ISSN: 2710-0723

Investigate the Antecedents of Cognitive Dissonance among Users of Smart Home Applications

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Abstract

With the rapid development of smart home, smart products are rapidly popularized, and users' dependence on smart home applications continues to increase. However, interface design and usability problems may lead to increased cognitive load of users, resulting in cognitive dissonance in psychological conflicts of users, and affect user experience. Based on the special environment and culture in Anhui Province, China, this study aims to explore the negative factors that trigger cognitive dissonance among users in smart home applications. Taking Mijia APP as an example, data was collected through semi-structured interviews, and the interview questions focused on interface design and usability. Qualitative interviews were conducted to investigate the specific effects of interface design and usability on user psychological conflict. The results of the interview reveal that the inadequacy of interface design and usability problems are important antecedents of cognitive dissonance. Based on the research results, it provides empirical reference for the improvement of smart home applications, aiming at reducing cognitive dissonance and improving user experience and satisfaction.

Keywords

Smart Home Applications; Cognitive Dissonance; Interface Design; Usability.

1. Introduction

Smart home applications are a class of software that runs on smart devices and is designed to provide users with remote control, monitoring and automated management of the home environment. These applications are often used in conjunction with various smart devices and sensors, enabling users to remotely control and monitor home devices through mobile phones, tablets or other smart devices[1]. Users can use apps to control lighting, temperature, security cameras, appliances and other devices in the home to achieve an intelligent home experience. Users prefer a more engaging and intuitive user interface to a dull or complex one. However, the resulting information overload and service interaction with users will affect the willingness of organizations and individuals to continue to use information systems and their satisfaction. Some researchers have taken cognitive dissonance as a research perspective and confirmed that some users may face inconsistencies and conflicts between pre-use expectations and post-use actual experience when using smart home systems or devices. In order to alleviate such conflicts, users will adopt some coping mechanisms to reduce cognitive dissonance. Thus, psychological balance can be achieved [2]. Therefore, the study of the antecedents and subsequent psychological reactions and behavioral patterns of users' cognitive dissonance is of great significance for improving user experience and interface design.

ISSN: 2710-0723

2. Literature Review

2.1. Smart Home Applications

Foreign research calls Smart Home smart Home or Home Automation, which refers to the integrated use of network wiring, communication and control, the integration and management of information of household appliances that were originally isolated from each other, and the completion of information transmission and control between adults and devices, devices and devices. Thus, a safer, more convenient, comfortable and environmentally friendly living environment can be built [3]. In order to facilitate users to use and control a variety of smart home products in the space, a certain number of smart home APP cloud platforms are derived, which associate smart home devices with mobile phone apps and control multiple devices through mobile phone terminals.

The interface design of current applications has been repeatedly criticized and is considered to be a factor that makes it difficult to promote smart home products. The reason for these problems is that the interface design of smart home applications does not fully consider the preferences and needs of users [4]. For example, the layout of the interface design does not conform to the user's intuition, resulting in users experiencing unnecessary learning curves when using smart home applications, which is particularly prominent in the rapid iteration of smart home devices [5]. For example, the color may not adequately convey the function or status of the application, or the color combination lacks sufficient contrast and is not friendly to visually impaired users. Small fonts or hard to read fonts can affect the speed and accuracy of reading, especially on mobile devices with limited screen sizes[6]. The size and spacing of buttons in the interface are not optimized, which makes users prone to misoperation when interacting, especially on touch devices, and this design deficiency will significantly affect user experience [7] Users can be frustrated when they are unable to adapt the interface to their own usage habits, and the absence of personalization options limits users' ability to tailor the interface to their personal preferences and needs [8-9]. The limitations of the above study further highlight the importance of studying smart home applications from a user perspective.

2.2. Cognitive Dissonance Theory

In 1957, Leon Festinger first proposed the theory of cognitive Dissonance (CDT) [10]. The core idea of this theory is that when individuals realize that their own attitude or attitude is inconsistent with their behavior, they will have internal discomfort and try to reduce this discomfort by adjusting their attitude or behavior[11]. Its ideological basis stems from Gestalt psychology, one of the most influential theories in the field of Western social psychology research in the 1950s and 1960s [12]. As one of the important theories to explain human attitude and behavior, CDT has been widely used in many fields such as education, psychology, management and information science [13].

