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Systematic Analysis of User Perception for Interface Design Enhancement

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Abstract:

In view of the importance of user perception in the design of human-computer interaction interfaces, this study proposed a systematic evaluation index system. With functional perception, interactive perception, and emotional perception as the core, a multi-dimensional evaluation framework covering efficiency, feedback timeliness, information clarity, emotional pleasure, and aesthetic satisfaction was constructed. Through questionnaire surveys and the collection of user behavior data, the advantages and disadvantages of interface design were deeply analyzed. The results show that users have a high evaluation of information clarity and feedback timeliness, indicating that the interface performs well in logical design and operational response; while there is room for improvement in aesthetic satisfaction and emotional experience. Based on these findings, the study proposed targeted optimization strategies, which provided theoretical support and practical guidance for the design and improvement of interactive interfaces. In the future, the study will further expand the application scenarios of the perception evaluation model and explore more refined user experience optimization methods in combination with personalized technology. This study not only provides quantitative tools for the evaluation and optimization of human-computer interaction interfaces but also opens up new directions for user experience research.

Keywords:

User perception; human-computer interaction; interface optimization; user experience

1. Introduction

With the rapid development of science and technology, the application of human-computer interaction interfaces in modern society is becoming more and more extensive, covering almost all fields from personal consumer electronic devices to industrial control systems [1,2]. The design of the interactive interface directly affects the user's cognition and experience of the product, and the core of this experience lies in the user's perception of the interface. Perception not only involves the visual presentation of the interface, but also includes factors such as the smoothness of operation, the ease of use of functions, and the user's emotional satisfaction. Traditional human-computer interaction research focuses more on the realization of interface functions and the optimization of technical performance, while user perception, a soft indicator, is often ignored [3]. However, with the market's increasing requirements for user experience, product developers and researchers have begun to realize that the optimization of perception is the key to improving the overall quality of human-computer interaction interfaces. Therefore, interface evaluation and improvement based on user perception has become an important research direction in the current field of human-computer interaction [4].

The core of user perception lies in the balance between subjective experience and objective performance. On the one hand, the user's perception of the interface is usually highly subjective, affected by various

factors such as personal experience, usage scenarios, and cultural background; on the other hand, this subjective experience can be reflected through certain quantitative indicators, thereby providing guidance for the improvement of interface design. For example, users' sensitivity to interface response speed, acceptance of information layout, and ability to understand interaction logic can all be quantified and analyzed through experimental data or questionnaires. On this basis, researchers can re-optimize the design logic of the interactive interface to better meet the needs of different user groups. However, the existing evaluation methods are still insufficient in accuracy and practicality. How to build a comprehensive and scientific evaluation model has become a research challenge in this field.

The focus of this study is to build a method system for evaluating the usability of human-computer interaction interfaces from the perspective of user perception, and propose specific optimization strategies based on this. Different from the previous functional-oriented interface design methods, this study takes user perception as the core element of design, combines data analysis and user feedback, and explores how to improve the perception of the interface in multiple dimensions. In the research process, we summarize the relevant theories and methods of current perception evaluation, and extract perception indicators closely related to user experience; then, through experiments and case analysis, these indicators are verified and optimized. Through such a systematic study, it is expected to provide designers with an efficient and quantifiable perception optimization tool [5].

Compared with traditional research, the innovation of this study lies in that its focus shifts from technical implementation to the quantification and practical application of user perception. Unlike functional testing methods that focus on a single dimension of interface performance, this study attempts to establish a connection between perception and usability from the perspective of user psychology and behavior patterns, combining big data analysis, laboratory testing, and user research. At the same time, the study will also explore how to integrate perception evaluation into the iterative design process of the interface, so that it does not just stay at the evaluation level, but can truly promote the dynamic optimization of interface design. Such a research perspective not only fills the current research gap in the field of human-computer interaction but also provides theoretical support for the development of related technologies in the future.

In summary, the evaluation and improvement of human-computer interaction interfaces based on user perception is not only an exploration of specific technical issues but also a new interpretation of the concept of human-computer interaction. Against the background of the rapid development of information and intelligent technology, user needs are becoming increasingly diversified, and traditional design models can no longer meet the requirements of the new era. By studying the key dimension of user perception, combined with scientific evaluation methods and optimization strategies, the innovation ability and applicability of interface design can be effectively improved, thus laying the foundation for building a better interactive experience. In the future, this study hopes to provide references for more fields, such as smart devices, virtual reality, and in-vehicle interactive systems, to further promote the advancement and development of human-computer interaction technology.

