Perceiving Mood in Color: The Effects of Mood States on Reaction Times

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This study examined the effects of a musical mood induction procedure on the reaction time required to perceive the colors yellow and blue. Thirty-six undergraduates listened to 5 min of happy music, sad music, or white noise. The participants then completed the Multiple Affect Adjective Checklist-Revised to assess their current mood, and reaction times to yellow and blue stimuli of varying intensities were recorded. Results showed that participants who listened to happy music felt happier, and participants who listened to sad music felt sadder. Significant differences were not found between the happiness and sadness groups for reaction times to yellow and blue stimuli. Surprisingly, the white noise group was significantly slower in reaction times to yellow and blue stimuli.

The normal human visual system is capable of perceiving color in every visual stimulus in the environment. In fact, color is such a dominant theme in the human experience that we have been known to associate our emotions with colors. The well-known sayings, "I feel blue," "I was so angry I saw red," and "I was green with envy" clearly demonstrate these associations. One may wonder why we tend to associate our moods with colors. More specifically, do our brains make this connection innately, or is this tendency purely learned?

Previous research has attempted to define these color-mood relationships by examining the type of emotional response that color induces (Gao & Xin, 2006; Hemphill, 1996; Kaya & Epps, 2004; Peretti, 1974a; Peretti, 1974b; Wexner, 1954; Xin, Cheng, Taylor, Sato, & Hansuebsai, 2002). For example, Kaya & Epps (2004) asked college students to indicate their emotional responses to different hues and found that yellow was related to happiness, and blue was linked to feelings of loneliness and sadness. In a similar study, the researcher investigated the color-emotion associations of 40 undergraduate students and reported that 61% of the responses to bright colors (such as white, pink, red, yellow, blue, purple, and green) were positive, compared with only 21% for dark colors such as brown, black, and gray (Hemphill, 1996). By examining how color affects one's emotional state, these studies showed that people can connect mood states to colors.

Xin et. al. (2002) reported that some researchers have suggested that color directly affects the parts of the human nervous system responsible for emotional arousal. If color can affect one's emotional arousal, then it is possible for one's emotional arousal to affect one's perception of color. For instance, being in a particular emotional state, such as sadness, could potentially affect the way one perceives a particular color, such as blue. If this is true, then it could indicate that these color-mood associations are not simply learned but have a neurological basis. Perhaps we say we "feel blue" because when we are sad, we perceive blue in a different way than when we are not sad.

Though few studies have attempted to address this question, Zeims and Christman (1998) did examine the effects of mood states on discrimination of colors that differed on valence (or pleasantness) and arousal. Valdez and Mehrabian (1994) had previously indicated that some colors possess properties of both pleasantness and arousal (e.g., the color blue-green was determined by the researchers to be high in pleasantness and high in arousal, and the color purple-blue was considered to be high in pleasantness and low in arousal). Zeims

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and Christman used these colors in their 1998 study and found that the emotional state of the observer affected the speed with which colors differing on the dimension of arousal were discriminated. More specifically, observers in a happy state were faster at discriminating high-arousal colors, and observers in a sad state were faster at discriminating low-arousal colors. These findings suggested that participants were faster at processing certain colors when in different mood states; therefore, emotional arousal affects perception of color.

Kunzendorf (2001) also investigated whether emotional state affects perception of color by attempting to test the validity of the sayings that angry people "see red" and sad people "feel blue." The researcher first split the participants into two conditions: anger and sadness. In the anger condition, participants were instructed to generate feelings of anger; while in the sadness condition, they were asked to generate feelings of sadness. The participants were then asked to rank the similarity of eight paired colors consisting of reds (such as red-orange and maroon) and blues (such as blue-violet and blue-green). The participants were shown eight pairs of such colors and were asked to rank the similarity of the pairs by writing the pair number of the most similar pair first, then the second most similar, and so on. The logic behind this test was if anger adds redness to colors and sadness adds blueness, then reddish hues should shift closer together in similarity to pure red, and bluish hues should shift closer in similarity to pure blue. An analysis of variance showed the average red pair was more similar for the anger group, and the average blue pair was more similar for the sadness group. Kunzendorf proposed that these results suggest that the observer's surroundings are subjectively perceived as redder during anger and bluer during sadness.

