EFFECTS OF COLOR PERCEPTION AND ENACTED AVOIDANCE BEHAVIOR ON INTELLECTUAL TASK PERFORMANCE IN AN ACHIEVEMENT CONTEXT

A Thesis
by
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FOREWORD

This thesis is written in accordance with the style of the *Publication Manual of the American Psychological Association (6th Edition)* as required by the Department of Psychology at Appalachian State University.

DEDICATION

I wish to dedicate this thesis to my parents, Romina and Jeff Thorstenson. Their timeless support has made my Graduate School experience possible.

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I would like to thank my thesis chair, Dr. Ken Steele, for his patience and advice throughout this thesis process. Additional thanks are warranted to my dedicated thesis committee, Dr. Emery and Dr. Webb, and the research assistant who served in our research lab, Charles Mautz.

Effects of Color Perception and Enacted Avoidance Behavior on Intellectual Task Performance in an Achievement Context

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Abstract

Previous research has established performance impairment in intellectual tasks as a consequence of brief exposure to the color red. Furthermore, previous research has established a mediational process in which avoidance-grounded processes mediate the effect of color perception on intellectual performance. A separate line of research has shown that enacting (i.e., physically engaging in) avoidance behavior elicits avoidance processes in a similar fashion as color. The present research focused on further documenting the relationship between color perception, intellectual performance, and avoidance motivation. Participants were exposed to a color (i.e., red, green, or gray) manipulation and subsequently engaged in an anagram task. Anagrams are often used as a measure of intellectual performance. Anagram tasks require a participant to find a correct solution word from a scrambled set of letters. Additionally, a variable of enacted avoidance behavior (EAB) was included to further assess the color's role as an avoidance cue. Results indicated that both red and EAB influenced anagram performance relative to other colors. However, potential artifacts were discovered in the anagram task. A problem occurred in the task such that participants could inflate their scores by rapidly entering correct solutions multiple times. Further, recent research suggests that the anagram words chosen may not be equated in difficulty. The discussion concludes with suggestions for anagram testing and ways to pursue similar studies in the future.

Effects of Color Perception and Enacted Avoidance Behavior
on Intellectual Task Performance in an Achievement Context

Color is a stimulus that is encountered constantly every day. Every object we encounter and interact with has a bounded property of color, which conveys meaningful information relevant to how we think, feel, and behave (Elliot & Maier, 2007). Given the ubiquitous nature of color, it is perhaps surprising that color experience is so challenging to define precisely. Almost everyone has first-hand experience with color, but very few can stringently define their perceptual experiences. Even for scientists devoted to the study of color, it is nearly impossible to define the perception of colored stimuli without use of qualitative examples (Fairchild, 2005).

Color can be defined as the “attribute of visual perception consisting of any combination of chromatic and achromatic content. This attribute can be described by chromatic color names such as yellow, orange, brown…etc., or by achromatic color names such as white, gray, black, etc.” (Fairchild, 2005, p.84). Just as color itself is difficult to define without example, so are the various attributes of color. While color is recognized categorically (e.g., red, green, blue), it changes continuously in terms of values ascribed to dimensions in color space (i.e., hue, lightness, and chroma; Komatsu, 1998). Using the perceptual definitions given by the *International Lighting Vocabulary* (Commission Internationale de l’Eclairage [CIE], 1987), *hue* is the attribute of a color that is described by terms like red, yellow, green, blue, or by a combination of these, and is dictated by wavelength. For example, the variance between wavelengths of ~570 nm and ~700 nm explain differences of perceived hue between yellow and red (Wyszecki & Stiles, 1967). *Lightness* (or whiteness) of a color describes how much light appears to be emitted and is similar to brightness (CIE, 1987). When comparing colors with equivalent hues (e.g., reds), a perceptually brighter red would have an increased lightness value. *Chroma* can be thought of as the relative “colorfulness,” or color content, similar to saturation. An achromatic color (e.g., black, white, or gray), by definition, has no chroma value (CIE, 1987).

In addition to its ubiquitous nature, color is particularly interesting as an object-feature exclusively perceived through vision, unlike other object-features such as size, shape, and space. Color is a central component of primate vision; perception of color is crucial to scene identification, recognition, and to visual memory (Gegenfurtner & Kiper, 2003; Hsu, Kraemer, Oliver, Schlichting, & Thompson-Schill, 2011). Further, in humans, color adds an aesthetic experience to visual stimuli, which is the basis for a large array of human decisions (Moller, Elliot, & Maier, 2009). For example, when making everyday choices between otherwise identical objects (e.g., cars, clothes, and accessories), color is often used as the determining factor. Moreover, color can be described both in categorical terms (e.g., red, green, blue) as well as in continuous values ascribed to dimensions in color space (e.g., lightness, chroma, hue). Finally, the fact that a large proportion of color perception is processed early in the visual system (i.e., in the retina and lateral geniculate nucleus [LGN]; Gegenfurtner & Kiper, 2003) and that stored visual information can influence processing in the early visual system (Kosslyn, Thompson, Kim, & Alpert, 1995) suggest that color knowledge can significantly bias perception of one’s environment.

Despite color’s significance to human experience, there exists surprisingly little empirical research on color in the realm of psychology. There exists a solid foundation of research defining fundamental color properties (i.e., color physics; CIE, 1986; Fairchild, 2005) and explaining photoreceptive qualities involved in color processing (i.e., color physiology; Gegenfurtner & Kiper, 2003; Glaser & Sadun, 1990), yet relatively little theoretical work regarding the influences of color on psychological functioning (i.e., color psychology; Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). Further, the scant amount of psychological research involving color has been descriptive (i.e., attempting to determine universal preferences to a range of colors) rather than aiming to explain color experience in terms of a developed theory (Palmer, Schloss, & Sammartino, 2012). Moreover, the remaining minority of past research has (until recently) failed to control for all properties of color (e.g., describing changes in hue without noting changes in chroma and lightness) and for the context in which colors are being presented (Whitfield & Whiltshire, 1990). Because of these poor controls, there have been considerable inconsistencies among research findings, in both results and interpretations (Valdez & Mehrabian, 1994).

The present study aimed to further document the relationship between color perception and psychological functioning. This was achieved by experimentally examining the effects of color on intellectual performance. The current paper will review literature relevant to color research, the effects of color on intellectual performance, the relationship between color and approach-avoidance motivation, the importance of context specificity, and likely sources of color meanings. Finally, specific hypotheses for experimental data are proposed, analyzed, and interpreted.

Color Standardization

Experimenters require reliable and universal color definitions in order to describe them in a systematic fashion. The CIE is a professional organization committed to standardizing the science of light. The CIE structure is a well-established international standard for specifying and expressing color (CIE, 1986; Fairchild, 2005).

The spectral absorption characteristics of human short (S), medium (M), and long (L) wavelength cones (i.e., the photoreceptors responsible for human color vision) are distinguished by the spectral sensitivities of their visual pigments (Gegenfurtner & Kiper, 2003). Human cone photoreceptors have wavelength maxima around 440 nm, 535 nm, and 562 nm for S-, M-, and L- cones, respectively (Shapley & Hawken, 2002). All color models developed by the CIE first specify stimuli in terms of CIE XYZ color space (i.e., a three-dimensional space which contains all perceivable colors). The CIE tristimulus (XYZ) values are derived from the amount of spectral absorption power required of each cone type to match a point in CIE XYZ color space (Fairchild, 2005). However, they do not correlate precisely to S-, M-, and L- cones. Z corresponds closely to the S-cone response, and X corresponds to an additive combination of all cone responses. The Y value corresponds to the intensity of light stimulus or *luminance* (Fairchild, 2005).

