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Research Article

The impact of color on furniture preference in the context of user emotions: The case of the Thonet No. 14 Chair

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Abstract
This study examines emotional responses evoked by colors and how these emotions influence furniture design, focusing on the iconic Thonet No. 14 Chair. An interactive simulation using PHP and JavaScript allowed potential consumers to perform a color-emotion matching task. Users viewed a 360-degree-rotatable Thonet No. 14 chair across 16 emotional contexts and chose from 12 color options. The primary aim is to explore the emotional effects of furniture color on users and incorporate these insights into the design process. Specifically designed for this research, the simulation represents an innovative model for future studies by integrating 3D visualization with user interaction. The research compares two groups: participants with formal color education and those without. A mixed-methods approach combining qualitative and quantitative techniques was employed to evaluate how color influences visual perception in furniture design. Data were securely serialized and stored in JSON format to ensure integrity and ease of analysis. Despite limitations regarding age range, sample size, and the absence of real spatial context, the study demonstrates that color significantly shapes users' affective responses to furniture. The results contribute to product design by highlighting the role of affective cognition and offering a replicable, scalable digital method for future studies.

Keywords: Furniture design, Thonet No. 14 Chair, Color perception, User perception, Interactive simulation

Extended Abstract

Introduction: Color emerges as a structural element that goes beyond mere visual componentry, establishing a strong relationship between the user and the object. In the fields of art and design, color plays a critical role in creating meaning, conveying emotion, and generating aesthetic impact. Moreover, it is regarded as a fundamental perceptual factor in the interpretation and processing of information from the environment through vision in everyday life. The concept of color emotion refers to the feelings that arise in an individual's mind upon perceiving a color; in this context, scientific studies have shown that colors can directly stimulate emotional areas of the human nervous system. The psychological and emotional effects of color on individuals have long been a subject of investigation across various disciplines. However, most of these studies have focused on interior design, architectural color use, or general environmental arrangements. The specific impact of furniture color on users' emotional states has received comparatively limited attention. As a fundamental design element that directly influences the atmosphere of space and furniture, particularly their color, furniture should be considered a significant variable in shaping the user experience.

Purpose and scope: This study analyzes the emotional and psychological effects of color, a key factor influencing visual perception in furniture design, using the iconic Thonet No. 14 chair without requiring any physical interaction with the product. To achieve this objective, the research employs a mixed-methods approach that integrates qualitative and

quantitative methodologies. The Thonet No. 14 chair was selected as the subject of the experiment due to its historical significance, widespread use, and cultural recognition. The version with a wooden seat surface was chosen to isolate the color variable, eliminating the influence of material and texture differences and thus focusing solely on the perceptual impact of color variations. To investigate users' emotional responses, a set of adjectives from Jordan's Product Personality Assignment method was cross-referenced with color-emotion associations identified in the literature. A semantic intersection set was established, from which the final selection of colors was derived. Using a custom-developed simulation program, participants were asked to colorize the Thonet chair by matching 16 specific emotional descriptors with one of 12 pre-defined colors. This setup enabled the assessment of affective responses solely from visual stimuli, without tactile interaction.

Method: A combined research methodology was used in this study. Both qualitative and quantitative research methods were employed to collect and analyze data. The study was carried out using a Thonet No. 14 chair as the experimental object; this chair was selected for its long history and formal significance in the world of furniture design. The research was performed through the development of a custom online simulation interface. The digital platform was designed using PHP and JavaScript, which were available to participants and enabled them to view the Thonet chair from any angle, repaint it according to 60 emotion/descriptor pairs referenced in the study, and finally select 4 pairs of the most suitable phrases. Participants used emotional descriptors to recolor the chair, and chair rotation was a visual variable. Both the background and the chair color were kept constant using RGB standards, as no colors other than these were available on the screen. Also, the users were prompted to complete the activity on a single screen to ensure the application would not be affected by color differences across different screen technologies. Participants were selected through purposive sampling and consisted of undergraduate students aged 18 to 25. The sample was divided into two experimental groups: the first comprised interior architecture students who had received formal color education, while the second comprised social sciences students with no such background. Each group included 30 participants, with equal gender distribution maintained. All collected data were serialized and securely stored in JSON format by the simulation software. In this respect, the study offers a novel user-centered method for color analysis, facilitating the measurement of the relationship between furniture design and user psychology in a digitally controlled environment.

Findings and conclusion: The data obtained in the study were analyzed using Python software specifically developed for this research. A total of 60 participants were divided into two groups, those with and without color education, while maintaining a balanced gender distribution. Participants were aged 18-25 years and grouped by educational background. The color-educated group mainly consisted of interior architecture students, whereas the non-color-educated group included participants from the social sciences and business administration. The findings revealed that participants without color education showed greater conformity with the color-emotion associations found in the literature. This can be attributed to the fact that most studies in the literature employ random sampling methods involving participants who generally lack formal color education. Conversely, the preferences of the color-educated group showed limited alignment with the literature, establishing meaningful associations only within specific emotions and adjectives. The hypothesis that positive adjectives would be associated with warm colors and negative adjectives with cool colors was only partially supported by participants' preferences. Among the color-educated group, only the adjective "bright" was closely associated with warm colors, and the rest of the positive adjectives displayed weaker and more evenly distributed correlations with warm colors. In the non-color-educated group, there was a tiny majority who saw only "kind" and "pure" as warm colors. Negative adjectives, on the other hand, were mainly tied to neutral colors like black and grey by both groups and did not have a clear relationship with cool colors. The use of a simulation environment and a purposive sampling technique in this research provided reliable opportunities for data collection and analysis. The findings offer valuable insights into how color selection in furniture design affects user psychology. It is recommended that future studies increase sample sizes, diversify color-adjective variables, and incorporate technologies such as virtual reality. This would enable more comprehensive research with immersive spatial experiences.

Keywords: Furniture design, Thonet No. 14 Chair, Color perception, User perception, Interactive simulation

INTRODUCTION

Color is one of the most influential elements in shaping the user-object relationship and serves as a fundamental component of design sectors where meaning and emotional expression are especially involved. Beyond its aesthetic function, it is also crucial in how we process and interpret visual information from our surroundings. Color emotion refers to the feelings evoked by the perception of color, which can directly stimulate emotional areas in the nervous system. According to Cheng (2020: 622-624), different color components evoke various emotional responses. While color itself doesn't carry emotions, it can trigger sensory reactions through visual stimuli. Puhalla (2005: 2) describes color as a key perceptual process that awakens visual awareness. Klem

(2013: 79-80) highlights that perception includes not only artistic but also physical, psychological, and cultural aspects. Since color perception and its meanings vary across cultures and individuals, color experience is highly subjective.

In product design, visual appeal is crucial not only for its visual appeal but also for the emotions it evokes in users. As a central element of visual communication, color conveys ideas and feelings that influence users both physically and emotionally (Hunjet & Ivancic, 2018: 10). Understanding the connection between emotion and design helps explain why some products are preferred and supports a user-centered design approach. Moreover, product personalization and consumer involvement in design decisions, such as color choices or feature customization, have become increasingly popular, positively influencing purchasing behavior. In this study, participants act as consumers, selecting colors that reflect their emotional preferences and thereby actively shaping the design process. The literature encompasses a diverse range of studies examining the relationship between color and space, with a particular focus on emotional aspects. However, investigations specifically examining the emotional impact of furniture color on users remain limited. Furniture is a crucial design element in establishing an overall atmosphere, and selecting furniture, along with color, is a critical aspect of interior design. Adopting a "from the part to the whole" perspective, the present study underscores that color-furniture-space interactions are integral to creating the desired ambiance.

