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Cultural Perception of Dominant Color in Static Systems

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ABSTRACT

Color is a fundamental component of various systems as well as a crucial aspect of everyday life for members of a given culture. Numerous studies have been conducted on how humans distinguish different colors, the effects of color on human behavior and risk factors, cultural differences in color perception, among many others. The goal of this empirical study was to evaluate how certain language components affect the perception of dominant color in certain static objects. To this end, a categorization of the static objects to be analyzed was generated, for which 18 digital works by Van Gogh were chosen. Additionally, the dominant color of each work was determined based on a color sample from each image, and color cards were generated using the hexadecimal system. Sixty-six volunteers were surveyed, who provided self-reported data on their age and context, and were given the freedom to select the color card that they believed corresponded to the dominant color in each presented image. Additionally, users were allowed to individually explore each image and its components. The findings show that there is a variation in the perception of the dominant color in the category of components integrated by textures in relation to the perception of color in the category of components integrated by people-animals, and everyday objects.

Keywords: Cultural perception, Dominant color, Static systems, Interaction of components in the image

INTRODUCTION

Color perception is a relevant topic as it is a part of our daily lives and has been approached in various fields of knowledge such as art, design, architecture, among others, from an artistic perspective to a greater extent. However, color perception in certain contexts can affect people's daily lives, the objects they interact with, the information to which they delegate attention among multiple factors. There is research related to modifying human behavior linked to this factor. From this perspective, studies conducted by Babin et al. (2003) suggest that consumers process atmospheric characteristics holistically (Babin et al., 2003). Similarly, Babur and Connolly (2011) studied how color perception can be affected not only by other colors but also by other atmospheric factors such as hypoxia in certain contexts, which focused on studying the effects of hypoxia on color perception, visual acuity, and contrast sensitivity (Barbur & Connolly, 2011). Likewise, Babur has contributed to other studies on detecting vision loss (Vemala et al., 2017). On the other hand, impairments related to color perception can impact people's safety in certain contexts. From this perspective, there are studies that have shown that color enables performing specific and specialized tasks in contexts such as aviation (Rodriguez-Carmona et al., 2012), navy, military, police, medicine, and other visually demanding work environments (Barbur & Rodriguez-Carmona 2017). Likewise, color can generate a categorization of products into hedonic and utilitarian in certain virtual contexts (Cai & Xu, 2011), and color appreciation determines certain behaviors in specific sectors related to particular objects (Boon & Dain, 2015). On the other hand, studies have detected alterations in color perception due to age. In this sense, studies conducted by Babur & Rodriguez-Carmona (2016) have been relevant, where they found that the thresholds for Red and Green; Yellow and Blue colors gradually decrease with age (Barbur & Rodriguez-Carmona, 2016). Additionally, plasticity in color perception has also been explored in individuals with a level of deficiency in it (Isherwood et al., 2020). New quantitative methods have been introduced to better understand the impacts of color and its impact on daily life. This includes the methodology employed by Rabin, Gooch, & Ivan (2011) for measuring color vision using the Cone Contrast Test (CCT) (Rabin et al., 2011), as well as detecting deficiencies in color perception through the Color Perception Deficiency Severity Index (CGDI) (Rodriguez-Carmona et al., 2012). Likewise, given the qualities of color and its influence on human behavior, color can be approached as a type of language that is affected by other languages. This is the case with Schirillo (2001), who reviewed literature on how color is perceived and used as a language in different cultures (Schirillo, 2001); Regier, & Kay, (2009) analyzed Whorf's hypothesis on how language influences the way we think and perceive the world from the perspective of color (Regier & Kay, 2009); Kay & Regier, (2006) observed that there is a close relationship between naming color and perception of it (Kay & Regier, 2006); and Hardin & Maffi, (1997) highlighted that the way people categorize and name colors varies worldwide and how this language categorization related to color influences a person's cognitive processes (Hardin & Maffi, 1997). Based on the literature review, color is a factor that affects people in multiple dimensions, including cognitive, psychological, physiological, and cultural. However, many studies still need to be done to better understand how color affects us in each of these dimensions, especially in an era where the influence of digital media has led to the perception of intercultural objects. In this sense, this study focuses on the study of color from the perspective of a local culture, where the aim is to observe how people perceive the dominant color in objects that are not part of their culture and have the quality of being static. For this purpose, paintings by an internationally recognized artist such as Van Gogh were chosen as static objects. However, we encountered the problem that these types of objects are integrated by a complex structure of visual signs such as shapes, colors, and textures (Wolfflin, 2015), which led us to approach them as static systems. Therefore, we decided to observe how the perception of the dominant color is affected by its interrelation with other visual components of the painting, such as shapes and textures. For better control, the independent variables were categorized into landscapes; category linked to textures, people-animals; category linked to shape recognition, and everyday objects; category linked to object recognition. Regarding the dependent variable, a sampling of the dominant color of a group of 18 digital paintings by Van Gogh was generated. The study only focused on Mexican volunteers at this stage. Furthermore, it was found that people must perform at least two types of processes in selecting the dominant color: visual perception and shape identification. In this sense, the study will not focus on analyzing the internal process; however, it is based on recognized positions that refer to these specialized processes being carried out naturally in people.

