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Coloring Trust:
Insights and Research Perspectives

КОСОВА Е.М.
ЦВЕТ ДОВЕРИЯ:
АНАЛИЗ И ИССЛЕДОВАТЕЛЬСКИЕ ПЕРСПЕКТИВЫ

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Color, as a unique perceptual characteristic, is gaining increasing importance in the digital age, significantly influencing our perception of virtual environments and our interactions with them. This article explores the intersection of two key areas of psychology: the psychology of trust and the psychology of color.

The primary aim of this work is to analyze both classical and contemporary studies on the influence of color on trust levels and to identify promising directions for further research. The study focuses on identifying specific factors and mechanisms that determine the influence of color on trust, such as psychological associations, cultural differences, and usage context. The practical application of this knowledge is particularly relevant in marketing, where the choice of color palette can significantly affect brand perception and consumer decision-making.

The article provides a theoretical framework for investigating the relationship between color and trust, with a special emphasis on methodological and conceptual challenges. Additional focus is placed on new horizons associated with the growing diversity of human activity environments and the dynamic nature of emerging digital realms, such as virtual and augmented reality.

The research findings indicate that color exerts a complex and multifaceted influence on trust, which varies depending on parameters such as hue, saturation, and brightness. These color parameters interact with trust and related psychological constructs, affecting perception and behavior in various contexts. Specifically, it is noted that cooler colors tend to be associated with higher levels of trust than warmer ones, and lower saturation is also linked to greater trust. Furthermore, the limitations of existing research and established paradigms are examined in detail; in particular, the postulate regarding the highest trustworthiness of the blue hue is critiqued as methodologically unreliable.

The solutions and directions for future research proposed in the article contribute to a deeper understanding of the role of color in the context of trust. This study makes a significant contribution to the development of color

psychology and provides valuable recommendations for designing interfaces that enhance trust in various fields, such as e-commerce, online banking, and social networks.

Key words: color, trust, human digital interaction, risk perception, online trust, hue, saturation, brightness, web interfaces

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1. Introduction

In today's world, where visual stimuli increasingly shape our perceptions and interactions, the influence of color on various aspects of human behavior and psychological processes is gaining significance. This study endeavors to explore the intersection of two broad areas in psychology: trust and color psychology.

Our objective is to analyze both classical and contemporary research on how color influences levels of trust and to pinpoint potential areas for further exploration. We seek to understand the specific factors and mechanisms underlying the impact of color on trust and its practical applications, including marketing, design, and interpersonal relationships.

Special emphasis will be placed on examining the limitations of existing studies and identifying avenues for future research. The theoretical framework presented will also propose ways to address methodological and conceptual challenges, paving the way for deeper exploration in the color psychology of trust.

2. Conceptual Framework

2.1. Understanding trust

Why do we consider the role of color within the realm of trust psychology? To address this query, we must first establish definitions pivotal to our discourse. Trust stands as a foundational psychological concept crucial for social functioning and fostering successful relationships across diverse social settings (Patrick, 2002). It can be conceptualized as a generalized expectation shared between two or more parties, reflecting one party's willingness to rely on another even amidst uncertainty, thus providing a sense of relative security (Rotter, 1980; McKnight, Chervany, 1996; Kosova, Gorbunova, 2023a). Patrick (2002) delineates customer trust as a fusion of thoughts, feelings, emotions, and behavioral responses exhibited when customers believe they can rely on the provider to act in their best interests, even when direct control is relinquished. Morgan and Hunt (1994)

characterize trust as the confidence one party holds in another owing to the partner's reliability and integrity. Lastly, Corritore and colleagues (2003) define online trust as the confidence a trusting party maintains that, amidst digital risks, vulnerabilities, and uncertainties, they will not be exploited by the trusted party.

Trust comprises diverse components, spanning organizational, cognitive, and affective dimensions (Kosova, Gorbunova, 2023a). Organizational elements entail the involvement of multiple parties (trustor and trustee), the process of interaction shaping trust, its manifestation in actions or inactions, and the risk borne by the trustor in case of misplaced trust (Vodicka, 2006; Wang, Emurian, 2005; Evans, Krueger, 2011). Cognitive components encompass expectations of benefits derived from displaying trust, the consistency and predictability of behavior, the perceived honesty and competence of the trusted party, and the goodwill exhibited by the trusted party (Evans, Krueger, 2011; Vodicka, 2006; O'Neill, 2017; Dowell et al., 2013; Dowell et al., 2015; McKnight et al., 2002). Affective components involve empathetic behavior from both the trustor and trustee, perceptions within social groups (e.g., favoring 'us' over 'them'), and intuition (Vodicka, 2006; Cikara et al., 2011; Huang, Murnighan, 2010).

It's crucial to acknowledge that trust operates within two temporal dimensions: primary trust, established during the initial encounter with another party, and stable trust, cultivated through repeated interactions (Koufaris, Hampton-Sosa, 2004). Primary trust holds significant importance as it emerges at the onset, laying the foundation for enduring relationships. In contrast, stable trust, nurtured over multiple interactions, tends to be more resilient and enduring in nature.

So, above, we briefly addressed the question of *what* trust is, but perhaps more importantly (from a practical standpoint), the question of *how* it is formed is crucial. Previous studies underscore the strong connection between trust and three other psychological constructs related to allegiance: satisfaction, loyalty, and reputation, although with differing perspectives. For instance, Chaudhuri and Holbrook (2001) highlight brand trust as a significant factor influencing customer loyalty, while Gul (2014) suggests that reputation precedes customer satisfaction, trust, and loyalty. This implies that a company's positive reputation fosters customer satisfaction, leading to increased trust and loyalty. Brand trust and influence, consequently, contribute to market share and higher relative prices for brand products. Leninkumar (2017) emphasizes customer satisfaction as a key influencer of loyalty, affirming that satisfaction precedes trust, which, in turn, influences loyalty. Similar perspectives are shared by Luo et al. (2008) and Hsu and Wang (2008), regarding trust as a predictor of loyalty.

Putting aside the intricate relationships with these closely related concepts, which we only broadly outline in this work, let's delve into another perspective: examining the trust system as a complex interplay of attributes between its participants – the trustor and the trustee. Let's posit that for each party, we can delineate between 'external' and 'internal' attributes of trust. In general terms, internal attributes should encompass the value-driven attitudes of both parties (referring back to the trust structure, we can define benevolence, intention to trust, or intention to uphold trust by meeting the terms of this 'social contract,' honesty, respect, and so forth). External attributes, on the other hand, should encompass everything related to the outward expression of internal attributes – essentially behavior; enclosing both behavior that reflects our internal attitudes toward the trust situation, and behavior that generally reflects our individuality, upon which the initial internal convictions of the parties regarding each other are formed. Additionally, besides the actual parties involved in trust, we must acknowledge that the nature of evolving relationships is influenced by the surrounding environment in which these relationships develop: given that the environment itself does not have consciousness, we propose to consider it as having only external attributes. Let's provide two examples, one in a 'physical' environment with a human-to-human trust format, and the other in a digital environment where trust manifests through human-interface interactions. For simplicity, let's explore the formation of primary trust in these examples, without the complexities of prior acquaintance or previous interaction experiences.

Imagine a spring evening with you and your friend strolling through the city center, enjoying a conversation in the pleasant shade of a linden alley. A stranger approaches, wanting to join in. You have mere seconds to decide whether to trust them. The stranger, dressed elegantly but with a slightly unsettling appearance, introduces himself politely. This situation mirrors a scene from Mikhail Bulgakov's *The Master and Margarita*, where characters Bezdomny and Berlioz encounter Voland. Their reactions differ based on the circumstances and their perceptions: Bezdomny is suspicious, while Berlioz is intrigued. The environment plays a crucial role in shaping their responses as the author of the novel states. The relaxed and friendly atmosphere of a spring evening in a pleasant setting makes Berlioz more open to engaging with the stranger. Conversely, had they been in a more rushed or stressful situation, like running late for a tram, their perception of the stranger would likely have been more guarded.

Now, here is example number two. You've taken the plunge and decided to venture into cryptocurrency trading by jumping onto what appears

to be a bandwagon and investing in Bitcoin. Despite having little prior involvement in cryptocurrency trading and a vague understanding of how it operates, you download an app from a cryptocurrency exchange onto your smartphone, completely unfamiliar with the platform (let's imagine you're a luddite, embarking on a journey of technological enlightenment). After registering on the app, you're confronted with a daunting decision: whether to trust this unfamiliar platform with your sensitive information. The app requests quite a bit from you: aside from your money (which you're planning to exchange for bitcoins), it also asks for your real-time photo (captured through access to your camera) and photos of your documents for verification purposes. What factors will you consider when deciding whether to trust this platform?

