

Color and Colorimetry Multidisciplinary Contributions

Vol. XX A

Edited by Filippo Cherubini and Andrea Siniscalco



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Introduction

The Color Conference, organized annually by the Italian Color Association (Gruppo del Colore - Associazione Italiana Colore), reached its Twentieth Edition in 2025.

The international two-day event took place on September 4th and 5th, 2025, at the University of Naples Parthenope in the beautiful city of Naples.

This milestone edition opened with three keynote presentations of exceptional breadth and inspiration. The conference began with Dr. Costanza Miliani from the CNR Institute of Heritage Science, who presented “Writing with Colors: Materials, Techniques, and Cultural Significance in Mesoamerican Codices”. The program continued with Studio Waldemeyer, featuring Farahbod Nazanin and Moritz Waldemeyer, and their evocative talk “Where Light Becomes Emotion”.

The morning session concluded with the Color Award 2025, conferred to Massimo Cantini Parrini in recognition of his extraordinary contribution to the world of costume and creativity.

The following day opened with an outstanding invited lecture by Dr. Massimiliano Guarnieri from ENEA, who presented “Artificial Intelligence and color features detection: some examples and future perspective”.

Sincere thanks go to the Chairs of the Conference, Giuliana Ramella (CNR – Institute for Applied Calculus “Mauro Picone”) Francesca Fragliasso (University of Naples Federico II) and Andrea Siniscalco (Dipartimento di Design, Politecnico di Milano), for their valuable guidance and coordination. A heartfelt appreciation also goes to the University of Naples Parthenope, host of this year’s edition.

We warmly thank Dr. Sofia Ceccarelli (CNR ISPC) for the local organization, the Program Committee, Professors Angelo Ciaramella and Emanuel Di Nardo (University of Naples Parthenope), Professors Laura Bellia and Francesca Diglio (University of Naples Federico II), as well as Dr. Filippo Cherubini, Secretary of the Association, and all the members of the Scientific Committee, for their fundamental contribution to the dissemination, review, and organization of the conference. Special thanks also go to Tectilia, the event sponsor, whose support helped make this conference both culturally enriching and welcoming.

The 2025 program once again confirmed the richness and interdisciplinarity that have always characterized the work of our community, spanning from design to education, and from cultural heritage to psychology.

These diverse perspectives continue to make the Conferenza del Colore a reference point for researchers, professionals, and enthusiasts working on the multifaceted study of color.

Finally, we extend our gratitude to all authors and speakers for the quality of their contributions, and to the institutions and associations that offered their patronage and collaboration, reinforcing the spirit of unity that defines this event.

The following pages collect the proceedings of the Twentieth Color Conference.

We wish you an inspiring read.