METHODOLOGY

The study was divided into six phases: In the first phase, an empirical approach was used where volunteers self-reported their age, mood, medication or alcohol consumption conditions, cultural context, level of education, disciplinary field, and gender. The context was classified into five regions based on the geographic location of the states and their proximity to the Pacific Coast, Gulf of Mexico, and Caribbean Sea. The regions were: North Region, Pacific Region, Central Region, Gulf Region, and Southeast Region. In the second phase, perceivers were assigned the task of observing a series of digital images and then detecting the dominant color in the image. The dominant color for this exercise was determined by the color that occupied the largest area in each image. For this purpose, the 50% of colors that integrated each image were obtained from a sample. Based on the data obtained, the dominant color was determined according to the highest percentage of color coverage obtained from the color sample, and this procedure was carried out with the 50% of predominant colors in each artwork. Based on this information, color cards were generated relative to the image in the hexadecimal system. In the third phase, a series of digital artworks were presented to the participants along with the color cards relative to each image, which were presented in the same order and with the same dimensions. In the fourth phase, the participants selected the color identified as dominant. In the fifth phase, the results were analyzed, with special attention given to the perception of the dominant color and its relationship with certain components of the image as part of a structured language configured by the artist. In the sixth phase, the interaction between objects in the images with higher and lower assertiveness was analyzed. The exercise was carried out in Mexico. It is important to mention that the technological devices used for color reproduction were personal. There is no single calibration standard for all devices, as each manufacturer uses their own calibration and color adjustment methods. However, some manufacturers have adopted industry standards to ensure that their devices reproduce accurate and consistent colors. Based on this, only those devices that comply with the sRGB and P3 standards were selected, taking into consideration those devices under these standards where users had not modified the color settings and they were set by the factory. Likewise, the devices under both standards are not older than 2015. Based on some recent studies, it has been observed that modern screens are capable of displaying images much closer to reality (Masia et al., 2013).

PROCESS DESCRIPTION

Of the total volunteers, it was observed that 54.6296% selected the correct Dominant Color (DC), of which 34.2592% were women and 20.3703% were men. Four images were detected with the highest percentage of DC assertiveness: IM2, IM10, IM12, IM17. Similarly, two colors were detected as having the highest assertiveness: yellow (IM2) and gray (IM10, IM12, IM17). In the case of IM2, the dominant color covered a total of 34.90% of the surface area; for IM10, DC = 44.20%; for IM12, DC = 41.10%; and for IM17, DC = 31.80% See Table 1. Therefore, the image that obtained the highest percentage of coverage with the gray color was IM10 with 44.20%, but it was not the most assertive. The most assertive one used a yellow color language with a difference of 9.3% coverage on the surface. On the other hand, it was also observed that the image with the highest assertiveness in the dominant color was the one with the highest illumination based on CIE-Lab standards, with L = 75.5.

Table 1. Color identification. Where: C=Category; IM=Image; CD=Assertiveness of Dominant Color; CDM=Dominant Color by Sampling; SH=Hexadecimal System; NC= Color's Name; I=Illuminance CIEL*ab.