Previous studies on online trust towards interfaces have identified four types of trust cues, all of which are linked, at least partially, to the external attributes of the interface serving as the trusted entity: cues related to the social abilities of the interface, structural usability cues, content cues, and atmospheric design cues (Kosova, Gorbunova, 2023a). The first type, social abilities cues, involves integrating auxiliary interfaces, social networks, and anthropomorphic elements into the structure and design (such as human-like avatars, social media icons, embedded chatbot interfaces, etc.). These cues aim to simulate human-to-human communication rather than impersonal human-machine interaction (Kosova, Gorbunova, 2023b). The second type, structural usability cues, refers to how information is presented to website users. The structural organization of the website aims to offer users simple and convenient access to its functionality, including providing navigational cues, ensuring consistent page structure, and implementing shortcuts in the menu, among other things. The third type of cues relates to the content displayed on the website, encompassing the completeness and quality of the information presented, as well as endorsements from third-party distributors. If the content serves as an example of 'internal' content cues (such as the meaning or emotional message of a blog post), then the 'external' attributes of content can include its format (text, photo, video), internal consistency (e.g., whether images complement the news), and so forth. Finally, the last category of cues, atmospheric design cues, focuses on the external presentation of the interface. Elements such as color, fonts, etc., are utilized to convey messages to the audience, attract and maintain attention, thereby enhancing the initial interaction and solidifying trust. By now, it's evident why discussions about trust also incorporate the role of color.

2.2. The essence of color

From a psychological standpoint, color represents a complex and multidimensional stimulus that transcends mere visual perception, intricately intertwining with emotions, low- and high-level cognitive processes, and behavior as a whole, thus exerting a profound influence on the human experience. Scientific inquiry into color spans a broad spectrum, encompassing its impacts on various facets of everyday life, including physics, physiology, language, and more (Bortolotti et al., 2021). Moreover, color carries significant cultural significance: while some cross-cultural studies suggest a universal preference for the color blue (Wieggersma, Van der Elst, 1988), other colors hold distinct importance within specific cultural contexts. For instance, orange bears sacred significance in Hinduism in India, while green holds religious importance for Muslims and Celts (Singh, 2006). Moreover, according to Pinna and Deiana (2018), color not only reflects reality, allowing us to perceive the world more clearly, but our color perception also shapes this reality. Color creates additional emergent properties in the environment: for example, colors help to segment, locate, and organize living organisms into parts and into a multiplicity of fragments. This enables us to better distinguish edible from inedible items, determine the weather and time of year in an image, perceive printed text more effectively, and so forth.

At its core, color comprises light wavelengths interpreted by the brain into the spectrum of colors perceived by the human eye (Singh, 2006). When we deconstruct color into its constituents, we can discern three primary dimensions: hue, saturation, and brightness.

Hue, or chromatic tone, plays a crucial role in distinguishing one color from another within the spectrum. This characteristic determines the category of pure colors to which a specific stimulus belongs (e.g., red, blue, or green). In studies concerning trust, hue often exhibits the most variation; for instance, warm hues (like red or yellow) are contrasted with cool hues (such as blue or green). While some studies suggest that hue alone may not significantly impact a person's emotional state. Some studies propose that the hue of color itself may not significantly impact a person's emotional state (Xin et al., 2004), however, this assertion remains ambiguous and subject to doubt. Other studies, focusing on physiological aspects, suggest that the color red may elevate blood pressure, blink rate, and respiratory rate in comparison to blue (Gerard, 1957), potentially leading to more emotionally charged behaviors, such as aggression (Bagchi, Cheema, 2013). However, it's worth noting that a review of studies on physiological responses to

color (Kaiser, 1984) has indicated that data from various physiological tests lack sufficient information to establish specific trends. Similarly, Detenber et al. (2000) found no evidence of color influencing the physiological component of emotional experiences.

Saturation, chroma, and colorfulness are often used interchangeably to describe the intensity or richness of a particular color. These terms typically denote the purity or vividness of a color relative to gray within a specific hue. This dimension characterizes the strength or intensity of a color without considering its brightness or lightness. For instance, high chroma signifies an intense and rich color, whereas low chroma suggests a more subdued or washed-out appearance within the same hue. Research indicates that colorful, or chromatic, images convey emotionally charged information, unlike achromatic ones, such as gray images (Jue, Kwon, 2013). Wilms and Oberfeld (2018) demonstrated that saturated and bright colors are linked to heightened emotional arousal, as well as stronger skin conductance responses. Additionally, achromatic colors were associated with a temporary decrease in heart rate, while chromatic colors led to acceleration. It's also noteworthy that individual theoretical studies suggest a relatively higher significance of color saturation compared to hue in shaping trust (Papachristos et al., 2006); however, this area is insufficiently researched to draw definitive conclusions.

Lightness and brightness are associated with the perceived intensity of light within a color. Lightness indicates the level of illumination in a color and the extent to which white or black affects its tonal value (Gilchrist, 2007). Meanwhile, brightness is closely linked to the perceived intensity of light emitted or reflected from the color stimulus (Bortolotti et al., 2021). Brightness often corresponds with emotional valence, with brighter colors typically associated with positive emotions (Geslin et al., 2016).

In psychological studies, color serves as a global visual characteristic that facilitates emotional perception, scene differentiation, and extraction of emotional content (Bekhtereva, Müller, 2017). Color also plays a pivotal role in directing visual attention to pertinent segments of a scene, contributing to the sensory salience of stimuli (Kunieccki et al., 2015). Furthermore, the color of an image significantly impacts the subjective feeling of pleasantness, amplifies emotional experiences, and profoundly influences the affective processing of visual scenes (Suk, Irtel, 2010).

Thus, color emerges as a nuanced and multifaceted stimulus intricately interwoven into the tapestry of human experience, emotions, and cognition. Its influence transcends mere visual perception, shaping tonal values, emotional states, and cognitive processes in intricate and profound ways.

3. Psychology of Color

3.1. Historical perspectives

The roots of color psychology can be traced back to ancient civilizations, where colors held symbolic meanings and cultural significance. For example, ancient Egyptians associated colors with gods and cosmic elements, as evidenced in the Book of the Dead, which highlighted specific colors in funerary rituals linked with the afterlife and rebirth. Green symbolized life's renewal and fertility, often associated with Osiris, the god of resurrection and eternal life. Red represented power, energy, and vitality, but also connoted blood and death, notably as the color of the god Seth representing desert and destruction. Yellow, associated with the sun god Ra, symbolized divine presence and spiritual rebirth, while blue, linked to the goddess Isis, represented water, the sky, and protection (Singer, 2016).

The ancient Greeks regarded colors not only as visual stimuli but also as symbolic representations of fundamental principles. Red was associated with the god Ares, embodying notions of strength, war, and vitality (May, 2016). Blue symbolized the sky and the sea, conveying depth, wisdom, and stability, often associated with the goddess Athena, alongside yellow or gold (Deacy, Villing, 2009). Intriguingly, the Classical Greek language lacked a distinct term for *blue* (Durão, 2022). References in *De Sensibilus* by Democritus denote simple colors – white, black, red, and *chloros* (often translated as *green*). Interestingly, *chloros* did not exclusively designate *green* at the time, making its significance vital in color determination. The debate persists over whether the Ancient Greeks perceived the color *blue*, arising from Pliny's catalog of pigments lacking *blue* and interpretations of Homer's poems seemingly overlooking a specific term for *blue*, referring to the sea's color as that of dark wine.

Plato's philosophical musings, found in works like *Timaeus*, explored the subjective nature of color perception, suggesting that colors emanate from bodies as a type of fire, interacting with moisture in the eye to produce sensations. He intricately detailed color synthesis: the mixture of bright and red yields yellow, while red combined with black and white creates purple, thus unveiling a nuanced understanding of color's complexity and subjective perception.

During the Middle Ages and the Renaissance, colors acquired spiritual connotations, particularly in religious art. Artists like Giotto and Fra Angelico employed colors symbolically to convey divine attributes, using white and red, for instance, to symbolize life and death and evoke emotional and spiritual responses in viewers (Singer, 2016).

Johann Wolfgang von Goethe's *Theory of Colors*, published in 1810, departed from the prevailing physical Newtonian understanding of color. Goethe's holistic exploration of color encompassed both objective observations and subjective human experiences, focusing on human perception and psychology rather than purely physical phenomena, and in this way creating a prototype of color psychology. He associated colors with moral qualities, linking yellow, red-yellow (orange) and yellow-red (minium, cinnabar) with excitement and aspiration, and blue, red-blue, and blue-red with a restless, anxious impression. Despite initial skepticism in the scientific community due to its abdication from empirical methods, Goethe's emphasis on the subjective experience of color has since gained recognition, influencing diverse disciplines and shaping the understanding of color perception and symbolism.

