

An Analysis of the Impact of Visual Design on Way-finding and Signage: The Role of Colors in Enhancing Cognitive Navigation

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Abstract

This research investigates the influence of color on way-finding systems, particularly within the context of the Seoul Metro. Way-finding is a crucial element of urban navigation, relying on effective visual communication to enable efficient movement through intricate environments. This study employs a mixed-methods approach, combining qualitative analysis of the Seoul Metro's signage system with quantitative survey data collected from 75 regular metro users from various cultural backgrounds. The results emphasize the importance of consistent, high-contrast color-coded signage in improving visibility, minimizing cognitive load, and facilitating intuitive navigation. Examples include yellow exit signs and line-specific color codes, which demonstrate how color contributes to seamless way-finding and lowers user stress levels. These findings provide valuable insights for urban planners and designers seeking to enhance accessibility and user experience in public transportation systems.

Keyword : Way-finding, Signage Systems, Visual Communication, Signage Design, Color-coded signage, colors in way-finding, intuitive navigation

1. Introduction

Way-finding is a spatial problem-solving process that combines decision making and development of a plan from decision to action. It is the processing of information to sustain the decision processes, which includes cognitive mapping [1]. For way-finding to be effectively performed by individuals, cognitive ease is significant to the seen-to-behave process. Factors such as limited proficiency in the language, difficulties in interpretation of language nuances, increased cognitive load, and cultural differences in communications can substantially hinder the way-finding and navigation process. Effective signage systems utilize effective visual elements to significantly enhance the user experience, making urban environments more accessible and substantially reducing stress levels for the users. The process of communication in way-finding is increasingly more visual than verbal, the visual communication elements set up the conditions in which experience takes place, responding to the society by communicating

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through shapes and more [1]. Designers need a deep understanding of how visual elements affect way-finding behavior, and the effects these elements have on the cognitive processes as individuals respond to the constructed environment. Current literatures tend to focus on the types of signage that influence behavior with limited attention to how psychological mechanisms behind visual elements that affect navigational behavior. In this regard, the study examines the roles that colors play in signage systems, how colors are utilized in current signage and way-finding system, the influences colors have on users and the way colors elevate user experience by inducing cognitive behaviors. The methods used in this study is qualitative analysis on Seoul Metro signage system and quantitative analysis from 75 frequent metro commuters from a diverse cultural background. The insights gained from this study can guide urban planners and designers to understand the role of color, as a visual design element and implementing best practices for signage systems in public environments, ultimately contributing to the development of more user-friendly and inclusive urban environments.

2. Visual design in way-finding and signage system

2.1 Signage systems and way-finding

Signage is a language in the society, composed of symbols and prompts, using both linguistic information and graphical features to transmit a message. It is akin to a type of linguistic communication defined by Searle as directives [2]. Signs as a device for communication can also be considered as a means of influencing human behaviors. In many ways within the advent of themed environment and as part of urban planning, way-finding emerged as a formal means in helping users navigating complex environments. The priority in designing way-finding system is to orientate users to the spatial environment, providing signs in the environment. The aim is to identify a particular sequence of paths through that environment with cognitive ease, to navigate pathways from one place to another. The way-finding experience consists of a series of interpretive episodes that capture users' attention, guide appropriate behaviors, and support engaging interactions that are satisfying and comfortable [3]. The role of communication design in making sense of such 'experience' is to create specific conditions that are intended to satisfy the motives for interacting with the environment. Therefore, visual design elements can influence the efficiency, effectiveness and create conditions for way-finding experiences. It is essential for designers to utilize universally understood visual element to better communicate signage information and foster better user experiences to a diverse user group.

2.2 Cognitive processing in way-finding

A visually effective communication system significantly enhances the effectiveness of way-finding and signage. The effectual use of consistent visual elements helps users quickly understand and interpret information, reducing cognitive load and making navigation more intuitive [4]. Well-designed way-finding and signage systems guide users efficiently from one point to another, fostering a sense of control and comfort. Such effectiveness relies on clear and intuitive visuals that are easily recognizable, reducing the mental effort needed to process information and contributing to cognitive ease. This cognitive ease enables individuals to move through spaces smoothly, without unnecessary interruptions or delays. It also enhances the overall navigation experience.