Alice Plutino

October 2025

Index

Keynote Speakers	10
<i>Artificial Intelligence and color features detection: some examples and future perspective</i>	<i>11</i>
Massimiliano Guarneri	
<i>Writing with Colors: Materials, Techniques, and Cultural Significance in Mesoamerican Codices</i>	<i>12</i>
Costanza Miliani	
<i>Where Light Becomes Emotion</i>	<i>13</i>
Moritz Waldemeyer, Nazanin Farahbod	
Color in Measurement - Color in Digital	14
<i>Color Difference Evaluation on Textiles: A Comparative Study of CIE76 and CMC(l:c) with Respect to Surface Topography</i>	<i>15</i>
Marijana Tkalec, Martina Glogar	
<i>Sustainable colour: a spectral perspective on natural vs synthetic dyes.....</i>	<i>24</i>
Martina Glogar, Ana Sutlović, Iva Brlek, Ivana Čorak	
<i>Developing a framework to study color variations in ancient ink: Preliminary analysis.....</i>	<i>32</i>
Miriam Alberico, Laura Bellia, Francesca Diglio, Francesca Fragliasso, Silvia Pizzimenti, Elif Ranaer Harputluoğlu, Alessandro Vergara	
Color and Lighting.....	40
<i>Enhancing the neutral: white surfaces and luminous quality in the historic spaces of Villa Argentina</i>	<i>41</i>
Franz Graf, Gianluca Guarini, Maurizio Rossi	
<i>Hue cancelation experiments and the quantum perceptual color space</i>	<i>49</i>
Edoardo Provenzi	
<i>Interactions of daylight and electric light with indoor colored surfaces: Effects on human circadian response.....</i>	<i>54</i>
Laura Bellia, Francesca Diglio, Francesca Fragliasso	
<i>Teaching the building up of the right image in the lighting design visual protocol.....</i>	<i>62</i>
Richard Caratti-Zarytkiewicz	
<i>Sensory Lighting and Design: Design Strategies for Multisensory Food Perception in Hospitality Settings.....</i>	<i>70</i>
Paola Bertolotti, Gianluca Guarini	
<i>Considerations about light and colour for human beings in microgravity conditions.....</i>	<i>79</i>
Andrea Siniscalco, Piero Santoro, Carlo D'Alesio, Mattia Toffanetti, Andrea Parato	
Color and Physiology	87
<i>The role of time arrows in colour perception</i>	<i>88</i>
Kazim Hilmi Or	
<i>The modulation of human aesthetic attraction by avian chromatic attributes</i>	<i>95</i>
Kazim Hilmi Or	
Color and Psychology.....	104
<i>Color Sensitivity: How Hue and Saturation Influence Food Selection in Nickel Allergy</i>	<i>105</i>
Alessandro Bortolotti, Federica Cocco, Andrea Siniscalco and Riccardo Palumbo	
<i>Stress Perception in Pediatric Clinics: A Pilot Study.....</i>	<i>113</i>
Sujinda Suramai, Vorapat Inkarojrit, Ph.D.	
<i>Color, Form, and States of Consciousness</i>	<i>122</i>
Sharon Avital	

<i>The Color of Creativity: From Bauhaus Theory to Digital Analysis</i>	128
Dalia Gallico, Francesco Rocchi	
<i>Can the adaptive colour shift help detect incomplete chromatic adaptation?</i>	133
Ágnes Urbin	
Color and Restoration	139
<i>"Il Borgognone" or his school? Assessing a 17th-century painting attribution through multi-analytical investigations</i>	140
Dario Giuffrida, Franz Saija, Rosina Celeste Ponterio	
<i>Colours of Early Cinema: The Case of Leopoldo Fregoli's Films (1897-1899) Through Diagnostic Investigation</i>	148
Valentina Rossetto, Lisa Vergelli, Alessandro Ciccola	
Color and Environment	158
<i>Color Beyond Vision: Exploring Synesthetic Interactions in Built Environments</i>	159
Paulo Eduardo Tonin, Marinella Ferrara	
<i>The Impact of Colour Schemes on Perception and Behavioural Intentions in a Coffee Shop Context</i>	168
Parla Özkul, İrem Ekin Atasoy, Nilgün Olguntürk	
<i>The Color as an element of space definition: Schlemmer's moving architectures</i>	176
Pina Russo	
<i>A magnificent and gloomy city. The Significance and Ecological Aspects of Achromatic Colors in Urban Landscapes</i>	184
Olga Lavrenova	
Color and Design	192
<i>Colouring outside the (stereotypical) lines: Rethinking colour and gender in design</i>	193
Labarta Labrador, Martina, Calvo Ivanovic, Ingrid	
<i>The emerging role of CMF designers in sustainable product development: insight from practice</i>	202
Sossini Lia, Del Curto Barbara	
<i>A tribute to the chromatic and geometric depth of Josef Albers</i>	211
Ilaria Alessandri	
<i>Color design for public space</i>	219
Jihye Choi	
Color and Culture	225
<i>Seeking Reciprocity through Light and Colour: Contemporary Art at Pitzhanger Manor</i>	226
Fiona McLachlan	
<i>Painted photography by Pierre Gusman.</i>	234
Annie-Dominique Denhez	
<i>A Contextual Analysis of Colour in Andy Warhol's Screen Prints in Relation to Commercial Colour Trends of the 1960s, 1970s, and 1980s</i>	
Agata Kwiatkowska-Lubańska	
Color and Education	251
<i>An illusive approach engaging colour, lighting and interior design</i>	252
Vien Cheung, Andrea Siniscalco, Maurizio Rossi	
<i>Friuli Venezia Giulia</i>	260
Francesca Valan	