In his second experiment, Kunzendorf (2001) investigated the mechanism behind this phenomenon. He proposed the neural threshold for red and blue sensations may be lowered when people experience anger and sadness, respectively. To test this, Kunzendorf split the participants into the same two groups, anger and sadness. He then flashed a series of slides containing either an angry or a sad face that was colored reddish-black or bluish-black and that was placed above or below a midline. The participants were then given 10 sec to determine whether the face was above or below the midline. The results showed that participants were more accurate at localizing red faces during anger and blue faces during sadness, but that the emotion expressed by the face had no effect on accuracy. Kunzendorf suggested that the feeling of anger may increase the detectability of red signals, and likewise that the feeling of sadness may increase the detectability of blue signals. These findings suggest the neural thresholds for triggering sensations of red and blue may be lowered during anger and sadness, respectively.

The current study aimed to further investigate the effects of emotional state on the perception of color. More specifically, the effects of happiness and sadness on the perceptions of yellow and blue were examined. It was hypothesized that participants in the happiness condition would have decreased reaction times to yellow stimuli, and that participants in the sadness condition would have decreased reaction times to blue stimuli. Additionally, a group of participants not exposed to any mood induction procedures served as a control group.

If the neural threshold for detecting colored stimuli is lowered during certain moods, as suggested by Kunzendorf (2001), then this would mean that the minimum degree of intensity needed to perceive that color would be lowered when a person is in the corresponding mood. Therefore, participants should be faster at reacting to that color because they would perceive it sooner. Consequently, the colors used in this study were manipulated by intensity (low, medium and high brightness) and reaction time required to perceive these colors was recorded. If reaction times to yellow and blue stimuli are found to be faster when a person is in a happy and sad mood respectively, then this would provide support for Kunzendorf's speculation that neural thresholds for perception of colored stimuli are lowered when a person is an associated mood state.

Method

Participants

Thirty-six students (34 women and 2 men) from a small New England college participated in this study. Participants were recruited from the college psychology department subject pool, and received one credit toward a research requirement in their General Psychology class. Participants were at least 18 years of age (M = 18.86 years old). Although vision was not tested, all subjects reported normal or corrected-to-normal vision, and no known color vision deficiencies.

Materials

Three different CD recordings were used: Mozart's Clarinet Concerto in A Major, Barber's Adagio pour Cortes, and white noise. The white noise was a continuous static sound. The music and white noise was played from a compact disk (CD) and captured via a Telex M-560 Super-Directional USB Digital Microphone. The music and white noise was then recorded onto a computer using the program Cool Edit Pro (v2.0) and was played back to participants using

Koss UR20 headphones.

This study also made use of the Multiple Affect Adjective Checklist-Revised, short form (MAACL-R). The MAACL-R is a mood assessment instrument used in research and clinical practice that contains multiple subscales such as depression, hostility, anxiety, sensation seeking, and positive affect subscales (Lubin, Whitlock, Reddy, & Petren, 2001). The instrument measures present (state) moods by requesting that participants check which adjectives in a set of 132 describe, "How you feel today, right now." Sufficient reliability (internal consistency and test-retest reliability) and validity (convergent, predictive, discriminant, and diagnostic) have been reported for the checklist. Specifically, in a community college population, Cronbach's alpha was reported to be .94 for the positive affect subscale and .84 for the depression subscale (Lubin & Zuckerman, 1999).

Participants also completed a two-alternative, forced-choice task that was constructed to measure reaction time following exposure to yellow and blue stimuli. The stimulus color of yellow was chosen based on Kaya and Epps (2004) and Wexner's (1954) results that showed that yellow is the color most associated with happiness, and the stimulus color of blue was chosen and based on the Kaya and Epps (2004) and Kunzendorf's (2001) studies that indicated that blue was associated with sadness and loneliness. This was a computer-generated task that was created using E-Prime software, a product of Psychology Software Tools, Inc. The colored stimuli were made using Microsoft Paint and varied at three intensities: low, medium, and high. Three blocks consisted of the hue 40 (yellow) with a saturation level of 240 pixels. These yellow blocks varied in intensity at 120 pixels (high), 210 pixels (medium), and 230 pixels (low). The hue 160 (blue) had the same saturation value as hue 40, but varied at the following three intensity values: 120 pixels (high), 215 pixels (medium), and 235 pixels (low). These intensity values were slightly different between colors so that the colors displayed the same *perceived* intensity, which varied slightly from the *physical* intensity. Prior to any testing of participants, the researcher evaluated perceived intensity by comparing the physical intensity values of each level of color and adjusting any colors that were too dissimilar from one another (e.g., adjusted *physical* intensity of low blue to match the same *perceived* intensity of low yellow). A second observer confirmed the researcher's final color choices, and the resulting color stimuli were used for all participants.