C	ID	CD	CDM	SH	NC	I CIE-L*ab
PAISAJE	IM1	71.21212121	23.70%	#769cd1	Blue	63.533
PAISAJE	IM2	98.48484848	34.90%	#cebb45	Yellow	75.51
OBJETO	IM3	74.24242424	40.70%	#c0a657	Brown	68.873
PAISAJE	IM4	54.54545455	38.60%	#555346	Grey	35.123
PAISAJE	IM5	18.18181818	65.00%	#43433e	Grey	28.262
PAISAJE	IM6	40.90909091	72.10%	#4f3f30	Brown	27.929
OBJETO	IM7	25.75757576	36.40%	#44352e	Grey	23.581
OBJETO	IM8	72.72727273	23.60%	#c8b599	Grey	74.59
OBJETO	IM9	75.75757576	33.00%	#2d3155	Violet	21.617
PERSONA	IM10	95.45454545	44.20%	#636b59	Grey	44.074
PERSONA	IM11	84.84848485	28.80%	#6d402d	Brown	32.052
PAISAJE	IM12	93.65079365	41.10%	#b3b1a4	Grey	72.033
PERSONA	IM13	3.03030303	22.50%	#3e392d	Grey	24.129
PERSONA	IM14	27.27272727	19.40%	#8bb6c5	Blue	71.538
OBJETO	IM15	37.87878788	22.70%	#495b77	Blue	38.252
OBJETO	IM16	15.15151515	33.10%	#262822	Black	15.722
PERSONA	IM17	92.42424242	31.80%	#868d6f	Grey	57.334
PERSONA	IM18	6.25	21.30%	#8a5b2e	Brown	42.89

This behavior correlates with scientific studies that suggest that brighter colors appear to occupy more space (see Fig. 1). Therefore, some factors that clearly influence the perception of the dominant color are its level of luminosity and percentage of coverage. However, it was observed that these are not the only components of the images presented in this study; other factors detected were textures and shapes. For this reason, we proceeded to analyze people's behavior in relation to the perception of the dominant color and the structural components of the image, classified into three categories: landscapes (where textures are perceived to a greater extent), people-animals (where there is a defined formal component), and everyday objects (where there is a defined formal component). Based on this classification, it was detected that landscape images had the highest assertiveness in relation to the dominant color, with a total of 20.9435%, of which 13.3838% were women and 7.3232% were men. Additionally, there is another quality in the language of the image related to horizontal and vertical orientation (see Fig. 1).

Figure 1: Images resulting from color mapping. Based on Van Gogh's paintings. Dominant colors by sampling from IM2 left, and IM10 right. Likewise, the image classification IM2=Landscape, IM10=Person (Elaboration Olmos & Gil 2023 by Tineye).

The presentation by sampling was clear regarding the dominant color of the image; however, the results show that there is a difference in the assertiveness of the dominant color when two types of visual languages are used in the image: textures and shapes. In the case of IM10, unlike assertiveness, it is probably not determined by the color that expands most perceptually or the brightest, but by the focal attention that the person gives to the components of the image, in this case, the human form. In IM10, the dominant color corresponds to the tone #606958 with 45.6% coverage; however, 15.1515%

of people chose the tone #22202e corresponding to the color of the person's blouse represented as the dominant color, suggesting an affectation derived from the representation. The mapping helps to perceive that the highest percentage of color does not lie in a fragment of the representation of the person but in the background. Since it was observed that there is an effect derived from the configuration of the elements of the image in relation to the perception of the dominant color, it was determined to analyze how the components of the image with higher assertiveness interact and their relationship with the dominant color (IM2), as well as with the components of the image with lower assertiveness (IM13). The process was described and analyzed using static networks, so the factors to be analyzed in IM2 were identified in the image: Objects (O), Object-Object Interaction (IOb), the colors Black (K), White (W), Green (G), Blue (B), Yellow (Y), Gray (Gr), Everyday Life Objects (OVCot): Windows (OVCvent), Elements of Nature: Trees (Enarb), Natural Elements: Earth (Entie), Natural Elements: Sky (Enciel), Objects: Houses (Ocas), Objects identified as handcrafted or artisanal (OArt). According to the analysis of the IM2 network (Fig. 2), the factor with the highest input and output centrality was diverse typologies of objects, among which stand out: colors, W, K, Y, G, B, OVCvent, OArt, Enciel, Entie, Enarb, Ocas. The typology of objects with the greatest influence were those related to everyday life and color. The colors that most affected other components were Y and G, the latter not appearing in a pure form but in combination with yellow tones. It can be observed in the network that the color component is very close to other objects that make up the image, such as Entie, Ocas, OVCvent, Enciel, and Enarb. In general terms, an interaction between objects (IOb) is distributed among homogeneous factors (typologies of objects).

