The Effect of Color on Conscious and Unconscious Cognition

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Abstract

Two experiments explored the hypothesis that colors produce different cognitive learning motivations: red produces an avoidance motivation and blue produces an approach motivation. The avoidance motivation results in better performance on detail-oriented tasks, and the approach motivation results in better performance on creative tasks. To test this prediction, the first study used a signal detection task manipulating word valence and color to independently measure (a) the ability to discriminate previously seen words from new words and (b) response bias. The second study used process dissociation, a method that separates conscious recollection from unconscious memory, to measure the effect of color and divided vs. full attention on a word-stem completion task. In both studies the effect of color was found to be non-significant while the secondary effects (word valence in the first study and attention in the second study) were found to be significant. These studies call into question the idea that color strongly influences cognitive task performance.

The Effect of Color on Conscious and Unconscious Cognition

Color is an important part of human perception. Many everyday objects have been designed to convey a message through color. The way that colors effects psychological processing has not been fully explained. In particular, past studies on the effect of color on cognitive tasks have presented contradicting results (Mehta & Zhu, 2009). These studies have often only assessed two of the three primary colors at a time and still had contradicting results. Most studies focus on comparing red to either blue or green. The results from the studies have been a mix with some of the studies showing red to enhance cognitive task performance over blue or green and the other studies showing the opposite affect.

Mehta and Zhu (2009) explain these results through achievement motivation theory. Different colors enhance different achievement motivations, which can then affect the performance on different types of cognitive tasks. For color to affect the performance on cognitive tasks, Elliot and Maier (2007) state six premises that must be met. First, color should be able to carry a specific meaning. If color were merely for aesthetic purposes then it would not have influence over psychological functioning. Second, the meaning of colors is based both on learned associations and on biological responses. For example, in an academic setting, red is often coupled with mistakes. A teacher corrects a paper is a red pen; this is a learned association. Biologically red can be a signal of danger as in some cases of an ape’s attack readiness (Maier, Elliot, & Lichtenfeld, 2008). Blue is more often associated with openness and peace instead of danger (Mehta & Zhu, 2009).

The third premise is that the perception of color alone will cause evaluative processes. Evaluative processes are defined as determining whether a stimulus is harmful or hospitable (Elliot & Maier, 2007). Fourth, these evaluative processes, which are caused by the perception of color, influence motivated behavior. Colors with a positive association would trigger an approach motivation, while colors with a negative association would trigger an avoidance motivation.

The fifth premise is that the influence of color on psychological functioning is implicit and automatic. The activation of the motivation behavior takes place without awareness. The sixth premise is that the meaning and effects of color are based on context. In different contexts a color can have different associations. Within an achievement setting, red is associated with danger and mistakes. If you are in a social context, red can be associated with romance and will then have a more positive association (Elliot & Niesta, 2008).

Based on these six premises, in an achievement context, red would be assumed to evoke an avoidance motivation and blue would be assumed to evoke an approach motivation. Red would evoke negative associations, which would trigger the avoidance motivation and blue would evoke positive associations, which would trigger the approach motivation. Previous research has also shown that participants shown read prefer easier test items, have more right prefrontal cortex activity, and show evidence or local focus, which are all associated with avoidance motivation (Elliot, Maier, Binser, Friedman, & Pekrun 2009).

Achievement Motivations

Though different colors can evoke different achievement motivations, how do these motivations influence cognitive task performance? Achievement motivation theory suggests that people try to obtain their goals through two different methods (Zhu &

Meyers-Levy, 2007). People either view their goals as a desire and wish or they view their goals as a responsibility and requirement. When people view their goal as a desire, they are more aware of the presence of a positive outcome (reaching the desired goal). In contrast, when people view their goal as a responsibility, they are more aware of the presence of a negative outcome (failing to reach the desired goal). The approach motivation is where the person views their goal as desire and is more aware of the positive outcomes. The avoidance motivation is where the person views their goal as a responsibility and is more aware of the negative outcomes. In both motivations, the person is trying to reach a goal but in one they want to reach the best outcome while in the other they just want to avoid failing.

Approach and avoidance motivations are conceived as midlevel constructs (Elliot & Church, 1997). These motivations are between global motivations (larger goals that the person hopes to obtain) and specific behaviors (current actions that the person could perform). The approach and avoidance motivations can be explained as the need to achieve and the need to avoid failure. Because of their hierarchical locations, achievement motivations can act as immediate regulators of behavior. Both physical behaviors and cognitive processes are influenced by these midlevel motivations.

