on color psychology is sparse, and with few exceptions, studies in this area have not been carried out in rigorous fashion. It is our hope that the present work demonstrates that research involving chromatic stimuli can not only be conducted rigorously but can also yield insights into the nature of basic psychological functioning. Color is typically considered in terms of aesthetics, but color can also serve as a nonlexical priming stimulus that has subtle but important implications for motivation and behavior.

NOTES

1. As noted by Gray and McNaughton, 1997, this type of avoidance behavior is particularly interesting because it takes place in a situation in which physical approach toward the aversive stimulus is also required (see also Lewin's [1935] discussion of this form of avoidance behavior).

2. Two virtually identical printouts (within 1.3 units on all parameters) were made for each color; the values in the text represent averages of these functionally equivalent colors.

3. The pilot test was a between-subjects experiment with 40 (23 male and 17 female) participants. Participants were shown the red or green test cover and responded to two questions: "To what degree is the color red?" and "To what degree is the color green?" (1 = *not at all* to 5 = *very much*). Separate *t* tests for each question revealed that participants indeed made accurate color categorizations ($ts \geq 28.09$, $p < .001$; each corresponding mean ≥ 4.55).

4. The magnitude and significance levels of all reported results remained the same with these participants excluded.

5. The pilot test was a between-subjects experiment with 30 (13 male and 17 female) participants. Participants were shown the red, green, or gray test cover and responded to three questions: "To what degree is the color red?" "To what degree is the color green?" and "To what degree is the color gray?" (1 = *not at all* to 5 = *very much*). Separate *t* tests for each question revealed that participants indeed made accurate color categorizations ($ts \geq 8.60$, $p < .001$; each corresponding mean ≥ 4.30).

REFERENCES

- Alexopoulos, T., & Ric, F. (2007). The evaluation-behavior link: Direct and beyond valence. *Journal of Experimental Social Psychology*, *43*, 1010-1016.
- Atkinson, J. W. (1964). *An introduction to motivation*. New York: D. Van Nostrand Company, Inc.
- Atkinson, J. W., & Litwin, G. H. (1960). Achievement motive and test anxiety conceived as motive to approach success and motive to avoid failure. *Journal of Abnormal and Social Psychology*, *60*, 52-64.
- Barelli, C., Heistermann, M., Boesch, C., & Reichard, U. H. (2007). Sexual swellings in wild white-handed gibbon females (*Hylobates lar*) indicate the probability of ovulation. *Hormones and Behavior*, *51*, 221-230.
- Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617-645.
- Barsalou, L. W., Niedenthal, P. M., Barbey, A. K., & Ruppert, J. A. (2003). Social embodiment. In B. Ross (Ed.), *The psychology of learning and motivation: Advances in theory and research* (pp. 43-92). San Diego, CA: Academic Press.
- Bradley, M. M., & Lang, P. J. (2000). Emotion and motivation: I. Defensive and appetitive reactions in picture processing. *Emotion*, *1*, 276-298.
- Chen, M., & Bargh, J. A. (1997). Nonconscious behavioral confirmation processes: The self-fulfilling consequences of automatic stereotype activation. *Journal of Experimental Social Psychology*, *33*, 541-560.
- Chen, M., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin*, *25*, 215-224.
- Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.
- Davidson, R. J. (1992). Anterior cerebral asymmetry and the nature of emotion. *Brain and Cognition*, *20*, 125-151.
- Derryberry, D., & Reed, M. A. (1994). Temperament and attention: Orienting toward and away from positive and negative signals. *Journal of Personality and Social Psychology*, *66*, 1128-1139.
- Dijksterhuis, A., & Smith, P. K. (2002). Affective habituation: Subliminal exposure to extreme stimuli decreases their extremity. *Emotion*, *2*, 203-214.
- Dixson, A. F. (1998). Primate sexuality: *Comparative studies of prosimians, monkeys, apes, and human beings*. New York: Oxford University Press.
- Duckworth, K. L., Bargh, J. A., Garcia, M., & Chaiken, S. (2002). The automatic evaluation of novel stimuli. *Psychological Science*, *13*, 513-519.
- Edgerton, R. B. (1992). *Sick societies: Challenging the myth of primitive harmony*. New York: Free Press.
- Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology*, *70*, 461-475.
- Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General*, *136*, 154-168.
- Elliot, A. J., & Niesta, D. (2008). Romantic red: Red enhances men's attraction to women. *Journal of Personality and Social Psychology*, *95*, 1150-1164.
- Fairchild, M. D. (2005). *Color appearance models* (2nd ed.). New York: John Wiley.
- Faneslaw, M. S. (1991). The midbrain periaqueductal gray as a coordinator of action in response to fear and anxiety. In A. Depaulis & R. Bandler (Eds.), *The midbrain periaqueductal grey matter: Functional, anatomical, and immunohistochemical organization* (pp. 151-173). New York: Plenum.
- Fehrman, K. R., & Fehrman, C. (2004). *Color: The secret influence* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