Design and Procedure

During the experiment, the 36 participants were randomly assigned to three conditions: happiness, sadness, and control. The 12 participants in the happiness group listened to 5 min of Mozart's Clarinet Concerto in A Major, the 12 participants in the sadness group listened to 5 min of Barber's Adagio pour Cortes, and the 12 participants in the control group listened to 5 min of white noise. All participants then completed the MAACL-R and the two-alternative, forced-choice task. Participants completed the musical MIP, MAACL-R, and the two-alternative, forced-choice task in isolation in order to prevent a possible Hawthorne Effect, which occurs when participants act differently simply because they are being observed, not because of an experimental manipulation (Adair, 1984). These procedures were carried out in a lab room that was furnished with a table, a chair, and a computer.

The Human Subjects Review Board of the campus approved the study and all participants provided written informed consent prior to initiation of study procedures. After consent was obtained and questions were answered, the participants were asked to complete the musical MIP. In the musical MIP, participants listen to a mood-suggestive piece of classical music after being instructed to try to get into the mood expressed by the music, without explicitly stating that mood. The type of mood induction procedure and the specific pieces of classical music that were used in this study were selected because they have been shown to be successful in inducing happy and sad moods in previous research on mood dependent memory (de I'Etoile, 2002), and on the effects of mood on color perception (Ziems & Christman, 1998). The participants were told, "You are going to listen to something play for 5 minutes. You want to try to determine if what you hear expresses a certain mood. If you think that it does, you want to try to get into that mood. Put on the headphones and hit the play button when you are ready. After the recording stops, please read the instructions and fill out this check list as quickly as possible. The checklist asks you to check the items that pertain to how you feel today, right now. I will also leave you this list for reference. Do you have any questions? I will be right outside; come and get me when you are finished." The list left for participants stated (a) put on the headphones and click play when ready; (b) try to determine if what you hear expresses a mood; (c) If it does, try to get into that mood; (d) when the music stops, read the instructions and quickly fill out the checklist; and (e) get researcher when finished.

Following completion of the checklist, which was utilized to perform a manipulation check regarding what mood was actually induced by the musical MIP, participants were asked to complete the two-alternative, forced-choice task. In this task, the participants were instructed to stare at a fixation point that consisted of cross bars (+) in the middle of the screen. The screen then changed and consisted of a block of color placed above or below a midline. The midline was a grey line separating the top half of the screen from the bottom half of the screen. Each of the six stimuli was placed at six different locations: three locations above the midline, and three locations below the midline. This design resulted in 36 different trials, which were shown twice, in random order, to each participant for a total of 72 trials. Participants were asked to hit the number 1 if they saw the stimulus above the midline, and to hit the number 2 if they saw the stimulus below the midline. Participants were told, "You are going to see a block of color either above or below a line that divides the screen in half. All you have to do is hit the number 1 if you see the block of color above the line, and hit the number 2 if you see the block of color below the line." These instructions were also shown on the screen before the trials were run, and the instructions informed participants to hit the enter button when ready to begin. To aid accuracy, a number 1 was placed on the top of the computer screen and a number 2 was placed on the bottom of the computer screen. Upon completion of the experiment, participants were debriefed and provided contact information to address study concerns and/or to access study results should they wish to learn the outcome of the study.

Results

The aim of this study was to determine if participants in a happy mood react faster to yellow stimuli, and if participants in a sad mood react faster to blue stimuli. To determine if the musical MIP was successful in altering mood, comparisons between groups on the MAACL-R scores were analyzed using a one-way analysis of variance (ANOVA). If a significant main effect was found, a Least Significant Difference (LSD) post hoc test was performed to determine which of the three groups differed significantly from each other. To determine if differences existed between mood groups on their reaction time to colored stimuli, a one-way ANOVA was performed. If a significant main effect was found, a LSD post hoc test was used to determine which of the three groups differed significantly from each other.