3.2. Current trends in color psychology

Today, color psychology embodies a broad and varied field of research, spanning neuroscience, fundamental psychology, linguistics, marketing, and numerous other scientific and quasi-scientific disciplines. Three primary factors underpin the significant impact of color psychology: multidisciplinary, an increasing need for practice-oriented research, and the fusion of science and business, alongside the emergence of new environmental paradigms, including not only digital but also mixed reality contexts.

Multidisciplinary propels color psychology forward by integrating knowledge and methodologies from diverse fields, enriching our understanding of this branch of psychology. One significant avenue of inquiry involves exploring the relationship between color semantics and cultural norms: do individuals across different cultures perceive colors similarly and attribute comparable meanings to them? This inquiry holds both theoretical and practical significance, offering insights into the cognitive mechanisms shaping our experiences while also ensuring direct benefits from implementing research findings in the design of commercial products and interfaces. Numerous studies suggest that color-emotion associations are widespread (e.g., Adams, Osgood, 1973; Gao et al., 2007); however, even in languages, such associations exhibit different specificities. For example, in English, fear may be linked with the color yellow (evidenced by phrases like 'yellow belly' or 'yellow dog' to denote cowardice), whereas in Russian, fear is often associated with the color white (expressions such as 'white as chalk' or 'pale as death'). Similarly, beyond emotional connotations, language establishes diverse color associations with non-emotional meanings. For instance, an English speaker may refer to nobility as 'blue blood,' whereas a

Russian speaker may use the expression ‘white bone’ (although ‘blue blood’ is still valid for Russian). These examples illustrate the non-universality of color semantics while also hinting at the universal tendency to imbue color with additional meanings, prompting inquiries into whether cross-modal associations (such as visual perception and language) stem from cultural influences or fundamental aspects of cognitive architecture.

The convergence of science and practice and the active application of knowledge generated by science in practical and business environments contribute to both the popularization of the scientific field of color psychology, attracting more attention and arousing greater interest, and introduce new research questions into the field. For example, the classical task of searching for semantic links between color and emotion acquires additional practical significance: in the fields of marketing and design, the development of color palettes becomes more science-oriented, moving away from simple ‘I’ll paint the website blue because I like it’ to ‘I’ll paint the website blue because this color is associated with trust by the user.’ The evolution of digital media and the ubiquitous presence of screens in our everyday lives further underscore the importance of considering color in user interfaces, digital content, and branding. The practical application of color psychology extends beyond digital technologies and encompasses architecture, interior design, and branding strategies. For example, hospitals can use light colors of walls to increase trust in medical services (Terres, Basso, 2018). Besides, more interesting and non-trivial effects of color on our cognitive mechanisms are being discovered. For example, it is observed in practice that casinos and other gambling establishments predominantly use warm (e.g., reddish) lighting. Furthermore, this factor has long been considered almost a key factor stimulating gambling behavior, although there are actually not so many studies dedicated to this issue (Brevers et al., 2015). Modern scientific research conducted in controlled conditions refines this relationship without disproving it: for instance, Spewyn et al. (2010) find that respondents tend to engage in faster gambling under the simultaneous influence of red lighting combined with fast tempo music, but not with red color alone. In turn, Brevers et al. (2015) refine these results, revealing that the combined effect of sound and red light associated with casinos modulates reaction time related to reward and loss: participants in the control group reacted more slowly to loss than to reward, whereas in the ‘casino context’ groups (with corresponding music and red lighting), there was no difference.

The evolution of new environments in which human activities occur presents fresh challenges to color psychology and contributes to its ongoing

development. While the physical world dominated human existence in the past century, with minimal diversification through interfaces like television screens, contemporary focus shifts towards digital realms, spanning various interface types from basic Internet spaces to fully immersive or entirely virtual environments. Each interface introduces unique nuances to color reproduction and interaction with humans. Television screens, for instance, differ in color rendition and calibration from mobile devices, influencing color perception during content consumption. Similarly, AR/VR interfaces demand meticulous attention to color representation, considering factors such as screen resolution, depth perception, and lighting simulation to ensure captivating and accurate color perception. These subtleties of color reproduction necessitate a deeper comprehension of how color impacts user interaction and emotions across diverse technological interfaces, fostering the advancement of color theory and its application in these domains. Recently, a notable trend within color psychology revolves around studying color's impact on emotions in video games. For instance, Geslin and colleagues (2016) discovered robust correlations between colorimetric diversity, saliency volume, and stimuli conspicuity with the emotions expressed by players. In turn, Joosten and colleagues (2010) concluded that red elicits strong arousal and negative emotional reactions, while yellow prompts positive ones, with inexperienced players showing more pronounced reactions to colors than experienced ones. Moreover, investigations into the interaction of color and trust have increasingly focused on digitally interface-saturated environments, including online stores (Sasidharan, Dhanesh, 2007; Sasidharan, 2010; Lee, Rao, 2010; Pelet, Papadopoulou, 2013; Pengnate, Sarathy, 2017; Broeder, van Doremalen, 2021), car interfaces (el Joughri et al., 2023), e-learning platforms (Pelet, Papadopoulou, 2011a, 2012), government and municipal web platforms (Cyr, Trevor-Smith, 2004), and digital banking platforms (Kim, Moon, 1998).

The multidimensional nature of color psychology, propelled by various influences, directs research across four primary domains: Foundational Color Theories, Emotive Color Semantics, and Color-Driven Cognition, Cross-Cultural Color Psychology (see table 1 for examples of research). These distinct approaches delineate the exploration of colors from emotional interpretations to cognitive mechanisms, laying the groundwork for practical real-world implementations.

Foundational color theories aim to construct comprehensive frameworks in color psychology by exploring the sophisticated connections between our color perception and psychological mechanisms. One such theory is the color-in-context theory proposed by Elliot and Maier (2012). This

theory emphasizes that color holds diverse meanings and connotations in different physical and psychological contexts, thereby exerting varied influences on our psychological mechanisms. For instance, blue may be associated with trust or sadness, red with aggression or love, and yellow with joy or caution, as illustrated by the use of a yellow card in soccer. Another fundamental theory is the conceptual metaphor theory by Meier and Robinson (2005). It suggests that individuals draw on metaphors derived from their sensory experiences with color to comprehend abstract concepts and navigate social interactions. For example, the expression ‘see red’ describing anger may originate from the physiological reaction of blushing, or reddening, when one is angry. Similarly, the metaphor of ‘blue blood,’ as mentioned earlier, might come from the pale skin of nobility, revealing their blue veins, rather than implying actual blue blood, as depicted in Neil Gaiman’s novel ‘Stardust’ and in the movie based on this story. A third foundational theory that warrants attention in color discussions is Norman’s (2004) model of emotional design. While not exclusively focused on colors, this model offers essential insights into their impact on psychological processes. The emotional design model categorizes user mental processes into three levels: visceral (affective), behavioral (cognitive), and reflective levels. In the realm of color research, the visceral level is particularly intriguing, as it is where the aesthetics of a system, such as the color palette of an interface, dominate over human biological reactions, leading to instantaneous judgments about the system’s quality, safety, and trustworthiness.

The field of **emotive color semantics** aims to explore the semantic connotations of colors, examining their influence on human emotions, behavior, and cultural symbolism. Researchers investigate the subjective nature of color interpretation, analyzing how colors are associated with specific feelings (potentially even eliciting these feelings), symbolize cultural values, and relate to human experience. For example, Sutton and Altarriba (2016) demonstrated that red is most commonly associated with negative emotions and emotion-laden words, while yellow and white are linked with positive emotions and emotion-laden words, respectively. Conversely, Chen et al. (2022) obtained somewhat contrasting results in their study comparing warm and cool colors, indicating that red and yellow were associated with positive emotions, while blue and green were associated with negative ones. When examining the concept of trust through the lens of emotive color semantics, it is noteworthy that the semantics of ‘trust,’ ‘confidence,’ and ‘security’ are primarily associated with the color blue. This is supported by the real-life prevalence of blue in the branding of financial institutions, which are characterized by heightened risks, or in the classic uniforms of government officials, such as police officers (Broeder, 2021; Su et al, 2019).

Color-driven cognition research focuses on studying the interaction between color and specific cognitive functions, such as how color directs attention, influences time perception, or affects memory. For example, Chai et al (2019) demonstrated that using chromatic multimedia learning materials compared to achromatic ones contributes to higher memory accuracy. Additionally, Mammarella et al. (2016) showed that individuals tend to have better memory for congruent color and valence (e.g., green-positive or red-negative) stimuli compared to incongruent ones, with older adults' memory being sensitive only to positive-green stimuli. A significant body of research on the influence of color on trust is realized within this color-driven cognition paradigm. In this case, researchers aim not only to identify semantic associations between colors and trust as a concept but also to determine how color manipulation leads to changes in the user's trust level towards an object (such as an interface) at the behavioral level. For instance, in the study by Lee and Rao (2010), participants were asked to choose which store – blue or green – to make a purchase from, with trust being considered a moderating factor measured through a trust/risk questionnaire. The results were intriguing, showing a strong effect in terms of store choice (65% of respondents preferred the blue store), while the difference in trust levels between the green and blue stores was almost insignificant ($p = .052$).