Moods and emotions are a conscious way to evoke the approach and avoidance motivations. They both have been shown to have influence on cognitive task performance (Phillips, Bull, Adams, & Fraser, 2002). Positive moods have been shown to increase the performance on some cognitive tasks and to decrease the performance on others. Being in a positive mood has been shown to enhance tasks that involve creativity, and those that involve the recall of happy memories. The feelings of happiness tend to increase the tendency to generate free associations and can then increase the ability to solve insight problems (Kuschel, Forster, & Denzler, 2010). Positive mood has been shown to impair cognitive tasks involving assessing memory, deductive reason, and planning. It is hypothesized that positive mood enhances tasks because it increases a person's ability to reinterpret material and switch between cognitive sets. Positive mood may increase the load on working memory, which causes poorer performance on cognitive tasks. Phillips, Bull, Adams, and Fraser (2002) show that positive mood can both enhance and impair cognitive task performance. On creative tasks positive mood enhances the performance, while on more detail-oriented tasks, positive mood inhibits the performance.

Kuschel, Forster, and Denzler (2010) explain these results through the cognitive tuning model. This model suggests that an individual's internal state informs them about their current situation, whether it is dangerous or safe, and can then conveys the processing requirements for that situation. Negative states signal a problematic or dangerous environment and will then convey a more systematic and detail-oriented processing style. While in this processing style, each solution that could change the situation would be carefully assessed and less creative thinking would be used because untested solutions could act to make the current situation worse. On the other hand, positive states signal a safe environment and will convey a more risky processing style. It is thought that internal knowledge structures desire to be enriched with new information and this can lead to more creative thinking.

Mood is one influencer of cognitive tuning, but it does not always have to be a conscious signal that an individual is aware exists (Kuschel, Forster, & Denzler, 2010). There are many signals, both implicit and explicit, that inform an individual about their current situation and can then modify the individual’s thought and behaviors. It has been shown that implicit signals also influence an individual’s thinking through cognitive tuning processes. This shows that color, which has been shown to evoke approach and avoidance motivations, can have the same effect on cognitive task performance as moods and emotions.

The cognitive tuning theory suggests how an individual interprets their environment is based on their perception of it. These interpretations then influence the way the individual think and have an effect on cognitive task performance. Zhu and Meyers-Levy (2007) explain these differences through two elaborations that an individual can do to the perceived information. The individual can either elaborate on the relational aspects or on the item-specific aspects. Individuals using an approach motivation tend to focus on the relational elaborations while individuals using an avoidance motivation tend to focus on the item-specific elaborations. When elaborating on item-specific features, an individual is more focused on the details and will not be as creative. When elaborating on the relational features, an individual will be more creative in their solutions.

Kuschel, Forster, and Denzler (2010) and Friedman and Forster (2005) have a related theory to that of elaboration through the access to higher order thinking. They showed that approach motivation helps increase access to higher order representations while avoidance motivation leads to more of a focus on immediate features and decreases access to higher order structures. The higher order information includes contextual information and structural relations for organization. When looking for creative solutions, it is important to go beyond the provided information and to use higher order information to find new solutions. An individual is then able to find new or uncommon solutions that may not have been apparent from the provided information. Different colors are then able to influence performance on detail-oriented or creative tasks by introducing one of the achievement motivations.

This paper describes two experiments conducted to further investigate the effects of color on cognition. Together, the experiments attempted to parse the previously observed effects of color. Experiment 1 separated effects on cognitive discrimination, that is, the ability to recognize previously learned words, and response bias, the tendency to say that test words were previously learned. Participants performed tasks where they studied a list of words and then were asked to indicate whether each word was old or new within a set of words. The participants were randomly assigned to a word valence condition: pleasant, unpleasant, or neutral. All participants performed three conditions based on color: red, blue, and white. The primary hypothesis was that color would have an effect on both the discrimination of old words from new words and the response bias. If red evokes the avoidance motivation then the participant would be more detail oriented so would have a higher rate of accuracy in distinguishing old and new words compared to the white and the blue conditions. If blue evokes the approach motivation then the participant would be more open to creative thinking and liberal so would be more biased to saying a word is old compared to the white and the red conditions.

Experiment 2 separated effects of color on conscious and unconscious components of memory. Participants performed tasks where they viewed a list of words in red or blue backgrounds and then were asked to complete words stems in two different ways. While viewing the words, the participants had either full attention or were distracted by a counting-backward test (divided attention). All the participants took part in each combination of color, attention, and test type. The primary hypothesis was that if red evoked the avoidance motivation, the red, the divided attention condition would lead to a higher probability of recollection compared to the blue, divided attention condition.