2. Related Work

In recent years, the research on human-computer interaction interfaces has gradually shifted from functional optimization to user experience-centered design, especially in the field of user perception. Traditional human-computer interaction research focuses on the technical performance and functional implementation of the interface, such as interface response time, simplification of operation steps, etc. However, these indicators can only reflect the objective performance of the interface design, and it is difficult to fully cover the subjective perception of users in actual use [6]. To this end, some researchers

have begun to incorporate user perception into the interface evaluation framework to explore how to measure the psychological and emotional experience of users in the interaction process through quantitative methods. The research on user perception covers multiple fields, from the user's aesthetic feeling of visual layout to the understanding of interaction logic, and the intuitive perception of operational convenience. These studies provide multi-dimensional references for interface optimization [7].

In terms of quantifying user perception, existing studies have proposed a variety of evaluation models and methods. For example, the user feedback collection method based on the Likert scale is widely used in perception surveys and research, which can capture users' subjective evaluations and convert them into quantifiable indicators. At the same time, eye tracking technology and physiological signal measurement technology have also been introduced into the study of user perception to observe the user's attention distribution on interface elements and the emotional fluctuations generated during use. The introduction of these technical means not only expands the depth of perception research but also provides a more scientific optimization basis for interactive interface design. However, the application of these methods still has certain limitations. For example, the experimental scenarios are too idealized and difficult to reflect the complex situations in the real environment. In addition, the personalized needs of different user groups have not been fully reflected in the existing models.

In terms of interactive interface design and improvement, research based on user perception has gradually emphasized the importance of personalization and dynamic adjustment. Some studies have tried to establish adaptive interface models through machine learning algorithms, combined with user behavior data and perception evaluation, to adjust the interface layout or function configuration in real time to meet user needs. However, these methods still face challenges in practical applications, such as how to balance model complexity and computational efficiency, and how to balance the contradiction between personalized design and universality [8]. Overall, although existing research has achieved certain results in the quantification and application of perception, there is still much room for improvement in the universality of the evaluation model, the practicality of the method, and the comprehensiveness of user experience optimization. This also provides a direction for further exploration in this study.

3. Construction and analysis of user perception evaluation indicators

User perception evaluation is a key link in the design of human-computer interaction interfaces. Its core lies in comprehensively quantifying the user's subjective perception of the interface through the construction of multi-dimensional indicators. To this end, this study combines relevant literature and user interviews to summarize the evaluation dimensions closely related to user perception and proposes specific indicators suitable for human-computer interaction interfaces based on this. These indicators cover many aspects of user experience, such as operation fluency, accuracy of information transmission and aesthetic satisfaction of the interface. Through the systematic analysis of indicators, a scientific basis can be provided for subsequent interface optimization.

First, based on the existing theory and practice of human-computer interaction interface, a framework system for user perception evaluation is constructed. This study divides user perception into three dimensions: functional perception, interactive perception, and emotional perception. Functional perception mainly measures the user's intuitive feeling about the realization of interface functions, such as the accuracy and efficiency of task completion; interactive perception focuses on the convenience of interface operation and the timeliness of feedback; emotional perception focuses on the emotions and

satisfaction generated by users during the interaction process. Combining these dimensions, this study sorted out relevant specific indicators, as shown in Table 1:

Table 1. User perception evaluation framework and specific indicators

Evaluation Dimensions	Specific indicators	Describe
Functional perception	accuracy	How well the user completes the task
	Efficiency	The time it takes for users to complete a task
	stability	Is the system running reliably? Are there any crashes or freezes?
Interactive Perception	Operational Fluency	The naturalness and consistency of the user's interface operation
	Timely feedback	The system's response speed to user operations
	Clarity of information delivery	The ease with which users understand the information conveyed by the interface
Emotional Perception	Aesthetic satisfaction	Users' subjective evaluation of interface visual design
	Emotional happiness	The user's pleasure during use
	Interaction experience satisfaction	User satisfaction with the overall interaction process

After clarifying the indicator system, this study designed a set of questionnaires to collect user evaluation data on these indicators. The questionnaire compilation process referred to the standardized methods in the relevant literature and was adjusted in combination with actual interaction scenarios. Each indicator corresponds to multiple questions, and user feedback is collected in the form of a Likert five-point scale (from "strongly disagree" to "strongly agree"). In addition, to ensure the scientificity and effectiveness of the questionnaire, this study invited a number of experts in the field to review the questionnaire after the questionnaire was designed and conducted a small-scale pre-survey. Table 2 shows some questionnaire questions and their corresponding indicators.

Table 2. User perception evaluation questionnaire example

Question Number	Problem Description	Corresponding indicators
Q1	I was able to quickly complete my target tasks on this interface.	Efficiency
Q2	The interface was responsive to my actions.	Timely feedback
Q3	The information transmission logic of the interface is clear and not easy to be misunderstood.	Clarity of information delivery
Q4	I find this interface a joy to use.	Emotional happiness

Q5	I am pleased with the visual design of the interface.	Aesthetic satisfaction

In addition to collecting questionnaire data, this study also refers to existing user behavior analysis methods and further verifies the comprehensiveness and rationality of the index system by observing the behavioral characteristics of users when operating the interface. For example, by recording the mouse trajectory, number of clicks, and other data when users operate the interface, it can indirectly reflect the user's perception of the smoothness of operation and the clarity of information transmission. To this end, this study compiled a series of common user behavior characteristics and their corresponding relationship with perception indicators, as shown in Table 3.