There are many CIE color models which have been developed to promote color space standardization. All of these models include tested transformations of tristimulus calculations to provide device-independent values, ensuring reliable description of a colored stimulus (CIE, 1986). These calculations are provided because equal steps of X, Y, and Z values do not produce equal changes in psychophysical perception. These models contrast RGB color space, which is a device-dependent color space based on the additive colors of red, green, and blue (Fairchild, 2005). RGB color models do not contain the human gamut (i.e., the entire visible spectrum; Fairchild, 2005).

The CIE LCh color model (used in the current study) was adapted from the CIE 1976 LAB model and can be described cylindrically with three axes; L, C, and h (CIE, 1986). Axis L describes *Lightness* vertically (i.e., values ranging 0-100 representing black to gray to white). Axis C describes *Chroma* horizontally (i.e., values ranging 0-100 representing the amount of saturation). Axis h represents *hue* circularly (i.e., values in units of degrees ranging from 0 [red] through 90 [yellow], through 180 [green], through 270 [blue], back to 0 [red]; CIE, 1986; Oberfeld, Hecht, Allendorf, & Wickelmaier, 2009; Wyszecki & Stiles, 2000).

Color Influences Intellectual Performance

Color psychology has shown progress across the domains of affect (Destefani & Whitfield, 2008; Palmer et al., 2012; Strauss, Schloss, & Palmer, 2010), cognition (Elliot et al., 2007; Maier, Elliot, & Lichtenfeld, 2008; Soldat, Sinclair, & Mark, 1997), and behavior (Elliot & Aarts, 2011; Elliot, Maier, Binser, Friedman, & Pekrun, 2009; Frank, Gilovich, Lavallee, 2008). The current review, however, will emphasize the theme of intellectual-task performance.

Elliot et al. (2007) devised four distinct experiments to demonstrate that the brief perception of red prior to an intellectual task impairs subsequent performance. Participants were assigned to an experimental condition (red, green, or achromatic color) and exposed to the manipulation in various ways. The subjects briefly (2-5 s) viewed either a colored cover page or observed a colored participant number placed on the corner of their test page. Subsequently, the participants engaged in an intellectual task: an anagram-solving measure (participants are required to find the correct solution word for a set of scrambled letters), an analogy subtest (participants are required to choose a correct word-pair to match a given word-pair) of the Intelligence Structure Test (a standardized measure designed to assess intelligence quotient or IQ; Elliot et al., 2007), or a numeric subtest (participants are required to solve a set of math problems) of the Intelligence Structure Test. The researchers found that performance on all tests in the red condition was significantly impaired relative to the green and achromatic conditions. Perception of red prior to the task resulted in lower scores on verbal and numeric test measures, and led to fewer anagrams being solved in the 5 min allotted.

Gnambs, Appel, and Batinic (2010) assessed color priming influences on a short German version of the General Knowledge Test in two studies. The researchers had participants take the General Knowledge Test on a web-based computer network, with the color manipulation being a colored (red vs. green) progress bar on-screen, or a colored (red vs. blue) “forward” button on-screen. Red, compared to other conditions, impaired test performance, but only for male participants. Those who perceived red prior to the test earned a lower sum of correct answers on the 40-question general knowledge test. It is important to note here that the participants were tested on their home computers, making color standardization and control impossible due to computer-monitor differences, which is a considerable methodological limitation.

In a classroom setting during a regularly scheduled midterm examination, Sinclair, Soldat, and Mark (1998) administered nearly identical forms to students, the exception being colored coversheets (red vs. blue) labeling the tests. Students with red coversheets performed significantly worse than those with blue cover sheets, especially on the more challenging questions. Unfortunately, there was no achromatic control color, which diminishes assessment regarding the directionality of color effects. It is inconclusive whether red impaired performance or blue enhanced it. The researchers concluded that blue improved performance; however, the trend of contemporary research (Elliot et al., 2007) suggests that adding a control group (e.g., a white coversheet) could have provided a baseline from which to assess the other two colors' effects.

Further, it appears that perception of the color itself is not necessary to elicit comparable effects; lexical representations of color (i.e., color words) are sufficient (Lichtenfeld, Maier, Elliot, & Pekrun, 2009). In a series of experiments, researchers demonstrated that the word, "red" perceived centrally (read as task-directions) or peripherally (visible as part of an ostensible copyright tag) impaired subsequent performance on various versions of an IQ test. Participants were given a 20-item verbal or numeric IQ test. Those who perceived the lexical red stimulus (the word "red") prior to the task achieved lower scores.

Color and Approach-Avoidance Motivation

The question arises as to why these relationships between color and intellectual performance exist. Unfortunately, many explanations regarding such relationships have been largely speculative. For example, Soldat et al. (1997) suppose that red is associated with happiness and blue with sadness, and so the colors should elicit nonsystematic and systematic cognitive processing, respectively. However, Mehta and Zhu (2009) propose that red is associated with danger, so it should make people detail-oriented, while blue should facilitate innovative problem-solving because of its supposed association with openness and peace.

Despite the inconsistent justifications for color meaning, there exist models which have been empirically tested. An explanation is offered from Maier et al. (2008) by demonstration of a process in which a motivation-grounded attentional focus mediates the effect of color perception on intellectual performance. Maier et al. (2008) first presented a colored cover page to participants. Those who viewed red solved fewer items on a subsequent 20-item numeric IQ test than those who viewed gray. The participant's attentional focus was also assessed by engaging in a local-versus-global processing task. In such a task, a participant must choose a comparison object (either a large square composed of smaller squares or a large triangle composed of smaller triangles) which best matches a target object (e.g., a square composed of triangles). Selection of the comparison consistent with the local (smaller) objects is considered local processing. This result is indicative of a constricted attentional focus (Gasper, 2004), which is an indicator of activated avoidance motivation (Derryberry & Tucker, 1994). Maier et al. (2008) found that those who perceived red exhibited more local processing than those who viewed gray, which in turn successfully predicted worse IQ-task performance.

Motivational valence (i.e., the attractiveness or averseness of a stimulus) is an essential factor that influences all behavior (Schneirla, 1959). A review of contemporary emotion literature suggests that all environmental stimuli (e.g., color) are initially processed in a rapid and automatic fashion into either an appetitive or aversive category. This biphasic category activates a motivational goal process that people use to determine behavior and cognition (Cacioppo & Gardner, 1999; Elliot & Niesta, 2009; Lang, 1995). For example, a tendency to interact with an appetitive stimulus would typically involve different behaviors (approaching, movement toward) than would a tendency to interact with an aversive stimulus (avoiding, movement away from). Further, consequential affective reactions can be elicited with minimal stimulus exposure (Zajonc, 1980, 1984), as supported by the brief (2-5 s) color manipulations in previously mentioned experiments.

Motivational states have a vast array of tested implications for mental processes but can be cumulatively described as eliciting direction of behavior either towards approaching desirable stimuli (e.g., success) or away from undesirable stimuli (e.g., failure; Elliot, 2006). According to the model of approach-avoidance motivation, all motivational goals are directed towards approaching desirable objects, outcomes, or events (i.e., approach motivation) or avoiding aversive objects, outcomes, or events (i.e., avoidance motivation; Elliot, 2008). Further, approach goals are considered to facilitate intrinsic motivation, such as problem-solving strategy, while avoidance goals have the opposite effect, inhibiting intrinsic motivation and intellectual performance (Elliot & McGregor, 1999). Elliot and McGregor (1999) designed a study to support the hypothesis that approach motivation facilitates and avoidance motivation inhibits intellectual performance. In their study, participants' achievement goals were assessed using Elliot and Church's (1997) achievement goal questionnaire. Items in the questionnaire are used to measure performance-approach and performance-avoidance goals, and responses are reported by participants on a 7-point scale. An example of a performance-approach item is "I am striving to demonstrate my ability relative to others in this class." A sample performance-avoidance item from the questionnaire is "I just want to avoid doing poorly in this class." After evaluating achievement goals, the participants were given a 50-question multiple-choice exam. Exam performance was measured by summing participants' correct responses. Elliot and McGregor (1999) found that the approach goals were positively related to exam performance, and that avoidance goals were negatively related to exam performance. In other words, those motivated by avoidance goals exhibited impaired performance relative to those motivated by approach goals. Finally, if motivational valence mediates any effect of color on intellectual performance (Maier et al., 2008), then there should be evidence of pre-existing color-valence associations.