Effects of Word Valence on Cognitive Discrimination vs. Response Bias

The first experiment used a signal detection theory paradigm (Green & Swets, 1966), which is used to separate cognitive discrimination from response bias. In addition to assessing the effects of color, the study also investigated how color interacted with word valence. Word valence has been shown to have an independent effect from that of arousal (Kousta, Vinson, & Vigliocco, 2009). Both Taylor (1991) and Kousta, Vinson, and Vigliocco (2009) argue that pleasant and unpleasant word valence cannot be thought of as two endpoints of a continuous scale. They should be thought of as categorical variables. When they are thought of as categorical variables, then the effects of word valence appear much stronger.

Some bodies of data show that negative valence words evoke a stronger response than both neutral and positive valence words. Gotoh (2007) says that threat related words are more likely to capture attention than neutral words and that individuals are more likely to detect a target when it is located where previously a threatening word was located compared to where a neutral word was located. Though this shows that there is a difference between unpleasant words and neutral words, there is no discussion of pleasant words.

Kousta, Vinson, and Vigliocco (2009) answer this question by showing that both pleasant and unpleasant valence words have an advantage over neutral words. This effect was independent of the arousal of the individual. There was no difference between the pleasant and the unpleasant valence words. This is explained by both polarities are relevant in adapting to match the current context of the situation.

For experiment 1, the secondary hypothesis was that the pleasant and unpleasant valence words would have a higher accuracy in distinguishing the old words from the new words and would be more biased towards old words compared with the neutral word valence condition. Emotion words would interact with colors to make the red and blue effects stronger. Emotion words and red would have a higher rate of accuracy in distinguishing words than all other conditions and emotion words and blue would have a lower response bias than any other condition because emotion words help to adapt to the situation faster.

Process-Dissociation

For the second experiment, a process-dissociation paradigm was used. The process-dissociation framework is a way to separate the conscious from the unconscious. In the past, to study conscious effects a direct test would be used and to study unconscious effects then an indirect test would be use (Jacoby, Toth, & Yonelinas, 1993). The indirect tests could often be contaminated with intentional uses of memory. Direct tests are also contaminated through the unintentional use of memory. This can cause an over-estimation of recollection. The process-dissociation framework can be used to solve these discrepancies.

Process-dissociation has some resemblance to signal detection theory in that the participants have a set of target stimuli that they must distinguish from other stimuli (Jacoby & Kelley, 1992). By using two conditions with each participant, it is able to separate out the conscious from the unconscious. The exclusion condition has the participant complete a word stem (can be other stimuli) with words that were not previously seen. Some of the popular stimuli are word stems or word fragments because the priming is similar for these two implicit memory tests (Roediger, Weldon, Stadler, & Riegler, 1992). In this case, if a word appears that was on the previously seen list, this action would be unintentional. In the inclusion condition, the participant is asked to complete the word stem with a word from the list or the first word that comes to mind. If a word appears that was on a previously seen list, this could be intentional or unintentional. The probability of recollection (conscious)vs. familiarity (unconscious) can be estimated from the inclusion and exclusion data, as explained below.

Process-dissociation has been used to show that there are different conscious and unconscious memories (Jacoby, 1998). When participants complete different conditions for divided and full attention, the recollection of the words decreases in the divided attention condition. Across the two conditions the familiarity remains constant though. This shows that there is a process that is not being affected by the divided attention and is not conscious. This framework can be used to study other variables that may affect memory such as aging, study duration, and color effect (Kelley & Jacoby, 2000).

In experiment 2, the secondary hypothesis was that if divided attention decreases conscious perception, then the divided attention conditions would have a lower probability of recollection compared to the full attention conditions. This would replicate previously seen results.

Experiment 1

Methods

Participants. Sixty undergraduates (33 females and 27 males), who attend Carnegie Mellon University, participated in the study. The participants were recruited from a psychology participation pool of students currently enrolled in a psychology class and were awarded one participation class credit for participating in the study. The participants were restricted to those that were not red-green color blind and those that spoke fluent English. The sixty participants were randomly assigned to one of the valance word conditions: neutral, pleasant, or unpleasant.

Design and Materials. The design was a 3 between (word valence: neutral vs. pleasant vs. unpleasant) x 3 within (color: white vs. red vs. blue) mixed factorial design. The dependent variables being measured were the d’ and the beta values of the signal detection theory, corresponding to discrimination and response bias, respectively.