Cross-cultural studies in color psychology stand somewhat apart within this structure. While not constituting a completely isolated field, they are nevertheless quite vividly represented in each of the highlighted domains of color psychology mentioned above. For example, research on the influence of color on art auction price formation by Ma et al. (2022), while conceptually falling under the domain of color-driven cognition (as it examines the impact of color on decision-making), simultaneously qualifies as cross-cultural, as it investigates decision-making specifics in China, the Netherlands, and the USA. Interestingly, representatives of all three cultures exhibited similar behavioral patterns, whereby an increase in the proportion of blue or red hue led to higher bids and a stronger intention to purchase the painting. On the other hand, the study by Jonauskaitė et al. (2020) fits well within the realm of emotive color semantics, as it compares color-emotion associations among representatives of 30 nations speaking 22 native languages. In the context of trust psychology, the study by Broeder и van Doremalen (2021) stands out, comparing the influence of color on trust and the willingness to make purchases at a store among Dutch and Russian consumers.

Table 1. Main Domains of Contemporary Color Psychology

Theory type	Description	Examples of studies
Foundational Color Theories	Macro theories of color psychology investigate the complex relationships between our color perception and psychological mechanisms.	Elliot and Maier (2012), Meier and Robinson (2005), Norman (2004)
Emotive Color Semantics	Research in color psychology focuses on examining the semantic connotations of colors, exploring how they influence human emotions, behavior, and cultural symbolism.	Sokolova et al. (2015); Sutton and Altarriba (2016); Thorstenson et al. (2018); Chen et al. (2022); Clarke and Costall (2008)
Color-Driven Cognition	The field of color-driven cognition focuses on examining the interaction between color and specific cognitive functions.	Chai et al (2019); Mammarella et al (2016); Kuniecki et al (2015); Bekhtereva and Müller (2017); Sasidharan and Dhanesh (2007); Lee and Rao (2010)
Cross-Cultural Color Psychology	Cross-cultural studies in color psychology examine the specificity of perception, interpretation, and the impact of colors on cognition as a function of cultural characteristics.	Sik-Lányi (2014); Ma et al. (2022); Gao et al. (2007); Jonauskaitė et al (2020); Broeder and van Doremalen (2021)

4. Color and Trust Dynamics

In color psychology research, studies on trust often align with two primary paradigms: emotive color semantics and color-driven cognition. Studies in the first category aim to associate specific colors with emotional or psychological reactions, such as identifying the ‘color of trust’, i.e. the color most commonly associated with trust in the semantic field. Conversely, studies in the second category consider trust as a psychological construct and aim to assess how color in general or a specific color influences the subjective manifestation of this construct – for example, whether trust can be induced by presenting the subject with a certain color.

While these paradigms typically operate independently, there are occasional efforts to integrate them. For instance, Su et al. (2019) conducted a study encompassing multiple stages and employing various methods to investigate trust. In the first stage, they utilized the Implicit Association Test (IAT) to establish the semantic association between color and trust, with results demonstrating a consistent link between ‘blue’ and trust (we won’t delve into the effectiveness of IAT as a method, but for criticism, one could refer to Schimmack (2021)). The subsequent stage applied a similar implicit

methodology, associating colored brand logos (red or blue) with photographs of trustworthy or untrustworthy-looking faces, again demonstrating a stable connection between the color blue and perceived trustworthiness. Finally, the third stage measured brand trust, brand attitudes, and perceived product quality for the red and blue logos of created brands, further affirming the consistent association between the color blue and trust. Notably, the latter stages of the study delved more into the cognitive aspects, combining both macro approaches of color psychology described earlier.

As we noted earlier, color can be conceptualized as a point in a three-dimensional space, with hue, saturation, and brightness as its dimensions. It's important to highlight that these dimensions are scales rather than distinct quantities. In research, a common approach involves identifying discrete values along each scale and comparing them. While this simplifies experimental design, it can introduce biases. One notable bias we'll address in the following subsection is the perception of blue as the most trustworthy color.

4.1. Hue: warm vs. cold colors

So, color hue can be seen as a scale, which is evident on almost any visible spectrum image (for example, besides 'pure' violet and 'pure' blue, there are many 'transitional' shades for which it's not so easy to find descriptions in language. However, attempting to explore the entire spectrum of color hues comprehensively within a single study is a daunting, if not unattainable, task—thus, it is seldom undertaken. Instead, researchers typically opt for discrete indicators along the color hue scale, roughly corresponding to the colors of the rainbow or the boundaries of wavelength, frequency, or photon energy ranges. These may include purple, blue, green, yellow, orange, and red.

Even this selection of six basic colors from the spectrum presents a substantial challenge in terms of data collection and subsequent analysis. Consequently, there are relatively few studies that aim to cover the full spectrum of hues in this manner. One such example is the work of Bonnardel et al. (2011), which, though not specifically focused on trust, explored website appeal. The study introduced a pragmatic approach to simplify the design. In the initial stage, participants evaluated interfaces of 23 hues, with 18 hues chosen around the color wheel with a 20-degree step, and 5 achromatic hues (white, three shades of gray, and black) added. The results indicated that the most preferred colors were blue and orange, with professional designers displaying a preference for the color gray. In the subsequent stage, the study delved into more detailed examinations of these three colors.

Similarly, Bottomley and Doyle (2006) explored appropriateness, a concept closely linked to situational normality which is an essential condition for trust formation (Gefen et al., 2003; Cho et al., 2007). They categorized brands as functional (satisfying practical needs) and sensory-social (satisfying symbolic needs). Their findings demonstrate that functional products were better suited to functional colors like gray, black, blue, and green, while sensory-social products matched better with colors like red, yellow, bright pink, and purple. This congruence between color type and brand type enhances stimulus processing and is perceived as more normal than incongruent combinations.

Lastly, Ha (2009) conducted extensive research correlating five colors of the spectrum (red, yellow, green, blue, purple) and gray with their emotive connotations and the level of trust. The study concluded that the most trustworthy color for a banking website is blue, followed by green. Importantly, only the accent colors varied on the website prototype, while the main background color consistently remained neutral white.

As evident, few studies have thoroughly explored the entire spectrum of hues concerning trust. However, there's a notable body of research aiming to categorize colors and compare groups of hues rather than individual shades, notably warm and cool colors, with red and blue being extensively studied and compared (Broeder, 2021). This inclination likely originates from the psychophysiological hypothesis suggesting that warm and cool colors, differing in wavelength, exert distinct physiological effects on the body. As mentioned earlier, this hypothesis remains somewhat ambiguous, with studies either affirming increased central nervous system excitability in response to warm colors or contesting the consistency of such reactions.

Nevertheless, within the intersection of color psychology and trust psychology, studies consistently demonstrate certain patterns: cool colors, particularly blue and to a lesser extent green, are consistently associated with higher levels of trust compared to warm colors like red and yellow. The substantial body of research contrasting cool shades against warm shades (Su et al, 2019; Coursaris et al., 2010; Kim, Moon, 1998; Mehta, Zhu, 2009) has led to a relatively stable position in the scientific community. Firstly, blue is commonly perceived as the most trustworthy color, although it's more precise to state that 'blue is more trustworthy than red, and data on other colors are insufficient.' Secondly, warm colors are generally perceived as untrustworthy. While the former assertion finds support from numerous studies, including those focusing on emotive-semantic associations, the latter warrants further investigation and cultural considerations.

For instance, a study by Hawlitschek et al. (2016), utilizing a computerized trust game methodology with interfaces colored in either blue or red, found no significant influence of color on trust. Conversely, Khuong et al. (2018) observed that warm orange elicited greater appeal and trust than neutral gray in a Vietnamese sample. Furthermore, studies comparing warm (mostly yellow) and neutral (mostly gray) colors either found no statistically significant difference in ratings (Golubović et al., 2022) or revealed a preference for gray, including among respondents from the Asian region (de Souza et al., 2010). Such inconsistencies highlight the need for further research into more nuanced and non-trivial color combinations beyond simple warm-cold distinctions.

4.2. Saturation: chromatics vs. achromatic colors

Within the realm of studying the influence of color saturation on trust, two research directions stand out: comparing less and more saturated variations of one color (or chromatic and achromatic interfaces as examples of extreme saturation values) and computer modeling of trust-related atmospheric factors to determine their relative significance.

