The Effect of Priming and Color Cues on Natural Scene Recognition

Anastasios Papapanagiotou

Deree- The American College of Greece

PS 3734A1 Experimental Cognitive Psychology

Dr. Ioanna Spentza

December 11, 2024

Abstract

This study explored the effects of priming and color on recognition of natural scenes. There were 99 participants (55 females, 44 males; average age 20.5 years), all undergraduate students at the American College of Greece. Using a 2x2 factorial design and each participant was assigned to one of the four groups (prime/color, no prime/color, prime/grayscale, no prime/grayscale). Each participant had to complete a demographics questionnaire, look at the paintings- with their prime if in the prime group- complete two distractor tasks, and then recognize new and old paintings presented. Results showed no main effects of either the prime or color, however a significant interaction was found indicating that those who were primed performed better with colored pictures than those with grayscale.

Keywords: priming, color cue, recognition, natural scene, painting

The Effect of Priming and Color Cues on Natural Scene Recognition

Stimuli recognition, like natural scenes, animals, and objects, involves multiple levels of cognitive processes to help us identify and recognize previously seen stimuli. Such cognitive processes include extraction of surface-level features, such as color and texture, spatial information, physical characteristics of objects to name a few. Another cognitive mechanism which can affect recognition is priming, in which exposure to previous stimuli can have an effect on processing of the visual stimuli, and thus on recognition as well. The effects of color and priming on recognition of visual stimuli have been heavily studied, however the results vary significantly. This study aims to address these conflicting results by exploring how priming, color, and their interaction can have an effect on recognition.

Firstly, the first line of research explores how certain features, like color, can enhance image recognition. While image recognition, object identification, and association with meaning is being done in the late stages of vision, earlier stages are responsible for extracting more general information, like spatial information or shape extraction (Ullman 1996; Biederman, 1987). At the earliest stages only surface and information are available like color, depth, and texture (Biederman, 1987; Wurm et al., 1993). Color has received increased attention because of the simplicity to test and manipulate it. Biederman and Ju (1998) suggest that color does not significant affect object recognition and segmentation. Opposing research suggests that in absence of certain features like high-resolution images, high contrast, or clearly visible edges, color and other surface features are significant (Wurm et al., 1993). Delorme et al. (2000) found that color is not essential for natural scene recognition while Li et al. additionally argued that it is not essential even in the absence of attention, however

some of their images included distinctive features (like specific body animal body parts) which may have influenced recognition.

Contrary to these findings, there are several results that highlight the importance of color in recognition. For example, it has been found that natural scene color, congruency and color cues can affect recognition, reaction times, and attention (Spence et al., 2005; Wichmann, Sharpe & Gegenfurtner, 2002; Oliva & Schyns, 2000; Dzulkifli & Mustafar, 2013). Furthermore, the importance of color can vary depending on the type of scene. For instance, green landscapes and rocky landscapes have differences in terms of recognition (Wichmann, Sharpe & Gegenfurtner, 2002). Thes researchers also found that surrounding an image with an irrelevant color improves recognition compared to a black-and-white frame.

Secondly, the effects of priming on recognition have been studied. Studies have shown that the use of certain features like color or spatial information as cues to improve reaction times and recognition. In particular, Bravo & Nakayama (1992) provide evidence that the knowledge of the target color can decrease reaction times while Folk and Remington (1998) showed that a green cue enhanced attention if the target was also green but not if it was red. Fecteau (2007) found that repeating a feature of the target like color can increase performance however only if color is part of the observer's intention. Leonard and Egeth (2008) concluded that informative cues, cues which provide knowledge about the upcoming target, can improve reaction time and recognition. These results replicate those of Bravo and Nakayama (1992) and directly contradict the results of Maljkovic and Nakayama (1994) who argue that simply expecting the color of the upcoming target does not provide any improvement. Moreover, similarity between the prime and the target, congruency effect, has been shown to play a critical role in improving reaction time and recognition (Kunde & Wuhr, 2006).