Humans, being relatively insensitive to both the quality and quantity of information [4], rely on intuitive understanding, which further emphasizes the importance of cohesive and straightforward visual design. Human decision-making operates through two systems: the Intuitive Decision-Making System (System 1) and the Analytical Decision-Making System (System 2) [5]. Intuitive Decision-Making System (System 1) is fast, automatic, intuitive, functioning for quick judgements and decisions based on instincts and immediate perceptions. In contrast, the Analytical Decision-Making System (System 2) is comparative slower, more deliberate, and analytical, and often used for complex problem-solving, decision-making and critical thinking [5]. System 1 operates automatically and continuously generates suggestions for System 2, these suggestions include impressions, intuitions, intentions and feelings. System 2 is only activated when System 1's intuitions fail to provide a sufficient answer [5]. Most human behaviors are governed by the automatic processes of System 1. Cognitive ease - which refers to whether information processing is effortless and smooth, is first being accessed by System1, and determines whether additional effort from System 2 is required for comprehension and judgment [5].

An effective way-finding system leverages System 1's intuitive and automatic processing. The quick identification of signage reduces cognitive load, enabling rapid decision-making without conscious effort. When signage features clear, easily understandable visual characteristics, System 1 can process the information effortlessly, eliminating the need for System 2 to engage in deeper analysis. As a result, users can navigate with minimal effort. In the design process of signage systems, it is essential for designers to utilize colors to create cognitive ease through visual impression and intuitions, engage System 1 for effortless processing and immediate comprehension. By effectively employing colors as a design component, designers can facilitate seamless navigation and promote an inclusive, user-friendly environment for individuals, even from diverse cultural backgrounds.

2.3 Visual design elements and their influences on human behaviors in way-finding

Way-finding is inherently dynamic, providing directional guidance one sign at a time in response to users' movement through a particular spatial environment. The meanings of signage and way-finding systems emerge from surrounding physical environment of the users. This view of interpretation challenges designers to move beyond their own assumptions about meaning of visual elements and to consider the possible novel interpretations that viewers may generate based on their own rich and varied experiences. These interpretations result from the designer's choices regarding form and message, as well as the physical, social, cultural, and technological contexts in which the message is situated, the characteristic cognitive behaviors and past experiences of the users [3]. Colors, being so captivating play a crucial role in the effectiveness of way-finding and signage systems design. Through applications and manipulations of visual elements, viewers can be more mentally focus and information can be communicated efficiently, thereby facilitating a positive navigation experience for users. Such availability of clear environmental information is essential for users to successfully complete way-finding tasks [6]. Designers focus their attentions on the elements that contribute to creating great design.

Good design begins with an understanding of psychology and requires good communications [7]. Human-centered design is a design philosophy rooted in deep understanding of people and the needs that the design aims to meet [7], ultimately contributing to pleasurable experience. Experience is therefore critical, as it shapes how positively an interaction is remembered. Cognition and emotion are closely intertwined, and integral to user experience that designers must consider both aspects in their approach. The following paragraphs will explore the relationship between the signage design element - colors and the users, in ways that influence behaviors and promote positive experience in way-finding experience.