Table 3. The correspondence between user behavior characteristics and perception indicators

User behavior characteristics	Describe	Corresponding perception index
Mouse trajectory complexity	Is the mouse movement path on the interface intuitive and concise?	Operational Fluency
Number of clicks	The number of clicks it takes for a user to complete a task	Efficiency
Dwell time	How long users stay on a specific UI element	Clarity of information delivery
Emotional voice fluctuations	Results of the user's voice emotion analysis during operation	Emotional happiness
Task completion time	The time it takes users to complete a specific task	Efficiency

Through the above framework and methods, this study established a systematic user perception evaluation index system and designed targeted questionnaires and behavioral data analysis methods. These results laid a theoretical foundation for subsequent experimental research and interface optimization and also provided a direction for a deeper understanding of user perception. Future research will further verify the effectiveness of these indicators and conduct application tests in different interaction scenarios.

4. Experiment

4.1 Datasets

This study uses a typical human-computer interaction dataset, which mainly contains information such as user behavior data, subjective feedback, and system log records when using the interactive interface. The dataset comes from a public user experience research project on Kaggle, involving multiple interactive tasks and scenario designs. The tasks in the dataset include browsing, searching, filling out forms, and operating complex functional modules, aiming to simulate the entire process of user interaction with the interface in real scenarios. The user groups participating in the experiment come from different industries and backgrounds, with great diversity, which provides a solid foundation for studying the universality of user perception.

The dataset contains three main types of data: the first type is user behavior data, such as mouse clicks, sliding trajectories, task completion time, and operation paths. These data reflect the user's interaction habits and task efficiency by recording every step of the user's operation in the interface; the second type

is user subjective feedback data, which is mainly collected through the Likert five-point scale, including ratings of interface fluency, information clarity, and aesthetic design; the third type is system log data, including interface response time, error rate, and function call records. These data together constitute a multi-dimensional perception evaluation system, providing rich information support for a comprehensive analysis of the interaction process between users and interfaces.

It is worth noting that the dataset has been rigorously preprocessed and cleaned to ensure the quality and consistency of the data. For example, for behavioral data, obvious outliers and unavailable log records were removed; for subjective feedback data, extreme values and unreasonable ratings were eliminated through statistical methods. The dataset not only provides reliable support for the perception evaluation model of this study but also provides reference value for user experience research in other fields. In the future, the dataset can be further expanded to cover more interaction scenarios and user groups to support a wider range of research needs.

4.2 Experimental Results

In this study, based on the construction of user perception evaluation indicators, systematic data analysis and model verification were carried out to evaluate the effectiveness of the designed framework. Through the multi-dimensional combination of user behavior data, subjective feedback, and system performance logs, the impact of different perception dimensions on interface usability was deeply explored. The goal of the experiment is to verify the correlation between user perception indicators and actual interaction performance and to evaluate its applicability in different task scenarios. During the research process, the potential relationship between user operation habits, feedback preferences, and interface optimization directions was revealed through visual analysis and statistical tests of data in multiple dimensions. In order to ensure the scientific nature of the experiment, representative user groups were selected, and a variety of interaction tasks were set. First, a user behavior data collection and analysis experiment were carried out, and the experimental results are shown in Figure 1.