The experiment was developed in Adobe Flash to be a full screen display. For the experiment, color background was manipulated employing the HSL scheme (hue-saturation-lightness). Saturation and lightness were held constant across the color conditions at 100 and 50 respectively. Red had a hue value of 0 and blue had a hue value of 240. The white background had a hue of 0, saturation of 0, and lightness of 100. Each participant used a Sony VAIO 15 inch laptop computer for the study. The participants used the touch pad mouse to advance through the study.

The words used for the three conditions were from the Dictionary of Affect in Language. The dictionary classifies words on the scale of pleasantness from one to three with one being unpleasant and three being pleasant. The unpleasant word sets had a mean pleasantness of 1.01 and a standard deviation of 0.03. The neutral word sets had a mean pleasantness of 2.00 with a standard deviation of 0.00. The pleasant word sets had a mean pleasantness of 2.88 with a standard deviation of 0.08. The words were standardized across conditions using word Thorndike and Lorge (1944) word frequencies. Each set of words had a comparable distribution of word frequencies and within each set the new words and the old words had a comparable distribution of word frequencies. The words were restricted to those that were between three and ten characters in length.

Procedure. The participants were tested individually with only the experimenter present in the room. Each participant completed tests on four sets of words. In each set they were asked to read through a list of 20 words. Each word was displayed on the screen for two seconds; one word followed another with no delay. After the list was complete, the participants were asked to go through a test list of 40 words indicating whether each word was a new word (not presented in the previous list) or an old word (presented in the previous list). The test list had the 20 original words and 20 distracters. The words used in the task were either pleasant, unpleasant, or neutral depending on the participants assigned condition. The first set of words was a trial for the participants so that they would be able to understand the procedure and would have initial words in their memory so the next three trials would not have a confounding variable of prior interference. This set of words was the same across all of the conditions with the words having a neutral valence and a white background. The next three sets of words were one of each of the colors: red, blue, or white. The order that the participants received the colors was counterbalanced to avoid any ordering effects, and across subjects, each word occurred in all colors.

For the test list of words in each task, the participants were given as much time as they needed to select whether it was an old or new word. To make the selection, the participant selected a button on the screen with the mouse labeled either old word or new word. This button recorded the participant's selection and advanced the screen to the next word.

Between each set of words, the participants were asked to complete anagrams. Each anagram was a letter string of six letters. The participant could only use each letter once but was allowed to make words that did not use all six of the letters. They were given two minutes to form as many words as they could while still using only the six letters. This task was to help clear the participant's memory between the sets of words. After the participant completed the four sets of words, the experimenter debriefed the participant.

Results

With respect to the primary hypothesis that color would affect cognitive performance, the mean d' (cognitive discrimination sensitivity) values across the color conditions were *M* = 2.18, *SD* = 0.79 for red, *M* = 2.27, *SD* = 0.83 for blue, and *M* = 2.20, *SD* = 0.67 for white. An alpha value of .05 was used for all statistical tests. A mixed measures ANOVA test was conducted to compare the effect of color on d' and β. The effect of color on d' was not statistically significant, $F(2, 56) = 0.33$, $p = .72$, $\eta^2_p = .012$, indicating that there was no difference between the color conditions on the accuracy of distinction. The mean β (response bias) values across the color conditions were *M* = 1.73, *SD* = 1.49 for red, *M* = 1.78, *SD* = 1.49 for blue, and *M* = 1.93, *SD* = 1.64 for white. The effect of color on β was not statistically significant, $F(2, 56) = 0.65$, $p = .53$, $\eta^2_p = .023$, indicating that there was no difference between the colors on the biases of distinction.

Figure 1 about Here

For the secondary hypothesis that word valence would affect performance, the mean d’ values across the word valence conditions were *M* = 2.31, *SD* = 0.75 for pleasant, *M* = 2.04, *SD* = 0.76 for unpleasant, and *M* = 2.30, *SD* = 0.76 for neutral. The effect of word valence on d’ was not statistically significant, $F(2, 57) = 1.17$, $p = .31$, $\eta^2_p = .04$, indicating that there was no difference between the word valence conditions with respect to discrimination between old and new words. The mean β values across the word valence conditions were *M* = 1.67, *SD* = 1.47 for pleasant, *M* = 1.35, *SD* = 1.28 for unpleasant, and *M* = 2.42, *SD* = 1.66 for neutral. Higher β corresponds to a more conservative response bias. The effect of word valence on β was statistically significant, $F(2, 57) = 4.47$, $p = .016$, $\eta^2_p = .14$, indicating that there was an effect for word valence on the bias of word distinction. A post hoc LSD test was conducted to compare the effect of the word valence conditions on β. There was a statistically significant difference between neutral words and pleasant words ($p = .046$) and neutral words and unpleasant words ($p = .005$). There was not a statistically significant difference between pleasant words and unpleasant words, $p = .39$.