In the context of the first research direction, the studies conducted by Pelet and colleagues (Pelet, Papadopoulou, 2009, 2011b, Pelet et al., 2013) stand out. Their research revealed that users generally prefer colored websites with over achromatic ones. However, when it comes to trust and confidence, users tend to lean towards websites featuring bright, low-saturated colors. These colors positively correlate with attributes such as competence, integrity, benevolence, and predictability of the site. Additionally, they are described as visually pleasing and attractive, contributing to an impression of professionalism. On the other hand, websites with bright, highly saturated colors are viewed as too aggressive and promotional, which negatively impacts trust levels. In a study by Pelet and colleagues (2013), it was also noted that using more saturated foreground colors can evoke feelings of excitement or energy in consumers navigating the website, which the authors interpret as a precursor to trust. Individuals who experience more pleasure or excitement while browsing a website are more likely to trust it.

These findings are supported by other studies as well. For example, Skulmowski et al. (2016) highlighted the detrimental effect of highly saturated colors on website perception. Similarly, Pichierri and Pino (2023), investigating the impact of color saturation in green marketing, found that consumers tend to associate lower color saturation with a softer impact of the product on the environment, thereby increasing trust in the product's ecological sustainability.

Furthermore, there appears to be a saturation threshold beyond which further desaturation leads to decreased trust, aligning with the idea that achromatic interfaces evoke less trust. For instance, Kaczmarek-Gajewska and McDonnell (2021), in a study on trust in websites across various content categories (e-commerce, online newspapers and news portals, company websites, social networking websites, search engines, various types), observed that interfaces with decreased saturation (−50% from the base level) had a negative effect on perceptions of trustworthiness compared to the control group (0%).

The second research direction is exemplified by the work of Papachristos and colleagues (2005, 2006), which details endeavors to construct a model illustrating the impact of color on trust in web interfaces. This approach entails employing machine learning techniques on a large dataset derived from a series of empirical studies. Utilizing this data, the researchers developed a Bayesian trust network, which connects a simple color model with the aesthetic and emotional facets of perception. The model attributes, as of 2006, comprised hue, brightness, saturation, warmth of both dominant and secondary colors, the contrast between brightness and hues of these colors, the type of color scheme, and the total number of interface colors, totaling 12 variables. Of particular note is the finding from empirical case studies indicating that the saturation of the secondary color had a more pronounced effect on the perceived value of the site compared to its hue.

4.3. Brightness: light vs. dark colors

In the previous subsection, we briefly addressed the issue of color brightness, which has been a subject of both modeling studies and empirical research. However, brightness and lightness have been explored as standalone topics in several studies. For example, the pioneering work by Kim and Moon (1998) emphasized brightness as a crucial parameter of interface color and proposed that trust is linked to colors with low brightness. Unfortunately, no further elaboration on this assertion, including details on the colors studied, was provided.

Yang and colleagues (2005) sought to examine this proposition in their study but found that low brightness was not a significant factor in inducing online trust. Similarly, in the continuation of research by Pelet and colleagues, Conway and colleagues (2010) found no statistically significant impact of color brightness on tension arousal, which was considered a moderating factor of trust.

On a different note, Chan et al. (2023) explored the influence of warm colors in AI influencers' social media posts on consumer responses and

concluded that brightness significantly moderates the relationship between warm colors and favorable consumer responses. Additionally, warm colors themselves elicited more favorable consumer responses.

As for cool colors, two studies investigating different brightness levels of the color blue (Sasidharan, Dhanesh, 2007; Broeder, Snijder, 2019) reached conflicting conclusions. Sasidharan and Dhanesh, examining trust using a banking web interface, found that light blue inspired the most trust among users compared to dark blue, with both shades of blue outperforming achromatic black and white versions of the interface. In contrast, Broeder and Snijder, studying an accommodation booking website with a multicultural sample (Chinese and Dutch), concluded a preference for a dark blue color scheme (trust in the website was measured through booking intention), without observing an effect of cultural differences.

Thus, color brightness emerges as one of the most controversial and debated areas in the study of the influence of color on trust, necessitating further research before any consensus can be reached.

5. Current Research Constraints and Future Directions

In this section of the article, we aim to outline the primary problem areas encountered in studies concerning the influence of color, whether as an element of the external environment or as an intrinsic attribute of a trusted object, on trust. We identify three groups of such challenges: conceptual (issues related to the complexity, multi-dimensionality, and interdisciplinary nature of the concepts of color and trust), methodological (limitations associated with the difficulty of creating ecologically valid and realistic research designs), and environmental (problems arising from the specificities and diversity of the contexts in which the interaction between trustor and trustee takes place). In a more detailed examination of these challenges, we will endeavor to propose examples of solutions and workarounds for these constraints, which may concurrently serve as new directions for research in the domain of color's influence on trust.

5.1. Conceptual Challenges

Both trust and color are complex phenomena. In the case of trust, the challenges begin at the conceptualization stage: in the section *Understanding Trust*, we provided a brief characterization of this concept, describing it through three primary component groups – organizational, cognitive, and affective. However, it is important to note that the list of components within these groups is neither universally consensual nor exhaustive; nor is the nature of the relationships between trust and related concepts fully agreed

upon, as we also discussed in that section. For instance, considering three prominent models of online trust: MoTEC by Egger (2000), TAM by Davis et al. (Davis, 1989; Davis et al., 1989), and the multi-dimensional model by McKnight et al. (2002), we encounter a remarkable situation: beyond the artificial groups “organizational,” “cognitive,” and “affective” (the composition of which is also debatable), it is extremely difficult to reconcile these models under a single framework.

For example, MoTEC identifies components of trust as Prepurchase Knowledge (reputation and transference, i.e., reports from trusted third parties), Interface Properties (familiarity, which aligns with Bottomley and Doyle’s (2006) idea of situational normality, and attitude), and Informational Content (risk, transparency, cooperation). TAM highlights perceived ease of use and perceived usefulness (both of which can be attributed to cognitive components), as well as attitude towards using technology. Finally, McKnight et al. (2002) delineate trusting beliefs (perceptions of the competence, benevolence, and integrity of the vendor) and trusting intentions, such as the willingness to depend (a decision to make oneself vulnerable to the vendor, closely related to the idea of user risk and vulnerability). These are examples of high-level models that do not encompass the numerous additional factors identified by researchers in mid-level studies, such as perceived distributor size (Horppu et al., 2008; Koufaris & Hampton-Sosa, 2004; Doney & Cannon, 1997), personalization factor (Doney & Cannon, 1997), or user-generated content characteristics (Dickinger, 2011; Fotis et al., 2012).

Although it may initially appear that the described issues have relatively little to do with the influence of color, they actually present two significant challenges for future research. First, studies on the impact of color on trust can generally be categorized as mid-level research. Therefore, it would be beneficial and productive to align them with more overarching theories of trust. This approach allows for the contextualization of studies, helping researchers understand how these aspects fit into the broader framework. It also ensures that researchers and their colleagues are genuinely discussing the same phenomenon and using consistent terminology, thereby avoiding conceptual manipulation.

Second, during the literature review and the description of research procedures, a clear conceptualization of the terms used and the alignment of the model with the chosen methodology are crucial. For instance, we currently cannot fully compare the results of two studies on the influence of blue color brightness on trust, which were discussed in the previous section. Apart from other limitations related to differences in the inter-

faces studied and the cultural specificity of the samples, we simply do not know how Sasidharan and Dhanesh (2007) conceptualized trust and what questions they posed to respondents. In contrast, for Broeder and Snijder (2019), one manifestation of trust, among others, was the behavioral factor of booking intention.

In the context of color, the situation appears somewhat clearer: the structure of color as a phenomenon is more established in the literature due to its physical nature. However, our review of the existing studies reveals a clear conceptual issue: most research on the influence of color on trust focuses primarily on color hue. Consequently, the aspects of color saturation and brightness remain significantly underexplored and demand further attention, particularly given that existing studies indicate rather contradictory findings.

Another relatively underexplored yet highly interesting area of research concerns the influence of color as an environmental component in combination with other epiphenomena. Based on the thesis of multimodal perception, one must hypothesize that at any given moment, our decisions, including those related to trust, are influenced by a confluence of external factors from various sensory modalities. Color, as an example of a visual modality, is only one such factor. This opens avenues for research of two types.

First, the study of the perceptual modalities of color: is color solely a visual phenomenon, or can it also be perceived and experienced through other modalities? For example, we previously mentioned the study by Wilms and Oberfeld (2018), which demonstrated that saturated and bright colors are associated with stronger skin conductance responses. Such studies investigating the connection between color and physiological reactions have been conducted multiple times using various methods and metrics, including galvanic skin response, EEG, and heart rate. However, a definitive conclusion about the existence of this influence remains elusive. Specifically, Kaiser (1984), in a critical review, suggests that color does indeed affect physiology to some extent, but the data are incongruent and not yet stringent enough to draw unequivocal conclusions.