Data analyses using a one-way ANOVA showed that the musical MIP was successful in inducing the appropriate mood. A significant difference was found between groups on the positive affect subscale of the MAACL-R, $df = 2$, $F(2,33) = 16.66$, $p < .01$; and a LSD post hoc test revealed a significant difference between the happiness and sadness groups ($p < .01$) and also between the happiness group and the control group ($p < .01$). On the positive affect subscale, a higher score indicates a stronger feeling of happiness by the test taker. The participants who listened to the happy music scored significantly higher on the positive affect subscale ($M = 10.00$, $SD = 5.38$) than participants who listened to the sad music ($M = 3.00$, $SD = 3.46$) and significantly higher than those in the control group ($M = 1.17$, $SD = 2.44$); thereby demonstrating that the individuals who listened to the happy music felt happier than those who listened to the sad music and those in the control group (see Figure 1).

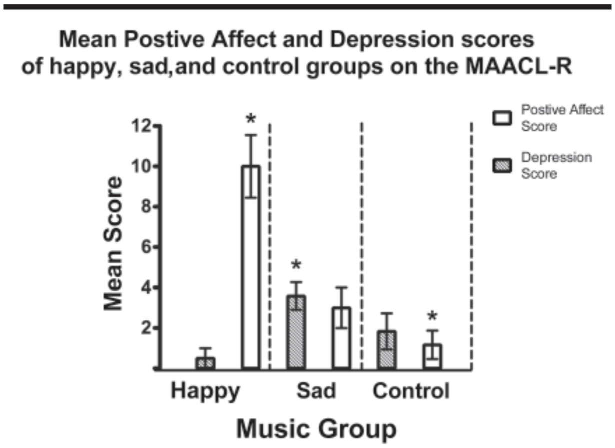
A significant difference was also found between groups on the depression subscale of the MAACL-R, $df = 2$, $F(2,33) = 4.74$, $p < .05$, and a LSD post hoc test revealed a significant difference between the happiness and sadness groups ($p < .01$) on the depression subscale, but no difference between the sadness and the control groups. On the depression subscale, a higher score indicates a stronger feeling of sadness by the test taker. The participants who listened to the sad music scored significantly higher on the depression subscale ($M = 3.58$, $SD = 2.35$) than participants who listened to the happy music ($M = 0.50$, $SD = 1.73$); thereby demonstrating that the individuals who listened to the sad music felt sadder than those who listened to the happy music (see Figure 1).

A one way ANOVA confirmed a significant difference between groups in their reaction times to yellow and blue stimuli, $df = 10$, $F(10, 165) = 2.20$, $p < .02$. A LSD post hoc test revealed unexpected significant differences between the control group and the happiness group ($p < .05$), and between the control group and the sadness group ($p < .05$), such that the control group exhibited significantly slower reaction times to yellow ($M = 1{,}117.48$ ms, $SD = 676.61$ ms) and blue

FIGURE 1

Mean scores of happiness, sadness, and control groups on the positive affect and depression subscales of the MAACL-R.

***Denotes a significant difference.**



(M = 918.68 ms, SD = 328.71 ms) stimuli (see Figure 2). Reaction times to yellow stimuli did not differ significantly between the happiness group (M = 777.86 ms, SD = 180.33 ms) and the sadness group (M = 801.84 ms, SD = 209.25 ms). Additionally, there was no significant difference in reaction times to blue stimuli between the happiness (M = 809.60 ms, SD = 195.49 ms) and sadness (M = 730.79 ms, SD = 131.50 ms) groups. Therefore, the participants who listened to the happy music did not react faster to the yellow stimuli, and the participants who listened to the sad music did not react faster to the blue stimuli (p = .81).

Consequently, the hypotheses that participants in a happy mood would react faster to yellow stimuli and participants in a sad mood would react faster to blue stimuli were not supported by these data. Additionally, a post hoc power analysis confirmed that the sample size (n = 36) had 91% power for detecting a medium-sized effect when employing the .05 criterion of statistical significance, and the effect size proved to be small (η_p^2 = .05).