In this study, a review of the existing literature identified the emotions evoked by various colors and the colors associated with these emotions. These identified color-emotion pairs were then presented to potential consumers through a participatory framework, allowing them to perform their own color-emotion matchings. For this purpose, an online simulation environment was created using PHP and JavaScript, enabling an interactive experience in which participants were integrated into the design process. Given its familiarity in contemporary consumer settings, the Thonet chair was chosen as the representative piece of furniture. Within this simulation, two experimental groups, one with formal color education and one without, colored the Thonet chair using 12 distinct color options and 16 emotional descriptors.

Theoretical Framework and Research Hypotheses

Color has been extensively studied in literature, attracting the attention of scholars and practitioners in fields such as the visual arts, design, architecture, cinema, psychology, engineering, and medicine. Despite the large body of research on color, investigations into the emotional effects of furniture-specific color choices on users appear limited. In design-oriented research, studies of color generally focus on its use in interior spaces. Kwallek et al. (1996) explored the impact of color red, green, and white on the mood and productivity of men and women working in differently colored office environments. A total of 222 participants (an equal number of men and women) spent time in offices painted in these three colors. Findings indicated that participants in the red office made the fewest errors, whereas those in the white office made the most. In a subsequent study, Kwallek et al. (2007) examined how the colors used in work environments affect user performance. Three actual office spaces identical in dimensions, geometry, and furnishings but differing in color schemes were employed as experimental settings. Ninety participants were recruited and initially grouped by attentiveness level; over four consecutive workdays, from 9:00 a.m. to 5:00 p.m., they performed various tests and proofreading tasks. Results revealed that, in terms of work performance, highly attentive participants in both the white and red offices outperformed those with medium or low attentiveness.

Jiang et al. (2020) investigated how the color preferences of adolescents (ages 12-16) in China influence the furniture choices in their bedrooms and study rooms. A total of 508 participants were involved in a two-stage online survey. In the first stage, participants indicated which colors they preferred for the presented furniture options; in the second stage, they were asked to rank their top three most and least favorite colors. The results revealed that children's color preferences influenced their furniture color choices in both their sleeping and study environments, though the effect was somewhat limited across product categories. Ouankhamchan and Fujinami (2020) conducted a study to assess user preferences for a sofa model using EEG devices. Twelve participants (seven men and five women) actively seeking to buy furniture took part. They evaluated four sofa models in 12 different colors using a Likert scale. The study involved collecting demographic data and favorite colors, followed by EEG measurements while viewing sofa color variations. Results showed that participants'

initial favorite colors did not always align with the colors they ultimately preferred, highlighting a difference between conscious preference and subconscious responses.

Insights gleaned from these and similar studies confirm that the first environmental stimulus individuals receive from the external world is visual, and one of the initial factors perceived by the eye is color. Accordingly, this research focuses on examining the emotions evoked in users by color when applied to a commonly used piece of furniture chair. To achieve this goal, experimental groups were formed and included in the study, leading to the following research hypotheses:

Hypothesis 1: The chairs colored by the experimental group that has received formal color education will align with the color-emotion pairings documented in the literature.

Hypothesis 2: The chairs colored by the experimental group that has not received formal color education will deviate from the color-emotion pairings documented in the literature.

Hypothesis 3: Both experimental groups will associate positive descriptors with warm colors.

Hypothesis 4: Both experimental groups will associate negative descriptors with cool colors.

METHOD

In this study, which analyzes affective responses to the color factor, which directly influences visual perception, through a selected piece of furniture without physical experience, both qualitative and quantitative research methods were employed. The sub-sections of this chapter provide a detailed explanation of the processes involved in the study.

Selection of Furniture for the Experimental Environment

In this study, the product selected for the experiment is a seating element, chosen based on the historical trajectory and significance of furniture design. Seating elements are among the most extensively researched and analyzed components in the history of furniture design. Many iconic furniture pieces, recognized by their era or designer, have garnered significant consumer interest at the time of their production. Some of these historically influential seating elements have retained their popularity and remain widely preferred by contemporary consumers. One such piece is the globally renowned “Thonet No.14” chair, designed by Michael Thonet. Owing to its formal simplicity and strong historical associations, this chair remains a versatile design element, seamlessly integrated into both modern and classical interior spaces (Figure 1).

Figure 1. No.14 Chair, Michael Thonet

Since its initial design, numerous variations of the Thonet No. 14 chair have emerged. The most common variations are distinguished by the material used for the seat surface, including wood, textile, and perforated woven cane (Figure 2).

Figure 2. Variations in seat surface materials

As seen in this figure, No. 14 chairs share a common structure in their backrests, legs, and seat-surface materials, while varying in specific details. For this reason, the study will be based on the original Thonet form as the primary reference.

In the experimental environment, the No.14 chair with a wooden seat surface was selected to measure the perceptual impact of different colors. This chair is most commonly found in the food and beverage industry, particularly in cafés and restaurants. Given the high human traffic in such venues, designers and business owners tend to prefer the wooden-seated version for its lower maintenance costs and greater durability. The widespread use of this variation has led to greater familiarity and user experience, making it a suitable selection for inclusion in the study. The No. 14 chair, with its wide range of applications, has been adapted into numerous variations by varying its material, texture, form, and color, while preserving the original Thonet structure. Within the scope of this study, the wooden-seated No. 14 chair was selected, as it is available in a broad range of color variations in contemporary design (Figure 3).

Figure 3. Examples of No.14 Chairs with different color applications

Selection of Colors to be Applied and Survey Design

Color can be scientifically defined as an optical property of radiation that enables an observer to distinguish objects of the same dimensions, shapes, and structures. This definition reduces color to the assessment of radiation power at different wavelengths within the visible spectrum. When considered as a physical quantity, color is a fundamental characteristic of light sources, objects, and their interactions. Furthermore, as a physical stimulus, it is closely linked to the psychophysical effects that mediate between human perception and emotional response. This is because color is not an intrinsic property of optical radiation or objects; rather, it is a perceptual phenomenon that forms an integral part of visual experience (IESNA, 2000: 6.1, 6.7).

In this study, which aims to investigate users' psychological responses and affective impacts of color, attitude scales were used. In the literature, attitude is defined as a positive or negative predisposition toward an object or idea and is considered to encompass emotional, behavioral, and cognitive components (Köklü, 1995). This study uses Patrick W. Jordan's "Product Personality Dimensions Method" to assess emotional responses to color variations in furniture without direct interaction with the product. The method uses pairs of opposing adjectives to assess users' immediate feelings, explore links between product preferences and personality traits, and gauge user satisfaction. Although originally applied to industrial products, this approach helps us understand how potential users emotionally perceive design elements, such as color changes. Table 1 presents the adjective pairs utilized in Jordan's study (Jordan, 2002).

Table 1. The product personality dimensions method scale was developed by Jordan

Positive Adjective	1	2	3	4	5	Negative Adjective
Kind						Unkind
Honest						Dishonest
Serious-minded						Light-hearted
Bright						Dim
Stable						Unstable
Humble						Narcissistic
Flexible						Inflexible
Liberal						Authoritarian
Value-driven						Non-value-driven
Extrovert						Introvert
Naive						Cynical
Moderate						Excessive
Conformist						Rebel
Energetic						Unenergetic
Gentle						Violent
Simple						Complex
Optimistic						Pessimistic

In this study, a participatory approach is employed, where individuals are expected to determine the colors of their own Thonet chairs based on specific emotional states. To facilitate this process, a computer-based simulation program has been developed. In this simulation, participants are presented with a selection of colors and emotions/adjectives to choose from. To determine the colors to be presented to participants, the study draws upon Hilliard's (2016) doctoral dissertation, titled "Optimizing Viewer Comprehension and Shaping Impressions and Attention". Hilliard conducted a semantic analysis by reviewing the works of various color theorists and extracting design and psychological paradigms related to color. As a result of this analysis, a color-emotion matching system was established that represents the general meanings associated with specific colors. This color-emotion association is presented in a list below, organized by emotion/adjective number for each color, while the selected colors are provided in Table 2.

