Application research on multi-terminal visual communication optimization strategy based on user cognition

Wenyu Sun, Yueran Ding, Xiaoyu Guo

Shandong University of Science and Technology, 250000, Shandong

Received: 10 Jun 2025
Revised: 12 Jun 2025
Accepted: 14 Jun 2025
Published: 16 Jun 2025

Abstract: With the popularity of smart devices, more and more users obtain information through different terminals. How to achieve efficient and consistent visual communication on these devices has become a key issue in the design field. Based on user cognition theory, this study explores the optimization strategy of visual communication in a multi-terminal environment. By analyzing the differences in visual perception, information processing needs and cognitive load of users on different terminals, this study proposes a series of optimization strategies, including the adjustment of visual elements such as color, fonts, typography, and images, as well as terminal adaptation and responsive design methods. At the same time, the study emphasizes maintaining a consistent brand image and visual style between different devices to ensure that users have a consistent visual experience in various terminals. Finally, this study provides a theoretical framework and operational strategies for the design practice of multi-terminal visual communication, and promotes the deep integration of user cognition and visual design.

Keywords: User Cognition; Multi-Terminal; Visual Communication; Optimization Strategy; Design Method

1 INTRODUCTION

In modern society, visual communication, as an important means of information dissemination, has deeply penetrated into all areas of our daily life. With the development of science and technology, especially the popularization of mobile Internet and smart devices, visual information dissemination in multi-terminal environments has become a norm. Whether it is mobile phones, tablets, computers or smart TVs, users' demand and expectations for visual content are increasing. The usage scenarios and display characteristics of different terminal devices are different, which makes multi-terminal visual communication face complex design challenges [1]. In this context, how to achieve the effectiveness and consistency of visual communication in multi-terminal devices has become a common concern of academia and industry. Especially from the perspective of user cognition, designers must deeply understand the cognitive needs and differences of users under different terminals, so as to provide scientific guidance for visual communication design [2].

User cognition occupies a core position in visual communication, because the communication effect of visual information is directly related to how users receive, process and understand this information. When facing visual design, each user will process information according to his or her own cognitive process, which includes multiple links such as attention, memory, and perception. In a multi-terminal environment, the user's cognitive load and information processing ability are affected by many factors such as device screen size,

resolution, and interaction method [3]. Therefore, understanding the cognitive characteristics and needs of users under different terminals has become the key to optimizing visual communication design. Only on the basis of fully considering the differences in user cognition can targeted optimization strategies be formulated to improve the effectiveness of visual communication and user experience.

The goal of this study is to propose a multi-terminal visual communication optimization strategy based on user cognition, aiming to explore how to optimize visual design based on the characteristics of different terminals and the cognitive behavior of users on various terminals. Through in-depth analysis of user cognition, this study will propose a series of optimization strategies to enhance the visual communication effect and improve the user's visual experience. Specifically, this study will focus on how to adjust design elements such as color, layout, fonts, and images according to the user's cognitive characteristics, so that they can maintain a good user experience on different devices and platforms.

2 THEORETICAL BACKGROUND AND TECHNICAL FOUNDATION

User cognition theory is the basis for understanding how visual communication is perceived and processed by users. Cognitive psychology reveals the complex process of human beings receiving external information, which mainly includes perception, attention, memory and other links. Perception is the process of people contacting external information through the five senses, and visual perception is one of the most direct cognitive methods. When users receive visual information, they first convert external images, colors, etc. into neural signals through their eyes, and then process the information through the brain. Attention determines which elements users focus on in complex information, which directly affects the degree of information acceptance and processing effect [4]. Memory refers to the user's ability to store and retrieve information, which is particularly important for the long-term impact of visual communication. In a multi-terminal environment, the concept of user cognitive load is particularly critical, because the display characteristics and interaction methods of different terminals may affect the user's information processing ability. Due to the small screen of the mobile terminal, the user's attention span is relatively short, so the simplicity and emphasis of the information are particularly important [5]. The desktop terminal can carry more content information, and the user's cognitive load is relatively low, but information overload still needs to be avoided.