Globally, the hypothesis of an additional modality of color stems from its physical nature and is related to the idea of wavelength differences between cool and warm hues. It is proposed that exposure to waves of different lengths elicits varying physiological responses in our bodies. In this context, experiments in the field of dermo-optical perception also appear to be of interest. Following Leontiev (2009), if we acknowledge the theoretical possibility of developing such sensitivity, there remains the potential

for the ability to recognize color hues through touch, as discussed in the critical commentary by Brugger and Weiss (2008) on dermo-optical perception as a challenge for neuroscience.

Another promising research direction related to the multimodality of perception involves the enhancement of experimental paradigms by increasing the number of manipulated variables. It is intriguing to explore how color influences trust not only in isolation but also in combination with other environmental factors, including those perceived through different sensory modalities. Previously, we cited a study on casinos: Spenny et al. (2010) demonstrated that while color alone did not directly influence gambling behavior, its effect emerged in combination with the tempo of music (an auditory modality). From this perspective, it would be valuable to investigate the combined influence of color with other modalities in various contexts, including trust.

Finally, an important limitation of contemporary research on the influence of color on trust lies in its temporal specificity. We can identify at least two temporal dimensions of trust: initial (emerging upon first encounter) and stable (developing through repeated interactions) (Koufaris, Hampton-Sosa, 2004). A significant portion of current studies on the impact of color is predominantly focused on initial trust. In these studies, users are typically presented with a previously unfamiliar stimulus created specifically for the experiment, interact with it for a brief period, and subsequently either fill out a trust questionnaire or have some other aspect of their reaction measured (such as satisfaction level or purchase intention). Neither the experimenter nor the participant revisits this interface afterwards.

As an exception to this general trend, research on loyalty, reputation, and brand trust can be considered (noting that loyalty and reputation should not be equated with trust without substantial justification). For instance, Baxter et al. (2018) demonstrated that users are susceptible to iconic brand color priming, though the influence on trust was not the focus of their investigation. Nevertheless, their findings could lead to hypotheses about the impact of color on long-term trust.

Longitudinal studies in this area can involve existing brands (while acknowledging the difficulty of isolating the effect of color from other brand-related factors) or repeated interactions with a fictitious experimental stimulus under stringent control of extraneous variables, excluding color. Promising research questions partly related to the issue of priming include: Will users trust a stimulus more if its color remains the same or changes to a more trust-inducing hue during subsequent interactions? Will trust decrease if the color changes to a less trustworthy shade? Does the number

and frequency of repeated exposures, or the time interval between them, impact trust?

To summarize this section, we will briefly outline key solutions to the conceptual challenges and suggest directions for further research.

Solutions:

1. Clearly align mid-level studies (such as research on the influence of color on trust) with higher-level theories that aim to conceptualize color and trust as phenomena.

2. Ensure precise operationalization of “trust” and “color” in research (determining whether we refer to trust itself or its correlate, and whether we address color comprehensively or focus solely on hues).

3. Carefully select trust measurement methodologies (ensuring that methods designed for commercial websites are suitable for non-commercial contexts, or that methods for measuring personalized trust are appropriate for non-personalized scenarios).

Promising Research Directions:

1. Investigating external correlates and predictors of trust, such as satisfaction or reputation, to consider the trustor-trustee relationship more holistically.

2. Broadening the Scope of Research: Moving beyond domains with obvious risks (such as commercial interfaces) and exploring other thematic domains.

3. Examining the temporal stability of color’s effect on trust levels, particularly during repeated interactions.

4. Conducting multimodal studies: on one hand, examining the multimodal impact of color on cognitive mechanisms; on the other hand, exploring cross-modal influences on decision-making, where color serves as one of several influencing factors.

5.2. Methodological Challenges

Returning briefly to the higher-level conceptualization of trust, it is noteworthy that many models, including MoTEC, the McKnight and colleagues’ model, and the three-factor model of online trust by Ang et al. (2001), emphasize risk or the vulnerability of the trusting party as a crucial attribute and condition for trust (in the Ang et al. model, this factor is expressed through the presence of a privacy policy on the trustee’s website). Herein lies a significant bottleneck in current research on the influence of color on trust: to ensure that the reaction elicited by color manipulation is

genuinely related to trust and not to a related concept (e.g., user satisfaction or general appeal), it is essential to create experimental conditions that generate a sense of risk for the trustor. Moreover, it is crucial to ensure that the trustor perceives their potential vulnerability in the experimental setup; otherwise, we risk measuring an irrelevant variable.

How can this be controlled? The most straightforward approach is to use validated, reliable, and valid instruments, including various trust scales and questionnaires. For example, Broeder and Snijder (2019) employed an adapted trust scale from Chen and Barnes (2007), developed in the context of online environments to assess user trust in commercial websites (also considering related parameters such as online purchase intention). However, the issue is that such methods are often not universal and are not a panacea. While the Chen and Barnes (2007) questionnaire may be well-suited for the purposes of Broeder and Snijder's (2019) study, which also assessed the impact of color on initial trust in e-commerce web interfaces, without proper validation of the instrument across different types of interfaces, we cannot be certain of its applicability for measuring the same construct of trust. Why, then, can't a singular, highly valid and reliable questionnaire be created or selected to simplify matters? Why complicate the research process?

The primary challenge lies in the complex structure and heterogeneity of trust. Trust is a multi-layered concept that encompasses various types of interactions. Can we measure both initial and stable trust using a single instrument? It is feasible if, in the case of stable trust, we employ a longitudinal method with regular, repeated measurements using the same questionnaire. However, distinction presents itself when considering personalized versus depersonalized trust. For example, Li (2007) fundamentally argues that personalized trust is closely associated with shared states between the trustor and trustee (e.g., shared interests, shared values, and shared emotions), whereas depersonalized interactions do not involve shared aspects and focus on the distinct characteristics of each party (e.g., ability, integrity, and benevolence). This concept aligns with studies showing that people tend to exhibit more empathy and trust towards *us* than *them* (Melloni et al., 2014; Cikara et al., 2011), identifying *us* based on kinship or friendship, shared interests.

Therefore, in measuring personalized and depersonalized trust, we must consider their unique characteristics. In the case of personalized trust, the methodology should emphasize the assessment of shared components by the trustor. In contrast, for depersonalized trust, the methodology should either exclude shared components entirely or give them much less weight.

This significantly complicates, if not renders impossible, the development of a comprehensive, universal measurement tool.

Returning to the issue of risk or vulnerability, another approach of addressing the challenge involves creating experimental conditions that inherently impose an identifiable risk on the user. In the context of studying the influence of color on trust in web interfaces, this can be accomplished in two ways: either by explicitly indicating the risk condition (e.g., in Kosova (2024), the risk condition is specified in the instructions through the task description given to respondents), or by using interfaces with an evident risk component as stimulus material (e.g., online shopping interfaces, as in the studies by Sasidharan and Dhanesh (2007), Lee and Rao (2010), Broeder and van Doremalen (2021); banking interfaces as in Kim and Moon (1998), and others).

Both methods are imperfect and require cautious application. In the first case, there is a risk of priming respondents to critically evaluate the interfaces due to an exaggerated perception of risk. In the second case, we do not actually control whether the respondent feels vulnerable and simply assume it to be so. This also significantly narrows the range of studied interface types as trustees, limiting the research to environments where risk is apparent and neglecting other equally interesting domains with non-obvious risk components.

For instance, the domain of media and new media interfaces – including news websites, social networks, messaging apps, computer games, and cinema – is almost entirely overlooked. These platforms not only deliver “pure” information but also foster connections and interactions among users, and can be sources of misinformation, deception, and propaganda for overly trusting individuals. It is crucial to emphasize that these domains are rarely studied in the context of the impact of color on trust, both in terms of “form” (e.g., interfaces and presentation of information) and “content” (e.g., the information itself). Overall, trust in media, whether personalized (e.g., trust in specific friends on social networks) or depersonalized (e.g., trust in a game development studio), is a pertinent topic in the psychology of trust, which is reflected in systematic literature reviews on trust in social media by Håkansson and Witmer (2015), on trust in fake news by Bryanov and Vziatyshcheva (2021), and on trust in online games by Gao (2005).

Another significant array of methodological limitations in the field of studying the influence of color on trust pertains specifically to color as an environmental phenomenon. Since color is a complex aspect of our surroundings and is virtually inseparable from everyday visual perception (unless we consider color perception anomalies, which themselves pose

new research challenges), isolating color or its aspects as a manipulatable variable poses considerable difficulties. To achieve reliable and reproducible research results, we must proceed systematically and refrain from overgeneralizing findings. For instance, we should avoid conclusions like “blue is the most trustworthy color” based solely on comparisons between blue and red, which are currently the two most studied hues in contemporary literature (Broeder, 2022).