2.4 Colors in way-finding system: Seoul Metro Analysis

Color is a powerful and influential design element within the physical environment. Color significantly impact visual search, as the most immediate and efficient form of coding, color information is typically the first aspect that grab users' attention [8]. Being as a part of the signage system, colors can enhance visibility and legibility [9]. The application of color effectively communicates environmental information, aiding users in analyzing and comprehending the built surroundings [10]. Way-finding cues are more clearly demarcated when color is introduced. When used as an accent on a signage, users will be more

visually focused to identify an environment. Different color applications evoke different associations, which can enhance clarity and meaning within way-finding and signage systems. For instance, distinct color schemes can delineate various functional areas within a space, guiding users intuitively to their destinations. The color code used to indicate exits in the Seoul Metro is yellow as shown in [Fig. 1]. This color is consistently applied throughout the entire metro system, both inside and outside the gates as shown in [Fig. 2], [Fig. 3], and [Fig. 4]. Color, as an important features of a space, fosters a sense of unity and consistency while serving as an effective guide to navigate users through intricate environments [9]. Colors triggered the sensory receptors in our brain and have an effect on environmental differentiation. The uniform use of yellow color on exit signs fosters cognitive ease, allowing subway users to immediately associate the yellow color with the concept of exit.



[Fig. 1] Exit sign on the platform, Seoul metro

In fact, Seoul Public Design Guidelines introduced a set of design principles for subway signage, in terms of colors, it clearly indicated that general signage should based on achromatic colors to emphasis the color of subway line, exclusive colors are assigned for each subway line, and exit numbers are clearly indicated by yellow color [11]. The first point reflected one of the critical aspect of effective color use in signage [10]. The attention-getting qualities of a color are influenced by its properties in juxtaposition with the other colors surrounding it [3]. That being said, high-contrast color combinations are an effective means of enhancing visibility and readability. The juxtaposition of colors can generate a more dynamic and captivating visual experience, thereby enhancing visual perception and enabling certain elements to stand out more prominently [12].



[Fig. 2] Exit sign next to exit, Seoul metro



[Fig. 3] Exit sign next to stairs, Seoul metro



[Fig. 4] Exit sign top of ceiling, Seoul metro

The combination of light and dark colors effectively captures attention and facilitates the easy identification of elements, even from a distance [12], it is particularly important in the context of signage, where quick recognition is crucial. In addition to the exit sign examples presented in [Fig. 1] to [Fig. 4], which illustrate the high-contrast combination of dark grey and vibrant yellow, [Fig. 5] and [Fig. 6] further demonstrated how signage from other dimensions within Seoul Metro signage system

effectively employs contrasting colors to enhance the visibility of textual information, making it more discernible to users.



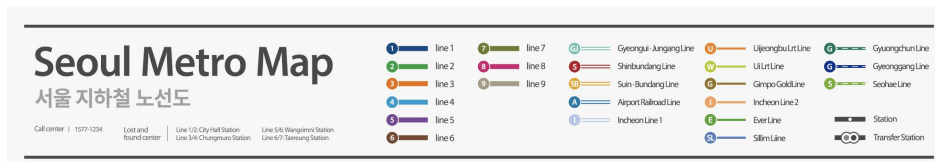
[Fig. 5] Subway Entrance Sign, Mapo Office Station



[Fig. 6] Pole Sign inside Hapjeong Station

The study indicates that employing such high-contrast combinations not only improves visibility but also facilitates quicker comprehension of the information presented. High contrast colors are often used to enhance legibility of text on signage, which refers to the ease with which visual elements can be understood under normal reading conditions. When information on a sign is easy to read, users experience less stress and misinterpretation, and their abilities to navigate improves. In the context of color, color-coding serves as a strategic method to convey information or categorize various types of

messages within a signage system. When information from different categories is grouped under specific color codes, for instance, blue color indicating informational signs, green colors signify exits, red colors for warnings, they become immediate visually differentiable and can facilitate navigation efficiency. The associations of colors and their contexts create visual cues [13], which allow designers to effectively guide behaviors and responses. While the use of color yellow to signify exits is an excellent example, as shown in [Fig. 7] and [Fig. 8], a more extensive application of color-coding is evident in differentiating the Seoul Metro subway lines [14][15].



[Fig. 7] Seoul Metro's color-coded representation for each line



[Fig. 8] Small part of Seoul Metro Map

The functions that color serves in human vision include grouping, categorization, attentional recruitment, memory and symbolism [16]. In the Seoul Metro system, each designated line is consistently color-coded throughout the entire network, which initially performed the function of grouping and categorization. As shown in [Fig. 7], a representative color is assigned to each corresponding line in order to facilitate instant visual recognition.