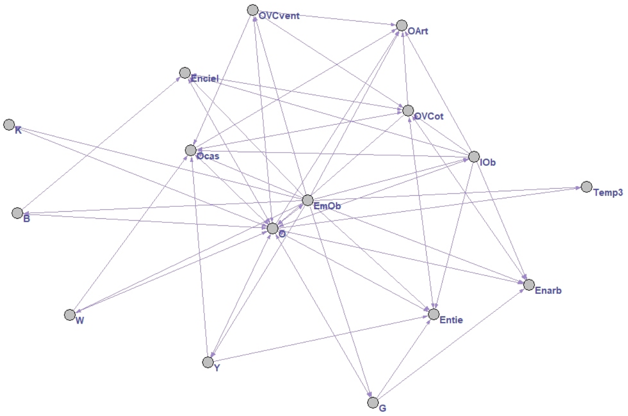

Figure 2: IM2.v112. Static network where the interrelation of elements in the painting can be observed. Image with higher assertiveness. Modeled in Pajek.

The factors to analyze in IM13 (Fig. 3) were those identified in the image: Man (H), Objects (O), Object-Object Interaction (IOb). The colors: Black (K), Red (R), Green (G), Blue (B), Yellow (Y), Gray (Gr)., Daily Life Objects (OVCot): Natural Elements: Earth (Entie), Natural Elements: Sky (Enciel), Objects identified as handmade or artisanal (OArt). According to the analysis of the IM13 network, two factors with the highest input and output centrality were observed: the first was the representation of a Man (H) with qualities such as being silent (PS), dressed (Vest), working (Ohabtrab) and the second factor were various typologies of objects including colors; K, R, Y, G, B, Gr; Natural objects: Enciel, Entie, Enarb; the qualities of objects such as Artisanal Objects: OArt and the interaction between objects (IOb). The typology of objects with the greatest influence were those referring to everyday life and color. The colors that most affected other components were Y and G, with the latter not appearing in a pure form but in combination with yellow tone. It can be observed in the network that the color component is very close to other objects that integrate the image, such as: H, Entie, Enciel. In general terms, an asymmetric interaction between objects (IOb) is observed, determined by the influence of two nodes with greater centrality: H and O. From these nodes, it is perceived that the greatest interaction occurs with the O node and to a lesser extent with the H node. The color B is perceived as an important link. In general terms, an interaction between objects (IOb) is observed, distributed among heterogeneous factors (H and O).

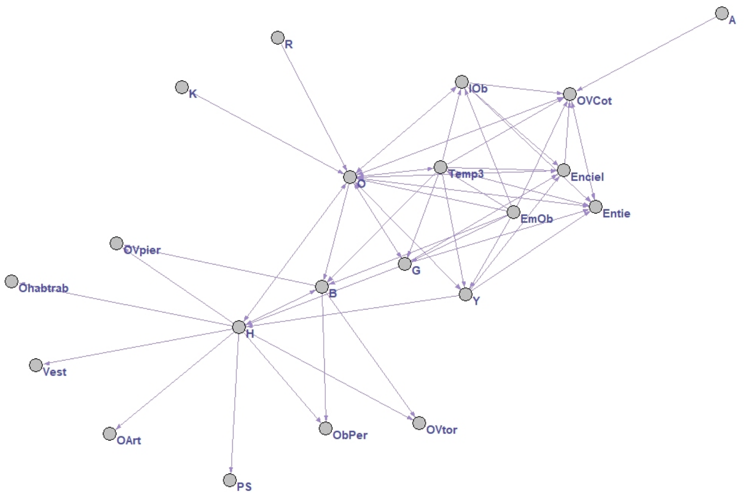

Figure 3: IM13.v226. Static network where the interrelation of elements in the painting can be observed. Image with lower assertiveness. Modeled in Pajek.

CONCLUSION

The process of selecting the dominant color, taking as an example the cultural behavior observed in Mexican volunteers, was perceived as complex, where the results obtained correlate with studies conducted by other authors. In this sense, it was observed that women perform better in color detection compared to the male sector. This is related to studies conducted by Abramov, Gordon, Feldman, & Chavarga (2012), where possible differences in color perception by gender are shown using different methods for the study (Conway, 2009). Additionally, it was observed that the perception of the dominant color is modified according to the qualities of the static system, where the interaction between homogeneous and heterogeneous objects plays a fundamental role in the perception process. Based on this observation, volunteers performed better in detecting the dominant color with homogeneous static systems compared to results in detecting the dominant color with heterogeneous static systems. On the other hand, the distribution of the same color in the static system also impacts the process of detecting the dominant color, where the proximity between similar tones makes it difficult to differentiate them since there is a tendency to perceive them as a unity, and the fragmentation of colors of the same tone also makes their perception difficult since there is a tendency not to consider them as a unity.

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