No interaction effects between color and valence were found.

Figure 1 shows the d' value across both the word valence and the color. It is very apparent that there is no effect of any variables on cognitive discrimination, or d'. Figure 2 shows the response bias, or β value, across both the word valence and the color. The effect of word valence can be seen here with the pleasant and unpleasant conditions being lower than the neutral condition for all colors.

Figure 2 about Here

Discussion

The results from this experiment did not support the primary hypotheses. There was not an effect of color on either the discrimination or the response bias parameter of signal detection. The color of the background did not have an effect on the cognitive task. Because the entire background of the screen was in this color, there little chance that the participants did not notice the color of the screen.

The secondary hypotheses were partially supported by the study. The word valence did not have a significant effect on the accuracy of the word discrimination. It did have an effect on the bias of the word discrimination though. The pleasant and the unpleasant word valence conditions were more liberal with labeling a word as old compared to the neutral word valence condition. There was not a significant difference between the pleasant and the unpleasant condition supporting the theory that there is no difference between the polarities. The reason for the lowered response criterion for emotional words is not clear.

Experiment 2

Methods

Participants. Twenty-one participants (8 females and 13 males), who were undergraduates at Carnegie Mellon University, participated in the study. They were recruited through a psychology participation pool for students currently enrolled in psychology classes. Each participant was awarded one psychology participation class credit for participating in the study. Participants were restricted to those that were not red-green colorblind and to those that were fluent in English.

Design and Materials. The design was a 2 within (color: red vs. blue) x 2 within (attention: divided vs. full) x 2 (type of memory: recollection, familiarity) factorial design. The dependent variables being measured were accuracy on two types of test, inclusion and exclusion, which were used to compute the two memory components (see below).

The experiment was developed in Adobe Flash to be a full screen display. For the experiment, color background was manipulated employing the HSL scheme (hue-saturation-lightness). Saturation and lightness were held constant across the color conditions at 100 and 50 respectively. Red had a hue value of 0 and blue had a hue value of 240. Each participant used a MacBook Pro 13 inch laptop computer for the study. The participants used the touch pad mouse to advance through the study.

Subjects took part in 5 trials, during each of which they viewed a list of words and then were tested on it in two ways, inclusion and exclusion. All of the words were five letters in length with a three-letter word stem that could be completed in at least two ways to make an English word. A total of 178 words were used for the experiment. One hundred twenty of these words were from a list of words used by Jacoby (1998) and were assigned to four experimental trials. Each experimental trial also had an additional five words at the beginning and end of each list to avoid primacy and recency effects. Another 18 words were used in a practice trial set at the beginning of the study.

The 120 words from Jacoby were divided into four sets, each assigned to a combination of attention level (divided, full) and test type (inclusion, exclusion), so that each set had 30 words. Each set of 30 words was then divided into two sets of 15 for the exclusion and inclusion tests. The words were equally distributed based on word frequency as cataloged by Thorndike and Lorge (1944). The word sets were also rotated through each of the four conditions for purposes of counterbalancing.

Procedure. The participants completed the study individually with only the experimenter present. On each trial, the participant viewed a set of 40 words (30 words from Jacoby, 1998, and 5 preceding and 5 following words). Each word was displayed on the screen for 1.5 seconds with 0.5 seconds of a blank screen in between each word. With the onset of each new word, there was a chime sound. In the divided attention conditions, the subject was first given a random number greater than 120 that was not a multiple of three, and with each sound the participant was asked to count down by three from the current value of the number.

After the participant completed reading through the list of words, a screen appeared with the instructions for both the exclusion condition (avoid completion with previously viewed words) and the inclusion condition (respond as quickly as possible, without regard to the list). The subject was then instructed to complete a set of word stems using the exclusion condition. After the exclusion condition was complete, the participant was again shown the instructions screen with both the instructions for the inclusion and exclusion and was instructed to start the inclusion condition.