With the development of technology, the diversification of terminal devices has brought unprecedented challenges to visual communication design. The design requirements and restrictions of different terminals are different, which requires designers to make targeted optimizations based on the characteristics of the devices. The mobile terminal has a small screen, and the interaction method mainly relies on touch. When designing, you need to pay attention to the size of elements such as buttons and text, as well as the simplicity of the page layout. The desktop terminal has a larger display space, allowing more content to be displayed, but it is also easy to cause information redundancy and visual fatigue. Therefore, when designing, it is necessary to ensure the hierarchy and clarity of page elements to avoid information piling up and causing cognitive obstacles to users [6]. The tablet terminal is similar to the mobile terminal, but the relatively large screen and flexible touch operation method allow more freedom in design, and designers need to adapt according to specific user scenarios. As a large-screen display device, the main features of the TV terminal are long-distance viewing and wide viewing angle. The optimization strategy of visual communication needs to take into account factors such as the user's viewing distance, viewing angle and screen resolution. Therefore, in multi-terminal design, how to balance the differences and unity of visual communication has become an important research topic [7].

Visual communication optimization technology is a key link in applying theory to practice. As one of the most intuitive elements in visual communication, color has a profound impact on user cognition. Different colors can stimulate different emotional reactions and also affect the user's attention allocation. Red usually attracts the user's attention, while blue conveys a sense of calmness and stability. Fonts and typography are also important factors that affect cognitive load. The size of the font, line spacing, and the choice of font shape will affect the user's reading speed and comprehension efficiency. For multi-terminal design, the choice of fonts must also take into account the readability of different devices, especially when the mobile screen is small. The hierarchy of the layout and the arrangement of information directly affect the user's reading fluency. A reasonable layout can help users quickly grasp the key points of information. In addition to these design elements, responsive design technology is also an important means of optimizing visual communication. Responsive design can automatically adjust the page layout according to the screen size and resolution of different terminal devices, so that users can get a consistent visual experience on different devices. These visual communication optimization technologies provide an effective solution for improving the user experience of multi-terminal design, helping to reduce cognitive load and improve the efficiency of information processing.

3 VISUAL COMMUNICATION OPTIMIZATION STRATEGY BASED ON USER COGNITION

In multi-terminal design, user cognitive analysis and understanding of needs are the basis for optimizing visual communication strategies. The differences in screen size, resolution and operation methods on different terminal devices lead to obvious differences in user visual perception. Mobile devices have smaller screens and limited user fields of view, so the visual elements displayed on mobile phones must be more concise and highly visible. In contrast, desktop screens are larger, and users' visual focus can be concentrated on a wider information area, allowing more content to be displayed [8]. The distribution of user attention on different terminals is also different. On mobile phones, users' attention span is usually short, which requires designers to capture users' attention and convey core information in a short time. On desktops, users can concentrate on browsing information for a longer time, so the presentation of content can be richer. In addition, users' needs for information processing vary between different devices. Mobile users tend to quickly obtain key information, while desktop users are more capable of processing more complex information. Therefore, when optimizing visual communication, it is necessary to adjust the priority of information according to the characteristics of the terminal to ensure that users can easily understand and process information in different environments [9].

In order to effectively improve the visual communication effect of multiple terminals, the optimization of color, fonts and layout is particularly important. Color is not just a decorative element, it can directly affect the user's emotions and attention. In multi-terminal design, a reasonable color scheme can help reduce cognitive burden and improve the efficiency of information transmission. Bright colors can guide users to pay attention to important content, while soft colors can provide visual comfort and reduce visual fatigue. At the same time, color also plays an important role in users' emotional response, so choosing the right color can enhance users' visual appeal and improve the usability of the interface. In terms of font and typography design, optimizing font size, line spacing and font shape is crucial for the

readability of multi-terminal users. For mobile terminals, designers need to ensure that the text is clear and easy to read on smaller screens, while desktop terminals can use larger fonts and more typography methods to improve the readability and hierarchy of information. The structured design of typography helps users better understand the flow of information and effectively guides users' reading paths. In addition, the design of images and graphics also plays a decisive role in the clarity and accuracy of information transmission [10]. Reasonable image design can not only improve the visualization of information, but also enhance users' understanding of information. In multi-terminal design, the resolution and size of the image must take into account the display capabilities of different terminals to avoid affecting the user's visual experience due to images that are too large or too small.