In this study we examined the effects of color cues as a prime and the use of color on recognition of natural scenes. We employed a procedure similar to the prime-target/prime-probe tasks (Fox & De Fockert, 1998; Kunde & Wuhr, 2006). We selected realistic looking paintings of natural scenes that mostly resembled tree with the dominant color being green and because of this we chose the prime condition as a green rectangle while the no-prime condition as a grayscale one. The study addresses the dichotomous findings of the aforementioned research by providing additional evidence to some of the results. Most importantly however, we investigate whether priming can account for the effects of color on recognition of natural scenes. In particular, we hypothesize that there is a main effect of color (colored paintings/grayscale paintings) and a main effect of priming (primed/not primed) on recognition. Additionally, we predict an interaction effect, where participants who were primed and presented with colored paintings would demonstrate better recognition than those who were primed but presented grayscale images.

Method

Participants

There were 103 participants, all students at the American College of Greece with mean age 20.5. The majority were women (55.3%) then men (42.7%), one participant identified as non-binary, and another preferred not to disclose. All participants agreed to participant and no vision problems were reported. Outlier analysis on reaction times revealed four outliers, which were removed leaving 99 participants in total.

Materials

Three types of stimuli were used throughout the experiment. The first type of stimuli was used for priming which included a 200x150 pixel green rectangle which is used for participants who are primed and are presented with colored paintings, and a grayscale

rectangle, which is used for participants who are primed and see grayscale paintings. Two images were used during the distraction phase which represented a “find the differences” task. Finally, 38 paintings of natural scenes were used as the stimuli to be remembered. All of the paintings mostly consisted of greenery, trees, and forests. For the participants in the colored condition viewed these paintings colored while participants in the grayscale condition viewed the same images but in grayscale.

Design and Procedure

A between-subjects factorial experimental design was used with two independent variables, prime with two levels (yes/no) and colored with two levels (colored/grayscale). This resulted into four different groups and the 99 participants were equally and randomly distributed across groups (prime-colored: N=25, no prime-grayscale: N=25, no prime-colored: N=24, no prime-grayscale: N=25).

Before starting with the procedure, each participant was provided with an informed consent (appendix A) to which they had to agree to before continuing. Additionally, they were asked to fill a demographics questionnaire than included their English comprehension, age, and gender. The procedure took approximately 5 minutes and consisted of three phases and each included instructions before it started. First was the presentation phase during which, 16 paintings were displayed at a random order either in color or in grayscale, depending on the participant’s group. Each painting was displayed for 5000ms. If the person was primed then before each painting, a fixation cross was displayed for 1000ms followed by the prime. The prime was displayed for 100ms and was green if the participants belonged to the color group and gray if in the grayscale group. Then came the distractor phase in which participants had to complete two distractor tasks. In each task a distractor image was presented, and the

participant was asked to complete the “find the differences” task. Each distractor task took 30 seconds. Lastly came the recognition phase in which the participant was presented with all 36 paintings (the color was the one corresponding to their group) in a random order and for each were asked to reply if they have seen the painting during the presentation phase or not. In the end, the participants were given a debriefing statement (appendix B) which included our hypotheses.

Based on their answers, three types of results arise. Recognition corresponds to the number of paintings which the participant correctly replied that they have seen the painting during the presentation phase, we call them “Old Positives”. Another result is the number of paintings that did not appear during the presentation phase and the participant correctly replied that they did not see them, these are referred as “New Positives”. Lastly, if the participant either does not recognize a previously displayed painting or falsely recognizes a non-displayed painting it counts as an error.

Results

An analysis of variance (ANOVA) revealed that participants who were not primed (M=13.20, SD=3.03) had better recognition than those who were primed (M=12.66, SD=2.66), however prime had no main effect on recognition, $p>.05$ (refer to table 2). A similar result has been found the effect of color, as those who saw grayscale paintings (M=13.14, SD=2.56) had higher recognition than participants who saw colored paintings (M=12.71, SD=3.13), no main effect of color on recognition was found, $p>.05$. A weak significant interaction effect between prime and color on recognition was observed, $F(1,95) = 4.47$, $p < .05$, partial $\eta^2 = .045$. In particular, from the participants who were primed, those who saw colored paintings (M=13.04, SD=3.02) performed better than those who saw grayscale paintings (M=12.28, SD=2.25) by about 6% (refer to table 1). However, from the

participants who were not primed, those who saw grayscale paintings (M=14.00, SD=2.60) had higher recognition than those who saw colored paintings (M=12.38, SD=3.27). Although there is significance, the convenience sampling method employed, the small sample size per group, and the weak effect size do not provide conclusive evidence of an interaction effect.