The participants were instructed to not complete the word stems with any plural or proper nouns. They were given 15 seconds to complete each word stem in both the exclusion and the inclusion condition. If the participant completed the word stem before the 15 seconds of time, he or she could click a button to advance to the next word. On the screen with each word was either the word EXCLUSION or INCLUSION corresponding to the current test condition.

Each participant took part in 5 trials, one practice and 4 experimental, corresponding to the crossing of attention (divided, full) and color (red, blue). The practice trial set had a white background and was a full attention condition. The order of the color and the order of the attention conditions within the color were counterbalanced across participants to avoid any ordering affects. Once the participants completed all five trials, they were debriefed on the study.

Results

One participant's data was removed from the analysis because she appeared to confuse the exclusion and inclusion directions. For analysis, the exclusion and inclusion test accuracies were used to compute probabilities of recollection and familiarity. Because the participant is asked not to include any words that they recollect are in the list, in the exclusion case, the exclusion is the probability of familiarity without the probability of recollection and familiarity ($P(F) – P(F \cap R)$). In the inclusion case, the participant will put down a word from the list if he or she either recollects it or it is familiar, so inclusion is the probability of recollection or familiarity ($P(F \cup R) = P(F) + P(R) – P(F \cap R)$). If you subtract exclusion from inclusion you can then find the probability of recollection ($[P(F) + P(R) – P(F \cap R)] – [P(F) – P(F \cap R)] = P(R)$). To find the probability of familiarity, you are able to divide the exclusion by 1- P(R) because the familiarity and the recollection are assumed to be independent ($[P(F) – P(F \cap R)]/[1- P(R)] = ([P(F) – P(F)P(R)]/[1- P(R)] = P(F)$).

An alpha value of .05 was used for all statistical tests. For the primary hypotheses, the means of the divided attention conditions for the probability of recollection were M = 0.26, SD = 0.16 for red and M = 0.23, SD = 0.18 for blue. A multivariate MANOVA test was conducted to compare the interactions of color, attention, and probabilities of recollection and familiarity. The effect of color was not statistically significant, $F(1, 19) = 0.00$, $p = .998$, $\eta^2_p = .000$, indicating that there was no difference between the color conditions.

Table 1 about Here

Table 1 shows the distribution of the means across the different conditions. For the secondary hypothesis the effect of divided versus full attention was statistically significant, $F(1, 19) = 4.47$, $p = .048$, $\eta^2_p = .19$, indicating that attention did have an effect on recollection and familiarity. There was also a statistically significant interaction between attention and recollection/familiarity ($F(1, 19) = 32.78$ $p < .001$, $\eta^2_p = .63$). Two paired t-test, independent of the previous test, were conducted to discover if the interaction was effecting both the recollect and the familiarity or just one of the probabilities. Both tests compare divided versus full attention and the effect on either recollection or familiarity. The effect of attention on recollection was statistically significant, $t(19) = -5.89$, $p < .001$, indicating there was a difference between divided and full attention on recollection. The effect of attention on familiarity was also statistically significant, $t(19) = 3.15$, $p < .01$, indicating there was a difference between divided and full attention on familiarity.

Discussion

The results from the second experiment again did not support the primary hypothesis. There was no effect of the color on the performance of the task. Again the entire background was changed for the color so would not have gone unrecognized by the participants.

The secondary hypothesis that attention would affect recollection was supported by the study. The study shows that the probability of recollection decreases when an individual’s attention is divided. They are then less likely to remember that they had seen a word previously. The results were not consistent with previous research because the increase of the probability of familiarity with divided attention was also statistically significant. This difference in familiarities cannot be explained by the current experiment.

General Discussion

Previous research has shown an influence of color on cognitive task performance (Elliot, Maier, Binser, Friedman, & Pekrun, 2009, Mehta & Zhu, 2009, Maier, Elliot, & Lichtenfeld, 2008, and Elliot & Maier, 2007). Most of this research explains this change in cognitive task performance through the association of color with achievement motivations. Because of the association of read with danger and blue with tranquility, they should activate the avoidance and approach motivations respectively. The results from both of the studies conducted do not support this claim. There was no difference in either the detail-oriented measures or the creative measures in the studies. In the first experiment the presence of color did not even cause any significant changes compared to the control color of white.

The color may not have had any effect on the performance of cognitive tasks because it may not have invoked achievement motivation. Because of either the tests or the setting of the experiments, the participants may not have invoked an achievement setting. If they did not feel they were in an achievement context then neither of the achievement motivations would have been invoked.