1. Grand, noble, exciting (Pralle, 2007); Harmonizing, wisdom, luxury, spiritual, exotic, creative, artistic, inspiring (Reynolds, 2010); Magnificent, honorable, dignified (Madden et al., 2000).
2. Calming (Singh, 2006); Compassionate, attentive, pleasant, relaxing (Crozier, 1996); Attractive (Kauppinen-Räisänen & Luomala, 2010); Lively, emotional, affectionate (Pralle, 2007); Honorable, professional, successful, loyal, peaceful, calm, positive, depressive (Reynolds, 2010); Wealthy, honest, sensitive, kind, soothing (Madden et al., 2000); Cold, pale, dull, peaceful (Manav, 2007).
3. Calm, honest, righteous, philosophical, non-threatening, peaceful, benevolent, serene (Pralle, 2007).
4. Primitive, intuitive, ancient, historic, strong, free (Pralle, 2007).
5. Analytical, composed, intelligent, goal-oriented, expressive (Pralle, 2007).
6. Bright, luxurious, infinite, magnificent (Pralle, 2007).
7. Mature, strong, restless, wise, ancient (Pralle, 2007).
8. Fresh, pure, clean, youthful (Pralle, 2007).
9. Soothing, relaxing (Crozier, 1996); Attractive, neutral (Kauppinen-Räisänen & Luomala, 2010); Healthy, natural, safe, vibrant, confident (Pralle, 2007); Natural, balanced, harmonious, healthy, calm, persistent,

lucky, reborn, spring, jealousy (Reynolds, 2010); Lively, dull, frightening, comforting, exhausting, annoying (Manav, 2007); Nature, trees, ease, serenity, happiness, tranquility (Kaya & Epps, 2004).

10. Attention-grabbing (Singh, 2006); Cheerful, exciting, affectionate, impulsive (Crozier, 1996); Stimulating (Elliot & Maier, 2007); Cheerful, eye-catching (Kauppinen-Räisänen & Luomala, 2010); Anxious, sharp, surprising (Pralle, 2007); Optimistic, cheerful, happy, peaceful, sunshine, inspiring, summer (Reynolds, 2010); Cheerful, energetic (Madden et al., 2000); Lively, energetic, positive, happy (Kaya & Epps, 2004); Warm, simple, dynamic, pleasant, classic (Manav, 2007).
11. Rich, sunny, cheerful, warm, associated with power (Pralle, 2007).
12. Soft, abundant, comfortable, authentic (Pralle, 2007).
13. Delicious, nourishing, associated with danger (Pralle, 2007); Warmth, affection, excitement, enthusiasm, energetic, playful, fun (Reynolds, 2010); Distressed, uneasy, sorrowful (Madden et al., 2000).
14. Wild, fiery, explosive, out of control, prominent (Pralle, 2007).
15. Natural, earth-related, solid, strong, reliable, comfortable, rough, soft, ordinary (Reynolds, 2010).
16. Desirable, persuasive, friendly, dramatic, warm (Singh, 2006).
17. Strong, aggressive, threatening, demanding attention (Pralle, 2007).
18. Stimulating (Singh, 2006); Adventurous, extroverted, powerful, protective, exciting (Crozier, 1996); Danger, passion (Elliot & Maier, 2007); Attention-grabbing, very strong (Kauppinen-Räisänen & Luomala, 2010); Distracting (Belizzi & Hite, 1992); Dangerous, exciting, noisy (Pralle, 2007); Assertive, strong, bold, urgent, fiery, passionate, dangerous, evil (Reynolds, 2010); Exciting, encouraging (Madden et al., 2000); Exhausting, striking (Manav, 2007).
19. Adorable, sensitive, feminine (Pralle, 2007); Romantic, soft, calm, passive, health, love, romance, joy (Reynolds, 2010); Warm, cheerful, romantic (Manav, 2007).
20. Bold, elegant, impressive, cultured, classic (Pralle, 2007).
21. Serious, thoughtful, spiritual (Pralle, 2007).
22. Elegant, formal, artistic, simple, power, death, fear, loss, distress, mourning (Reynolds, 2010); Unhappy (Madden et al., 2000).
23. Neutral, respectful, humble, static, wise, simple, determined, blurred, dull, depressive, negativity (Reynolds, 2010).
24. Pure, innocent, clean, new, simple, fresh, cool winter, soft, ordinary, sterile (Reynolds, 2010).

Table 2. Adjectives/emotions derived from the color paradigms of color theorists in the literature

No	Color (RGB)	Visual Repres.	No	Color (RGB)	Visual Repres.	No	Color (RGB)	Visual Repres.
1	Purple 160-32-240		9	Green 0-255-0		17	Crimson 220-20-60	
2	Blue 0-0-255		10	Yellow 255-255-0		18	Red 255-0-0	
3	Sky blue 135-206-250		11	Gold 255-215-0		19	Pink 255-192-203	
4	Teal 0-128-128		12	Amber 255-126-0		20	Mauve 224-176-255	
5	Cyan 0-255-255		13	Orange 255-165-0		21	Violet 238-130-238	
6	Emerald 80-200-120		14	Coral 255-127-80		22	Black 0-0-0	
7	Sea Green 46-139-87		15	Brown 165-42-42		23	Grey 128-128-128	
8	Lime 50-205-50		16	Scarlet 255-36-0		24	White 255-255-255	

Within the scope of the study, the emotions identified by color theorists through a literature review were compared with the emotions and adjectives used in Jordan's Product Personality Dimensions Method. As a result, the overlapping adjectives and emotions were identified (Figure 4).

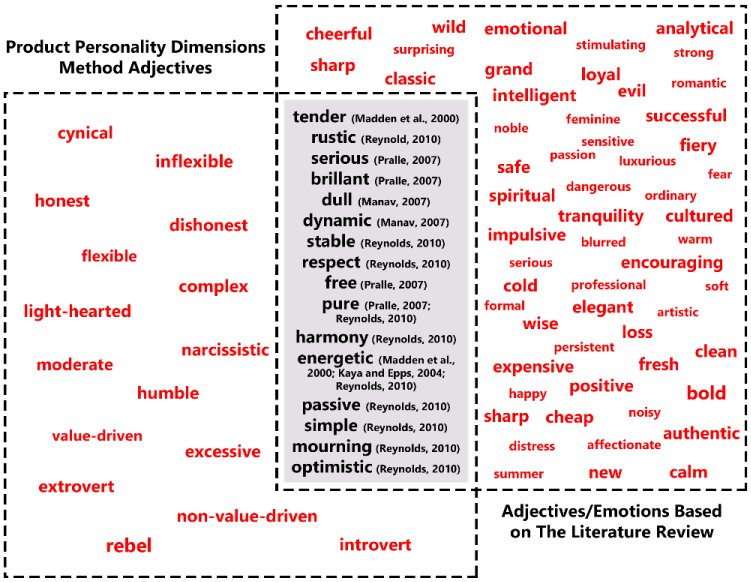

Figure 4. Intersection of emotions/adjectives derived from color paradigms in the literature and those used in the product personality dimensions method

The colors corresponding to the emotions/adjectives identified in the intersection set were selected for use in the study. These colors, along with their associated emotions/adjectives, are presented in Figure 5.