- Ferguson, M. J., & Bargh, J. A. (2008). Beyond the attitude object: Automatic attitudes spring from object-centered-contexts. In B. Wittenbrink & N. Schwarz (Eds.), *Implicit measures of attitudes* (pp. 216-246). New York: Guilford.
- Förster, J., Higgins, E. T., & Idson, L. C. (1998). Approach and avoidance strength during goal attainment: Regulatory focus and the "goal looms larger effect." *Journal of Personality and Social Psychology, 75*, 1115-1131.
- Frank, M. G., & Gilovich, T. (1988). The dark side of self and social perception: Black uniforms and aggression in professional sports. *Journal of Personality and Social Psychology, 54*, 74-85.
- Gamberale-Stille, G., & Tullberg, B. S. (2001). Fruit or aposematic insect? Context-dependent color preferences in domestic chicks. *Proceedings of the Royal Society of London B, 268*, 2525-2529.
- Geen, R. G. (1987). Test anxiety and behavioral avoidance. *Journal of Research in Personality, 21*, 481-488.
- Gegenfurtner, K. R., & Kiper, D. C. (2003). Color vision. *Annual Review of Neuroscience, 26*, 181-206.
- Goldstein, K. (1942). Some experimental observations concerning the influence of colors on the functioning of the organism. *Occupational Therapy and Rehabilitation, 21*, 147-151.
- Gray, J. A., & McNaughton, N. (1997). The neuropsychology of anxiety: Reprise. *Nebraska Symposium on Motivation, 28*, 61-134.
- Guarnaschelli, S., McKelvey, R. D., & Palfrey, T. R. (2000). An experimental study of jury decision rules. *American Political Science Review, 94*, 407-423.
- Hansson G. Å., Asterland, P., Holmer, N. G., & Skerfving, S. (2001). Validity and reliability of triaxial accelerometers for inclinometry in posture analysis. *Medical and Biological Engineering and Computing, 39*, 405-413.
- Harmon-Jones, E., Vaughn-Scott, K., Mohr, S., Sigelman, J., & Harmon-Jones, C. (2004). The effect of manipulated sympathy and anger on left and right frontal cortical activity. *Emotion, 4*, 95-101.
- Hillman, C. H., Rosengren, K. S., & Smith, D. P. (2004). Emotion and motivated behavior: Postural adjustments to affective picture viewing. *Biological Psychology, 66*, 51-62.
- Kenrick, D. T., & Shiota, M. N. (2008). Approach and avoidance motivation(s): An evolutionary perspective. In A. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 273-288). London: Taylor & Francis.
- Klauer, K. C., & Musch, J. (2003). Affective priming: Findings and theories. In K. Klauer & J. Musch (Eds.), *The psychology of evaluation: Affective processes in cognition and emotion* (pp. 7-49). Mahwah, NJ: Lawrence Erlbaum.
- Lang, P. J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist, 50*, 372-385.
- Lewin, K. (1935). *A dynamic theory of personality*. New York: McGraw-Hill.
- Maier, M. A., Elliot, A. J., & Lichtenfeld, S. (2008). Mediation of the negative effect of red on intellectual performance. *Personality and Social Psychology Bulletin, 34*, 1530-1540.
- Markman, A. B., & Brendl, C. M. (2005). Constraining theories of embodied social cognition. *Psychological Science, 16*, 6-10.
- Mathiak, K., Hertrich, I., Lutzenberger, W., & Ackermann, H. (2002). Functional cerebral asymmetries of pitch processing during dichotic stimulus application: A whole-head magnetoencephalography study. *Neuropsychologia, 46*, 585-593.
- Mathie, M. J., Coster, A. C. F., Lovell, N. H., & Celler, B. G. (2004). Accelerometry: Providing an integrated, practical method for long-term, ambulatory monitoring of human movement. *Physiological Measurement, 25*, 1-20.
- Maxwell, J. S., & Davidson, R. J. (2007). Emotion as motion: Asymmetries in approach and avoidance actions. *Psychological Science, 18*, 1113-1119.
- Neumann, R., Hülsenbeck, K., & Seibt, B. (2004). Attitudes towards people with AIDS and avoidance behavior: Automatic and reflective bases of behavior. *Journal of Experimental Social Psychology, 40*, 543-550.