The effect of word valence presented in the first study and the effect of attention presented in the second study support findings of previous research. Word valence in the first study did not have any effect on the accuracy but did affect the bias with users being more liberal with choosing old words when the word valence was pleasant or unpleasant. These results show that word valence did not affect the more detail-oriented task but it did cause people to be more creative and open-minded. Kousta, Vinson, and Vigliocco (2009) suggest that emotion-evoking stimuli can lead to rapid modification of behavior to match the context. The pleasant and unpleasant words may influence the participant’s bias to the more liberal side because the participant is more open-minded to the possibilities in the context and make more relations from the current word to other past situations so are then more likely to say a word is old. To test this, another study would have to be conducted to see if the pleasant and unpleasant words cause participants to free-associate more than the neutral words and to recall more past events relating to that word.

The second study supported previous research through the replication of results showing that recollection decreases with divided attention compared to full attention. There was also a statically significant increase of familiarity with divided attention compared to full attention. This does not support previous research but does still show the use of unconscious memory. A person can be familiar with a stimulus but not recollect where that sense of familiarity is from. This finding can be used to study if stimuli that disrupt the conscious perception also disrupt the unconscious perception.

Further research could be done on how color affects cognition by comparing different levels of achievement settings. By looking at different levels of achievement settings, you could see if the effect of color is based on a scale so that what participants classify as more achievement based tasks show more of an effect of color or if it is definitive categories where either the achievement motivations are activated and color has an effect or they are not.

References

Elliot, A. J. & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*(1), 218-232.

Elliot, A. J., & Maier, M. A. (2007). Color and psychological functioning. *Current Directions in Psychological Science, 16*(5), 250-254.

Elliot, A. J., Maier, M. A., Binser, M. J., Friedman, R., & Pekrun, R. (2009). The effect of red on avoidance behavior in achievement contexts. *Personality and Social Psychology Bulletin, 35,* 365-375.

Elliot, A. J. & Niesta, D. (2008). Romantic red: Red enhances men's attraction to women. *Journal of Personality and Social Psychology, 95,* 1150-1164.

Friedman, R. S. & Forster, J. (2005). Effects of motivational cues on perceptual asymmetry: Implications for creativity and analytical problem solving. *Journal of Personality and Social Psychology, 88*(2), 263-275.

Gotoh, F. (2008). Influence of affective valence on working memory processes. *International Journal of Psychology, 43*(1), 59-71.

Green, D.M., Swets J.A. (1966). *Signal detection theory and psychophysics*. New York: Wiley.

Jacoby, L. L. (1998). Invariance in automatic influences of memory: Toward a user's guide for the process-dissociation procedure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*(1), 3-26.

Jacoby, L. L. & Kelley, C. M. (1992). A process-dissociation framework for investigating unconscious influences: Freudian slips, projective tests, subliminal perception, and signal detection theory. *Current Directions in Psychological Sciences, 1*(6), 174-179.

Jacoby, L. L., Toth, J. P., & Yonelinas, A. P. (1993). Separating conscious and unconscious influences of memory: Measuring recollection. *Journal of Experimental Psychology: General, 122*(2), 139-154.

Kelley, C. M. & Jacoby, L. L. (2000). Recollection and familiarity: Process-dissociation. In E. Tulving & F.I.M. Craik (Eds.), *The Oxford handbook of memory*. New York, NY: Oxford University Press.

Kousta, S., Vinson, D. P., & Vigliocco, G. (2009). Emotion words, regardless of polarity, have a processing advantage over neutral words. *Cognition, 112,* 473-481.

Kuschel, S., Forster, J., & Denzler, M. (2010). Going beyond information given: How approach versus avoidance cues influence access to higher order information. *Social Psychology and Personality Science, 1*(1), 4-11.

Maier, M. A., Elliot, A. J., & Lichtenfeld. (2008). Mediation of the negative effect of red on intellectual performance. *Personality and Social Psychology Bulletin, 34*(11), 1530-1540.

Mehta, R. & Zhu, R. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science, 323*, 1226-1229.

Phillips, L. H., Bull, R., Adams, E., & Fraser, L. (2002). Positive mood and executive function: Evidence from stroop and fluency tasks. *Emotion, 2*(1), 12-22.

Roediger III, H. L., Weldon, M. S., Stadler, M. L., & Riegler, G. L. (1992). Direct comparison of two implicit memory tests: word fragment and word stem completion. *Journal of Experimental Psychology: Learning, Memory, and*

Cognition, 18(6), 1251-1269.