Terminal adaptation and responsive design are the key to ensure that visual communication optimization strategies can achieve consistent experience on different devices. Visual consistency requires maintaining a unified design language and visual style in different terminals to ensure the continuity of the brand image and the uniformity of the user experience. When designing, although the display characteristics of different terminals are different, the elements such as color, font, and layout should be coordinated and consistent, so that users can feel the same brand atmosphere and visual style when switching between different devices. Responsive layout is a design method that automatically adjusts the content layout according to the screen size and resolution of the terminal device. It can automatically optimize the layout and image size of the page according to the changes in screen size to ensure that users can get the best browsing experience on different devices. In this way, the accessibility and usability of information can be greatly improved, and the inconsistent user experience caused by device differences can be reduced.

Interaction design plays a vital role in optimizing user cognitive load. User interaction behavior is closely related to cognitive load. Complex interaction design will increase the user's cognitive burden and reduce the efficiency of information processing. Therefore, when optimizing the interactive experience, designers must simplify the interaction process and reduce unnecessary operation steps according to the user's cognitive characteristics. Through visual communication means, designers can guide users to perform efficient operations and reduce cognitive load. Through clear button design, clear navigation bar and consistent interaction mode, users can quickly understand the operation steps and reduce the possibility of wrong operation. At the same time, the feedback mechanism in the design is also an important part of optimizing the user experience. Through timely visual feedback and interaction prompts, users can understand their operation status more clearly, thereby improving the interactive experience and sense of participation. This optimization can not only reduce the user's cognitive burden, but also improve the user's satisfaction with the interface and stickiness.

4 APPLICATION OF OPTIMIZATION STRATEGIES IN MULTI-TERMINAL PLATFORMS

In multi-terminal platforms, visual communication faces design differences and challenges between different devices. The visual design differences between mobile and

desktop are particularly prominent. The mobile screen is small and the user's attention span is short, so simplicity and efficiency must be considered in the design to ensure that key information can quickly attract the user's attention. The design of icons, text and buttons needs to highlight clarity and clickability, while minimizing the sense of crowding of visual elements. In contrast, due to the large screen space on the desktop, users can process more information content, so the visual design can be relatively rich, allowing for more content display and interaction methods. The design of the desktop needs to pay attention to the hierarchy and guidance of information to ensure that users can quickly find the key information they need and avoid information overload. For tablets and large-screen devices, due to the increase in screen size, the design needs to consider the changes in user viewing distance and viewing angle. On the TV side, since users usually watch from a distance, the text and buttons need to be larger and clearer, and the interaction design should be simpler to reduce the complexity of user operations. On these devices, visual design not only needs to adapt to larger screens, but also take into account user viewing comfort and interaction fluency.

The application of visual optimization in multi-terminal design requires flexible adjustment of visual communication strategies according to the characteristics of different terminals. For mobile terminals, color and layout optimization is particularly important. Designers need to ensure that users can grasp the core information in a short time through reasonable color matching and concise layout. For desktop terminals, designers can use more visual elements, such as detailed icons, long text information, and complex interactive design to meet users' browsing needs for a longer time. On tablets and large-screen devices, designers should pay attention to the clarity of images and layouts, and adjust the layout to adapt to the display of large screens to ensure the clarity and accuracy of information transmission. In different terminals, the application of optimization strategies must fully consider the performance of the device and user behavior habits, so the optimization method must have high adaptability and operability. Designers need to adjust the visual hierarchy, interaction method, and content presentation method of the design according to the characteristics of each terminal to ensure that users can get a consistent and smooth visual experience in various terminals.

In a multi-terminal environment, maintaining consistency in visual communication is an important task in design. In order to maintain a unified brand image and visual style across multiple terminals, designers need to ensure the consistency of elements such as color schemes, font styles, and icon designs. A brand's visual image may convey its unique temperament through specific color combinations and font styles. This style needs to be reasonably adapted and continued on all terminals to ensure the consistency of the brand image. However, despite the different design requirements of each terminal, designers still need to maintain consistency in visual elements to avoid confusion in information transmission or fragmentation of the brand image. To achieve this goal, designers can adopt responsive design and dynamically adjust the layout to provide consistent visual presentation on different devices. On this basis, designers also need to pay attention to coordinating visual elements in a multi-terminal environment to ensure the uniformity of information layout, interaction methods, and image clarity on different devices, so as to provide a consistent user experience. Through sophisticated design and optimization, it can ensure that users can feel a unified visual style and brand

atmosphere on any terminal, thereby enhancing user recognition and brand loyalty.