Color Meanings

The idea that color carries meaning is a staple of the present investigation. The premise that color influences performance by way of approach-avoidance processes suggests that color is somehow associated with motivationally relevant stimuli. For example, if avoidance-based processes are activated by the sight of red, the color, in this case, is conveying information which is relevant as a cue to avoid an aversive stimulus. In order for red to work as an avoidance cue, in this example, red must have some association with aversive stimuli (Cacioppo & Gardner, 1999; Elliot & Maier, 2007). Consistent with this idea, there exist various explanations which account for the sources of color-valence associations.

Learning color meanings. Environmental stimuli which elicit affective reactions are often learned through consistent association of emotionally neutral stimuli with emotionally salient stimuli (Fellous, Armony, & LeDoux, 2002), a process known as classical conditioning. Classical conditioning is an extensively studied example of simple associative learning (Clark & Squire, 1998). By consistently pairing colors with motivationally relevant objects in everyday situations, conditioning is a likely source of color-valence associations. For example, red is commonly used to convey avoidance information, such as in stop signs, traffic lights, sirens, alarms, warning signals, terrorist alerts, and financial statements (Moller et al., 2009). Because of the consistent pairing of red and danger in daily situations, it is likely that red carries an avoidance connotation when a context is not otherwise specified. By the same reasoning, green is often used to convey safety and has the welcoming indication of “go” in traffic lights (Derefeldt, Swartling, Berggrund, & Bodrogi, 2004). Green is also perceived to be associated with success words (Moller et al., 2009), suggesting that the color green likely carries a generally positive connotation.

Empirical evidence of red carrying a negative connotation was reported by investigating the common practice of red pen use in grading situations. Writing in red pen has been commonly associated with evaluative harshness in academic settings (Rutchick, Slepian, & Ferris, 2010), often used by graders to denote errors and point out mistakes. Merely the sight of work returned with red marks results in aversive responses from students (Semke, 1984). Because of this association, it is likely that seeing the color red in such a setting primes avoidance concepts in both students and graders. Rutchick et al. (2010) suggested that even evaluators become more aversely motivated when using red ink. Through a series of experiments, the researchers demonstrated that participants using red ink, relative to other colors, completed more error-related words in a word-stem task, marked more errors when correcting essays, and awarded lower grades to those essays.

Additionally, the color red is more positively-associated early in life, but becomes less positively-associated after elementary school. Three-month-old infants show preference for long-wavelength colors (reds) over short-wavelength colors (blues; Bornstein, 1975; Zemach, Chang, & Teller, 2007), while adults tend to show the opposite pattern in laboratory settings (Adams, 1987). These observations suggest that the color red carries significant meaning relevant to affect in an academic setting, and that this association has been learned over a long period of time.

In contrast to longitudinal conditioning of color meaning, there also exists evidence of very rapid color-association learning. If an ambiguous word (e.g., MOVE or SENT) is consistently presented in a specific color (e.g., MOVE in blue text 75% of the time, SENT in green text 75% of the time), then participants will respond significantly quicker to the color-consistent pair (e.g., MOVE in blue) than to an inconsistent pair (e.g., MOVE in green). This effect is evident in as little as 18 trials (Schmidt, De Houwer, & Besner, 2010), suggesting that color associations can be learned quite rapidly.

Because color associations can be learned over time, it follows that an individual's experience can moderate different meanings for color. Ecological valence theory proposes that color preferences are determined by the average affective response to previously encountered objects associated with each color (Palmer & Schloss, 2010). Simply, people prefer colors associated with objects they like. Additionally, color preferences can be influenced by exposing people to colored objects with salient affective valence (Strauss et al., 2010). For example, exposure to green trees will increase preference for green, while exposure to green mold will decrease preference for green. Combined, these studies further indicate that color associations can be learned, and that color-associations can mediate color-preferences.

Neuroanatomy. In order to understand how these color-valence associations are processed to allow humans to evaluate the biological significance of a stimulus, it is helpful to explore the progression in which the brain encodes, stores, and retrieves associations between formerly meaningless and meaningful stimuli. By reviewing anatomical circuits in the trichromatic primate brain, it is certainly evident that communication between visual and memory systems allows for conditioning of color-valence associations. The first stage of retinal color processing is relayed through retino-geniculate channels where simple wavelength is first analyzed in visual cortical areas, V1 and V2. V4 receives wavelength discriminations and further processes for color constancy and some color categorization. The inferotemporal cortex is the final stage of analysis, where color categories are compared to prototypical templates regarding memory and learning. The cortical area TG takes the composite information and communicates with the emotional system of the amygdala (Kiernan & Barr, 2008; Nieuwenhuys, Voogd, & Huijzen, 2008; Walsh, 1999).

Visual information inputs to the lateral amygdaloid nucleus, and the lateral basal amygdaloid nucleus returns the feedback projections to all levels of the ventral visual processing stream (i.e., V1, V2, V4, inferotemporal cortex, and TG). One model of visual processing suggests that the neutral visual information to the lateral amygdaloid nucleus evokes emotional and motivational mechanisms, which is extensively processed via the complex intraamygdaloid connections, and the lateral basal amygdaloid nucleus returns the coded affective information to each of the visual areas (Iwai et al., 1990). Therefore, the amygdala does not only process affective states, but it also receives information about visual stimuli that can be associated with such states through learning (Rolls, 2003).

Biology. While it is clear that color associations can be learned over time, it can also be argued that the strength of such associations are compounded by, or even derived from, a biologically embedded penchant to associate colors with motivational value. The evolution of the trichromatic visual system is critical for red-green discrimination (Gegenfurtner & Kiper, 2003). A biological account of color meaning would explain color associations as a consequence of behaviorally significant color discriminations (Hurlbert & Ling, 2007), which arose from the signals conveyed by colors in the environment (Humphrey, 1976). For example, presence of red on the chest of a male primate can signal dominance, a negative message which deters lower-order males from approaching (Setchell & Wickings, 2005). In contrast, recognition of green would have facilitated the adaptive movement towards lush green landscapes, which signaled the indication of water, nutrients, and prosperity (Hartmann & Apaolaza-Ibáñez, 2010).

Context-Specific Color Effects

While there is considerable evidence which generally points to red as being avoidance-associated and green being approach-associated, contrary patterns exist. For example, protein-rich red leaves carry more adaptive value in contrast to mature green leaves (Dominy & Lucas, 2001), and some primate females have been known to advertise their sexual readiness with red bodily swellings (Nunn, 1999). Even humans in a laboratory setting will rate a stimulus person as more attractive if the image of the person is bordered by red (Elliot et al., 2010; Elliot & Niesta, 2008). However, such discrepancies can be accounted for with the specification of context. By differentiating between appetitive and aversive contexts, Maier, Barchfeld, Elliot, and Pekrun (2009) determined that infants preferred red in an appetitive context (primed by a smiling face), but avoided red in the aversive context (primed by an angry face).