SPECIAL SESSION: Color and Artificial Intelligence	267
<i>Authenticity in the Age of AI: Challenges in Colorizing Classic Cinema.....</i>	<i>268</i>
Alice Plutino	

Color and Environment

Color Beyond Vision: Exploring Synesthetic Interactions in Built Environments

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Abstract

Anchored in interdisciplinary studies from cognitive science, phenomenology, and sensory design, this paper investigates color as a multisensory catalyst in spatial design. Through a mixed-methods approach—combining literature review with non-interventionist field observation in retail built environments—it examines how color interacts with scent and texture to shape affective atmospheres. Two case studies—a futuristic boutique in Seoul and a classical perfumery in Milan—demonstrate how the color red evokes contrasting sensory and emotional responses. Findings highlight both the potential and the challenges of applying multisensory color strategies in experiential environments. By reframing color as an embodied, affective phenomenon, the paper offers new pathways for crafting more immersive, inclusive, and emotionally resonant experiences.

Keywords: multisensory design, synesthetic perception, color psychology, built environments, spatial experience.

Introduction

In contemporary design practice, color has evolved from a primarily visual and symbolic element to a multisensory agent capable of influencing perception, emotion, and behavior. Studies in neuroscience, cognitive and environmental psychology demonstrate that sensory perception is inherently cross-modal and embodied, involving dynamic integration across modalities such as smell, touch, hearing, and taste (Mehrabian and Russell, 1974; Spence, 2011). Within this point of view, color can operate as a trigger for complex sensory associations, aligning with the phenomenon of synesthesia, typically defined as a condition in which stimulation in one sensory modality involuntarily evokes experiences in another. Although often considered rare and neurological in origin, research shows that synesthetic correspondences also occur in the general population and can be strategically leveraged in design contexts to enrich experience and engagement (Haverkamp, 2013). In built environments—especially in affective, commercial, or exhibition spaces—color holds potential as a catalyst for evoking textures, temperatures, sounds, and scents (Malnar and Vodvarka, 2004). These understandings have significantly influenced design disciplines, fostering experiential approaches in the conception of objects, materials, and spaces (Ferrara, 2020).

Despite the growing discourse on multisensory design, the role of color in cross-modal perception remains underexplored in both theory and practice. This article investigates the following research question: “*How can color function as a multisensory agent in the design of built environments, and what mechanisms support its capacity to trigger, modulate, or amplify sensory experiences beyond vision?*”. Combining critical literature review, analysis of key experimental studies and non-interventional field observation in selected retail environments, this study focus on how specific chromatic strategies—particularly the use of red—contribute to sensory and emotional experience. By reframing color as an active agent in multisensory storytelling, the study highlights its role in shaping spatial atmospheres and embodied experiences. It also examines the relevance of semantic anchoring—verbal associations that connect color to affective or sensory attributes—as a tool to support design coherence and perceptual resonance. Ultimately, the research supports a shift toward sensory-integrated approaches in spatial and brand experience design.

Methodology

This paper adopts a qualitative exploratory mixed-methods approach, combining: (a) Comprehensive state-of-the-art literature review; (b) Analysis of foundational experiments exploring cross-sensory effects; (c) Field non-interventionist observations at selected retail spaces. The literature review draws from diverse fields, including design, neuroscience, cognitive and environmental psychology. This interdisciplinary approach informs an understanding of how color influences psychological processes such as mood, perception, memory, and behavior, and how these insights can improve sensory integration in spatial design. To support this, the study includes a scanning of experiments that consider cross-sensory aspects. The selection and examination of these studies were guided by two criteria: (1) Sensory modalities involved (such as color in interaction with smell, touch, or sound); and (2) Key findings or contributions relevant to understanding the affective and perceptual impact of chromatic stimuli.

This structured review contributed to identifying recurring mechanisms of sensory interaction and assisted the interpretation of spatial observations that complement the theoretical insights. The non-interventionist observations were conducted in two contrasting retail environments Case Studies — Born to Stand Out (Seoul), a futuristic boutique with synthetic scents, and The Merchant of Venice (Milan), a classical perfumery characterized by natural fragrances. These locations were selected for their distinct sensory and chromatic strategies, particularly the use of red to shape immersive brand atmospheres. Rooted in ethnographic and phenomenological traditions, the observations focused on embodied sensory experience without interference or participant interaction. Although this approach limits generalizability due to the absence of controlled experimentation or biometric data, it prioritizes rich contextual understanding of how color can activate multisensory and emotional responses in curated retail spaces. The methodology is particularly suited to experiential retail and brand storytelling, but further research is needed to validate it in areas like healthcare and education.