Cognitive Dissonance theory (CDT) is an important psychological theory that is widely used in information systems research, especially in exploring an individual's behavioral response when there is a cognitive difference between expected and actual product performance. Post-purchase cognitive dissonance will occur when consumers' perceptions of products before and after purchase are inconsistent[14，15，16]. To reduce the likelihood of cognitive dissonance, consumers need valid information to help them make rational decisions before purchasing. The existing researches mainly focus on the field of consumer decision-making and marketing, but there are few researches on cognitive dissonance in smart home user experience, especially its negative factors and specific trigger mechanisms.

ISSN: 2710-0723

2.3. User Experience

User experience is an interdisciplinary subject, involving a wide range of content, the factors that affect user experience include users, products themselves, social culture and environment, use background and so on. User experience is "how users feel and react when using or expecting to use A product, system, or service"[17]. User experience is not only a matter of perception and emotion, but also includes various factors related to smart home systems, such as interface design, interactivity, feedback mechanisms, performance and reliability. This integrated experience is formed when users use smart home systems and can influence whether they are willing to continue using them, recommend them to others, and their attitudes towards the system or product [18].From the perspective of the content of user experience, the literature generally believes that user experience involves three aspects: user, product and interactive environment. The most influential definition of user experience is that given in ISO9241-210: all reactions and consequences of a product, system, or service used or expected to be used[19]. This definition points out that user experience is generated during the interaction between users and products, including users' psychological feelings, physical feelings and the results brought by user experience. The experience results mainly include users' perceptions and reactions, including emotional and physiological reactions. The second is the definition given by the Usability Professional Association (UPA), which summarizes user experience as all user perceptions composed of all aspects of interacting with a product, service, or enterprise[20].The above definition does not give specific factors for evaluating user experience and how to measure user experience. Hassenzahl and Tractinsky defined user experience as the result of the user's inner state (tendency, expectation, demand, motivation, mood, etc.) and the system with certain characteristics (complexity, purpose, usability, functionality, etc.) under a specific interactive environment [21]. In comparison, the definition given by the latter includes almost all aspects of user experience and has certain operability [22].

Through the research of the existing literature, the key role of interface design and usability in the user experience of smart home applications is found. Literature shows that color, pattern and text in interface design may lead to cognitive dissonance of users [8，23]. Similarly, poor usability, such as slow response, cumbersome interaction or unintuitive operations, can also trigger negative emotions and cognitive discomfort among users [24-26]. During the use of smart home applications, users may encounter some negative experiences that trigger cognitive dissonance. In order to delve into the specific factors that trigger these negative experiences, the interviews will revolve around interface design and usability, specifically the obstacles, inconveniences, or design elements they encounter during use that confuse or frustrate them. Interviews provide insight into how users feel and react when using smart home applications, identifying specific issues that may trigger cognitive dissonance.

3. Methods

3.1. Setting of Interview Questions

The question design of this interview mainly focuses on the following contents:

The interview framework(Figure 1) shows the quality of the system that affects the user experience, and the framework is divided into two parts, namely Interface Design and Usability, each of which is subdivided into several elements.