5 DESIGN METHODS AND FRAMEWORKS BASED ON USER COGNITION

The design method based on user cognition emphasizes building an optimized visual communication process from the perspective of user perception and cognition. The core of design is to understand the cognitive needs of users in different situations and guide each design decision through accurate user cognitive analysis. The design process centered on user cognition usually includes several steps such as user research, cognitive needs analysis, design strategy formulation, prototype design and iterative optimization. First of all, designers need to deeply understand the cognitive characteristics and information processing habits of users on different terminals through questionnaires, user interviews or behavioral observations. Mobile users usually focus on quickly obtaining key information, while desktop users tend to process complex information for a long time. Based on these cognitive differences, designers can adjust the display of visual elements in a targeted manner. When formulating design strategies, in addition to considering the optimization of visual elements, it is also necessary to consider the emotional needs of users, minimize cognitive load, and improve the efficiency of information communication. Through this user cognition-oriented design process, it can ensure that visual communication not only meets the basic needs of users, but also improves the overall experience of users through innovation and optimization.

The formulation of user cognitive analysis tools and strategies is a key link in the optimization design process. Common cognitive analysis tools include user portraits, situational analysis, cognitive load testing, etc. User portraits help designers deeply understand the needs, behavioral habits, preferences and pain points of target users, thus providing a clear direction for design. Contextual analysis helps to determine the cognitive characteristics of users in specific devices and usage scenarios. Users tend to process simple and intuitive information when using mobile devices, while they may need to process complex content when using desktops. Cognitive load testing can evaluate the cognitive burden of users under different design schemes through experimental methods, thereby helping designers choose the design scheme that best meets the cognitive characteristics of users. On this basis, the formulation of strategies is not limited to visual optimization, but should also focus on users' operating habits, expected interaction methods, and the efficiency of information presentation to ensure that design decisions are consistent with users' cognitive needs.

In the actual design process, the implementation framework of visual communication optimization should be combined with user cognitive analysis to formulate clear design steps. First, it is necessary to set design goals and clarify optimization directions through a comprehensive understanding of user cognitive needs. Next, designers should select appropriate visual elements and interaction methods based on the characteristics of different terminals and users' cognitive needs, and conduct prototype design. The design at this stage should not only focus on visual effects, but also consider the hierarchy, readability and ease of use of information. After the design is completed, iterative optimization of the design is carried out through repeated testing and feedback collection. The design of the mobile terminal needs to consider the limitation of the small screen space. The layout should be as simple and clear as

possible, avoiding too much text content and complex interaction methods; while the desktop terminal can display more information through a larger screen, but the orderly arrangement and clarity of the information must still be maintained. The implementation of the design framework requires not only optimization at the visual level, but also attention should be paid to the user's operation process to ensure that the information is conveyed accurately and efficiently.

Design strategies need to be flexibly adjusted for the characteristics of different terminals. Taking the mobile terminal as an example, the design should focus on improving the rapid transmission and interaction efficiency of information to ensure that users can quickly understand key information within the limited screen space. On the desktop side, the design should use a wider screen space to provide more information display and complex interaction modes, but at the same time avoid information overload and keep the interface neat and simple. On tablets and large-screen devices, designers need to consider the user's viewing distance and visual comfort, and ensure that users can read and operate easily by adjusting elements such as font size and image resolution. In short, the design method based on user cognition requires designers to flexibly adjust the design strategy according to the characteristics of different terminals and the user's cognitive needs, and improve the user experience in a multi-terminal environment through precise visual optimization.

6 CONCLUSION AND OUTLOOK

This study focuses on the optimization strategy of multi-terminal visual communication based on user cognition, and deeply explores how to improve the efficiency and effect of visual communication on different terminal devices by understanding the cognitive characteristics of users. Through systematic literature review and theoretical analysis, this study summarizes the important influence of user cognition on visual design, and emphasizes how to reduce the user's cognitive load and improve the accuracy and speed of information processing by optimizing visual elements, layout, color and interaction methods in a multi-terminal environment. Studies have shown that users' cognitive differences, terminal characteristics and information processing needs are significantly different on different devices, and design optimization strategies must be flexibly adjusted according to these differences. Through the strategies proposed in this study, the user experience on multi-terminal platforms can be effectively improved to ensure the consistency and efficiency of visual communication. Therefore, this study not only provides a theoretical framework for multi-terminal visual communication optimization for the academic community, but also provides operational guidance and application solutions for actual design practice.