All stations of the particular line are grouped and categorized under the same color [Fig. 9] & [Fig. 10], for instant, brown color for line 6 and green color for line 2. Color-coded signage here acts as a mental 'tag' that organizes information in the brain, facilitate quick and accurate recall of details

associated with the specific colors [17]. Such clear color distinction reduces the cognitive load associated with relying solely on textual information, as color association enables commuters to quickly identify the specific route they are traveling on. It is important to note that a signage system does not serve only a directional purpose; it also serves other domains, such as clarification [18]. Color-coded signage system in Seoul Metro assists users in directional, identification and confirmation tasks. To further elaborate, a sign indicating a specific underground station is not merely an identifier; like shown below in [Fig. 9] and [Fig. 10], the assigned color also serves as a visual cue and acts as a confirmation point for commuters arriving at their destination [19].



[Fig. 9] Line 6, Mapo-Gu Office Station



[Fig. 10] Line 2, Jamsil Station

Colors convey non-verbal messages and function as a universal languages, especially within environment where language barriers exist [20]. Given the different cultural backgrounds and range of cognitive abilities of users, color coding and general use of color can be a valuable tool in guiding the

way-finding process. The clear applications of color-coding in signage serves as effective visual management through the way-finding process, the intuitive and clear visual effortlessly guide users by simulating their System 1 for quick judgements and decisions. This functionality further demonstrates that color is an imperative part of human interaction and environmental understanding. Color is believed to be the most essential visual experience to human beings, as it triggers intrinsic human responses, it functions as a powerful information channel to the human cognitive system, encoding, retaining and retrieving environment information [21]. The role played by color in making certain information memorable and enhancing our attention level is undisputable. Arousal Theory [22] suggested that colors can heighten arousal levels, thereby increasing attention, enhance engagement, and improving memory retention. The encoding process of signage message is enhanced by color [15], the presence of color makes an image or an object more visually stimulating and distinctive, which in turn lead to better initial processing and facilitate storage in the brain.



[Fig. 11] Floor Sign and Ceiling Sign

The color-coded signage system of Seoul Metro also presents in other forms on various dimensions, such as floor and ceiling of the train for identification and to influence directional mobility as shown [Fig. 11]. The application of consistent use of color-coded signage on floors and ceilings is strategic due to their universal presence in all architectural structures [23], maximize their potential to facilitate directional mobility, subtly guiding commuters through these visual cues. In busy commuting environments, where individuals may be focused on their phones or distracted by advertising clutter, signage positioned in these spatial dimensions supports subconscious and cognitive navigation. This approach helps maintain navigational efficiency even when traditional signage may be overlooked. These signage design creates a flow of direction through the colored line, made the navigation process easy to follow subconsciously by foot. The color-coded elements, in a behavioral science perspectives, ‘nudge’

commuters with the visual cues, simplified decision-making processes. By presenting information in an intuitive and accessible manner, signage reduces cognitive load and lead to more efficient behaviors [24]. Colors use on signage, viewed individually may not appeared to be much, but in the aggregate they can contribute to substantial improvements in way-finding experience, nudge users' behaviors towards more efficient and desirable actions. Intuitive navigation and cognitive ease that is stimulated by System 1 is the main focus, using colors as visually engaging element on signage to ensure commuters from diverse backgrounds can easily find the way. Color, as a visual design element, provides a one size fits all solution, and has also influenced way-finding systems in major transportation hubs globally.