Throughout much of the color psychology literature, contextual specificity has been mostly ignored (Elliot et al., 2009). Contextual specificity implies that a color can hold multiple, distinct meanings depending on the conditions of perception.

Throughout the previously mentioned investigations of color effects on intellectual performance, the participants took tests which would ostensibly be graded or scored. In these studies, the participants are put into an achievement context. That is, they are trying to attain high performance in a setting where they believe they will be evaluated. The influence of red in this context is presumed to be mediated by the association of red with failure. If no achievement context was specified (i.e., no explicit awareness of intent to grade), there would be no observable color effects (Elliot et al., 2009).

In an empirical investigation into the achievement-context dependency of the negative-red effect, Elliot et al. (2009) induced either an achievement context (where the participant would ostensibly be graded), or a non-achievement context (where the participant only expected to complete likeability ratings of the task). After receiving the color manipulation, the participants were asked to knock on the closed door of another room, a disguised behavioral measure. Those in the achievement context exhibited the negative-red effect; red-exposed participants knocked reliably fewer times than green-exposed participants, which was interpreted as behavioral avoidance. Those in the non-achievement condition displayed no differences between color groups.

Another example of context-dependency in color associations lies with a color-preference experiment. Kearney (1966) had participants rate individual colors as “warm” or “cool.” A pattern of wavelength was discovered, such that participants typically rated long wavelength colors (e.g., reds and yellows) as “warmer” but rated short wavelengths (e.g., blues and greens) as “cooler.” Following the initial ratings, the researcher manipulated the ambient temperature of the room and had another set of participants rate their color preferences. Results indicated that those in the cold room consistently preferred the warmer colors, and those in the warm room preferred the cooler colors.

These experiments suggest that the physical properties of color are not the only variables influencing affect, cognition, and behavior, but that color has distinct meaning depending on the context in which it is presented. This explanation gives a potential account of why past research might be littered with vast inconsistencies. For example, many studies have failed to support a general color preference model because of inconsistencies in preference ratings (Whitfield & Whiltshire, 1990). This shortcoming is possibly due to a lack of contextual control, meaning the failure to stipulate specific contexts from which to base judgments.

Given the evidence for strong negative associations with the color red in achievement contexts, that exposure to negative stimuli automatically activates avoidance motivational processes (Bargh & Chartrand, 1999), and that activated avoidance-motivational processes negatively influence intellectual performance (Elliot & McGregor, 1999), it was expected that perception of red would impair intellectual performance via avoidance processes. By a similar logical progression, the positively-associated color, green, was predicted to contribute positively to intellectual performance.

Enactment of Avoidance Behavior

Enactment of avoidance behavior (EAB) has been labeled as an implicit affective cue (Friedman & Förster, 2010), used to reliably prime avoidance processes in past research (Förster, Friedman, Özelsel, & Denzler, 2006; Friedman & Förster, 2001, 2005a, 2005b; Neumann & Strack, 2000). Evidence from EAB research suggests that manifestations of behavior consistent with approach-avoidance dimensions subsequently facilitate their appropriate motivational systems. For example, a task which requires physical engagement (i.e., enactment) representative of avoiding a stimulus (e.g., evading danger) is semantically consistent with avoidance motivation and will elicit avoidance processes in an individual.

Friedman and Förster (2001) developed such a task in which participants would enact either approach or avoidance cues by completing a paper-and-pencil maze. In the approach condition, a mouse was depicted in the center of a circular maze with a piece of cheese lying outside. The participant's instructions were to "find the way for the mouse." In this case, the participant activated the semantic concept of approaching a desirable stimulus. In the avoidance condition, the maze and instructions were identical except for replacing the cheese with an owl hovering above, presumably ready to catch the mouse if it did not escape. In this case, the participant activated the semantic concept of avoiding an aversive outcome. As mentioned previously, constricted attentional focus is a consequence of avoidance-motivation activation (Maier et al., 2008). Förster et al. (2006) found that participants who completed the owl (avoidance) maze exhibited a more constricted attentional focus than those who completed the cheese (approach) maze. Specifically, those with a more constricted focus of attention responded quicker to local perceptual features of an object while responding slower to global perceptual features of an object.

Friedman and Förster (2005b) extended this finding using a Stroop paradigm. The Stroop task is a well-known measure in which participants are presented with color words (e.g., the word "red") but are required to name the color of the ink in which the words are printed. The color and word can be congruent ("red" printed in red ink) or incongruent ("red" printed in blue ink). The Stroop task can be considered a measure of attentional focus because responding to the incongruent pair requires breaking the mental set by diverting attention from the natural inclination to respond to the color word and focusing on the goal of responding to the color itself (MacLeod, 1991). Friedman and Förster (2005b) found that participants cued with the avoidance maze were slower to respond to the incongruent colors than those cued with the approach maze, suggesting a more constricted attentional focus for those motivated aversely.

Electrophysiological evidence supports the notion that approach and avoidance cues activate distinct motivational states. Davidson, Ekman, Saron, Senulis, and Friesen (1990) employed an electroencephalogram measure to demonstrate differences in cerebral hemispheric activity during either appetitive or aversive experiences. While appetitively motivated (watching a 60 s clip intended to evoke positive emotions), participants exhibited greater relative left-hemispheric activity in the anterior temporal region. While aversely motivated (watching a 60 s clip intended to evoke negative emotions), participants showed greater relative right-hemispheric activity in the frontal and anterior temporal regions.

Anagrams

Anagram solving has long been used as a measure of intellectual functioning (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Gavurin, 1967b; Sarason, 1961). Anagram tasks involve a participant being presented with a scrambled set of letters (for example, LENAK) for which they have to find the single correct solution word using those letters (for example, ANKLE). As expected from a measure of intellectual performance, there are frequently documented individual differences in anagram solving ability (Elliot et al., 2007; Gailliot, Plant, Butz, & Baumeister, 2007; Gavurin, 1967a; Gordijn, Hindriks, Koomen, Dijksterhuis, & Van Knippenberg, 2004). Additionally, anagram solving involves a participant holding and manipulating information within working memory (Masicampo & Baumeister, 2011), which are executive functions (Miyake et al., 2000; Shimamura, 2000). Based on executive function research (Baddeley, 1992), we should expect to see differences in overall anagram solving ability between individual participants.

There are several previously investigated predictors of anagram difficulty. Some previous research has focused on factors related to the features of the solution word, such as frequency and familiarity. Others have focused on factors related to anagram construction, such as pronounceability (Gilhooly & Johnson, 1978). Two word-frequency measures that have been often studied as important predictors of anagram difficulty are bigram rank (BR) and greater-than-zero (GTZero; Knight & Muncer, 2011). A bigram is a two-letter sequence (for example, *be* is a bigram of BEACH). These frequency measures are based on counts of a bigram in specific positions in a word. Because there are four bigram positions in a five-lettered word (for example *be*, *ea*, *ac*, and *ch*), there are 20 different possible combinations of bigrams for five-lettered words. To compose a matrix of all possible combinations of bigrams in each possible position would require 80 cells. BR is the total number of cells in the matrix that contain more frequent incorrect bigram entries than correct bigram entries (Mendelsohn & O'Brien, 1974). For example, *he* is an incorrect bigram because this sequence does not appear in BEACH. However, it appears more frequently in certain positions in the matrix than correct bigrams. The more likely this is to happen, the higher the BR value, and, therefore, more difficult to solve because it draws more competition for the possible locations of the letters. GTZero is the total number of bigrams in a word with a frequency greater than zero in the matrix (Mendelsohn, 1976). For example, the matrix would have more greater-than-zero entries for *ca* and *ch* because these bigrams would appear as correct bigrams in other words, while *hb* and *bh* would not appear as correct bigrams in any other words. The more entries that are greater-than-zero, the more difficult the anagram is to solve because of more possible correct competitions. Both of these frequency measures have been found to be highly predictive of anagram difficulty (Gilhooly, 1978).

