Colorful Attitudes: The Effects of Processing Speed and Color Variation on Affect

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ABSTRACT

Because affective disorders are highly prevalent mental disorders in the United States, creating rapid, effective treatments for those who suffer from such disorders should be a priority in clinical psychology research. Past research suggests that affect can be temporarily altered by introducing an individual to color stimuli or variable processing speeds (Kaya & Epps, 2006; Pronin & Wegner, 2008). More specifically, principal colors (green, yellow, and blue) or System 1 have been attributed to an increase in affect, but achromatic colors (white, grey, and black) or System 2 have been attributed to a decrease in affect (Kaya & Epps, 2006). We hypothesized that principal colors combined with System 1 processing speed will produce an even greater impact on mood than any other color~processing speed combination: achromatic~System 1, principal~System 2, achromatic~System 2. To detect a change in mood amongst participants, we gave participants a pre-test and post-test using a modified version of the Positive and Negative Affect Schedule (PANAS). Overall, our results did not support our hypothesis that combining System 1 processing speed with principal colors would result in a significant increase in affect compared to the other three conditions participants were randomly assigned.

*Keywords:* affect, color, processing speed

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Affective disorders are some of the most prevalent disorders in the United States (National Institute of Mental Health, 2017). In any given year, nearly one in eleven adults in the United States will experience symptoms severe enough to qualify for a mood disorder diagnosis. Over the course of a lifetime, nearly one in five US adults will qualify for a mood disorder diagnosis (National Institute of Mental Health, 2017). Therefore, finding effective therapeutic interventions for affective disorders is critical. Before psychologists, psychotherapists, and psychiatrists can administer successful therapies to sufferers of affective disorders, clinical psychology and psychiatry must first understand how affect is both manipulated and manifested in the individual. Current literature suggests that the establishment of emotions is a neuro-psycho-social phenomenon that has a cornucopia of causes and symptoms (Barrett, 2018; Kandel, 2019; Batgiotas 2017), which makes the search for psychological interventions in severe affective disorders such as bipolar 1 disorder difficult.

Though the etiology of affective disorders is expansive (Kandel, 2019), two potential mechanisms stand out in particular: processing speed deficits and color/sensory processing irregularities in people with mood disorders. These mechanisms are reverberated throughout social, clinical, and cognitive psychology literature (Kandel, 2019; Barrett 2018; Engel-Yeger et. al, 2016; Kaya and Epps, 2004). For example, Eric R Kandel 2019 describes in his book “The Disordered Mind” that “our language overflows with colorful descriptions of how we feel” (p. 56). Likewise, Lisa Feldman Barrett compares the evolution of color recognition and emotion perception as constructs and concepts created by cultures and individuals that can potentially influence each other and how one engages with oneself and the outside world given their internalization of such concept (Barrett, 2018). Furthermore, implicit in both Kandel’s and Barrett’s arguments are the foundational importance of information processing: whether it be sensory processing or processing speeds. In other words, both authors stress the importance of understanding how one is processing information and how such processing of information can yield alterations in affect (Kandel, 2019; Barrett, 2018).

If psychologists could understand how processing speed and color/sensory processing irregularities result in mood alterations, one could hypothetically develop an intervention that combines both systems of processing to provide therapeutic relief to those with affective disorder diagnoses. The literature has studied how processing speed and color/sensory processing irregularities result in mood alterations, separately. However, to our knowledge, there has yet to be a study that examines both processing systems simultaneously. Thus, to form a hypothesis on the effects of both processing speed and color/sensory processing changes on mood, one must first understand what the psychology field has theorized about each processing system’s effect on affect separately.