3. Methodology and Survey Results

The study employed a mixed-methods approach, combining both qualitative and quantitative research to comprehensively assess the impact of color on way-finding within the Seoul Metro system. A survey was administered to 75 respondents aged 18 to 55, with the majority (61%) falling within the 25 to 34 age range, followed by 21% aged 35 to 44, 15% aged 18 to 24, and 3% aged 45 to 55. Among these participants, 59% were Korean, while 41% were non-Korean speakers from diverse backgrounds including individuals from Eastern, Southern, and Western Europe, as well as Southeast, East, and Northern Asia. All respondents were frequent Seoul Metro users, familiar with the transportation system's functions and patterns and regularly encountering its signage and way-finding systems. The survey featured a combination of multiple-choice and predominantly dichotomous questions, designed to elicit clear and targeted responses regarding the role of color in signage and its influence on way-finding experiences. Specifically, the survey addressed how color functions within signage systems and examined visual and psychological mechanisms that may enhance navigational ease and accuracy. Survey findings are summarized in the [Table 1].

[Table 1] The Influence of Color on Cognitive Behaviors and Intuitive Way-finding

No.	Questions	Yes(%)	No(%)
1.	Are you a native speaker of the language used in the signage systems you frequently encounter?	66.7%	33.3%
2.	In the subway station, color-coded signage is helpful in identifying specific areas and destinations (e.g. Subway Line, Exits, Information, Facilities).	96%	4%
3.	When I am at the subway station, I realize immediately it is an exit as soon as i spot a yellow sign, even from a distance.	84%	16%
4.	The use of colors on signage grabs my attention, improves readability and visual clarity in crowded or busy environments. (e.g. exit sign, subway line, facilities, etc)	89.3%	10.7%

5.	The contrast of white text on dark background makes it easy for me to read the information on the sign.	86.5%	13.5%
6.	When I am searching for a particular line (e.g. Line 6), I use color (e.g. brown) instead of text for more efficient processing of information.	90.7%	9.3%
7.	When scanning for signage information in the subway, color is the first thing that grabs my attention.	89.3%	10.7%
8.	The color-coded signage in the subway directs me easily and allow me to identify my path during navigation.	93.3%	6.7%
9.	The use of colors on signage allows me to identify directions intuitively with little thought.	88%	12%
10.	Which aspect of color-coded signage most influences your navigation?		
	Distinguish of information (e.g. yellow representing Exits)	45.3%	-
	High contrast for visibility	16%	-
	Consistency across signage	9.3%	-
	Make information easier to understand	13.3%	-
	ALL OF ABOVE	16%	-
11.	The use of colors on signage creates a smooth navigation experience and reduces my stress level during navigation.	89.3%	10.7%

The survey results reveal a strong consensus among commuters regarding the effectiveness of color-coded signage in enhancing way-finding within the Seoul Metro system. Key findings indicate that 96% of respondents believe color-coded signage aids in identifying specific areas and destinations (question 2). Color-coded elements, such as those marking subway lines and exits, underscore the role of color in improving navigational clarity and readability. Responses to question 4 to 6 subsequently indicate that color in signage functions as a efficient visual cue; 89.3% of participants agree that color attracts attention and enhances readability in crowded environments, 90.7% prefer color over text for recognizing specific routes during way-finding, and 86.5% acknowledged that the juxtaposition of colors enhances visual perception and the visibility of textual information. Responses to question 10, regarding distinguish of information (45.3%) and high contrast for visibility (16%) further highlight the role colors play in increasing readability and facilitating comprehension of signage information. These functions underscore the indispensable role of color in supporting cognitive ease, as demonstrated by Question 9, where 88% of commuters reported that color allows for intuitive navigation. Color's contributions to cognitive ease are also reflected in the high response rate (89.3%) recognizing that color-coded signage creates a smooth navigation experience and reduces stress levels. Subconscious navigation behaviors guided by color are evident in responses to Questions 7, 8, and 10: 89.3% noted that colors in signage are attention-capturing, a substantial 93.3% stated that color allows easy path identification, and 88%

confirmed that directions are identified intuitively with minimal thought.