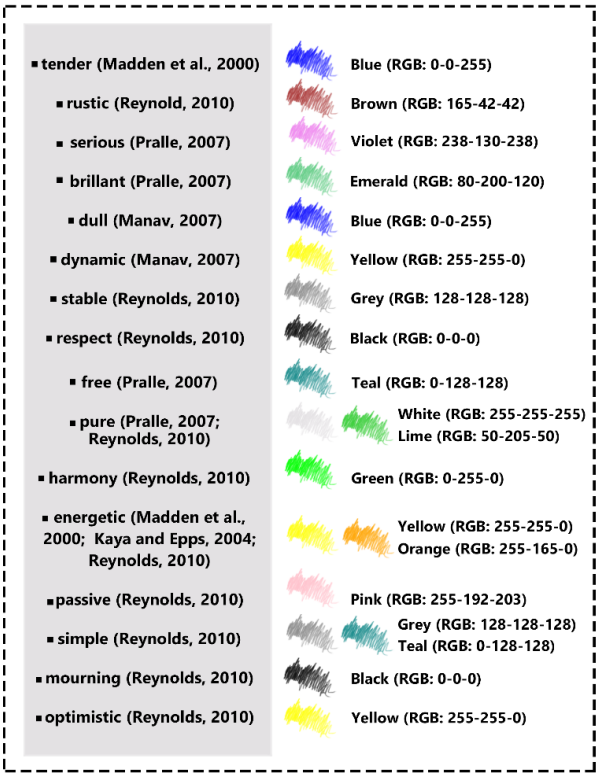

Figure 5. Colors and adjectives derived from the intersection set

Among the presented colors, repetitive colors were removed, and white was excluded because the simulation program's background was white. As a result, 12 colors were selected for use in the study (Table 3).

Table 3. Information on colors to be used in the study

No	Color	Visual Repres.	No	Color	Visual Repres.	No	Color	Visual Repres.
1	Blue 0-0-255		5	Yellow 255-255-0		9	Green 0-255-0	
2	Brown 165-42-42		6	Grey 128-128-128		10	Orange 255-165-0	
3	Violet 238-130-238		7	Black 0-0-0		11	Pink 255-192-203	
4	Emerald 80-200-120		8	Teal 0-128-128		12	Lime 50-205-50	

As a result, participants will color the Thonet chair in the simulation environment using 12 selected colors, based on their personal perceptions and affective responses, and will use the 16 emotions/adjectives identified in the intersection set. These colors are represented in the RGB color space as shown in Figure 6.

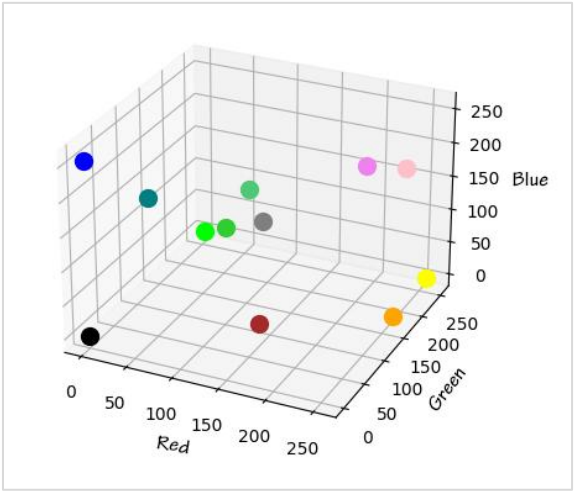

Figure 6. Representation of colors in the RGB color space

Since the colored furniture will not be rated later by the participants themselves or another experimental group, the Likert scale used by Jordan was excluded from the study. At the beginning of the study, a demographic information screen is included to systematically categorize the two different experimental groups. While no personal data is collected, participants are asked to provide information on age, gender, field of study, and whether they have received any formal education in color theory. After entering this information, participants gain access to the simulation environment. At the beginning of the study, a demographic information screen is included to systematically categorize the two different experimental groups. While no personal data is collected, participants are asked to provide information on age, gender, field of study, and whether they have received any formal education in color theory. Once they enter this information, they gain access to the simulation environment.

Study Group

In qualitative research, the focus is on deep analysis of specific individuals or situations rather than generalizing results, so purposeful sampling is commonly used (Creswell, 2009: 112). Based on this perspective, purposeful sampling was chosen for this study to align with the nature of qualitative research and the study's objectives. The research aims to measure affective responses to colors among individuals with formal education in color theory and those without, as well as among individuals of different genders. To best represent the target population, the sample was structured into two distinct experimental groups:

- The first experimental group consists of third- and fourth-year students from Marmara University's Interior Architecture Department, who have received formal color education. These students have been exposed to art and design education that involves both direct and indirect use of color since the beginning of their undergraduate studies, and they have taken advanced courses in color theory in the later stages of their education.
- The second experimental group comprises students from various social science disciplines who have not received formal education in color theory.

This comparative approach aims to assess differences in affective responses to colors based on educational background and gender. Colors can be categorized into innate (inborn) reactions and learned responses based on human responses. Innate reactions can be explained through the identification of universal emotional associations with colors, whereas learned responses are shaped by specific demographic factors such as age, gender, and culture, leading to subjective color experiences (Hilliard, 2016). For this reason, in this study conducted with individuals raised within the same cultural context, demographic factors such as age and education level were controlled to ensure consistency. Specifically, the experimental group consisted of undergraduate students aged 18-25, with a particular focus on third- and fourth-year students who were known to have similar levels of color education. After determining the sampling area, another critical aspect to address is the sample size. In qualitative research, the sample size should be determined not in terms of quantity but in terms of its ability to best represent the population qualitatively (Neuman & Robson, 2014). Instead of analyzing large groups, qualitative studies require selecting samples that yield rich, detailed data aligned with the research objectives (Coyne, 1997). For this study, the sample size was not excessively expanded, as the study design involved 16 emotion sets and 12 colors, requiring an in-depth analysis to obtain rich, high-quality data. Therefore, two experimental groups, each comprising 30 participants, were deemed appropriate. Since the study aims to analyze responses by gender and color knowledge, an equal distribution of participants was ensured by keeping the number of participants equal across both experimental groups. Additionally, within each group, an equal number of male and female participants contributed to the study to maintain balanced representation.

Research Environment

In this study, the virtual environment-based assessment method, which has been widely used in various studies (Slatter & Whitfield, 1977; Park & Guerin, 2002; Stone, 2003; Babin et al., 2003; Wang et al., 2007; Müezzinoğlu et al., 2021; Yıldırım et al., 2011; Odabaşıoğlu & Olguntürk, 2020; Tantanatwin & Inkarojrit, 2016), was also implemented. A web-based simulation environment, developed by a contributing researcher using PHP and JavaScript, was designed to facilitate online access. The study's demographic data were collected using this software prior to the simulation phase. To prevent data loss, the research findings were serialized in JSON format and stored by the software. This method ensured that the data were securely recorded and structured for further analysis. The results obtained from the data analysis are detailed in the Findings section. In accordance with the study's purpose and scope, the simulation program allows participants to view a 360-degree-rotatable Thonet chair with 12 color switches, as shown in Figure 7.

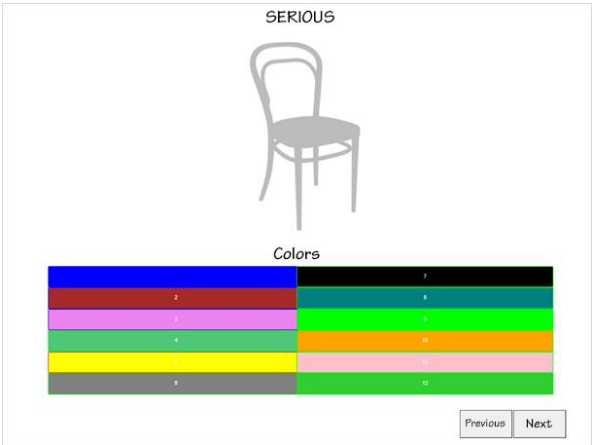

Figure 7. The simulation environment used in the study

The simulation environment is the part that is exemplary and belongs to, or is installed specifically for, the present investigation. It has significant implications for further research as a trend-setting method. Unlike the traditional approach of only showing furniture or space visuals, this method of actively involving testers in the research harnesses participants' power to conduct interactive evaluations in a three-dimensional simulation environment. This feature enhances the study's originality and offers a unique methodological framework for future research. In particular, the ability to collect data from many participants simultaneously allows the test to be administered globally in real time, increasing the generalizability of the findings and the diversity of the participant pool. With these distinctive attributes, this study makes a significant methodological contribution to the literature, offering a novel approach that can be applied in future studies.