Broadly, within the context of studying color and its effects on trust, we can identify four methodological challenges: isolating the manipulated color from the colorful environment, distinguishing and not conflating individual aspects of color, considering color as a continuum rather than discrete units, and accounting for the cultural specificity of color perception and semantics.

The first of these challenges – isolating the manipulated color from the colorful environment – relates to the fact that, in our surrounding reality, not only can the object of trust itself possess a color, but color can be considered an inherent characteristic of the environment inhabited by a creature with color vision. Pinna and Deiana (2018) emphasize the emergent semantic significance of color, i.e., color adds meaning to environmental objects, allowing us to interact with them differently and, in some cases, more informed (for example, not eating a green cherry but waiting for it to turn red). Thorstenson et al.'s (2018) research on the relationship between perceived emotions and changes in facial color, caused by changes in skin oxygenation, along with studies focusing on the impact of perceived emotions on trust (e.g., Feinberg et al., 2012), suggest that changes in a conversant's facial color may affect our trust towards them. Similarly, as discussed earlier, in digital environments, the color palette of an interface can influence trust in an object. Concurrently, other environmental colors, such as the color of the walls, floor, and ceiling of a laboratory, or even the light from a window or lightbulbs, continuously influence us.

Although these variables are not the direct target of manipulation and study, they can still exert an influence on trust, at least indirectly, through their impact on respondents' emotions. For instance, Terres and Basso (2018) showed that the design of a hospital room, including wall color, affects a patient's initial trust in a doctor through their trust in the hospital. Simonsohn's (2007, 2010) research on the influence of weather conditions (among other things, altering the level of natural light) on academic career decisions serves as an example of indirect environmental influences on decision-making (trust decisions being a subset of these).

Ideally, the challenge of isolating the manipulated color from the overall environmental colors is addressed by controlling and equalizing environmental colors. In a laboratory setting, we can control the room's color, lighting, monitor color reproduction, and even the respondent's clothing colors. The only factors beyond our control would be individual differences in color perception and respondents' personal characteristics (e.g., personal semantic associations with specific colors). However, in real-world research conditions, particularly in field studies or when working with large and diverse samples, such a level of control might be excessive, impractical, or impossible. This raises the question of how accurately data collected under conditions with many uncontrolled color variables can be interpreted. It is essential to account for potential biases and strive to minimize them. An alternative approach could be to conduct experiments under controlled laboratory conditions while also performing additional, similarly designed studies with reduced control. Comparing the results of these studies could provide a more comprehensive understanding of the influence of color on trust.

The second issue – distinguishing and not conflating individual aspects of color – arises from the complex structure of color. Color consists of at least three parameters: hue, saturation, and brightness. When studying the influence of color on trust or another psychological phenomenon, researchers can examine either the complex effect of color or the influence of its specific aspects or their intersections (e.g., hue + saturation or hue + brightness). Depending on which color parameter is being studied and manipulated, the other parameters should ideally be equalized and controlled (comparing a bright saturated red with a dim unsaturated blue will not allow us to make a definitive conclusion about how red and blue hues influence trust).

Additionally, it is important to recognize which variables we can realistically control. For example, in online experiments conducted outside of a laboratory setting, controlling color brightness is significantly more challenging. The brightness of personal devices used by participants can vary widely and can be adjusted by users during the experiment. To address this, we would need to implement either technological measures to prevent brightness adjustments or at least include instructions prohibiting such changes.

This also brings up the question of whether such strict control is relevant to the subject and environment of the research (which we will discuss further in the section on environmental issues). If the ability to adjust display brightness is an inherent or frequent characteristic of the digital envi-

ronment, restricting it in studies of digital contexts might be unnecessary and could frustrate participants, thereby distorting the results (unless, of course, we are studying the influence of brightness on trust itself).

The third issue pertains to the color continuum versus discrete values. In real life, each dimension of color, whether hue, saturation, or brightness, exists on a continuous spectrum, with smooth transitions from one state to another. We have noted this problem previously in the discussion of hue studies, but to reiterate: researchers today primarily work with discrete variations of color extracted from the continuum (e.g., red vs. blue, high vs. medium vs. low saturation, high vs. low brightness). Attempts to overcome this methodological challenge are less frequent than desirable. For instance, Bonnardel et al. (2011) identified more discrete hues, reducing the bias on the color wheel between them. Researchers in other domains, such as linguistic relativity (e.g., Winawer et al., 2007), have also adopted similar approaches. Although this reduces color discretization, it can still result in the loss of information about transitional shades and their potential effects.

The optimal solution would be an experimental design where color is represented as a true continuum. However, this approach has not yet been realized, at least in the context of studying the influence of color on trust. In digital environments, such a study is technically conceivable – for example, through the continuous dynamic change of hue, saturation, or brightness across the entire interface or its individual elements. However, this scenario raises additional questions about how to frame questions or tasks for respondents, how to account for individual color sensitivity, and how to manage the challenge that gradual changes in the color spectrum might be difficult for users to notice and respond to accurately.

The fourth issue – cultural specificity in the perception and semantics of color – relates to the sociocultural environment in which a person resides. We have touched upon this topic several times in the section on *The Essence of Color*, so we will not repeat those points here. In different cultures, the same colors can have varying associative and emotional connotations, which must be taken into account both when conducting research and interpreting results. Studies that directly transfer experimental findings from one cultural group to another may face issues of interpretability and reproducibility. Interesting cases in this context include the studies by Khuong et al. (2018) on a Vietnamese sample and Kosova (2024) on a Russian sample. In the first study, users exhibited higher loyalty to a warm orange web interface compared to a neutral gray one (with CV websites as the stimulus material). The second study demonstrated somewhat more conservative, yet still atypical, results: users showed the highest trust towards

cold green and neutral gray shades in monochromatic news web interfaces, while warm shades (yellow and red) and the typically most trustworthy blue shade were among the least trusted. The author partially attributes these findings to the specificity of the design (monochromatic interfaces are quite rare in real life), but cultural specificity of the respondents might also have played a role. For instance, gray is one of the most frequently used accent colors among the top 10 most-cited Russian news websites and is regularly employed in logos and web pages to highlight individual news items or sections.

In summarizing this section, we again highlight the key solutions to the methodological challenges and suggest directions for future research.

Solutions:

1. Implementing additional control methods: this includes controlling factors significant for trust formation, particularly risk or vulnerability, which can be achieved either through direct indication of risk or indirectly by using appropriate stimuli and procedures.

2. Combining field and laboratory experiments: this involves using different levels of control over target variables, especially the varying parameters of color.

3. Examining the influence of each color parameter: studying hue, saturation, and brightness separately or in combination while controlling for the other parameters. Machine learning techniques, such as feature importance tests, can assess the significance of multiple factors and rank them by their influence on the target variable.

Promising Research Directions:

1. Expanding assessment tools: this includes adapting and validating existing methods of trust assessment for various contexts to universalize them, as well as creating new mid-level tools that evaluate trust within specific contexts rather than as a universal construct.

2. Conducting cross-cultural studies: accumulating more diverse data to deepen our understanding of the relationship between sociocultural environment, color, and user willingness to trust.

3. Developing innovative methodologies: exploring new methodologies that allow us to consider color and its parameters not just as discrete values but as a continuous color spectrum.

5.3. Environmental Challenges

In contemporary literature focused on offline trust, relatively few studies examine the influence of color; however, such investigations are more prevalent within the broader domain of decision making. For instance, Babin et al. (2003) reveal that consumer reactions to store environments vary based on interactions between color, lighting, and price. They found that blue interiors are generally preferred in fashion stores, but a combination of soft lighting and orange interiors significantly improves perceptions of price fairness and overall store evaluations. Koenigstorfer et al. (2014) demonstrate that traffic light color-coded nutrition labels on food packages help low self-control consumers make healthier food choices, aligning with their long-term dietary goals, while high self-control consumers are not similarly influenced. Chisini et al. (2018) found that dentists' treatment decisions were influenced by patients' skin color, with black patients more likely to be referred for less costly and simpler procedures, indicating potential racial discrimination in dental care practices. This suggests that the effect may not be due to color itself, but rather the stereotypes associated with race marked by skin color. Chan and Park (2015) proposed that product images in business plans generally increase favorable venture investment screening decisions, while the use of red decreases favorability and blue increases it, and found partial support for these hypotheses. Another insightful study conducted by Jiang et al. (2014) demonstrates that stock market color conventions significantly influence economic growth predictions, with Mainland Chinese associating red with positive outcomes and green with negative, while Hong Kong participants exhibit opposite associations. This highlights the impact of culturally specific environmental cues on prediction and judgment. Within the scope of this section and the present work, we do not aim to cover all studies on the influence of color on decision making, as the field is quite varied and extensive. However, for those interested, we recommend reviewing Bortolotti et al. (2022) for insights into the influence of color brightness on psychological functions.