Literature Review

Color perception has traditionally been framed within a visual paradigm that privileges sight over other sensory modalities, particularly in architecture and spatial design. This ocularcentric orientation tends to reduce the multisensory complexity of spatial experience, overlooking how perception emerges from embodied and integrated sensory input. Phenomenological thinkers such as Merleau-Ponty (1962) offer a foundational critique of this bias, suggesting that perception is not a passive visual act, but an active, corporeal engagement with the world. In this embodied view, space is simultaneously seen, smelled, touched, tasted and heard—its meaning constructed through dynamic sensorimotor interaction (Zatore and Belin, 2001). Interdisciplinary research supports a shift from this visual-centric approach toward multisensory approaches. Cognitive neuroscience and environmental psychology have demonstrated the interdependence of sensory systems, especially through crossmodal interactions—phenomena where stimuli in one sensory modality influence perception in another. Studies by Spence (2011, 2015) reveal that visual information modulates tactile, olfactory, and even gustatory responses, underscoring the multisensory nature of human experience. Within this expanded approach, color emerges not as an isolated chromatic value but as a perceptual trigger capable of activating a wide range of embodied and emotional associations.

Beyond sensory processing, color functions as a semiotic system within the broader context of cultural and environmental meaning-making. Semioticians such as Barthes (1977) and Eco (1976) have emphasized how color operates as a code, carrying denotative and connotative significance that is culturally and contextually contingent. For instance, red may evoke urgency, passion, or danger depending on the setting and cultural background. This symbolic dimension interacts dynamically

with perceptual processes, meaning that color influences not only how spaces are seen but also how they are interpreted and emotionally experienced (Farina, 1990). In design theory, this expanded understanding has inspired new methodologies that actively integrate multisensory cues. Malnar and Vodvarka (2004) advocate for sensory design strategies prioritizing emotional resonance, memory formation, and immersive affective engagement beyond mere surface aesthetics. Color, when combined with olfactory, tactile, and acoustic stimuli, becomes a powerful agent in crafting immersive environments, particularly in retail contexts where emotional engagement is central to brand communication. This sensorial language of design, as argued by Lupton and Lipps (2018), moves beyond purely visual stylization toward an inclusive and holistic sensory articulation.

Empirical research elucidates these multisensory interactions further. Crossmodal correspondences—learned or innate associations between sensory features—demonstrate how color systematically links to other sensory modalities. For example, warm colors like red are commonly associated with sweet tastes (Spence, 2011, 2015), while certain hues correspond consistently with specific odors (Gilbert *et al.*, 1996; Zellner, 2013). Although synesthesia—characterized by involuntary, consistent cross-sensory experiences—is neurologically rare, it offers a conceptual model inspiring design practices that blur sensory boundaries (Haverkamp, 2013). At the neural level, studies by Gottfried and Dolan (2003) and Osterbauer *et al.* (2005) reveal that color can influence olfactory perception via convergent activation in the orbitofrontal cortex. These neural mechanisms underpin observed behavioral effects in consumer settings, where congruent color–odor pairings enhance product recognition and hedonic ratings (Zellner *et al.*, 1991; 2013), whereas incongruent pairings tend to disrupt perception and attenuate affective response (Stevenson & Oaten, 2008; Tamura *et al.*, 2018).