Since the study focuses solely on the color variable in furniture, other design elements such as lighting, background, and reflections were kept constant throughout the simulation. To ensure colors were perceived as accurately as possible, the background color was set to RGB: 255-255-255, HSB: 0-0-100, while the furniture's initial state before coloring was set to RGB: 128-128-128, HSB: 0-0-50. At this stage of the study, the adjectives included in the experiment appeared on the screen, and participants were asked to reflect on their emotional association with each adjective before selecting a color for the furniture. Using the "Next" button, participants proceeded to the next adjective, continuing this process until all 16 adjectives had been assigned a corresponding color selection. Given that computer monitors vary in resolution, color accuracy, and brightness, the experiment was conducted on a single standardized monitor. This approach minimized potential variations in color perception, thereby enhancing the study's reliability.

FINDINGS

The data stored in the research environment described in the previous section were analyzed using Python, a widely used programming language for modern data analysis. A custom-developed Python script, tailored specifically for this study, was used to process the data and generate original visual representations in the form of graphs and charts. The findings obtained from the data analysis are presented and explained in the following sections.

Demographic Results of the Experimental Groups

A total of 60 participants contributed to the study, and their distribution by education status (whether they received formal education) and gender is shown in the graph in Figure 8.

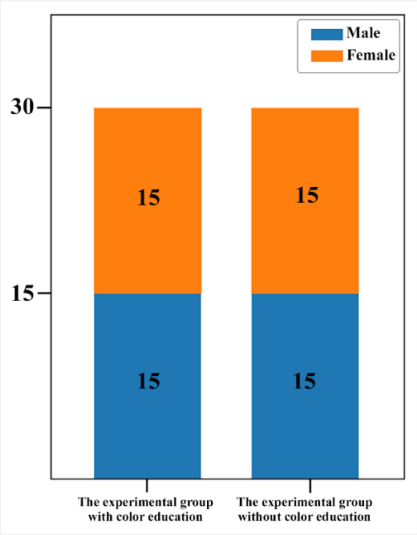

Figure 8. Demographic distribution of participants

In accordance with the study's objective, participants were equally distributed between those who had received formal color education and those who had not, as well as between male and female participants. Additionally,

since the study does not include an analysis based on the age variable, the age range of participants was restricted to 18-25 years. The collected data on age distribution is presented in Figure 9.

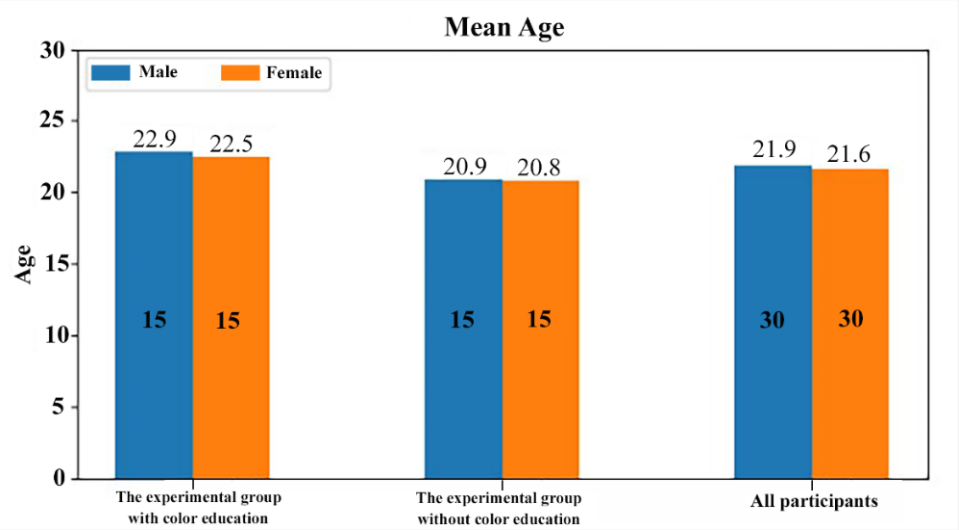

Figure 9. Mean age of participant groups

In the 30-person experimental group that received color education, 26 participants were from the Interior Architecture Department, and 4 were from the Interior Architecture and Environmental Design Department. In the 30-person experimental group without color education, 19 participants were studying Business Management, 8 were in International Trade, 1 was in Primary School Teaching, and 1 was in Turkish Language Teaching.

Results of Color Selections in Experimental Groups

In the study, Hypothesis 1 states: "The chairs colored by the experimental group with color education will align with the color-emotion associations found in the literature." Similarly, Hypothesis 2 states: "The chairs colored by the experimental group without color education will not align with the color-emotion associations found in the literature." To verify these hypotheses, the graphs presented in Figures 10 and 11 were generated.