4. Discussion

The study underscores the critical role of colors play in creating effective and inclusive signage with the purpose of facilitating cognitive ease and ultimately contribute to way-finding efficiency. By integrating use of colors and understanding human cognitive behaviors, designers can create signage systems that are not only visually clear but also culturally accessible. Color use on signage, as shown by the survey results, functions effectively across diverse user demographics, demonstrating its inclusivity and ease of comprehension for individuals from various cultural backgrounds and cognitive abilities. With 41% of survey respondents representing non-Korean speakers from diverse regions, the findings underscore that color is a universal design that is inherently understood by users regardless of cultural or linguistic differences. Its visual and psychological impact, including its ability to heighten attention, create cognitive ease and the characteristics to support subconscious navigation, makes it a valuable tool for visual management and an essential part of human interaction within the built environment. By triggering intrinsic responses, colors guide behaviors and responses naturally, making navigation more efficient and user-friendly. Color in signage, as a directive element, when applied consistently and clearly in the form of color-coded can act as an intuitive visual cue that System 1 processes automatically, facilitating rapid, effortless decision-making. This intuitive processing minimizes cognitive load, enabling users to navigate complex environments smoothly and with confidence. The consistent use of colors throughout way-finding systems not only simplifies navigation but also fosters a sense of unity and coherence within the environment, as color-coded elements visually unify different parts of the system and establish predictable patterns for users. High-contrast color combinations further support the functionality of way-finding systems by enhancing the visibility and legibility of textual information. Survey responses indicate that such color contrasts, like the juxtaposition of white text on dark backgrounds, improve both attention capture and comprehension. This reinforces the notion that color is an effective means of visual communication that facilitates efficient information processing and quick recognition, even in crowded or high-stress environments.

However, while use of color, as a universally understood language is an effective tool in design, certain limitations remain. Firstly, while colors can aid in way-finding, users must learn the specific meaning assigned to each color. Secondly, it is crucial to use colors that are distinct and easily recognizable; typically, only six to eight colors are recommended to avoid confusion for users. Finally,

designers cannot rely solely on color coding, and it is unrealistic to do so considering the existence of users with color blindness.

To address the challenge of accommodating users with color blindness, it is essential to explore complementary design strategies that integrate tactile or auditory cues alongside visual elements. Tactile solutions such as raised symbols or textures on signage, can provide a physical means of navigation, allowing users to identify key information through touch. For instance, tactile markers on subway handrails or floor surfaces could indicate directionality or proximity to exits. Similarly, auditory cues, such as spoken announcements or subtle sound signals, can reinforce visual information and guide users intuitively through complex environments. For example, auditory alerts can be synchronized with visual cues, such as a distinct chime paired with the yellow exit signs in the Seoul Metro, to signal important transitions or destinations. These multimodal approaches not only enhance accessibility for individuals with color blindness but also create a more inclusive way-finding system that caters to a diverse range of users, including those with other sensory impairments or cognitive challenges. By combining visual, tactile, and auditory elements, designers can ensure a seamless and universally accessible navigation experience.

5. Conclusion

In conclusion, all the above considerations require designers to prioritize audience diversity from the beginning, placing human needs, capabilities, and behaviors at the forefront of the design process. The findings of this study validate the importance of color as a powerful, inclusive, and effective element in signage and way-finding systems. Its ability to support cognitive ease, foster intuitive navigation, and provide seamless visual cues for diverse users emphasizes its role as a fundamental aspect of universal design. Incorporating colors with an understanding of their psychological impact allows designers to effectively reduce language and cultural barriers and automate way-finding behaviors through enhanced cognitive processing.

The study primarily addresses the visual aspects of signage and does not delve deeply into multimodal design solutions, such as the integration of tactile or auditory cues, which could enhance accessibility for users with visual impairments or color blindness. To address its limitation, future research can be done to explore the interplay of multiple sensory modalities in way-finding systems and examine how cultural differences influence the perception and effectiveness of design elements like color. Ultimately, these insights provide a valuable foundation for creating signage that fosters positive

user experiences and encourage urban planners and designers to utilize color as a core component of visual design, thereby creating public spaces that are accessible, efficient, and responsive to the diverse needs of urban populations.

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