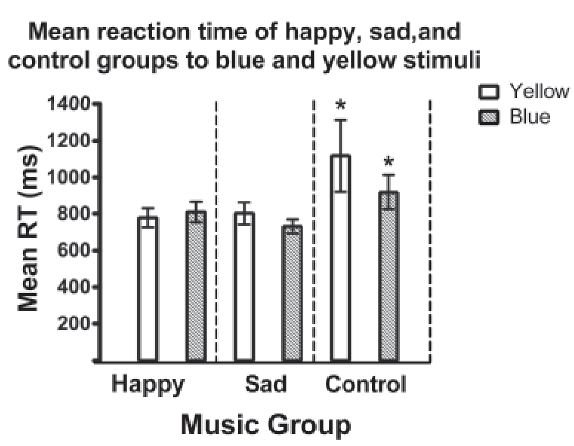
Discussion

The aim of this study was to determine if participants in a happy mood react faster to yellow stimuli, and if participants in a sad mood react faster to blue stimuli. The results showed that participants who listened to the happy music felt happier and participants who listened to the sad music felt sadder, indicating that the musical MIP was effective in altering mood. Surprisingly, the participants in the control group who listened to white noise were significantly less happy than the happy group and exhibited a trend to score lower on the positive affect subscale than the sad group, although not significantly lower. This discovery indicates that white noise may not be a neutral sound and may have the ability to alter mood states. These participants may have been in a different mood than the ones for which they were tested.

FIGURE 2

Mean reaction times of happiness, sadness, and control groups to yellow and blue stimuli.

***Denotes a significant difference.**



This study suggests that listening to white noise delays reaction time to colored stimuli. An alternative explanation for this result may be that it is suggestive of the Yerkes-Dodson Law (1908), which states that the relationship between arousal and performance is an inverted-U function. This implies that performance will be low if arousal is low. Participants who listened to the white noise may have found the task repetitive and boring and may have been less stimulated than the participants who listened to the music, consequently hindering performance on the two-alternative, forced-choice task. If white noise does in fact produce a low arousal state, then this study supports the Yerkes-Dodson theory.

If a faster reaction time to colored stimuli had been observed, it would have suggested a lowered perceptual threshold for that color. The results failed to support this hypothesis. Although the MAACL-R was effective in inducing the appropriate mood, participants in the happiness group did not have faster reaction times to yellow stimuli, and participants in the sadness group did not have faster reaction times to blue stimuli. Unexpectedly, the control group was significantly slower at reacting to both colored stimuli than the happiness and sadness groups. These results are somewhat contrary to previous studies, which showed that being in a sad mood increases the ability to detect blue stimuli (Kunzendorf, 2001). This discrepancy between findings may be due to limitations of this study, methodological differences between Kunzendorf's study and the current study, or may be a truly contradictory finding.

A methodological difference between the present study and Kunzendorf's (2001) study is the choice of the mood induction procedure; the present study used music to induce mood while Kunzendorf instructed participants to self-generate feelings of anger and sadness. The instructions for the musical MIP used in this study asked the participants to determine themselves if the piece of music conveyed a particular mood without explicitly stating the desired mood. This procedure has been shown to control for demand characteristics (Westermann, Spies, Stahl & Hesse, 1996) and to be successful in altering mood (de l'Etoile, 2002; Etzel, Johnsen, Dickerson, Tranel, & Adolphs, 2006; Ferraro, King, Ronning, Pekarski, Risan, 2003; Lewis, Dember, Schefft, & Radenhausen, 1995; Westermann et al., 1996). Moreover, it has been previously shown that happy and sad music are significantly discriminated by diastolic blood pressure, electrodermal activity, and zygomatic muscle activity involved in the smile response (Khalfa, Roy, Rainville, Dalla, & Bella, 2008) which suggests that happy and sad music cause physiological changes in the listener that could potentially be attributable to changes in affect. Kunzendorf's mood-induction procedures consisted of instructing the participants to "generate feelings of anger and sadness." By explicitly stating the mood to be achieved, demand characteristics may have been present and could account for the differences in results. Participants may have falsely reported feelings of anger and sadness in order to comply with experimental demands, and/or they may have deduced the purpose of the study, making it possible that this effect could account for the differences in results. Although research has found explicitly stating the desired mood is more successful in inducing the desired mood (Westermann et al.), it could be argued that the operational definition of "successful" typically relies on self-reports that again, may be attributable to demand characteristics.