Digital transformation brings significant changes to human life. Our habitat is expanding to unimaginable scales – life transitions from being relatively local to easily accessible globality through the development of new means of instant communication, where distances (practically) do not matter (we will set aside technical aspects here and focus on the user experience). Concurrently, the digital environment fundamentally alters the mechanics of interaction: while in the physical world, individuals communicate directly, in the digital world, every interaction is mediated by an interface. Some researchers (e.g., Marcella, 1999) even suggest that the interface

can be considered an additional party in the interaction. Furthermore, the spatial structure of interaction changes (Bailenson, Beall, 2006): through technology, we can literally put ourselves in the position of our interaction partner and see the situation from their perspective. A practical example of this is found in computer games, where a player can see their character's behavior through the eyes of other participants in real-time.

Moreover, digitalisation transforms sensory perception by limiting the number of available modalities (for now): for example, digital environments currently cannot fully convey taste or smell. On the other hand, color perception remains intact, and technologies are gradually being developed to provide increasingly immersive virtual experiences (such as gloves that allow users to feel digital objects). All these developments pose new challenges for researchers studying trust: first, it is essential to organically integrate the study of digital environments and their subtypes (including XR, AR, VR) into the existing body of literature; second, identify trust factors that are specific to the new environment; and third, reassess the role of previously identified factors. The latter includes examining color as a factor influencing user trust.

In this context, three distinctive characteristics of the color aspects in digital environments should be highlighted. First, we must note the dynamic nature of these environments: user preferences in the color design of digital entities (such as brands, websites, avatars, etc.) quickly become outdated, leading to constant transformation of the digital landscape. Reflect on the appearance of the internet in the early 2000s, filled with vibrant WordArt, and compare it with the contemporary online space where you are likely reading this article; you undoubtedly perceive a difference. Notably, the dynamism of the digital realm also generates specific cognitive biases, such as the baby duck syndrome, where users prefer the old interface over the new one (Glebko, 2024).

Second, virtual environments provide designers with an extensive set of tools to manipulate colors according to their communicative objectives. Designers can adjust the saturation or brightness of colors to artificially high levels to create super-stimuli that better attract and retain the recipient's attention.

Third, the digital realm also provides users with tools to enhance the flexibility of individual color settings. For instance, in response to the increased brightness designed into a digital interface, users can reduce their screen brightness or adjust color rendering using special programs that include features like blue light filters. Outside the virtual environment, such flexibility is less accessible; while we might wear tinted glasses to alter the

color of our surroundings, this is a limited case compared to the range of possibilities in digital spaces. This raises a pertinent question: if both the user and the designer have roughly equal capabilities for adjusting and controlling the color aspects of the environment, how does the role of color transform in the mechanics of human interaction and the formation of trust?

Solutions:

1. Regular reevaluation: the dynamic nature of the digital environment and user preferences necessitates the continuous reassessment of previous research findings and the updating of stimulus materials to keep them relevant and contemporary.

2. Expanding studied domains: the evolving nature of digital interfaces necessitates broadening the scope of research to include various interface types. For instance, Roth et al. (2010) identified six popular interface types – is this categorization still applicable today?

Promising Research Directions:

1. Integrating trust models: integrate models of trust and the influence of color on trust within the existing body of literature on the impact of color on decision making in offline environments.

2. Comparative studies in different environments: conduct comparative studies examining the influence of color on trust in both physical and digital environments using similar research designs. This will provide insights into how these environments relate to each other on this specific issue. It would also be beneficial to examine sub-environments within the virtual space, such as mixed reality interfaces.

3. Mechanics of color communication: investigate the mechanics of color communication between designers and message recipients, including how these aspects transform during interactions. This will help identify which aspects of color should be emphasized in studies of the digital environment and which are subject to significant changes during interactions. For example, users are likely to adjust screen brightness, affecting color brightness, but are less likely to use filters that distort hues. These nuances require clarification.

5.4. Dynamic Nature of the Environment

A significant portion of research on the interplay between color and trust focuses on the digital environment. One crucial characteristic of this

environment is its extreme dynamism, evident in its ever-evolving color palettes. Reflect on the internet's appearance in the early 2000s, filled with vibrant WordArt, and compare it with the contemporary internet landscape where you're likely accessing this article. Can we confidently predict that the digital environment will not undergo further transformations in another ten or twenty years? Not only is the digital environment dynamic, but it's also autopoietic, continuously reproducing itself – our actions within it not only respond to the environment but also shape it.

Solutions:

1. This environmental dynamism poses several challenges for studying the color-trust relationship. Firstly, past research findings may become outdated and necessitate regular reassessment – replicating old studies may yield intriguing outcomes with potential deviations. Consider the divergence in results between two studies on the brightness levels of blue conducted 12 years apart – could changes in the environment have influenced these results?

2. Secondly, it's crucial to monitor the quality and relevance of stimulus materials. Presenting a website designed in the early 2000s as a stimulus today may not elicit the same responses as a contemporary-looking website.

3. Thirdly, there's a need to track and update the functional typology of interfaces, as different interface types may evoke distinct user reactions. For example, Roth et al. (2010) identified six popular interface types – has user categorization remained static since then?

4. Lastly, the environment's dynamism extends to the emergence of new substantive forms or even entirely new environments, such as augmented, virtual, and mixed reality, necessitating novel research approaches tailored to these domains.

6. Conclusion

This paper provides a comprehensive snapshot of the current state of the intersection between trust psychology and color psychology. Our objective was to analyze both classical and recent research on how color influences trust and to outline potential directions for further advancement in this field. We explored the fundamental factors shaping modern color psychology and delineated key macro approaches and avenues within this domain. Additionally, we examined studies investigating the impact of specific color elements – such as hue, saturation, and brightness – on trust and related constructs.

Our work critically assessed limitations and areas of weakness in the existing research on the color psychology of trust. These include the intricate nature of the phenomena under study, methodological constraints, overlooked domains with inherent risks, and the dynamic nature of the environment where much of the research is conducted. Importantly, we didn't just identify these weaknesses but also proposed potential solutions, highlighting areas for future research and addressing gaps in our understanding of the color psychology of trust.

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Цвет доверия:

анализ и исследовательские перспективы

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Цвет как уникальная перцептивная характеристика приобретает все большее значение в эпоху цифровизации, оказывая значительное влияние на наше восприятие объектов виртуальной среды и взаимодействие с ними. В данной статье исследуется пересечение двух ключевых областей психологии — психологии доверия и психологии цвета. Основной целью работы является анализ как классических, так и современных исследований, посвященных

влиянию цвета на уровень доверия, а также выявление перспективных направлений для дальнейшего изучения.

Исследование направлено на выявление специфических факторов и механизмов, определяющих влияние цвета на доверие таких, как психологические ассоциации, культурные различия и контекст использования. Практическое применение этих знаний особенно актуально в маркетинге, где выбор цветовой палитры может существенно повлиять на восприятие бренда и принятие решений потребителями.

В статье предлагается теоретическая основа для исследования взаимосвязи между цветом и доверием, с особым акцентом на методологические и концептуальные вызовы. Дополнительный акцент делается на новые горизонты, связанные с растущим разнообразием сред деятельности человека и динамической природой новых цифровых сред таких, как виртуальная и дополненная реальность.

Результаты исследования показывают, что цвет оказывает сложное и многогранное влияние на доверие, которое варьируется в зависимости от таких параметров, как оттенок, насыщенность и яркость. Эти параметры цвета взаимодействуют с доверием и смежными психологическими конструктами, влияя на восприятие и поведение человека в различных контекстах. В частности, указывается, что холодные цвета способствуют атрибуции более высокого уровня доверия, чем теплые; и меньшая насыщенность цвета также связывается с большим доверием. При этом детально рассматриваются ограничения существующих исследований и устоявшихся парадигм: в частности, постулат о наибольшей доверительности синего оттенка критикуется как методологически недостоверный.

Предложенные в статье решения и направления для будущих исследований способствуют более глубокому пониманию роли цвета в контексте доверия. Это исследование вносит значительный вклад в развитие психологии цвета и предоставляет ценные рекомендации для разработки интерфейсов, способствующих повышению доверия в различных областях таких, как электронная коммерция, онлайн-банкинг и социальные сети.

Ключевые слова: цвет, доверие, человек-цифровое взаимодействие, восприятие риска, онлайн-доверие, оттенок, насыщенность, яркость, веб-интерфейсы

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