Additionally, the number of syllables in a presented anagram contributes to difficulty in word solving. Muncer and Knight (2011) showed that the number of syllables in a 5-letter anagram had a large effect on solution difficulty. By reanalyzing past anagram studies, the researchers discovered that the number of syllables was often a confound, finding that three-syllabled words were more difficult to solve than two-syllabled ones, which were likewise more difficult to solve than one-syllabled words. Muncer and Knight (2011) suggest that number of syllables had a larger effect than other variables being examined in past anagram studies.

Anagram difficulty can also be predicted as a function of letter-moves (Dominowski, 1966). For example, consider the original pattern to be 12345 (e.g., ALBUM). To solve an order of 31425 (e.g., BAULM) requires two letter-moves, by placing 2 (L) and 3 (B) between 1 (A) and 4 (U). If a different pattern, 21435, was implemented, a different anagram would be constructed (e.g., LAUBM), but still would require two letter-moves to solve. Solving an anagram with the pattern 13425 (e.g., ABULM) would require only one letter-move. The more letter-moves required to solve an anagram increases its difficulty.

Method

The current study sought to replicate past research where red was reported to impair intellectual performance (Elliot et al., 2007). Red was chosen as the avoidance-consistent color based on strong negative associations with the color (Moller et al., 2009). Green was chosen as a chromatic contrast to red because of its seemingly opposite connotations (e.g., go vs. stop, safety vs. danger, etc.; Derefeldt et al., 2004). Unique to this study, the inclusion of an EAB condition allowed the assessment of red as an implicit affective cue (Friedman & Förster, 2010), by comparing the effects of red and EAB side by side. The dependent variable was anagram performance.

Participants

There were 173 (53 men, 120 women) Appalachian State University (ASU) undergraduate students (M = 19.4 years old) who participated in the experiment to receive course credit. Participants volunteered for the study by selecting among experiments provided through the Department of Psychology's online recruitment system. All participants were treated with adherence to ethical standards as outlined by the ASU Institutional Review Board (IRB). The current study was approved and determined to be exempt from further review by the IRB Office under "exemption category (2) Anonymous Educational Tests; Surveys, Interviews, or Observations under 45 CFR 46.101(b)." Notice of exemption was given on April 14, 2011. See Appendix A for a copy of the IRB approval.

Design

To determine intended sample size, GPower (version 3.1.2; Erdfelder, Faul, & Buchner, 1996) was used to conduct a power analysis based on previously reported color effects (Elliot et al., 2007). Given a moderate effect size, f = .31, the probability of making a type I error, α = .05, and the researchers' three manipulation groups, the power analysis indicated 160 total participants should provide sufficient power to detect the effects of interest. Therefore, the present study aimed to include forty participants for each of the four manipulation conditions (the three color conditions and the addition of the EAB condition). Participants were assigned randomly to one of four between-subjects conditions: red (n = 42), green (n = 41), gray (n = 45), or enacted avoidance behavior (EAB, n = 45).

Materials

The experiment was programmed using E-Prime (version 2.0). Participant data were collected using Dell Optiplex 780 computers with Dell P2210 monitors. A Datacolor Spyder 3 Elite colorimeter was used to assure accurate color representation based on the specified values. This colorimeter measures the spectral output of the monitor, as well as the ambient light in the room, to automatically calibrate the monitor and provide standardized color values.

Color presentation. The colors were categorically red (as the hypothesized avoidance-associated color), green (a chromatic contrast to red), and gray (an achromatic control color). The computer was programmed to display the colors using RGB values [255,0,0], [0,255,0], and [85,85,85], respectively. The corresponding CIE LCh values (lightness, chroma, and hue) are red, LCh[53.23, 104.58, 40]; green, LCh[86.19, 117.99, 136.02]; and gray, LCh[36.15, -, 253.36].

Enacting avoidance motivation. In the EAB condition, participants filled out a paper-and-pencil version of the owl maze (Friedman & Förster, 2001) in place of the color manipulation. The task depicted an owl hovering over a maze with a mouse in the center. The puzzle directed the participant to “find the way for the mouse before the owl swoops down and catches it.” See Figure 1 for a copy of the EAB maze.

Intellectual performance. To assess intellectual performance, 20 moderately difficult anagrams were selected from a published list of anagrams with multiple measures of difficulty, including BR and GTZero (Gilhooly, 1978). For a practice anagram task, 20 additional anagrams were selected in the same fashion. All anagrams were five-letters, had a single solution, and were of comparable difficulty. All anagrams were constructed identically using the order 45213. For example, if the solution, “ALBUM,” is ordered 12345, then the anagram was constructed as “UMLAB.” All anagrams were constructed using this 45213 pattern. The dependent measure was anagram performance (i.e., the number of correctly solved anagrams). Premanipulation practice anagram performance was measured as a covariate. See Table 1 for a complete list of anagrams used.

Procedure

Participants were greeted by the experimenter and seated at a computer with their condition-specific program preloaded. All instructions and tasks, unless otherwise noted, were read and performed from the computer. See Appendix B for a copy of the informed consent form participants were required to read before proceeding. The participants were introduced to the anagram task with instructions to unscramble the letters into the correct order. Participants were further briefed that they would have 5 min to complete a practice anagram test, which would be followed by another 5 min anagram test to be graded. The participants read the instructions for the anagram task and indicated when they were ready to proceed. They were then given 5 min to complete the practice anagram task, where the data for premanipulation anagram performance were collected. Following the practice task, the participants indicated they were ready to proceed to the ostensibly real test. At this time, the manipulation was instantiated as follows. The participants received a brief reiteration of the anagram-task instructions on the monitor, with text color being matched to their condition (red, green, or gray), for exactly 5 s. Those in the EAB condition received instructions for, and completed, the owl maze (using paper and a pencil) before receiving the reiterated anagram instructions (text color gray, as in the control). See Appendix C for complete instructions to the anagram and maze tasks. Participants then had 5 min to complete the anagram task. When the participants concluded the task, they were asked to report sex, age, and were probed for awareness by describing the perceived purpose of the experiment. Participants indicating awareness of the color manipulation would have been discarded from subsequent analysis. Finally, the participants were screened for color blindness using a short, 8-item version of the Ishihara Color Test, which is capable of identifying red-green color deficiencies (Ishihara, 1972).

Results

No participants mentioned color in their response to the awareness debriefing. One participant’s data were excluded from analysis after detection of color-blindness. A univariate (red vs. green vs. gray vs. EAB conditions) between-subjects analysis of covariance (ANCOVA) was conducted on anagram performance (*M* = 8.33, *SD* = 10.56) with premanipulation anagram performance (*M* = 6.23, *SD* = 5.13) as a covariate. Planned comparisons with least significant difference testing provided evaluation of directional hypotheses. As expected, there was an effect of premanipulation anagram performance on anagram performance, $F(1, 168) = 118.29$, $p < .001$, $\eta_p^2 = .41$, meaning those who were better at solving anagrams in practice continued to do better the second time. There was also a main effect of manipulation condition on anagram performance, $F(3, 168) = 3.22$, $p = .024$, $\eta_p^2 = .054$. When included as a fixed effect, there was no effect of participant sex, $F(1, 164) = 0.55$, $p = .46$, $\eta_p^2 = .003$, so no further analysis was conducted with this variable.