ISSN: 2710-0723

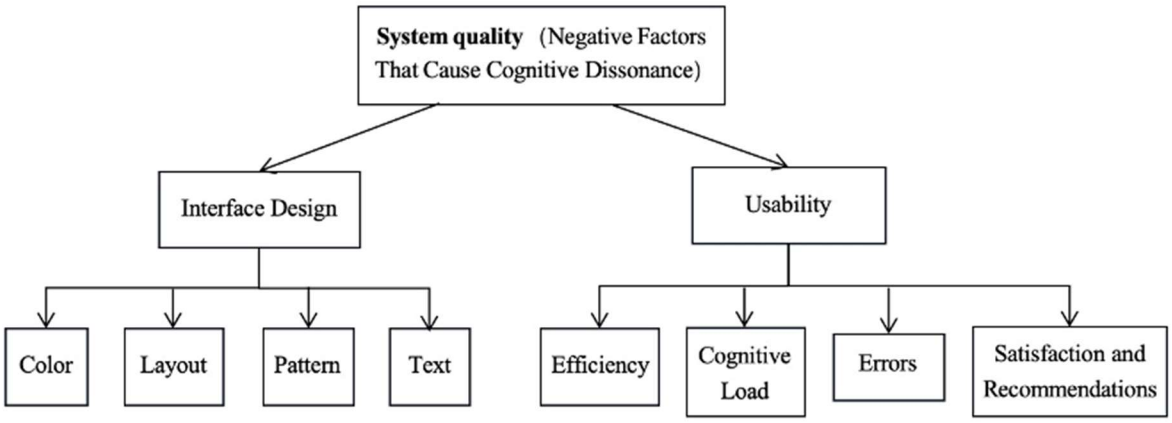

Figure 1. Interview framework

3.2. Data Analysis

Using the method of semi-structured interview, a total of 5 interviewees' interview data were collected. These interviewees are interface designers, experts, and experienced users with some experience. The interview questions revolve around interface design (color, layout, text, pattern) and usability (efficiency, cognitive load, errors, overall satisfaction), with the aim of exploring the negative factors that users face during their use. Subject analysis method was adopted for data analysis. Nvivo software was used to encode and classify the text data.

Table 1. Coded content

Subcategory	Corresponding Category	Connotation of Category
Others	Lack of personalization	Unable to customize page colors and layouts based on preferences.
Icons	Functions not intuitive	Icon design is unclear, requiring clicks to understand functions.
Colors	Poor contrast	Background and text contrast is insufficient; buttons blend in.
Text	Poor readability	Fonts are faint, tightly spaced, small, or use hard-to-understand terms.
Layout	Lack of simplicity	Complex menu layers, non-intuitive page design, and too many ads.
Efficiency	Tedious operations	Features lack instructions, slow connection, complex automation, and poor device compatibility.
Errors	Issues unresolved	Scene settings and device connections fail; system bugs or unresponsive pages.
Cognitive Load	Complex and confusing	Too many technical terms, persistent ads, multi-step operations, and unclear functions.
Overall Satisfaction and Suggestions	Improve compatibility and experience	Enhance automation settings, system stability, and personalization; remove ads and focus on user research.

ISSN: 2710-0723

Table 2. Three-level topic coding

Main category	Subcategory	Frequency
Interface design	Icon	10
	color	12
	Text	13
	layout	16
	other	9
Usability	efficiency	17
	err	19
	Cognitive load	19
	Overall satisfaction and recommendations	42

Through systematic analysis of the data obtained from the interview, in terms of interface design, the interview found that user satisfaction was affected by ICONS, colors, text, layout and other elements. In particular, the understanding of ICONS, the brightness of color matching, the readability of text and the rationality of functional layout all have an important impact on user experience[27]. In terms of usability, efficiency, error frequency, cognitive load, and system stability are key factors in the user experience. Interviews show that improving operation efficiency and reducing error rate can significantly improve user satisfaction [18]. In addition, users also put forward other suggestions, such as adding intelligent recommendation function, improving device compatibility and optimizing user feedback mechanism, which provided valuable references for the improvement direction of Mijia APP [21].

(1) Interface design

In the interview, respondents mentioned that the unclear function of ICONS in interface design, complex layout and single color are the main factors leading to their cognitive dissonance. Specifically, users have reflected that the design of some functional ICONS is too abstract, lacking intuitiveness, and unable to quickly convey its functional meaning, especially when new users use it for the first time, they need to understand its actual use through repeated attempts. This design defect not only increases the cognitive load of the user, but also makes the user feel confused and frustrated in the process of use. The "scene automation" function icon in the smart home application mentioned by the respondents seems simple and beautiful, but the lack of functional prompts leads them to misunderstanding. This kind of icon design is too abstract, which leads to insufficient information transmission in interface design, aggravates the cognitive burden of users, and leads to psychological conflicts [27]. Secondly, the interview results also pointed out that complex interface and single color are also key factors leading to cognitive dissonance. Some interviewed users reported that in the process of setting complex functions, the interface has too many layers, the operation path is not intuitive, and it takes many clicks to find the target function. For example, when you set Device Linkage, you need to search for related options in the multilevel menu, which increases the operation cost. In addition, the single color is believed to reduce the interface recognition, especially in the