**Processing Speed**

Kahneman reified the two types of processing systems that are believed to be most central for human beings: System 1 and System 2 (Kahneman, 2011). System 1 is responsible for fast, automatic thought such as instinctual responses to danger or threats upon the amygdala’s activation of the fight, flight, or freeze system. System 2, conversely, is responsible for slow, deliberate thought such as a student carefully thinking about a question a teacher proposed to the class (Kahneman, 2011). Past studies have shown that System 1 and System 2 thinking, though important for basic cognizance, are significant impactors of one’s affective state (Pronin & Wegner, 2006). In their classical 2006 study, Pronin and Wegner (2006) postulated that thought speed and mood were positively correlated. They centered their theory on the psychiatric model of manic episodes (an affective spectrum disorder symptom) in which an individual experiences faster thought and disabling elevated moods. Pronin and Wegner had participants read words at variable speeds letter by letter as they appeared on a computer screen. Pronin and Wegner induced that fast reading was positively correlated with an elevated mood, and slower reading was positively correlated with a depressed mood. Thus, based on Kahneman’s model of System 1 and System 2 thinking, Pronin and Wegner demonstrated that System 1 thinking is correlated with an increase in mood; whereas System 2 thinking is correlated with a neutralization or decrease in mood (Pronin & Wegner, 2006; Kahneman, 2011). It logically follows then that individuals with affective disorders likely experience some disruption of System 1 and/or System 2. For example, Sarapas et. al (2018) provide evidence that slower processing speeds in individuals with affective disorders are significant indicators of disease progression.

Though slower processing speeds are predictive of a worse future prognosis, there are easy interventions individuals with affective disorders can access to remedy their processing speed deficits such as mindfulness. Mindfulness practices in people with depressive symptoms are likely to increase processing speeds of positive stimuli (Sass et. al., 2019). Other literature related to anxiety suggests that a reduced processing speed deficit allows for greater ‘attention switching,’ or successful diversion of one’s attentional faculties from stressful and worrying thoughts to more benign thoughts (Jankowski, 2020). In theory, increased attention switching could also be beneficial to individuals with affective disorders who are hyperfocused on distressing thoughts, further improving the proposed benefits of mindfulness on processing speeds in people with mood disorders.

**Sensory Processing and Color**

Like processing speed, sensory processing in people with affective disorders differs from people without a psychiatric illness (Engel-Yeger et. al., 2016). Unlike processing speed, sensory processing in people with some people affective disorders is not a deficit but a disorder that exists on a spectrum (Engel-Yeger et.al., 2016). Engel-Yeger et. al. performed a study comparing individual’s affective disorder symptomology and their interaction with sensory stimuli daily. The results concluded that people with affective disorders were more likely to have altered sensory processing through multiple systems like hypersensitivity to sensory information, hyposensitivity to sensory information, and avoidance of sensory information (Engel-Yeger et. al., 2016). To balance sensory processing in people with psychiatric disorders, therapists and psychologists have proposed ‘grounding techniques’ as a coping method (De Tord et. al., 2015. Though there is a dearth of literature on grounding techniques, possibly due to its non-complexity, internet forums, blogs, and reputed organizational websites have listed grounding techniques as an effective method to soothe anxiety, anger, distress, and any other extreme symptoms of psychiatric and affective disorders. Grounding techniques work by distancing the individual from their cognitive processes and introducing them to the physical stimuli to engage awareness of surroundings and reality (De Tord et. al, 2015; Hackney, 2002). Examples of grounding techniques include feeling a surface and focusing on its texture, tasting something pleasant, or even dancing (De Tord et.al., 2015). The objective is to engage any of the five senses to allow the participant to appreciate their present state of existence (Hackney, 2002). Taking this information, we theorize that engaging in grounding techniques can improve Sensory Processing Disorder symptomatology in people with affective disorders just as engaging in mindfulness improve processing speed deficits.

Though mindfulness and grounding techniques methods are effective at providing temporary and long-term reduction in affective disorder symptoms for some patients (Sass et. al., 2020; Jankowski, 2019, De Tord et. al., 2015; Hackney, 2002). the literature fails to provide an analysis of how mood is altered when both processing speed deficits and sensory processing imbalances are both targeted. This may be for two reasons. The first is that there is, as aforementioned, already a lack of research into grounding techniques as a coping mechanism. The second is that there may be limited coping mechanisms already in use that explicitly target both processing speed deficits and sensory processing imbalances.