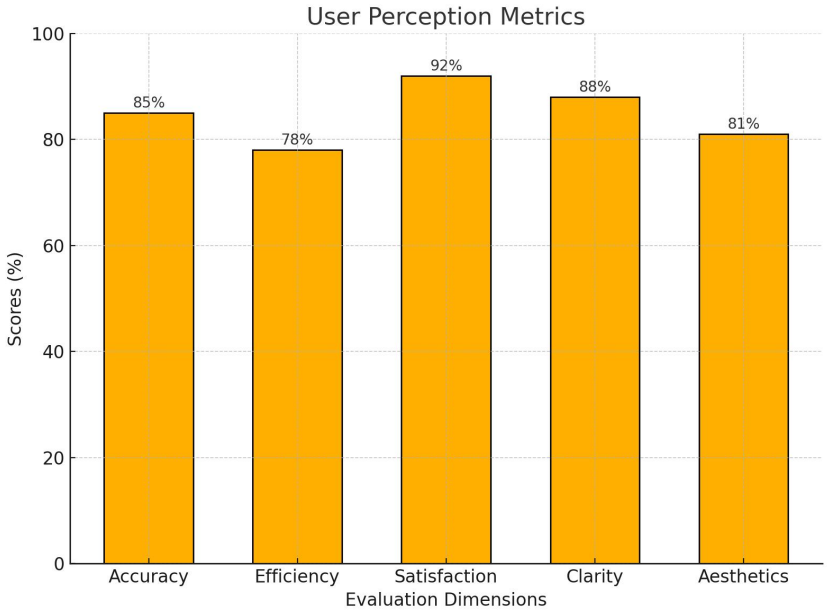

Figure 1. User Perception Metrics

As can be seen from the figure, the scores of the five dimensions of user perception show certain differences. Among them, the score of the Satisfaction dimension is the highest, reaching 92%, indicating that users are subjectively satisfied with the overall interactive experience of the interface. This may be related to the intuitiveness of the interface design and the ease of use of the functions, which is also one of the core indicators of user perception. At the same time, the score of the Clarity dimension is also relatively outstanding, reaching 88%, reflecting the good logic and readability of the information transmitted by the interface.

In contrast, the score of the Efficiency dimension is relatively low, only 78%. This result shows that there may be some room for improvement in the time consumption or operation steps of users to complete tasks. Although efficiency is not the only determinant of perception, its impact on the overall user experience cannot be ignored. Other dimensions such as Accuracy and Aesthetics scored 85% and 81% respectively, which are acceptable, but their importance in user perception may be lower than satisfaction and clarity.

Overall, these scores reflect the advantages and disadvantages of the interface in the user perception dimension. High satisfaction and clarity scores indicate that the basic quality of the interface design is high, but the relative weakness of efficiency reveals potential optimization directions. This suggests that in the future, users' perception and experience quality can be further improved by reducing the number of operation steps or increasing the system response speed.

Secondly, a user subjective feedback collection experiment was conducted, and the experimental results are shown in Table 4.

Table 4. User perception evaluation questionnaire example

Question Number	Problem Description	Corresponding indicators	Average rating (out of 5 points)
Q1	I was able to quickly complete my target tasks on this interface.	Efficiency	4.2
Q2	The interface was responsive to my actions.	Timely feedback	4.5
Q3	The information transmission logic of the interface is clear and not easy to be misunderstood.	Clarity of information delivery	4.6
Q4	I find this interface a joy to use.	Emotional happiness	4.3
Q5	I am pleased with the visual design of the interface.	Aesthetic satisfaction	4.1

From the experimental results, it can be seen that users have the highest evaluation in the two dimensions of logical clarity of information transmission and timeliness of feedback, with average scores of 4.6 and 4.5 respectively. This shows that the interface performs well in terms of logical design and response speed, and users can quickly understand the information provided by the interface and feel the immediate response of the interface to operations. The high scores in these two dimensions reflect that the design of the interactive interface is more humane, which can meet the core needs of users and improve operational efficiency and user experience.

In contrast, the score of aesthetic satisfaction is 4.1, slightly lower than other dimensions. This shows that although the visual design of the interface basically meets user needs, there is still room for improvement.

At the same time, the scores of efficiencies and emotional pleasure are 4.2 and 4.3 respectively, indicating that users have high satisfaction with task completion speed and emotional experience, but there may still be room for improvement in some complex task scenarios or personalized needs. Overall, the interface performs well in key indicators of user perception, but it still needs to be further optimized in terms of visual design and overall pleasure to enhance the user's comprehensive experience.

5. Conclusion

This study focuses on the evaluation and optimization of user perception, constructs an index system with functional perception, interactive perception, and emotional perception as the core, and conducts a systematic analysis through the collection of user subjective feedback and behavioral data. The results show that user perception evaluation can effectively reflect the pros and cons of interface design and provide a scientific basis for interface optimization. In multiple dimensions, clear logic design and timely system feedback have been proven to be important factors in improving user perception, while visual design and emotional experience are key areas that need further improvement.

Through quantitative analysis of user feedback data, this study verifies the close connection between perception indicators and actual interactive experience. The high scores of users for information transmission logic and operation feedback indicate that the interface performs well in basic functions and interactive performance, while the relatively low scores for aesthetics and emotional experience indicate the shortcomings of the interface in design aesthetics and emotional interaction. These findings not only provide verification for the index system proposed in this study but also point out the direction for future optimization of human-computer interaction interfaces.

Overall, the evaluation method and index system of user perception provide quantitative tools for interface design and highlight the importance of user experience in modern human-computer interaction design. Future research can further expand the applicable scenarios of the perception evaluation model, combine emerging technologies such as artificial intelligence and personalized recommendations, explore how to more accurately meet user needs, and provide more intelligent and personalized design solutions for interactive interfaces. Through such optimization, not only can the user experience be improved, but it will also promote the development and innovation of the field of human-computer interaction.

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