ISSN: 2710-0723

information-intensive interface, the lack of color contrast, making it difficult for users to quickly distinguish the functions of different modules, increasing the psychological burden. These problems are more obvious in the process of long-term use, and users are easy to feel dissatisfied because of visual fatigue. Relevant studies also show that the complexity of layout and insufficient color design are common problems that lead to poor user interface experience, especially in multi-step operations involving function Settings, and these design defects are more likely to trigger cognitive conflict[28].

(2) Usability

The interviews also revealed that usability issues, in particular system response delays, device connectivity failures, and the instability of automation functions, are another core factor triggering cognitive dissonance among users. Respondents generally reported that during the device connection process, some smart home devices required multiple attempts to successfully connect, or were interrupted in the middle of the connection. This not only increases the user's time cost, but also weakens the user's sense of trust in the system. Some respondents also mentioned that after the connection failed, the system failed to provide clear error prompts or guidance, causing them to repeatedly try the wrong operation path, resulting in frustration and anxiety, leading users to perceive significant inconsistencies between the functional design and the intended effect, which aggravated psychological conflict. Secondly, the instability of the automation function is also a major pain point in the user experience. Some users said that when setting up smart home automation scenarios, it is often impossible to achieve the expected operation. The uncertainty of this automation function not only creates a strong sense of frustration among users, but also increases their doubts about the reliability of the system. Interview data show that the root cause of such problems is that the functional design of smart home applications fails to fully consider user needs and device compatibility in complex scenarios, resulting in cognitive dissonance. Relevant studies have also pointed out that the unreliability of automated functions can significantly reduce user satisfaction and become a major source of cognitive burden[29].

4. Discussion

4.1. Interface Design Improvement Measures

(1) Enhance the intuitiveness of the icon

As the main medium for users to interact with the interface, the intuitive design of ICONS directly affects the user's understanding of functions and the fluency of operations. In the study, it was found that some users could not quickly recognize their functions because the icon design was too abstract, resulting in increased operation time and even frustration. Therefore, improving icon intuitiveness is one of the key links to optimize the interface. By optimizing the design logic and visualization effect of ICONS, the exploratory operation of users in the interface can be reduced, the cognitive load can be reduced, and the user can be provided with a more convenient user experience.

(2) Increase the layer of the interface

The visual hierarchy of the interface is an important factor affecting the user's visual experience and operation efficiency. The results show that some users have visual fatigue and operation trouble when using the interface for a long time because of single color matching and unclear module distribution. Therefore, optimizing the layout and color collocation of the interface to increase the sense of layer can not only improve the aesthetic of the interface, but also significantly improve the user experience. Secondly, optimizing color matching is the key to increasing visual layers. At present, many interface designs tend to use a single tone to keep the style simple, but this design will reduce the user's recognition of interface elements to a certain extent. It is recommended that on the basis of maintaining the overall color consistency, the

ISSN: 2710-0723

appropriate introduction of contrasting colors or accent colors is used to highlight the core information or operation buttons. It can also be combined with gradient color and shadow design to enhance the layer effect of interface elements. By optimizing the layout and color matching, the interface can not only be more visually distinct, but also more functionally guided and easy to operate.

4.2. Conclusion

This study conducted an in-depth investigation into the main negative factors that trigger cognitive dissonance in the interaction process of smart home application users through qualitative interviews, and identified specific factors that trigger cognitive dissonance. The results of the interview reveal that the inadequacy of interface design and usability problems are important antecedents of cognitive dissonance. Based on the interview results, this paper puts forward improvement strategies to improve application interface design. Based on the cognitive dissonance theory, this paper extends its application to the research of smart home user experience, providing a new perspective for the existing research.

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