In spatial environments, such multisensory integration extends to atmospheric perception. Color primes olfactory expectations and modulates emotional encoding of scents (Dubose *et al.*, 1980), strategies increasingly employed in retail and wellness spaces to communicate affective qualities. Additionally, color influences cognitive processes including attention, memory, and decision-making. For instance, warm hues are linked to arousal and tenacity (Spence, 2011, 2015), while cool tones facilitate calm and introspection. These effects are culturally mediated, reinforcing the importance of contextualized design approaches (Heller, 2004; Barbara *et al.*, 2021). Other studies have further extended the understanding of crossmodal color associations beyond olfaction and taste to include tactile perception. Spence (2011, 2015) demonstrated that individuals consistently associate tactile textures with specific chromatic qualities—smooth textures were linked to lighter or cooler colors such as white and blue, while rough textures evoked darker or earthier tones such as brown or burgundy. These findings point to stable cognitive mappings between tactile and visual domains, which can be strategically leveraged in material and spatial design (Haverkamp, 2013; Lupton and Lipps, 2018).

Crossmodal associations are shaped by culture. Levitan *et al.* (2014) found that while color–odor pairings were consistent within each cultural group, they varied significantly across cultures—likely influenced by factors such as diet, symbolism, and sensory traditions. These findings highlight the need for culturally attuned design strategies that consider local sensory meanings. Taken together, these theoretical, cultural, and empirical insights establish color as a dynamic sensory interface—one that communicates meaning through both direct perceptual input and associative semiotic layering. Recognizing color’s multisensory and semiotic roles enables designers to craft spaces that are immersive, emotionally engaging, and culturally resonant. To advance this understanding, Table 1 presents the result of an analytical review obtained from key crossmodal experiments involving color, categorized by the sensory modalities involved and principal findings related to color as a

multisensory agente. This synthesis lays the foundation for investigations into how multisensory color integration can enhance the psychological and emotional experience within built environments.

<i>Author(s)</i>	<i>Sensory Modalities</i>	<i>Key Findings / Contributions</i>
<i>Baron-Cohen et al. (1987)</i>	Vision, Audition	Case study of lexical–color synesthesia showing involuntary and consistent color associations with spoken words.
<i>Dubose et al. (1980)</i>	Vision, Olfaction	Showed that color primes olfactory expectations and modulates emotional encoding of scents.
<i>Gilbert et al. (1996)</i>	Vision, Olfaction	Identified systematic color–odor correspondences in non-synesthetes; suggests shared or learned crossmodal mappings.
<i>Gottfried & Dolan (2003)</i>	Vision, Olfaction	Demonstrated convergent activation in orbitofrontal cortex for visual and olfactory stimuli, revealing neural basis for crossmodal perception.
<i>Levitan et al. (2014)</i>	Vision, Olfaction	Revealed consistent and divergent odor–color correspondences across cultures.
<i>Osterbauer et al. (2005)</i>	Vision, Olfaction	Found chromatic stimuli modulate odor perception in the brain.
<i>Spence (2011, 2015)</i>	Vision, Taste, Touch	Tested associations between color and taste and demonstrated consistent correspondences between tactile textures and colors: smooth textures were associated with light or cool colors, while rough textures corresponded to dark or earthy tones.
<i>Stevenson & Oaten (2008)</i>	Vision, Olfaction	Demonstrated that appropriate color cues improve odor discrimination.
<i>Tamura et al. (2018)</i>	Vision, Olfaction	Showed citrus-like smells enhance memory for orange color stimuli.
<i>Zellner & Whitten (1999)</i>	Vision, Olfaction	Showed that color intensity affects odor identification and pleasantness.
<i>Zellner (2013)</i>	Vision, Olfaction, Taste	Synthesized research on color-odor interactions, proposed integrative models.
<i>Zellner et al. (1991)</i>	Vision, Olfaction	Found influence of color on odor identification and liking ratings.

Table 1 – Summary of Key Studies on Cross-Modal Interactions Involving Color

Case Studies

This section presents a comparative analysis of two distinct retail environments where the color red functions as a pivotal sensory catalyst, shaping emotional, cognitive, and spatial experiences. Both cases exemplify the concept of color beyond vision, illustrating how chromatic elements interact multisensorially with form, texture, and scent to produce immersive brand narratives. The *Born to Stand Out* (Figure 1) boutique in Seoul embodies a radical, futuristic aesthetic that challenges traditional retail design conventions. Here, red is deployed not merely as a visual stimulus but as a dynamic multisensory agent that evokes urgency, movement, and noise. The space’s design features organic, fluid forms juxtaposed with satin-like surfaces, rustic stone, mirrors, and carpet textures, producing a tactile complexity that complements the chromatic vibrancy (Malnar and Vodvarka, 2004; Lupton and Lipps, 2018). The predominance of satin finishes—distinct from gloss or matte—introduces subtle light diffusion, intensifying the perceptual richness of red while avoiding overt glare (Heller, 2004; Spence, 2011, 2015).