The innovation of this study is to combine user cognition theory with multi-terminal visual communication optimization strategy, and propose a design method and framework with user cognition as the core, breaking through the limitation of traditional visual communication optimization methods that rely only on intuition and experience. Different from the existing multi-terminal design research, this study focuses on analyzing the behavior and needs of users on different devices from the perspective of cognitive psychology, and clearly points out that the visual communication design of different terminals should not only consider aesthetics and

functionality, but also fully consider the cognitive burden of users on each terminal. This innovative method helps to optimize the visual communication design more accurately, so that it is more in line with the cognitive habits of users in actual use, especially in information-intensive and complex interactive environments. In addition, the study also proposed a combination of terminal adaptation and responsive design, and provided a specific solution to maintain visual consistency and improve user experience between different devices.

Looking forward to the future, with the continuous advancement of technology and the continuous changes in user needs, the optimization direction of visual communication will be more diversified. Especially with the popularization of 5G technology and the rise of artificial intelligence, visual communication on multi-terminal platforms will face more complex challenges. Future research can further explore how to use emerging technologies, such as artificial intelligence and machine learning, to achieve more intelligent and personalized visual communication optimization. AI can automatically adjust the visual design based on the user's behavioral data to improve the user experience. On this basis, user cognitive theory may play a greater role in emerging technologies such as AR/VR. The emergence of these technologies not only provides a richer form of expression for visual communication, but also opens up new paths for user cognitive processing. By applying optimization strategies based on user cognition in virtual and augmented reality environments, a more immersive and interactive visual experience can be achieved, further improving the efficiency of information communication and user perception. Therefore, future research directions will focus on how to combine user cognition theory with these emerging technologies to promote further optimization and innovation of visual communication on multi-terminal platforms.

REFERENCES

[1] Vieira, M., Vieira, M. A., Galvão, G., Louro, P., Vieira, P., & Fantoni, A. (2024, June). Enhancing indoor navigation in multi-terminal airports through visible light communication signals. In *Optical Sensing and Detection VIII* (Vol. 12999, pp. 292-307). SPIE.

[2] Hao, Y., Miao, Y., Chen, M., Gharavi, H., & Leung, V. C. (2021). 6G cognitive informa tion theory: A mailbox perspective. *Big Data and Cognitive Computing*, *5*(4), 56.

[3] Zhu, J., Li, N., Zhang, J., Rao, Y., Pang, C., Tang, R., & Zhao, H. (2025). Adaptive Ge ographic Scene Expression Driven by User Needs: A Case Study of the Twin Highway T unnel Scene. *Transactions in GIS*, *29*(2), e70044.

[4] Li, W., Zhou, Y., Luo, S., & Dong, Y. (2022). Design factors to improve the consistency and sustainable user experience of responsive Interface Design. *Sustainability*, *14*(15), 913 1.

[5] Wu, Y., & Chen, M. (2022, October). Multi-terminal Sharing System of Interconnected D ynamic Data Network Assisting College Sports Practice Information. In *2022 International Conference on Edge Computing and Applications (ICECAA)* (pp. 441-444). IEEE.

[6] Huang, J., & Li, W. (2023, July). Research on the communication mode of mobile applic ations under the human-computer interaction mode. In *International Conference on Human-Computer Interaction* (pp. 40-52). Cham: Springer Nature Switzerland.

[7] Ng, S. E., Vishwanath, S. K., Yang, J., Periyal, S. S., Nirmal, A., Jamaludin, N. F., ... & Mathews, N. (2024). Advances in Multi-Terminal Transistors as Reconfigurable Intercon nections for Neuromorphic Sensing and Processing. *Advanced Electronic Materials*, *10*(2), 2 300540.

[8] She, M., & Zhao, Y. (2024, August). Smart Fire Digital Twin Scene and Multi-Terminal Collaboration: A Systematic Design. In *2024 5th International Conference on Electronics a nd Sustainable Communication Systems (ICESC)* (pp. 595-600). IEEE.

[9] Chenxu, H., Jiashuang, L., Huanhuan, C., & Wei, X. (2023). Research on interactive expe rience design of tram charging pile based on user perspective—Taking Quanzhou Normal University as an example. *perspectives*, *5*(2), 1-8.

[10] Wen, L., Lin, W., & Guo, M. (2022). Study on optimization of marketing communication strategies in the era of artificial intelligence. *Mobile Information Systems*, *2022*(1), 160418 4.