Table 2 shows the unadjusted descriptive statistics of anagram performance by condition. The table shows the means and standard deviations of correctly solved anagrams between red, green, gray, and EAB groups. Results in the table show that people in the green condition (*M* = 11.02, *SD* = 15.35) correctly solved more anagrams than those in the red (*M* = 7.26, *SD* = 9.49), gray (*M* = 9.22, *SD* = 10.39), and EAB (*M* = 5.98, *SD* = 3.92) conditions.

Planned comparisons did not fully support the specific hypotheses. Table 3 shows the means of anagram performance, after being adjusted for the covariate, premanipulation anagram performance. I expected that those in the green condition would correctly solve more anagrams than those in the red and EAB conditions. In support of this hypothesis, participants in the green condition correctly solved more anagrams than those in the red, $t(80) = 2.84$, $p = .005$, $\eta_p^2 = .046$, and EAB, $t(83) = 2.53$, $p = .012$, $\eta_p^2 = .037$, conditions.

Further, I expected that those in the green condition would correctly solve more anagrams than those in the gray control condition; however, the difference of correctly solved anagrams between green and gray conditions did not reach statistical significance, $t(83) = 1.97$, $p = .051$, $\eta_p^2 = .023$.

Additionally, I expected that red and EAB conditions would perform comparably. Consistent with this hypothesis, performance between red and EAB conditions did not differ, $t(84) = 0.36$, $p = .72$, $\eta_p^2 = .0008$.

Finally, I expected that red and EAB performances would be significantly impaired relative to the gray control condition. This hypothesis was not supported, in that there were no significant differences in performance between gray and red, $t(84) = 0.92$, $p = .36$, $\eta_p^2 = .005$, or between gray and EAB, $t(87) = 0.56$, $p = .57$, $\eta_p^2 = .002$, conditions.

After these preliminary analyses, I discovered a problem with the anagram procedure. Figure 2 shows boxplots of the 4 conditions. The boxplot represents the numeric quartile data of each condition as well as identifies frequency of outliers. Note the number of outliers which are above 20 correct solutions. While participants only had 20 possible anagrams to solve, E-prime continued to present previously solved anagrams to the participants. In these cases, the participants could continue to improve their anagram performance scores. In one case, a participant completed as many as 83 anagrams. This error was not revealed in pilot testing. Discussion of the results and implications of this error will follow.

Discussion

The results of the current study indicate a partial replication of past research. Perception of the color red impairs subsequent intellectual performance relative to viewing green. Further, the unique contribution of the present study is the suggestion that red acts in a similar fashion as EAB, supported by the comparable anagram performances between those groups. However, neither red nor EAB groups differed significantly from the achromatic control group. While those who viewed green exhibited the highest performance of the groups, the difference between green and control groups also failed to reach statistical significance. The present findings partially support the theory that perceiving red subsequently activates avoidance processes, which inhibits problem-solving when achievement is at stake. It is likely that EAB acts in a similar manner. In contrast, perception of green appears to elicit approach processes, which facilitate problem-solving in the same context. These effects were subtle enough to be detected only when compared to each other, but not when compared to a control group.

Given the current interpretation of the results, it also became evident that the anagram task was not as rigorously controlled as hoped. After noticing that the present arithmetic means were well above previously reported values, further examination of the data confirmed a deficiency in the anagram task. First, it was clear that participants were solving, and in some cases resolving, more anagrams than allowed (e.g., completing 30 anagrams when there were only 20 different anagrams in a given task). This was an unexpected finding that did not occur during pilot trials. Further, I suspect that, because all anagrams were constructed in an identical pattern, some participants merely identified that pattern and rearranged letters accordingly. Second, discovering the anagram pattern would lead to quick solutions which, in turn, meant that people would see the same anagram multiple times. This would have allowed for such an elevation of performance scores.

Limitations and Future Directions

Anagrams. When constructing all anagrams for the present study, the same pattern was used. For example, constructing ALBUM using the pattern 45213 resulted in UMLAB. All anagrams were constructed using the 45213 pattern. Therefore, a participant who determined the pattern would have been able to forgo solving anagrams individually and instead “plug in” the letters of the anagram according to the pattern. It is, however, possible to alternate patterns while still controlling for difficulty. This can be done by rearranging patterns in a different series, but in the same number of letter moves. For any five-lettered word there are 61 possible two-move anagram-orders, all with comparable difficulty (Dominowski, 1966). Rearranging anagrams by the same number of letter-moves, but with differing patterns, would eliminate the current problem while still controlling for difficulty.

An additional component of anagram construction, which was not addressed in the current study, is the role of syllables in anagram difficulty. Past research has not paid much attention to the importance of syllables in anagram solving (Adams, Stone, Vincent, & Muncer, 2011). The anagrams used in the present study were not rated with any mention of syllabic differences (Gilhooly, 1978). A recent study has determined that the number of syllables is important for anagram solving, specifically suggesting that polysyllabic words are harder to solve than monosyllabic ones (Adams et al., 2011). The anagrams chosen for the present study varied in syllables, which will be corrected by a more careful selection of equal syllabled anagrams.

Colors. The colors chosen were based on categorical values of red, green, and gray, without continuously controlling for other properties of color (i.e., equating lightness and chroma while varying only hue). The benefit of this method is an increase in ecological validity. For example, while color changes continuously in color space, it is recognized categorically across cultures and species (Komatsu, 1998). Adhering to both biological and conditioned explanations of color-meaning associations, it is reasonable to note that humans and other primates do not regularly experience colors equated on other dimensions in their environments. Nevertheless, this limitation will be addressed in a future study by equating lightness and chroma while manipulating hue.

EAB condition. By using only the “owl” maze and excluding the “cheese” version used by Förster et al. (2006), there lies an unlikely confound such that semantic avoidance engagement does not account for the impaired performance, but that it is a result of engagement in general. This is a reasonable claim considering that the owl (EAB) condition was the only one that involved any physical engagement in a task. The choice to exclude the approach (cheese) version of the maze was made based on past research (Förster et al., 2006). Based on such research, there was not expected to be a difference between approach (cheese condition) and control groups because of a ceiling effect where individuals tend to initially exhibit approach processes in general (Förster et al., 2006). Additionally, pilot testing indicated that participants took less than 1 min to complete the maze and reported it to be “very” easy, which suggests that the observed effect was much more likely a result of semantic processing than the minimal effort required of the task. However, inclusion of the approach-equivalent maze in the future would be beneficial to determine if perception of green acts as an approach cue, in addition to the hypothesis that red acts as an avoidance cue.

Conclusion

After discovering methodological deficiencies in the anagram task, there are clear directions on how to correct them moving forward. Nevertheless, the current study gives evidence that perception of color can influence cognitive functioning. Decisions to use color in a variety of contexts are often products of aesthetic preferences. In light of current evidence, however, perhaps more attention should be paid when considering what colored clothes to wear, paint to decorate, and even pens to use. This notion is especially applicable in testing environments where colored environments or stimuli are rarely controlled. While the recent research has increasingly provided awareness of the consequences of simple color manipulations in laboratory settings, more work is needed to generalize these effects to the natural environment where mixtures of colors continuously assail the visual system. If color acts as an affective cue, as the current research suggests, then more needs to be said about color meaning conveyance in more contexts and with more colors. Future research in the area of color psychology is intriguing and should continue to explore the cognitive, affective, and behavioral implications of such a ubiquitous stimulus.