Therefore, to fill this gap in the literature, this research paper will study the effects of both processing speed and sensory processing on mood alterations. Because this area of study is nuanced and new, the researchers of this experiment will start by asking the basic question ‘When combined, how do processing speed and sensory processing alter mood?’ To answer this question, we have considered what will be good metrics of processing speed and sensory processing as it pertains to mood. As for processing speed, we selected to incorporate the theory of System 1 vs System 2 thinking that increases and decreases mood, respectively (Pronin & Wegner, 2006). For sensory processing, we selected to manipulate color as a sensory stimulator. Previous literature demonstrates that color, depending on someone’s cultural roots, can cause feelings of placidity, arouse emotions like anger, or create sensations of joy or despondency (Wei et. al., 2018; Kaya & Epps, 2004). In fact, Kaya and Epps have attributed which universal colors are attributed to which emotional constructs. Principal colors, which the authors define as yellow, blue, and green, were shown to have the highest association with positive emotions, illustrating that simply viewing colors can alter an individual’s affect. Likewise, achromatic colors, which the authors define as yellow, black, and grey, were shown to have the highest association with neutral and negative emotions (Kaya and Epps, 2004).

We hypothesize, thus, that pairing colors associated with positive mood and fast processing speed will increase an individual’s mood more than any of the following conditions: pairing colors associated with positive mood and slow processing speed, pairing colors associated with negative mood and fast processing speed, and pairing colors associated with negative mood and slow processing speed.

If results affirm our hypotheses, this would be motivation for clinical psychologists to perform further research into the creation of a coping mechanism that combines both sensory processing and processing speed to alter mood in those experiencing depressive and/or manic episodes.

**Method**

**Design**

The dependent variable in this study is mood. The independent variables are processing speed and color. To test for the effect of color and processing speed on mood, color will be manipulated by using principal and achromatic colors. Principal colors are green, yellow, and blue. Achromatic colors are grey, black, and white (Kaya & Epps, 2004). The manipulation of color was used to measure the construct of sensory processing variability in people. Processing speed will be manipulated by creating a condition for System 1 processing and a condition for System 2 processing. Participants will be placed into either one of four conditions: System 1—principal (S1P), System 1—achromatic(S1A), System 2—principal (S2P), and System 2 achromatic (S2A).

**Participants**

Participants were recruited from MTurk, a survey platform that allows people to participate in surveys for a monetary reward. Our participants came from a diverse background. We had 108 participants, over 60% of whom were older than 25 years. 62% of our participants were Asian, 30% were White, 3.5% were black, 1.2% were Native Hawaiian/Other Pacific Islander, and the remaining participants selected not to disclose their racial background. The overwhelming majority of our participants were cisgender, with 45.71% being cisgender men and 20.57% being cisgender women. 11.43% were agender, 1.71% were nonbinary, 1.71% were transgender men, and 0.57% were transgender women. Most of our participants were either from India or the United States.

**Materials**

We employed the Positive and Negative Affect Schedule (PANAS) to measure positive affect (Watson and Tellegen, 1988). The Positive and Negative Affect Schedule asks respondents to rate their mood over the past week on twenty different emotional levels, with ten of those emotional levels being associated with positive affect and the other ten of those emotional levels being associated with negative affect. The questionnaire uses a Likert scale of 1 (very slightly or not at all) to 5 (extremely). An example emotional level a participant would be asked to measure positive affect is ‘enthusiastic.’ Conversely, to measure negative affect, for example, participants would be asked to rate how ‘hostile’ they felt. Positive affect for a singular participant was measured by summing the participant’s responses to all the positive emotional levels on the PANAS for a maximum score of 50. Because we were concerned with the immediate effect of color and processing speed on mood, instead of asking participants to rate their mood within the past week, for the pre-test we asked participants to rate their mood within the past hour. The post-test consisted of the same items as the pre-test and asked a slightly altered question: “Indicate the extent to which you feel this way right now.” The positive schedule for the PANAS has a Cronbach’s Alpha or approximately 0.80 (Garcia-Diaz et. al., 2020).