Table 1

Descriptive statistics of recognition of old pictures

Color	Prime	Mean	Std. Deviation	N
Color	Prime	13.04	3.020	25
	No Prime	12.38	3.268	24
	Total	12.71	3.129	49
Gray	Prime	12.28	2.246	25
	No Prime	14.00	2.598	25
	Total	13.14	2.556	50
Total	Prime	12.66	2.662	50
	No Prime	13.20	3.028	49
	Total	12.93	2.847	99

Table 2

Test of between-subjects effects of recognition

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Color	4.628	1	4.628	.588	.445	.006
Prime	6.885	1	6.885	.875	.352	.009
Color * Prime	35.185	1	35.185	4.471	.037	.045
Error	747.625	95	7.870			
Total	17344.000	99				

An analysis of variance (ANOVA) revealed that participants who were not primed (M=1452.76, SD=405.27) had greater reaction times than those who were primed (M=1435.30, SD=298.29), however prime had no main effect on reaction times, $p>.05$ (refer

to table 4). A similar result has been found the effect of color, as those who saw grayscale paintings (M=1453.24, SD=377.62) had higher reaction times than participants who saw colored paintings (M=1434.45, SD=330.89), no main effect of color on reaction times was found, p>.05. The test of between-subjects effects did not indicate a significant interaction effect of color and prime on reaction time, p>.05.

Table 3

Descriptive statistics of mean reaction time

Color	Prime	Mean	Std. Deviation	N
Color	Prime	1450.68	283.570	25
	No Prime	1417.54	379.472	24
	Total	1434.45	330.886	49
Gray	Prime	1419.92	317.425	25
	No Prime	1486.56	433.662	25
	Total	1453.24	377.619	50
Total	Prime	1435.30	298.292	50
	No Prime	1452.76	405.273	49
	Total	1443.94	353.572	99

Table 4

Test of between-subjects effects of Mean Reaction Time

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Color	9053.815	1	9053.815	.071	.791	.001
Prime	6942.443	1	6942.443	.054	.816	.001
Color * Prime	61581.747	1	61581.747	.481	.490	.005
Error	12173563.398	95	128142.773			
Total	218662396.000	99				

Discussion

This study aimed to explore the effects of colored images and priming on recognition and reaction time. Previous literature was conflicted as some provided evidence that color

played an important role on recognition while others supported the hypothesis that recognition of color and grayscale images do not differ significantly. The same has been found for priming, as some suggest that providing informative color cues before the presentation of an image can improve recognition, whereas the opposition provide evidence showing that priming using colors provides no difference than when no priming is used.

Our initial hypotheses were not supported as our results indicate that neither color nor priming had a significant effect on either recognition or reaction times. However, there is a trend in the same direction for the second hypothesis as those who were primed did better when they saw colored images than when they saw grayscale images. Conversely, those who were not primed performed better when they saw grayscale images than colored images. Due to the sample solely consisting of undergraduate students along with the small effect size of the interaction effect, these results do not confidently support either side of the literature but provide only a mere trend towards literature that supports the hypothesis that color or priming does not have any significant effect.

The absence of a main effect showed that color or priming on their own did not produce any difference in terms of recognition or reaction times. This agrees with the results of Biederman and Ju (1998), which also found that color does not significantly influence object recognition and with the results of Maljkovic and Nakayama (1994) who suggest that providing a prime before each presentation of the image does not make a difference on recognition. Color on its own also does not provide any difference, creating a trend towards results like those of Li et al. or Delorme et al. (2000) who argue that color information is not important for recognition or reaction time. In the presence of priming however, color has a weak but significant effect on recognition. This result could be interpreted through the ideas presented by Leonard and Egeth (2008) who suggested that prior cues related to features of the target, like color, can enhance recognition.