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Table 1

Complete List of Words Used in Premanipulation and Postmanipulation Anagram Tasks

Premanipulation		Postmanipulation	
Solution	Anagram	Solution	Anagram
ALBUM	UMLAB	ANKLE	LENAK
APRON	ONPAR	BATON	ONABT
BLADE	DELBA	BRAWL	WLRBA
BUYER	ERUBY	CRAFT	FTRCA
CRAMP	MPRCA	DEMON	ONEDM
DRAWL	WLRDA	FAULT	LTAFU
FLAKE	KELFA	FLAME	MELFA
FLIRT	RTLFI	FORUM	UMOFR
FRAUD	UDRFA	GLEAM	AMLGE
HAVOC	OCAHV	INDEX	EXNID
INPUT	UTNIP	KNIFE	FENKI
LIMBO	BOILM	LOGIC	ICOLG
MEDAL	ALEMD	MERCY	CYEMR
MIXER	ERIMX	OPERA	RAPOE
ORBIT	ITROB	PERCH	CHEPR
PILOT	OTIPL	PIVOT	OTIPV
PRIZE	ZERPI	POWER	EROPW
SCARF	RFCSA	SCOUT	UTCSO
SNACK	CKNSA	UNCLE	LENUC
VIPER	ERIVP	VIRUS	USIVR

Note. Words came with difficulty ratings from Gilhooly (1978).

Table 2

Unadjusted Descriptive Statistics of Anagram Performance by Condition

Condition	*n*	*M*	(*SD*)
Red	42	7.26	(9.49)
Green	41	11.02	(15.35)
Gray	45	9.22	(10.39)
EAB	45	5.98	(3.92)
Total	173	8.33	(10.56)

Note. EAB = Enacted avoidance behavior.

Table 3

Descriptive Statistics for Anagram Performance Adjusted for Premanipulation Anagram Performance

				95% Confidence Interval	
Condition	*n*	*M*	*SE*	Lower Bound	Upper Bound
Red	42	6.56	1.24	4.11	9.02
Green	41	11.59	1..26	9.10	14.07
Gray	45	8.15	1.20	5.78	10.53
EAB	45	7.19	1.20	4.81	9.57

Note. EAB = Enacted avoidance behavior.

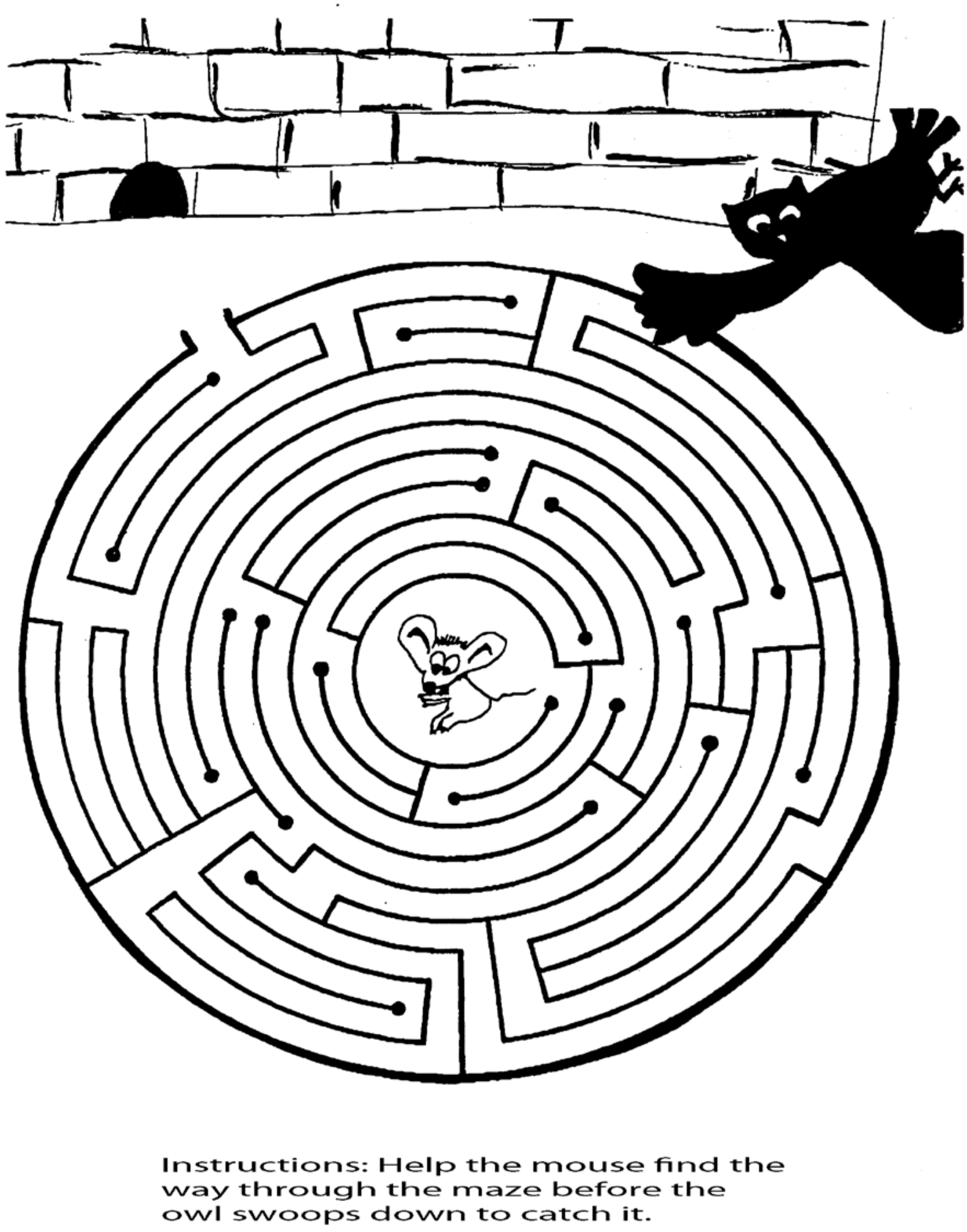

Figure 1. Owl maze participants completed in the enacted avoidance behavior conditions.