To test for color, we placed pictures of random, everyday objects such as an ice cream cone or a hat onto two different backgrounds: an achromatic background or a principal background. We also decided to make the colors the background as a manipulation, serving as a distraction so that participants feel as though they are focusing on the objects in the picture and not the background color.

To test for processing speed, we had participants describe the pictures shown to them in one of two ways. They were either asked to “Respond to the picture above in one or two creative sentences” or they were asked to “Respond to the picture above in one word.” This process would beckon slow, diligent thinking—system 2—and rapid, manic thinking—system 1—respectively. Neither condition was given a time limit to complete the survey and answer any questions.

**Procedure**

We created a survey in Qualtrics with the following components: a consent attestation, demographic information, PANAS pre-test, the randomly assigned four conditions, PANAS post-test, and the debriefing form. Participants were recruited via MTurk and were randomly assigned to one of the four conditions. Unfortunately, the number of the participants in each condition varied and was not equivalent. We are not sure why the number of participants in each condition is inequivalent, but we believe it was an error within MTurk’s random assignment system. At the end of the study, participants were paid via MTurk’s system. Participants were paid 33 cents for their participation in a study that lasted, on average, 22 minutes.

**Results**

We used a factorial analysis of variance to determine if there was a main effect of color and/or processing speed on affect. To calculate the change in affect in our participants, we subtracted the PANAS positive affect post-test results from the PANAS positive affect pre-test results. A positive number indicated that there was a positive increase in positive affect in a participant; whereas a negative number indicated that there was a negative increase in positive affect. If the difference between the post-test and the pre-test yielded a result of zero, we concluded there was no change in positive mood in our test.

We completed two factorial analysis of variance tests. Our first test encompassed all the responses from all participants. There was no main effect of color on mood, F (1,98) = 3.402, p > 0.05, nor was there a main effect of processing speed on mood in our first test, F (1,98) = 0.009, p > 0.05. There was also no interaction betwixt color and processing speed on mood, F (1,98) = 0.187, p = 0.05. The exact p-values for each independent variable can be found in Table 1. Overall, our first test concluded that neither color nor processing speed has a statistically significant effect on the mean difference in positive affect.

From the researcher’s understanding, one assumption for a factorial ANOVA is that there should not be significant outliers within the dataset. Therefore, for our second ANOVA, we removed all outliers from each condition. All outliers are denoted by a circle above or below the interquartile range in Figure 1. Our second test yielded the same results. There was not a main effect of color or processing speed on affect, nor was there an interaction between the two (e.g., Table 1 demonstrates the change in F-statistics and p-values for color, processing speed, and the interaction). However, we did see a decrease in the overall p-values for the main effect of color and the main effect of processing speed. The p-value for color reduced to, F (1, 94) = 3.664, p = 0.0588, which suggests a trend towards significance of the results. Yet, we still concluded to fail to reject the null hypothesis that the difference in means of each condition is zero.

Furthermore, though none of our F-values would be considered statistically significant, Figure 1 is correlated with our initial hypothesis that the principal colors and System 1 thinking combined would have the greatest positive effect on positive affect. Though Figure 2 does not show data wholly correlated with our initial hypothesis in relation to mean (M) and standard deviation (sd), there is a clear contrast between being placed in the achromatic color condition vs the principal color condition. Those placed in the achromatic condition saw a lower mean increase in positive affect compared to those placed in the principal condition. The same logic does not hold true for the processing speed condition.

**Discussion**

Our hypothesis that faster processing speed and colors associated with positive mood would increase affect was not supported by the data. Trends do suggest, however, there may be an effect of color on mood.

**Limitations and Study Suggestions**

Though our results were not statistically significant, we are confident that previous literature’s assessment of color and processing speed on affect separately are accurate because our study had porous external and construct validity.