Olfactory elements further reinforce this dystopian atmosphere. The brand’s synthetic fragrances, characterized by atypical and chemically derived notes, resonate with the unsettling, synthetic nature of the environment, enhancing the sensory dissonance and conceptual urgency (Gottfried & Dolan, 2003; Barbara *et al.*, 2021). This sensory orchestration aligns with crossmodal correspondences, whereby color and scent mutually amplify emotional impact (Osterbauer *et al.*, 2005; Spence, 2011). Through this multisensory layering, red in this space transcends a purely aesthetic role to become a

catalyst for embodied experience, eliciting visceral responses of alertness and dynamism that mirror the brand's avant-garde identity. Contrasting sharply with *Born to Stand Out*, *The Merchant of Venice* (Figure 1) perfumery invokes tradition and refinement. Here, red assumes a more classic and restrained character, supporting an environment steeped in historical references and sensory sophistication. The interior design features polished lacquered surfaces and classic furniture, which reflect light to create a luminous environment where red hues signify luxury and elegance (Farina, 1990; Leder *et al.*, 2004; Heller, 2004). The chromatic use is more controlled and semantic, functioning as a signifier of heritage and craftsmanship. Natural and often floral fragrances permeate the space, corresponding to the rich olfactory heritage of the brand.



Fig. 1 – *Born to Stand Out* (left) and *The Merchant of Venice* (right). Source: Author.

This olfactory authenticity synergizes with the visual richness of red, enhancing the sensory narrative with notes of warmth and exclusivity. This synergy between red and scent, combined with tactile cues from glossy materials, constructs a multisensory environment where red catalyzes associations of refinement, elegance, and timelessness. It demonstrates the capacity of color to anchor semantic meanings that extend beyond visual perception, consistent with synesthetic design principles (Haverkamp, 2013; Spence, 2011, 2015). These case studies illustrate the polysemic nature of red, demonstrating its versatility as a sensory catalyst that can evoke divergent affective states depending on contextual variables such as materiality, scent, and spatial form. By integrating these sensory modalities, designers can harness the power of red not only to attract attention but to orchestrate embodied experiences that resonate emotionally and cognitively with users.

Discussion

The comparative analysis of *Born to Stand Out* and *The Merchant of Venice* underscores the strategic role of red as a multisensory catalyst in retail spaces, contributing to distinct experiential outcomes through its interaction with other sensory modalities. This reinforces the theoretical proposition that color operates beyond mere visual perception, functioning within complex sensory ecologies that shape consumer experience (Spence, 2011; Lupton and Lipps, 2018). The findings align with models of cross-modal correspondences which describe how sensory modalities such as vision, olfaction, and

touch co-activate and mutually influence perception and affective states (Osterbauer *et al.*, 2005; Zellner, 2013). In both retail contexts, the deployment of red is not isolated but entwined with scent profiles and tactile materials, enabling emotional modulation—urgency and dynamism in one case, elegance and sophistication in the other. This supports Leder *et al.* (2004) model of aesthetic appreciation, which posits that sensory stimuli evoke cognitive and emotional responses through an interplay of perceptual and contextual factors.

By engaging multiple senses coherently, retail environments can foster deep embodied experiences that enhance brand meaning and consumer engagement (Merleau-Ponty, 1962; Mehrabian and Russell, 1974; Malnar and Vodvarka, 2004). The contrasting sensory narratives exemplify the context-dependent nature of color perception and meaning-making. As Farina (1990) and Heller (2004) emphasize, cultural and environmental contexts influence color semantics, shaping the psychological and emotional connotations that color invokes. The use of synthetic vs. natural fragrances in tandem with chromatic cues highlights the potential for sensory congruence or dissonance to reinforce or disrupt brand identity narratives (Gottfried & Dolan, 2003; Tamura *et al.*, 2018). This dynamic interaction exemplifies the concept of sensory anchoring, whereby non-visual cues stabilize and elaborate the emotional and cognitive effects elicited by color (Leder, 2004; Heller, 2004; Spence, 2011). From a design practice perspective, the cases highlight both opportunities and constraints in implementing multisensory color strategies. The Born to Stand Out store illustrates how red's association with urgency can activate consumer attention and stimulate movement within space, beneficial in contexts requiring high engagement (Farina, 1990; Spence, 2011; Barbara *et al.*, 2021).