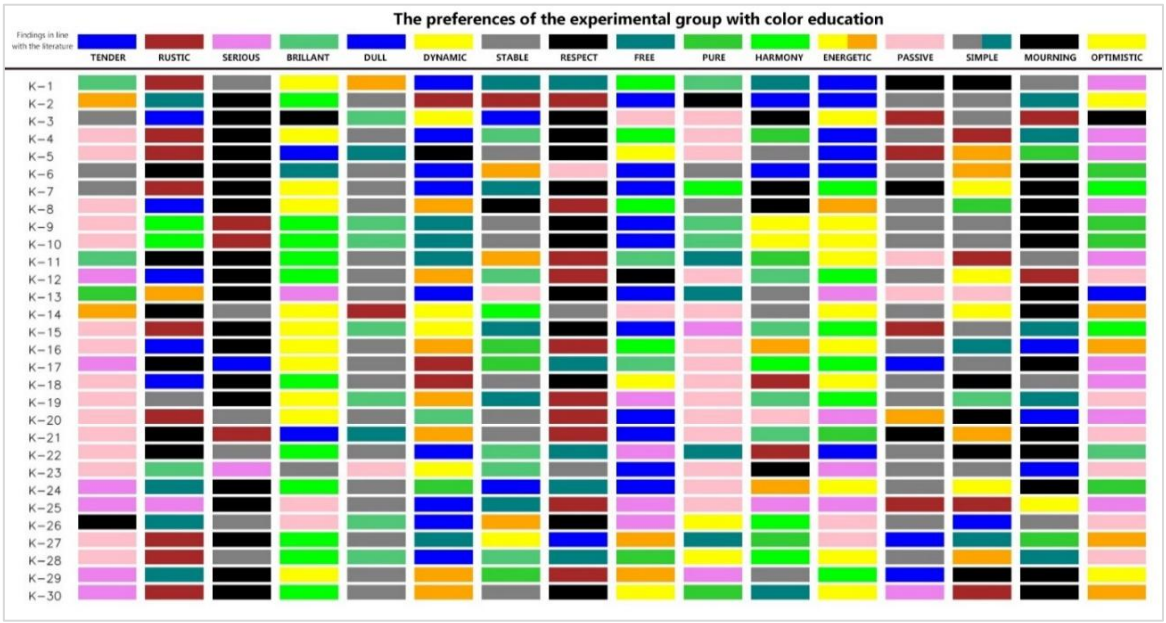

Figure 10. Color preferences of the experimental group with color education

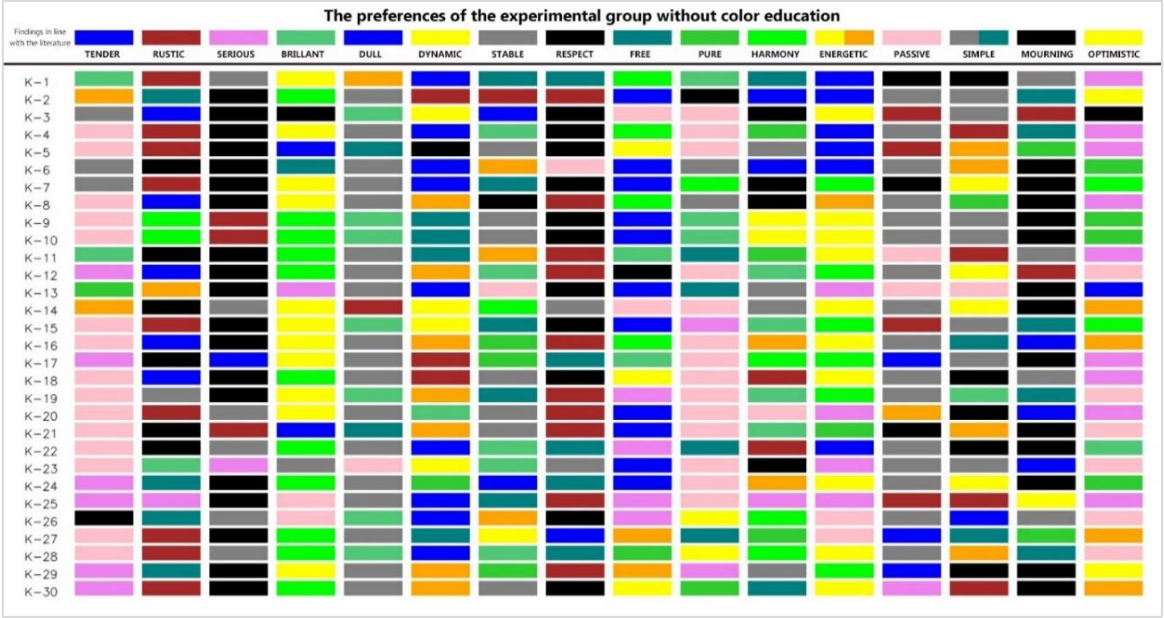

Figure 11. Color preferences of the experimental group without color education

Here, participants have been coded from K-1 to K-30. The top row represents the colors associated with emotions and adjectives in the literature. The colors selected by the participants are cumulatively displayed in the graphs below (Figures 12 and 13).

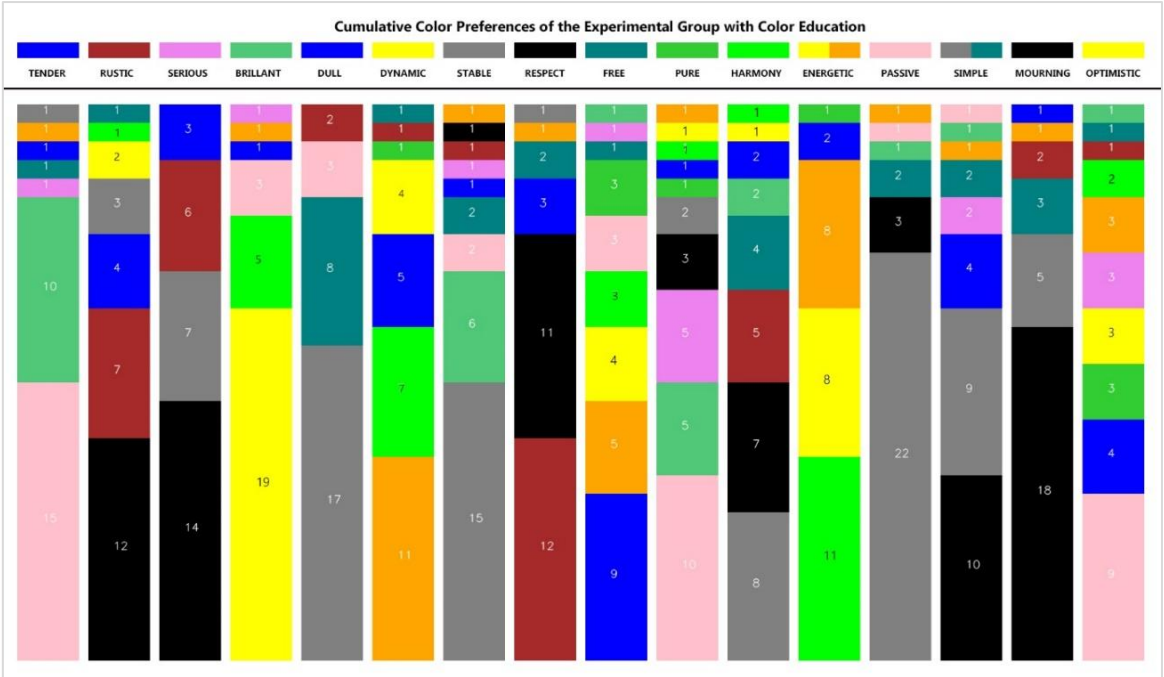

Figure 12. Cumulative color preferences of the experimental group with color education

When analyzing the cumulative values presented in the graphs, it was observed that among the 16 adjectives, only the emotions static, energetic, and pessimistic showed statistically significant associations with the color-emotion relationship for participants who had received color education. Additionally, the most strongly associated adjective-color pairs identified by participants were:

- “Dull” with gray,
- “Bright” with yellow,
- “Lifeless” with gray.

A particularly notable finding was that most participants associated the adjective “bright” with sunlight and daylight, leading them to select yellow, as expected. Similarly, the dominant association of the color gray with “lifeless” was understandable, as it is the most neutral among the provided alternatives.

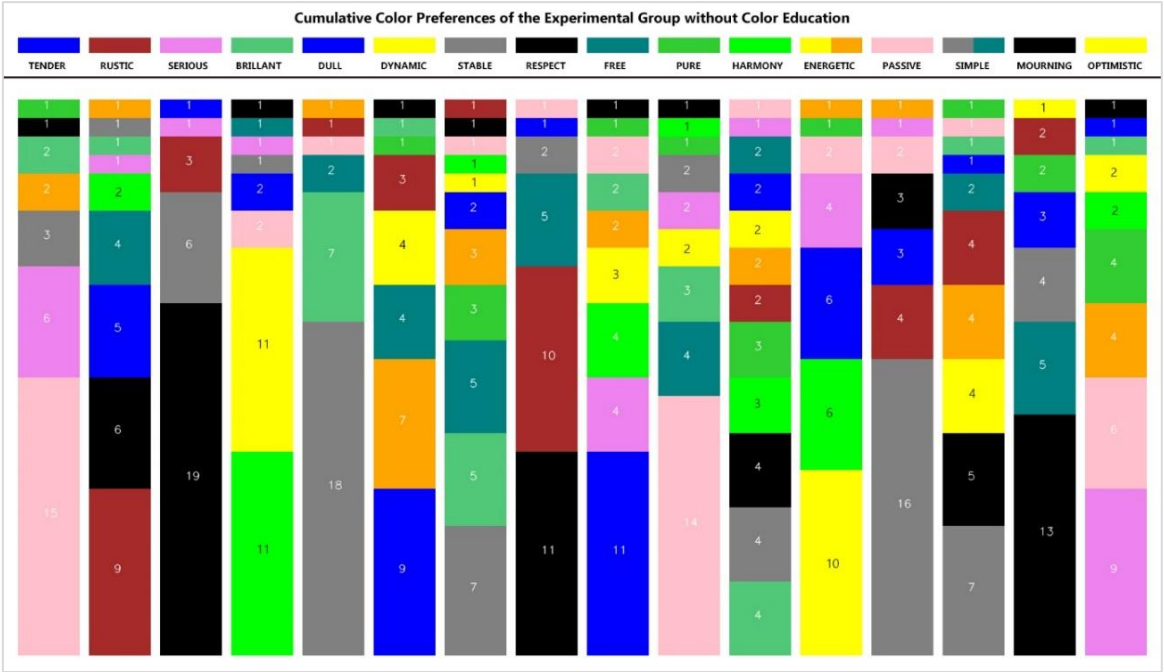

Figure 13. Cumulative color preferences of the experimental group without color education

When the cumulative color preferences of participants without color education were examined in relation to the color-emotion associations reported in the literature, the emotions *rough*, *static*, *energetic*, *simple*, and *pessimistic* were found to be statistically significant within the existing color-emotion relationships. Furthermore, although some color-adjective pairings were not statistically significant, they were still strongly associated with and preferred by the participants. These include:

- “Bright” being associated with green and yellow,
- “Dull” being associated with gray,
- “Lifeless” is associated with gray.