Our first notable limitation is our failure to control for a participant’s country of origin. Color and emotion concepts perception vary culturally (Kayy and Epps, 2004; Barrett, Lisa Feldman, 2018; Wei, Erqi, & Jinxia, 2018). For example, citizens of Country A may perceive blue as a color that incites feelings of happiness. But citizens of Country B may perceive blue as a color that incites feelings of anger. Therefore, participants from Country A would be likely to score substantially higher on the positive questions associated with the PANAS questionnaire than participants from Country B. Because our study was run on MTurk, participants were from various parts of the globe. Furthermore, because we only had 108 participants, if we chose one country (the USA) to represent a culture that we thought would replicate Kayy and Epps’s findings in principal color perception vs achromatic color perception, our sample size would be too small and violate statistical assumptions.

Another limitation lies within our construct validity. First, we cannot assume that having participants respond with one word to a picture they were seen activates System 1 processing. System 1 processing is automatic, typically taking place unconsciously. As reviewed in the introduction section, Pronin and Wegner’s study effectively captures System 1 processing by adding letters to words as an individual reads. This method only allows participants time to automatically read the words shown to them instead of encoding the deeper meaning behind such words. Furthermore, to guarantee an increase in thought speed, one could have participants ingest safe doses of natural and psychotropic stimulants such as Adderall or caffeine (Owen et. al., 2018). Caffeine and other natural/psychotropic stimulants work by creating a sense of alertness, thus potentially activating a quicker and more responsive System 1 processing mechanism.

Furthermore, our construct validity for color was flawed. The photos we selected for participants to respond to only had principal or achromatic colors as the background. The items that were the foreground of the picture were colored and probably had positive valence attached to them, such as an ice cream cone eliciting joy. Previous studies that suggest color does influence affect typically expose participants to one color at a time and emphasize that specific color to the participants (Kayy and Epps, 2004; Wei, Erqi, & Jinxia, 2018). Thus, having colored items in the foreground created a confounding variable that should be controlled for in future studies. In the future, researchers may elect to use symbols and characters of neutral valence and color.

Despite these limitations, our results illustrate that processing speed and color, when combined, may not have a significant effect on mood. These data are important as they suggest future coping mechanisms developed by clinical psychologists and psychiatrists should avoid heavily combining fast processing speeds and bright, principal colors to stimulate positive affect. These methods should not be avoided simply for risk of harming the patient but because, overall, they may not offer any support for the patient or person suffering from symptoms of an affective disorder. Going forward it is imperative for researchers to design a study that measures the impact of processing speeds and color on mood with greater construct, internal, and external validity.

If there does happen to be a significant impact of both color and System 1 vs System 2 thinking, the field’s next steps could be to determine if moods are elevated or depressed at healthy levels. A superfluous increase or decrease in mood could trigger a manic or depressive episode that clinicians could have initially been attempting to avoid (Pronin & Wegner, 2006). If there does not happen to be a significant impact of both color and System 1 and System 2 thinking, then researchers may opt to consider how this could be used to people with affective disorder’s advantages. Could this neutrality in mood change provide long-term benefits, allowing researchers to develop a coping mechanism that reduces chances of affective disorder symptom relapse in people in remission?

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Table 1:

*Effect Sizes and Statistical Significance per Independent Variable*

|  |  |  |
| --- | --- | --- |
|  | F-Statistic | P-Value |
| Color | 3.402 | 0.0683 |
| Color (ro)\* | 3.664 | 0.0588 |
| Processing Speed | 0.009 | 0.9254 |
| Processing Speed (ro) | 0.831 | 0.3644 |
| Interaction | 0.187 | 0.6666 |
| Interaction (ro) | .007 | 0.9343 |

\* (ro) means ‘Removed Outliers.’ (ro) statistics report the effect sizes and statistical significance for each independent variable given outliers were removed from the sample.

Chart, box and whisker chart

Description automatically generated

*Figure 1*: Boxplots of each condition

*Figure 2:* The average mean difference for each condition is shown.