Another methodological difference between Kunzendorf's (2001) study and the present study is the choice of the dependent variable. The present study examined reaction time required to perceive a colored stimulus, while Kunzendorf examined accuracy of locating a colored stimulus with an angry or sad face. One interpretation of the differences in results could be that sad people may be more accurate at indicating the location of blue stimuli because they are more apt to notice the color, but that they perceptually need the same degree of intensity in order to perceive it. The present study suggests that the mechanism proposed by Kunzendorf (2001) in order to explain the findings of his study (i.e., the neural threshold of perception of blue stimuli is lowered during feelings of sadness) may not be the mechanism at work.

Another possibility for the difference in results may be attributable to the music itself and not related to the mood induced by the music. In 1993, Rauscher, Shaw, and Ky found that exposure to a Mozart sonata enhanced performance on visuospatial tasks and they coined this phenomenon the "Mozart Effect." Similar studies have also found support for an effect of classical music on performance (Nantais & Schellenberg, 1999; Rideout, Dougherty & Wernert, 1998; Wilson & Brown, 1997). However, there are also many studies (Carstens, Huskins, & Hounshell, 1995; Hui, 2006; Kenealy & Monsef, 1994; McCutcheon, 2000; Newman, Rosenbach, Burns, Latimer, Matocha & Vogt, 1995; Steele, Bass & Crook, 1999) that failed to show support for the so-called Mozart Effect. Meta-analyses have provided contradictory support for this effect, as weak support has been found (Chabris, 1999) and stronger support has been found (Hetland, 2000). It could be argued that the present study shows support for Rauscher, et al. (1993) Mozart Effect as participants who listened to the classical music responded faster to the colored stimuli than participants who listened to the white noise. However, due to the conflicting findings of previous studies investigating the effects of classical music on performance, it is not possible to make any strong conclusions regarding the present study as being suggestive of a Mozart Effect.

One limitation of the current study was that the participants comprised a small convenience sample of nearly all women (34 women and 2 men). Previous literature regarding gender differences in color-mood associations has been conflicting. While no gender differences in color-mood relationships have been reported (Wexner, 1954), others have found that women are more likely than men to relate blue to sadness and yellow to happiness (Peretti, 1974a; Peretti, 1974b). Based on Peretti's results (1974a; 1974b) one could assume that because this study consisted of mainly female participants, any effect of mood on the perception of yellow and blue stimuli may have been exaggerated. However, because significant effects were not detected, it is reasonable to assert that a difference between the reaction times of the happiness and sadness groups to yellow and blue stimuli may not exist. Conversely, due to the limitations of the sample size and makeup, it is impossible to evaluate gender differences or to generalize the results.

Another potential limitation of the current study was that color vision deficiencies were not tested. Although none of the participants reported known color vision defects, there is the potential that some participants suffered from color vision problems outside of their awareness. Any future research in this area should test color vision by administrating the Ishihara Test for Color Blindness (1917), or a comparable test of this nature, to ensure that color deficiencies do not confound the data.

In examining the effects of mood on color perception, future researchers could employ different techniques to measure perceptual threshold of color after administering a mood induction procedure. Reaction time has been reported to be one of the most common measures of neurological function (Crabtree & Antrim, 1988), and some researchers have found that cognizant intention to act appears only after a delay of approximately 350–400 ms from the onset of cerebral activity that precedes a voluntary act (Libet, 1993). In contrast, Hanes and Schall (1996) state that humans' reaction times tend to be long and variable relative to neural transduction and transmission times because decision processes interfere. Therefore, the use of reaction time to measure neural threshold has its limitations. Other procedures, however, may be more useful in measuring threshold values, such as the method of constant stimuli, the method of adjustment, the method of limits, or the staircase procedure. These procedures would allow one to determine an average absolute threshold value for each group (happy, sad, and control) and to compare those values to see if there are significant differences between them. Future researchers should avoid using a white noise stimulus for the control group because it has been shown to cause significant effects on reaction times to colored stimuli. Alternatively, one could use a "no-music" group or "no mood induction" group as a control group. Data gained from such research would be an informative addition to the study of color and emotion.

A second direction future research could take would be to investigate the effects of white noise on visual threshold. Past research in this area has been scarce and discordant. In one study, perceived intensity of red, green, and blue lights was increased under white noise conditions at 100 db (Chason & Berry, 1971). Another study found large individual differences in the effect of white noise on visual threshold (Ince, 1968). It is suggested that future research examine the effect of white noise using different threshold-measuring procedures such as the method of constant stimuli, in order to provide evidence for a possible visual threshold-altering mechanism.

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