When the two experimental groups were compared, most adjective-color associations were not statistically significant. However, the experimental group without color education demonstrated greater alignment with established color-emotion associations. A possible explanation for this result is that participants in previous color-emotion studies were typically selected through random sampling, meaning that the majority lacked formal color education, which may have led to stronger alignment with the preferences of participants in the non-color-educated group in this study. To verify Hypothesis 3, which states: “Both experimental groups associate positive adjectives with warm colors,” graphs were generated in Figures 14 and 15. Figure 14 presents the warm color-positive adjective associations for participants with color education. Figure 15 shows the same associations for participants without color education. This situation can also be explained by the fact that individuals who have received color education reject more common standard associations by applying the knowledge acquired during their training. Furthermore, this difference may be attributed to variations in aesthetic and sensory experience, as well as associative perception, since individuals with color education are exposed to a greater number of color-related studies throughout their education than the other experimental group.

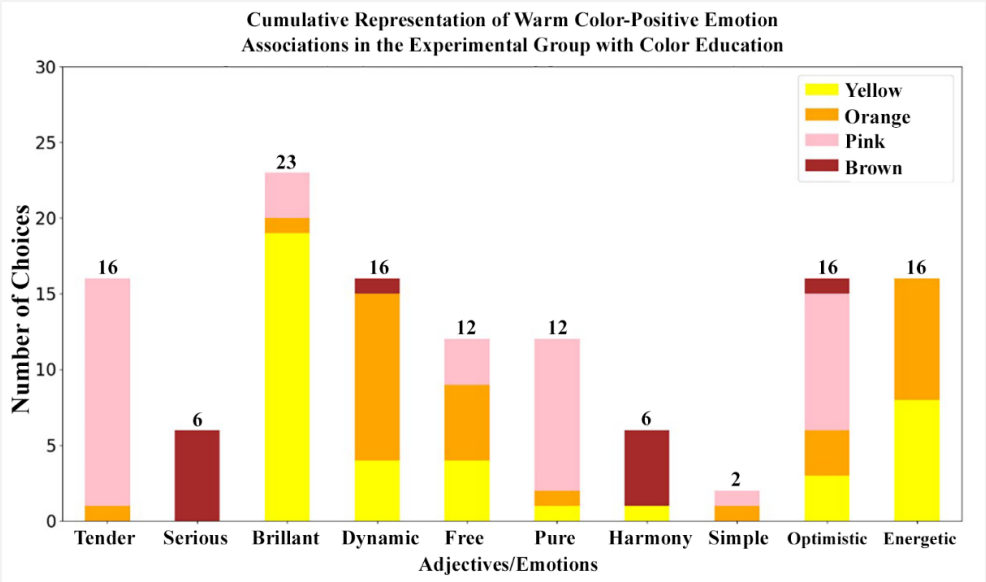

Figure 14. Cumulative representation of warm color-positive emotion associations in the experimental group with color education

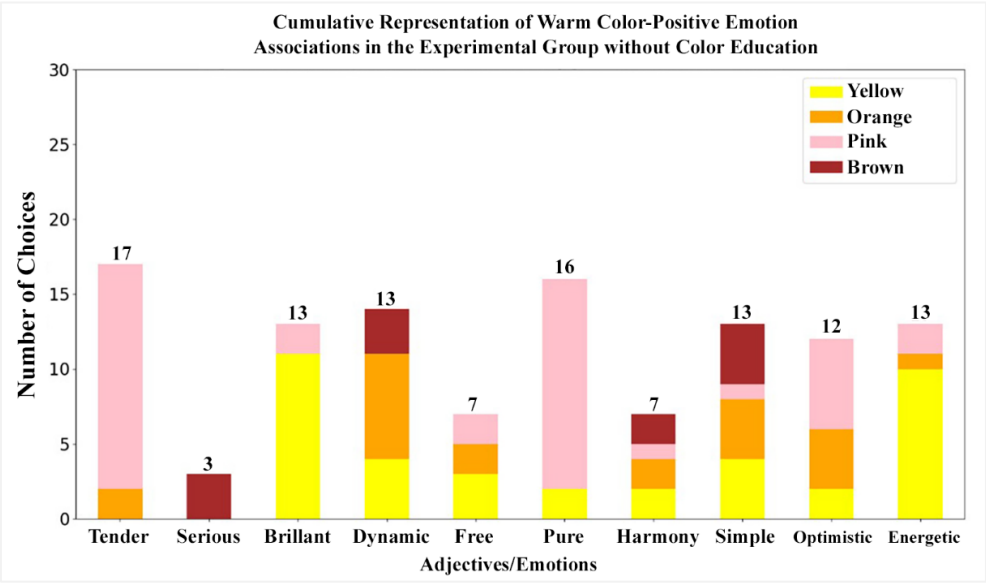

Figure 15. Cumulative representation of warm color-positive emotion associations in the experimental group without color education

Within the scope of the study, the 10 positive adjectives were incorporated into the graphs presented in the figures. Additionally, when examining the colors in the study, only four warm colors are observed: yellow, orange, brown, and pink.

The hypothesis states that positive emotions will be more strongly associated with warm colors in both experimental groups. However, in the color-educated experimental group of 30 participants, only the adjective “bright” was predominantly associated with warm colors by 23 participants. Apart from “bright,” the adjectives “polite,” “dynamic,” “energetic,” and “optimistic” were associated with warm colors by slightly more than half of the participants (16 individuals) in the color-educated group.

When examining the associations between positive adjectives and warm colors in the non-color-educated experimental group, notable differences were observed compared to the color-educated group. As seen in the graph, within this 30-participant group, only the adjectives “polite” and “pure” were associated with warm

colors by slightly more than half of the participants. Apart from these two adjectives, none of the other positive adjectives were predominantly associated with warm colors by most participants in this group.

To test Hypothesis 4, which states: "Both experimental groups associate negative adjectives with cool colors," graphs were generated in Figures 16 and 17. Figure 16 presents the cool color-negative adjective associations for participants with color education. Figure 17 displays the same associations for participants without color education.