- Niedenthal, P. M. (2007). Embodying emotion. *Science, 316*, 1002-1005.
- Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*, 184-211.
- Osgood, C. E. (1953). *Method and theory in experimental psychology*. New York: Oxford University Press.
- Payne, B. K. (2001). Prejudice and perception: The role of automatic and controlled processes in misperceiving a weapon. *Journal of Personality and Social Psychology, 81*, 181-192.
- Pucca, R. M., Rinkenauer, G., & Breidenstein, C. (2006). Individual differences in approach and avoidance movements: How the avoidance motive influences response force. *Journal of Personality, 74*, 979-1014.
- Robinson, M. D., Wilkowski, B. M., & Meier, B. P. (in press). Approach, avoidance, and self-regulatory conflict: An individual differences perspective. *Journal of Experimental Social Psychology*.
- Rothermund, K., Wentura, D., & Bak, P. M. (2001). Automatic attention to stimuli signaling chances and dangers: Moderating effects of positive and negative goal and action contexts. *Cognition and Emotion, 15*, 231-248.
- Rotteveel, M., & Phaf, R. H. (2004). Automatic affective evaluation does not automatically predispose for arm flexion and extension. *Emotion, 4*, 156-172.
- Schmidt, V., & Schaefer, H. M. (2004). Unlearned preference for red may facilitate recognition of palatable food in young omnivorous birds. *Evolutionary Psychology Research, 6*, 919-925.
- Schneirla, T. C. (1959). An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. *Nebraska Symposium on Motivation, 7*, 1-43.
- Schuler, W., & Roper, T. J. (1992). Responses to warning coloration in avian predators. *Advances in the Study of Behavior, 21*, 111-146.
- Seibt, B., Neumann, R., Nussinson, R., & Strack, F. (2008). Movement direction or change in distance? Self- and object-related approach-avoidance motions. *Journal of Experimental Social Psychology, 44*, 713-720.
- Setchell, J. M., & Wickings, E. J. (2005). Dominance, status signals, and coloration in male mandrills (*Mandrillus sphinx*). *Ethology, 111*, 25-50.
- Setchell, J. M., Wickings, E. J., & Knapp, L. A. (2006). Signal content of red facial coloration in female mandrills (*Mandrillus sphinx*). *Proceedings of the Royal Society of Biology, 273*, 2395-2400.
- Solarz, A. K. (1960). Latency of instrumental responses as a function of compatibility with the meaning of eliciting verbal signs. *Journal of Experimental Psychology, 59*, 239-245.
- Triandis, H. (2007). Culture and psychology: A history of the study of their relationship. In S. Kitayama & D. Cohen (Eds.), *Handbook of cultural psychology* (pp. 59-76). New York: Guilford.
- Trommershauser, J., Maloney, L. T., & Landy, M. S. (2003). Statistic decision theory and the selection of rapid, goal-directed movements. *Journal of the Optical Society of America, 20*, 1419-1433.
- Valdez, P., & Mehrabian, A. (1994). Effects of colors on emotions. *Journal of Experimental Psychology: General, 123*, 394-409.
- Wentura, D., Rothermund, K., & Bak, P. (2000). Automatic vigilance: The attention-grabbing power of approach- and avoidance-related information. *Journal of Personality and Social Psychology, 78*, 1024-1037.
- Whitfield, T. W., & Wiltshire, T. J. (1990). Color psychology: A critical review. *Genetic, Social, and General Psychology Monographs, 116*, 387-412.
- Willowski, B., & Robinson, M. D. (2006). Stopping dead in one's tracks: Motor inhibition following incidental evaluations. *Journal of Experimental Social Psychology, 42*, 479-490.
- Zachar, G., Schrott, A., & Kabai, P. (2008). Context-dependent prey avoidance in chicks persists following complete telencephalectomy. *Brain Research Bulletin, 76*, 289-292.

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