Conversely, The Merchant of Venice illustrates how red can convey heritage and exclusivity, aligning with luxury retail goals where sensory harmony and emotional subtlety are central (Leder *et al.*, 2004; Heller, 2004). Despite its potential, multisensory color integration presents several design challenges. Managing olfactory dispersion in open spaces, ensuring sensory congruence across materials and scents, and addressing individual or cultural variability in color-scent associations require careful, context-specific calibration (Stevenson & Oaten, 2008). Designers must also consider environmental constraints, ventilation systems, and cross-cultural interpretations to avoid misalignment in sensory messaging (Levitan *et al.*, 2014). In sum, this study advances an approach to understanding color as a multisensory, experiential catalyst in retail design, showing how strategic integration of chromatic, olfactory, and tactile elements can shape distinctive brand atmospheres and consumer experiences. This aligns with sensory design paradigms that prioritize embodied, cross-modal engagement over visual dominance (Lupton and Lipps, 2018).

Conclusion

This study explored the role of red color as a multisensory catalyst within retail environments, emphasizing its capacity to transcend visual perception and orchestrate a coherent sensory experience through the integration of olfactory, tactile, and spatial elements. The analysis of the *Born to Stand Out* and *The Merchant of Venice* stores demonstrated how chromatic design, in concert with complementary sensory stimuli, can evoke distinct emotional and cognitive responses, shaping consumer engagement and brand identity. The findings contribute to the growing body of literature that challenges the traditional primacy of vision in design, advocating for embodied, multisensory approaches that recognize the complexity of human perception. They underscore the importance of contextual and cultural factors in shaping the semantic and affective qualities of color. From a practical standpoint, the study illustrates that retail designers can leverage multisensory color strategies to create differentiated, immersive experiences that align with brand narratives, whether oriented towards dynamism and futurism or tradition and sophistication. From these insights, the following pathways offer strategic guidance for integrating color as a multisensory design element to craft immersive, inclusive, and emotionally resonant environments (Table 2).

Pathway	Description	Benefit
<i>Multisensory Integration</i>	Combine color with texture, scent, flavor and sound	Deeper emotional engagement
<i>Contextual Adaptation</i>	Adjust color tone and finish by cultural context	Cultural relevance
<i>Dynamic Surfaces</i>	Use lighting and material finishes to alter color	Stimulates interest
<i>Inclusive Design</i>	Pair color with other sensory cues for accessibility	Broader audience engagement
<i>Olfactory-Color Pairing</i>	Match scents with color tones	Stronger sensory narrative
<i>Semantic Anchoring</i>	Use color to anchor brand meaning	Brand identity reinforcement
<i>Phygital Experience</i>	Blend physical and digital color interactions	Interactive engagement

Table 2 – Summary of Key Studies on Cross-Modal Interactions Involving Color

The study also underscores challenges related to sensory coherence and individual variability, which demand greater methodological rigor and design sensitivity. Future research should adopt empirical and experimental approaches to quantify the multisensory interactions of color across varied retail contexts, utilizing perceptual studies, sensory mapping, longitudinal behavior analysis and cross-cultural comparisons to test and expand the proposed approach. Emerging neuroscientific and biometric tools—such as eye tracking, neuroimaging, and psychophysiological measures—offer promising methods for objectively evaluating embodied sensory experience and enhancing multisensory design principles. Finally, the evolution of digital and phygital retail environments introduces new complexities and opportunities for color-based sensory design, requiring interdisciplinary collaboration across design, technology, and cognitive science to advance sensory branding strategies in omnichannel retailing. These insights are particularly relevant to experiential retail, exhibition design, and brand environments where emotional engagement is a design priority. As such, they inform both academic discourse and practical strategies for creating immersive, inclusive, and affectively resonant spaces.

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