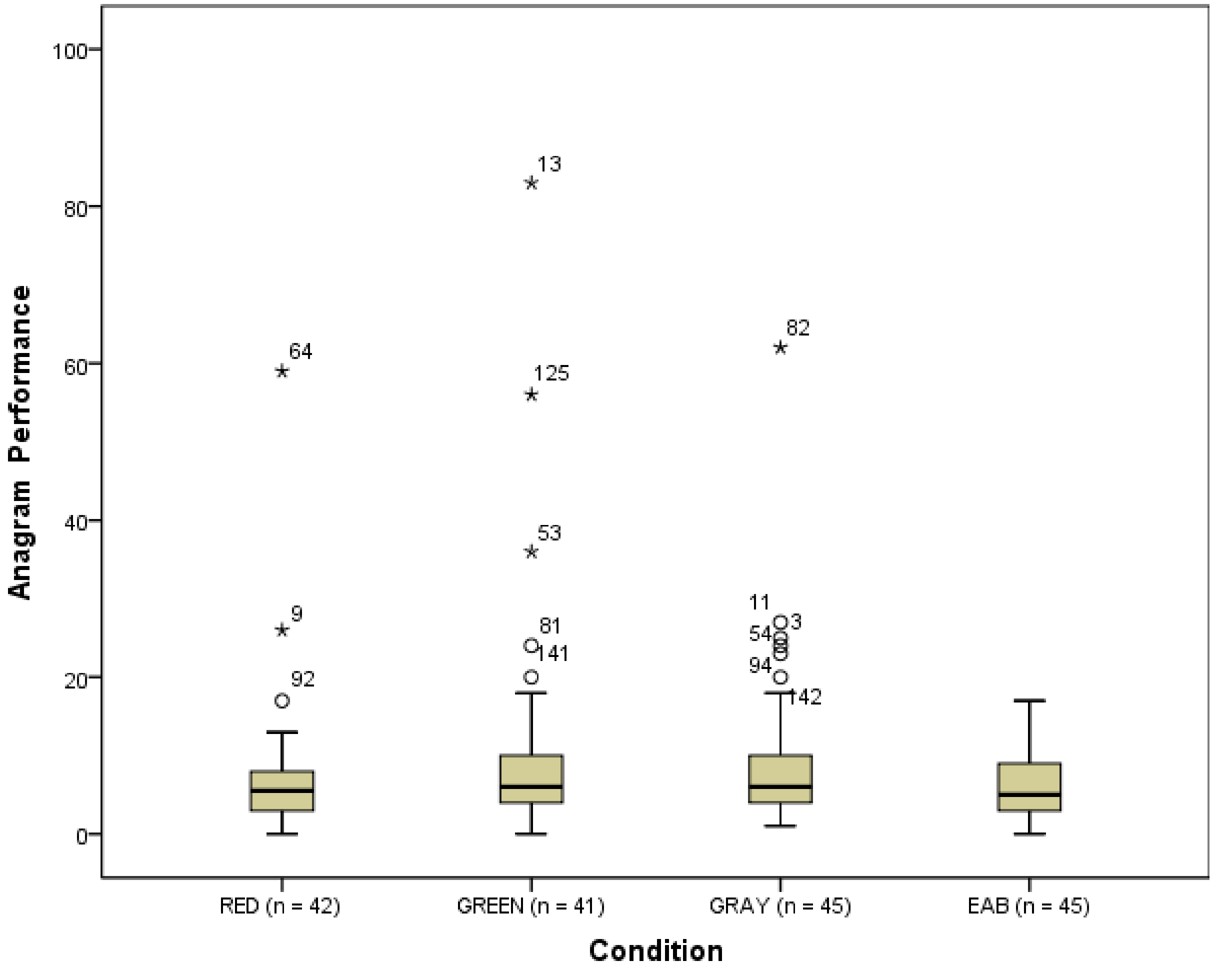

Figure 2. Overview of outliers in the post-manipulation anagram task as a result of a programming error. Participants were given up to 20 different anagrams to solve but were, in some cases, allowed to continue entering correct responses. Flagged markers represent participant (case) numbers. EAB = enacted avoidance behavior.

Appendix A

To: Christopher Thorstenson
Psychology
CAMPUS MAIL

From: Robin Tyndall, Institutional Review Board

Date: 4/14/2011

RE: Notice of IRB Exemption

Study #: 11-0265

Study Title: The Effect of Color Perception and Enacted Avoidance Behavior on Intellectual Performance and Attentional Focus
Exemption Category: (2) Anonymous Educational Tests; Surveys, Interviews or Observations

This submission has been reviewed by the IRB Office and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b). Should you change any aspect of the proposal, you must contact the IRB before implementing the changes to make sure the exempt status continues to apply. Otherwise, you do not need to request an annual renewal of IRB approval. Please notify the IRB Office when you have completed the study.

Best wishes with your research!

CC:
Kenneth Steele, Psychology

Appendix B

Appalachian State University

Consent to Participate in Research
Information to Consider About this Research

Intelligence and Puzzle Task Performance
Principal Investigator: Christopher Thorstenson
Department: Psychology
Contact Information:
Dr. Ken Steele
Department of Psychology
Appalachian State University
Boone, NC 28608
Phone: 828.262.2731

What is the purpose of this research?
You are being invited to take part in a research study about performance on intelligence tests and puzzles. If you take part in this study, you will be one of about 200 people to do so. By doing this study we hope to learn what influences intelligence and puzzle performance.

What will I be asked to do?
The research procedures will be conducted at Smith-Wright Hall room 201. You will need to come here 1 time during the study. That visit will take about 30 minutes.
You will be asked to complete puzzles and an IQ test

You should not volunteer for this study if are under 18 years of age.

What are possible harms or discomforts that I might experience during the research?

To the best of our knowledge, the risk of harm for participating in this research study is no more than you would experience in everyday life. We know about the following risks or discomforts that you may experience if you choose to volunteer for this study:

- *If looking at a computer screen for 30 minutes is extremely uncomfortable for you, let the experimenter know.*

During the course of this research, if we find out any new reason why you may no longer wish to participate, we will provide you with that information.

What are the possible benefits of this research?

There may be no personal benefit from your participation but the information gained by doing this research may help others in the future.

This study should help us learn about factors that influence intelligence tests and puzzle performance.

Appendix B (continued)

Will I be paid for taking part in the research?

We will not pay you for the time you volunteer while being in this study. You are eligible for class credit by participating in this study. You will receive 1 ELC credit for 30 minutes of participation.

How will you keep my private information confidential?

Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about the combined information. You will not be identified in any published or presented materials.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you.

There will be no documents linking your name with the research data

Who can I contact if I have questions?

The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact Christopher Thorstenson at thorstensonca@appstate.edu If you have questions about your rights as someone taking part in research, contact the Appalachian Institutional Review Board Administrator at 828-262-2130, through email at irb@appstate.edu or at Appalachian State University, Office of Research and Sponsored Programs, IRB Administrator, Boone, NC 28608.

Do I have to participate? What else should I know?

Your participation in this research is completely voluntary. If you choose not to volunteer, there will be no penalty and you will not lose any benefits or rights you would normally have. If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. There will be no penalty and no loss of benefits or rights if you decide at any time to stop participating in the study.

Sometimes the researchers may determine that your participation is no longer needed. We will notify you if you should no longer participate in this study.

The IRB determined that this research project is exempt from IRB approval as (2) Anonymous Educational Tests; Surveys, Interviews or Observations under 45 CFR 46.101(b).

I have decided I want to take part in this research. What should I do now?

The person obtaining informed consent will ask you to read the following and if you agree, you should indicate your agreement:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I understand that I can stop taking part in this study at any time.
- I understand I am not giving up any of my rights.

By continuing on to the experiment you acknowledge you have read and agree to the descriptions and terms outlined in this consent form, and voluntarily agree to participate in this research.

Appendix C

[Introduction]

You will now be completing a series of word puzzles. You will see a word with the letters in the wrong order, and your task is to unscramble the letters into a real word.

You may skip words by entering a blank response, but only correctly solved words will count towards your score.

You will have 5 minutes to complete a practice test and then will start the real test. After the practice you will have 5 minutes to solve as many sets as possible.

You will be graded on your performance. Please press SPACEBAR to begin the practice task.

[Maze directions. Only those in the EAB condition received these.]

In front of you should be a sheet of paper with a maze printed on the other side.

When you are ready turn the paper over and notice that in the center of the maze there is a mouse with an owl hovering above. Your task is to find the way for the mouse before the owl swoops down and catches it.

Please use a pencil to draw the way from the mouse to the exit. You have 5 minutes to complete this task.

Begin now. Press SPACEBAR when you have completed the maze.

Appendix C (continued)

Press Space to continue to the scored test.

[Anagram-task reiteration, text was colored according to assigned condition. Presented for exactly 5 seconds.]

Solve as many sets as you can in 5 minutes, your performance will be scored.

Note. Bracketed text was not visible to the participant.

VITA

Christopher Thorstenson was born in Miami, Florida, on October 31, 1986. He graduated from Lake Brantley High School in Altamonte Springs, Florida, in 2005. The following fall, he entered Florida State University to study Psychology and Philosophy, and in May 2009 he was awarded the Bachelor of Science degree. In the fall of 2010, he accepted a research assistantship in General Experimental Psychology at Appalachian State University and began study toward a Master of Arts degree. The M.A. was awarded in May 2012. In September, 2012, Mr. Thorstenson will commence work toward his Ph.D in Social Psychology at The University of Rochester.