Even though some of our results agree with previous literature, several limitations and extraneous variables could have confounded our results. First and foremost, the sample size for each group is relatively small and consists mostly of undergraduate students at the American College of Greece. This can lead to bias, as most come from a high socioeconomic status and the fact that all are students adds bias to cognitive functions like attention and memory. Additionally, there was not control for other features of images like luminance and contrast, as previous studies have shown that these can have an effect on recognition (Gegenfurtner, 2003; Bramão et al., 2011; Wurm et al., 1993). Last but not least, the presentation time of each stimulus could have been very high. The long presentation time could enable participants to construct strategies or use more complex and lower-level cognitive functions to help with recognition. Because color is a low-level process and happens very quickly (Breitmeyer, Ogmen, & Chen, 2003), strategies could dominate the effect of color on recognition. Similarly, cognitive strategies could dominate the implicit memory which confounds the effect of priming on recognition. According to Spence et al. (2005) presentation duration has a significant main effect on recognition and the effect size was very large.

Future research could try to replicate our results and address some of the limitations, for example by selecting a sample that is more representative of the population, control for brightness and luminance, and decrease the presentation time. Additionally, this research has not explored the importance of congruency between the prime and the target, as it has been done by different colors can affect cognitive processes differently, for example Breitmeyer, Ogmen and Chen (2003) other than using the same color for the prime and target, they additionally use neutral colors as primes. Color congruency was not assessed by this study and has its importance has not been extensively studied. Wichmann, Sharp, and Gegenfurtner

(2002) have found that color incongruency between the stimulus and learned knowledge about the stimulus can have negative effects on recognition.

In conclusion, this study was designed to contribute to the conflicting results of the effects of color and priming on recognition of natural scens. While the results from the main effects of priming and color did not directly support or reject these views, the observed interaction provides a potential importance of priming and cues on the on the effect of color on recognition.

References

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review*, *94*(2), 115–147. https://doi.org/10.1037/0033-295x.94.2.115

Biederman, I., & Ju, G. (1988). Surface versus edge-based determinants of visual recognition. *Cognitive Psychology*, *20*(1), 38–64. https://doi.org/10.1016/0010-0285(88)90024-2

Bramão, I., Reis, A., Petersson, K. M., & Faísca, L. (2011). The role of color information on object recognition: A review and meta-analysis. *Acta Psychologica*, *138*(1), 244–253. https://doi.org/10.1016/j.actpsy.2011.06.010

Bravo, M. J., & Nakayama, K. (1992). The role of attention in different visual-search tasks. *Perception & Psychophysics*, *51*(5), 465–472. https://doi.org/10.3758/bf03211642

Breitmeyer, B. G., Ogmen, H., & Chen, J. (2003). Unconscious priming by color and form: Different processes and levels. *Consciousness and Cognition*, *13*(1), 138–157. https://doi.org/10.1016/j.concog.2003.07.004

Delorme, A., Richard, G., & Fabre-Thorpe, M. (2000). Ultra-rapid categorisation of natural scenes does not rely on colour cues: a study in monkeys and humans. *Vision Research*, *40*(16), 2187–2200. https://doi.org/10.1016/s0042-6989(00)00083-3

Dzulkifli, M. A., & Mustafar, M. F. (2013). *The Influence of colour on memory Performance: a review*. https://pmc.ncbi.nlm.nih.gov/articles/PMC3743993/

Fecteau, J. H. (2007). Priming of pop-out depends upon the current goals of observers. *Journal of Vision*, *7*(6), 1. https://doi.org/10.1167/7.6.1

Folk, C. L., & Remington, R. (1998). Selectivity in distraction by irrelevant featural singletons: Evidence for two forms of attentional capture. *Journal of Experimental Psychology Human Perception & Performance*, *24*(3), 847–858. https://doi.org/10.1037/0096-1523.24.3.847

Fox, E., & De Fockert, J. W. (1998). Negative priming depends on prime-probe similarity: Evidence for episodic retrieval. *Psychonomic Bulletin & Review*, *5*(1), 107–113. https://doi.org/10.3758/bf03209464

Gegenfurtner, K. R. (2003). Cortical mechanisms of colour vision. *Nature Reviews. Neuroscience*, *4*(7), 563–572. https://doi.org/10.1038/nrn1138

Kunde, W., & Wühr, P. (2006). Sequential modulations of correspondence effects across spatial dimensions and tasks. *Memory & Cognition*, *34*(2), 356–367. https://doi.org/10.3758/bf03193413

Leonard, C. J., & Egeth, H. E. (2008). Attentional guidance in singleton search: An examination of top-down, bottom-up, and intertrial factors. *Visual Cognition*, *16*(8), 1078–1091. https://doi.org/10.1080/13506280701580698