Taylor, S. E. (1991). Asymmetrical effects of positive and negative events: The mobilization-minimization hypothesis. *Psychological Bulletin, 110*(1), 67-85.

Thorndike, E. L. and Lorge, I. (1944). *The Teacher's Word Book of 30,000 Words.* New York: Teachers College, Columbia University.

Whissell, C. & Dewson, M. (1989). The dictionary of affect in language. *Social and Behavioral Science Documents*.

Zhu, R. & Meyers-Levy, J. (2007). Exploring the cognitive mechanism that underlies regulatory focus effects. *Journal of Consumer Research, 34.*

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Table 1

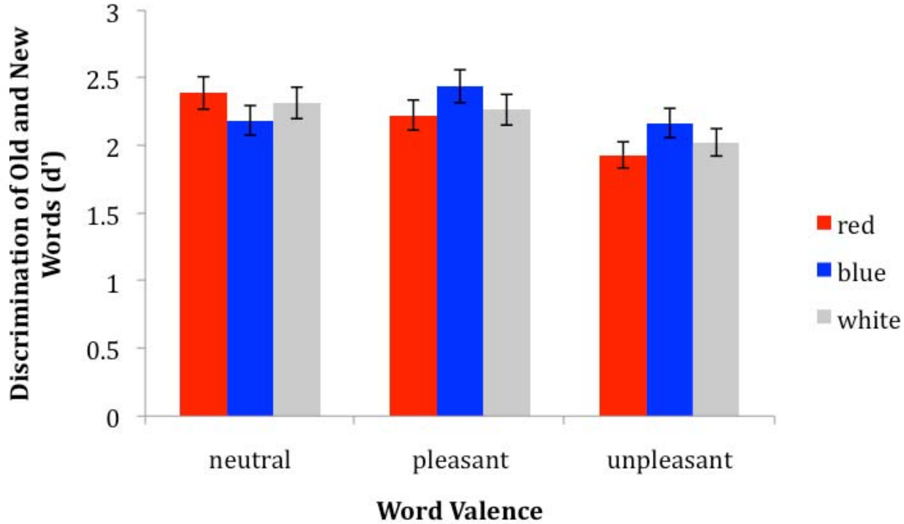
Probabilities of Word Recollection and Familiarity

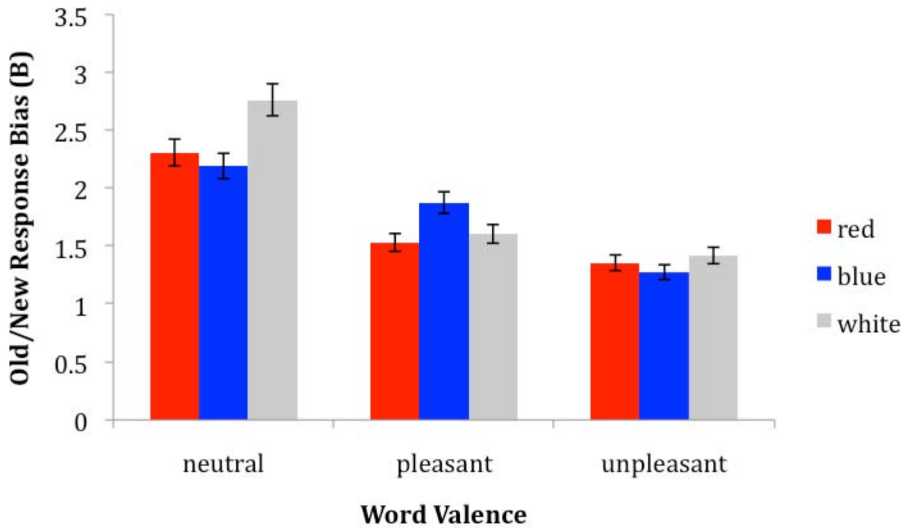
Attention	Recollection	Familiarity
	Red	
Divided	0.26	0.35
Full	0.46	0.23
	Blue	
Divided	0.23	0.36
Full	0.47	0.24

Figure Caption

Figure 1. Discrimination of old and new words (d’) across word valence and color conditions.

Figure 2. Old/new response bias (β) across word valence and color conditions.


3
2.5
2
1.5
1
0.5
0
Discrimination of Old and New Words (d')
neutral
pleasant
unpleasant
Word Valence
red
blue
white


3.5
3
2.5
2
1.5
1
0.5
0
Old/New Response Bias (B)
neutral
pleasant
unpleasant
Word Valence
red
blue
white