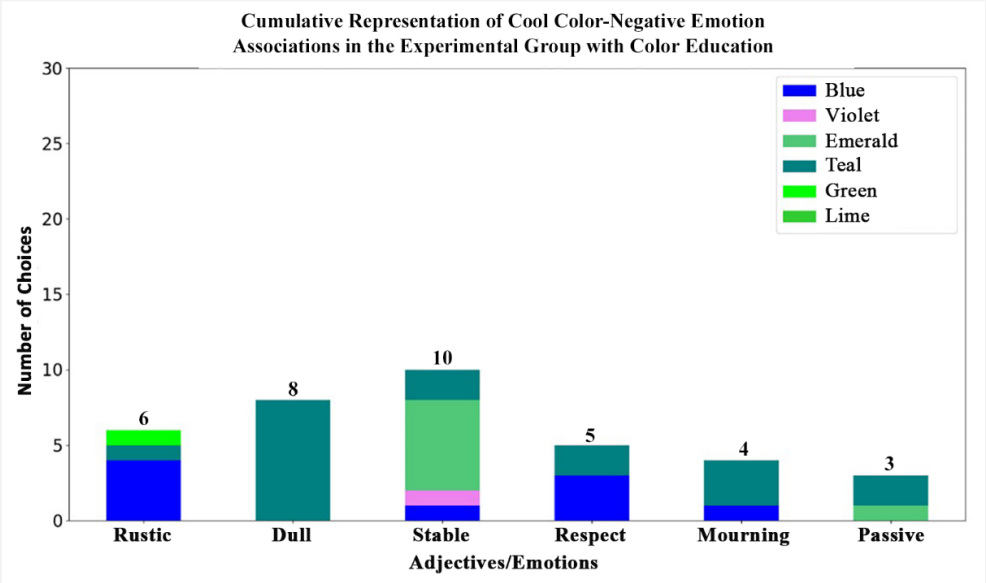

Figure 16. Cumulative representation of cool color-negative emotion associations in the experimental group with color education

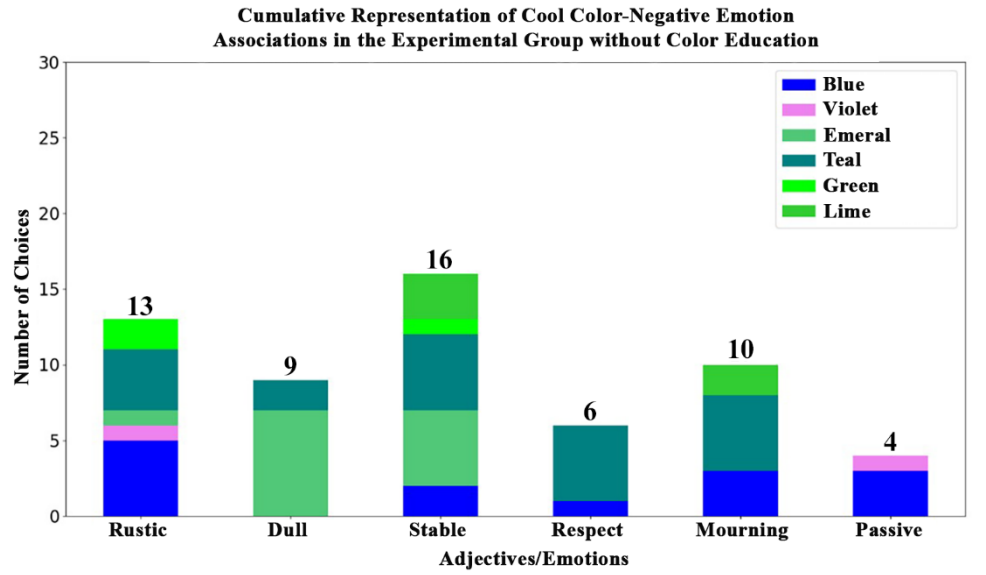

Figure 17. Cumulative representation of cool color-negative emotion associations in the experimental group without color education

Within the scope of the study, six of the presented adjectives represent negative emotions, and these have been incorporated into the graphs shown in the figures. Additionally, among the colors used in the study, the following belong to the cool color category: Blue, Violet, Emerald, Turquoise, Green, and Lime. The hypothesis suggests that negative emotions will be more strongly associated with cool colors in both experimental groups. However, when analyzing the graph for the color-educated experimental group, none of the negative adjectives were represented in cool colors at an above-average level. In the non-color-educated

experimental group, only the adjective "static" was associated with cool colors by slightly more than half of the participants. As a result, in both experimental groups, negative adjectives such as "rude," "dull," "static," "authoritative," and "lifeless" were predominantly associated with achromatic colors, such as black and gray. In such an experimental study, conducting research based on a specific composition rather than a single piece of furniture may be more appropriate to enhance the validity of color perception and interpretation. This approach would allow participants to evaluate colors not only in relation to a single object but also within environmental contexts and in terms of contextual integrity. Future studies may further investigate the effects of this approach in greater detail.

CONCLUSION

This study presents a comprehensive and detailed investigation into the impact of color on the furniture design process and its effects on user emotions. The primary focus areas of the study include examining users' emotional responses to colors, identifying relationships between colors and emotions, comparing participants with and without color education, and conducting the experiment using a specific furniture example: the Thonet No. 14 chair. The study's methodology, which used a simulation environment, enabled participants to engage interactively in the experimental process, thereby enhancing the study's reliability. Additionally, the purposeful sampling technique was employed with precision to select the sample group, ensuring a balanced participant profile. This careful selection contributed to the generalizability of the research findings.

When analyzing the study's findings, it is evident that differences exist in the color-emotion associations between the two experimental groups, those with and without color education. For instance, according to Hypothesis 1, the color-educated experimental group's coloring choices should align with the color-emotion associations found in the literature. Meanwhile, Hypothesis 2 suggests that the non-color-educated group's color choices should deviate from these established associations. However, upon examining the graphs, it was observed that the color-educated participants demonstrated alignment with the literature only for certain adjectives. In contrast, the non-color-educated group's color choices exhibited greater alignment with color-emotion associations from previous studies. Ultimately, while both groups' choices generally did not align with the literature, the non-color-educated group's preferences showed a stronger correlation with existing color-emotion pairings. This finding may be explained by the fact that previous studies on color-emotion associations in the literature were conducted with participants who were predominantly individuals without formal color education. Hypothesis 3 proposed that both experimental groups would associate positive adjectives with warm colors. However, when analyzing the graphs, it was observed that in the color-educated group, only the adjective "bright" was strongly associated with warm colors. The adjectives "polite," "dynamic," "optimistic," and "energetic" were only weakly associated with warm colors, while the other positive adjectives were distributed inconsistently across various colors. In the non-color-educated group, only the adjectives "polite" and "pure" were linked to warm colors, and even then, this preference was only observed in a small majority of participants. Hypothesis 4 suggested that both experimental groups would associate negative adjectives with cool colors. However, in the color-educated group, none of the negative adjectives were clearly associated with cool colors. In contrast, in the non-color-educated group, only the adjective "static" was associated with cool colors by a slight majority (16 participants). Overall, both experimental groups frequently associated negative adjectives with achromatic colors, such as black and gray. The findings indicate that neither experimental group showed a strong, consistent association between positive adjectives and warm colors or between negative adjectives and cool colors. Therefore, Hypotheses 3 and 4 could not be confirmed.

The findings of this study indicate that the color factor plays a crucial role in the furniture design process and significantly influences users' emotional responses. In particular, the observation that individuals with color education exhibit preferences more aligned with the color-emotion associations found in the literature provides valuable insights for designers and industrial product developers.

In conclusion, this study makes a significant contribution to understanding how color influences the furniture design process in the context of user emotions. It emphasizes the crucial role of colors in design perception and user experience, offering valuable guidance for future design projects. In product design, the importance

of considering the emotional impact of color in decision-making processes targeting specific user groups has been clearly demonstrated. Furthermore, the interactive simulation method employed in this study stands out as a repeatable, scalable tool for advancing research in design and user psychology. The findings can be used in product design practices for target audiences, and the simulation program developed within the scope of this study may also be adopted by furniture design, manufacturing, and marketing companies as a consumer-oriented tool.

For future research, it is recommended that the simulation environment be enhanced with technological tools, such as virtual reality, to allow users to engage in a spatial experience. Additionally, the use of computer software to create simulated environments and to collect, store, and analyze data would further improve the reliability of the study and its contribution to the literature. This study serves as a foundation for future research by expanding the sample size, increasing the number of variables, creating color compositions, and diversifying the presented color-adjective pairings.

Authors' Contributions

The 1st author contributed 50%, the 2nd author contributed 25%, and the 3rd author contributed 25% to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval dated 03/07/2024 and numbered 2024-4/2 was obtained by Marmara University Social Sciences Research Ethics Committee.

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