Maljkovic, V., & Nakayama, K. (1994). Priming of pop-out: I. Role of features. *Memory & Cognition*, *22*(6), 657–672. https://doi.org/10.3758/bf03209251

Oliva, A., & Schyns, P. G. (2000). Diagnostic colors mediate scene recognition. *Cognitive Psychology*, *41*(2), 176–210. https://doi.org/10.1006/cogp.1999.0728

Spence, I., Wong, P., Rusan, M., & Rastegar, N. (2005). How color enhances visual memory for natural scenes. *Psychological Science*, *17*(1), 1–6. https://doi.org/10.1111/j.1467-9280.2005.01656.x

Wichmann, F. A., Sharpe, L. T., & Gegenfurtner, K. R. (2002). The contributions of color to recognition memory for natural scenes. *Journal of Experimental Psychology Learning Memory and Cognition*, *28*(3), 509–520. https://doi.org/10.1037/0278-7393.28.3.509

Wurm, L. H., Legge, G. E., Isenberg, L. M., & Luebker, A. (1993). Color improves object recognition in normal and low vision. *Journal of Experimental Psychology Human Perception & Performance*, *19*(4), 899–911. https://doi.org/10.1037/0096-1523.19.4.899

Appendix A

Informed Consent Form

PURPOSE AND PROCEDURE

The purpose of this study is the effects of priming on recognition and if color affects this interaction If you agree to be in this study, you will be asked to do the following:

1. Reply to a demographic questionnaire
2. View some paintings
3. Perform a short mathematical task
4. Indicate whether or not you have seen the paintings you will be presented with

BENEFITS/RISKS TO PARTICIPANTS

There are no known risks for this study. The prospective benefits are aiding in the scientific progress and potential learning about new cognitive concepts.

DATA COLLECTED AND Voluntary Nature of the Study

Data collected is confidential and will only be viewed and used by the experimenter. Data collected will be destroyed after three years and will not be used for future research, even if de-identified. Results will be reported only in the aggregate. Your participation in this study is entirely voluntary. If for any reason during this study you do not feel comfortable, you may withdraw without any penalty and your information will be discarded.

By clicking 'YES' you confirm that you have read and understood the information provided above, that you are over 18, and you willingly agree to participate in this study.

Appendix B

Debriefing Form

Dear Participant,

Thank you for participating in this study. The aim of this study is to investigate the effects of priming in recognition of paintings. In particular the study explores if the participants who were primed could identify correctly the paintings that were presented or not. At first some paintings were shown with some of them having a very brief presentation of color before them to be used as a primer. Following that you were asked to complete a distractor task in order for some time to pass and the memory of the paintings to pass to long-term memory. Finally, the previous paintings were shown again mixed with some new ones. A choice was asked to be made on whether they were previously presented or new. In the study two groups were examined those who were presented only with colored paintings and those who were presented only with gray-scale paintings. The actual purpose of the study and the examined factors were not disclosed to you initially to allow you to complete the experiment in an unbiased manner not formed by psychological studies. Please do not reveal the aforementioned information to your fellow students, who might participate in the experiment, as this would contaminate the data, until the 1st of January when the data collection will have been completed.

In case you experience any unforeseen negative outcomes or you have concerns as a result of participating in the study you can contact the following sites where supporting services are offered free of charge. For ACG students: Counseling Center at the American College of Greece (210-6009800 ext. 1080, 1081) at http://www.acg.edu/currentstudents/student-services/acg-counseling-center For all participants: Psy-Diktyo (Ψ-Δίκτυο) http://psy-diktyo.gr/

We would like to thank you once again for your time and interest.

If you are interested about the topic, here are some indicative sources you might wish to read:

Hauptmann, B., & Karni, A. (2002). From primed to learn: the saturation of repetition priming and the induction of long-term memory. Cognitive Brain Research, 13(3), 313-322. https://doi.org/10.1016/S0926-6410(01)00124-0

Spence, I., Wong, P., Rusan, M., & Rastegar, N. (2006). How color enhances visual memory for natural scenes. Psychological science, 17(1), 1-6. https://doi.org/10.1111/j.1467-9280.2005.01656.x

Thank you for your participation!