Research on the Attenuation Law of User Experience Satisfaction of Mobile Phone

Xuesheng Pei1,2*, Yang Wang1
1 School of Art and Design, Henan University of Science and Technology, Luoyang, Henan, 471000, China
2 School of Mechatronic Engineering and Automation, Shanghai University, Shanghai, 200000, China
*Corresponding author’s e-mail: pxsh12@126.com

Abstract. With the continuous development and widespread popularity of smart phones, people have been deeply studying mobile phones, and pay more attention to user experience. Based on literature research, this paper establishes a hierarchical chart of influencing factors of user experience satisfaction of mobile phone. A calculation method of user experience satisfaction is proposed. User interviews are used to determine the key factors, and user satisfaction model is constructed. Using questionnaire survey method to collect data and explore the process and rules of satisfaction changes in the process of purchasing, using and replacing mobile phones. The results show that user experience satisfaction of mobile phone decreases with the increase of mobile phone usage time, and battery loss, running stuck, damage and insufficient storage space are all key factors affecting the satisfaction of mobile phone users. Through data analysis, the change rule of user experience satisfaction of each key factor is obtained, and then guide relevant enterprises to upgrade and improve products pertinently.

1. Introduction
With the rapid development of mobile Internet technology, smart phones are rapidly popularized. However, the measurement and evaluation of mobile phones are often based on the evaluation of their hardware and software performance, but lack of attention to user experience. For a mobile phone, users will experience the process of purchase, use, (maintenance), replacement and so on. Especially in the use stage, user experience satisfaction change with the use of time. At present, there is still a lack of research on some issues, such as the factors leading to the change of satisfaction and the regularity of the change of satisfaction. Therefore, this study analyzes the influencing factors of mobile user experience satisfaction, establish a satisfaction model, and explore the reasons and rules of the change of mobile user experience satisfaction. This study will help mobile phone developers to improve the metrics of mobile phones in a targeted manner and improve user loyalty to the brand. At the same time, this study also provides some reference for the related research of user experience satisfaction.

2. Relevant research status

2.1. Summary of user experience evaluation
By consulting relevant literature, the current concept of user experience satisfaction mainly comes
from the research of user experience measurement. Through reviewing the development and achievements of user experience at home and abroad, Ding Yi et al. put forward the elements of user experience, measurement methods, evaluation model, especially the evaluation method of integrating multiple evaluation indicators, which are the focus and difficulties in future research[1]. User experience has the characteristics of constantly changing with the process of using products by users. Therefore, it is necessary to collect data of user experience at different stages, including some measurements which aim at expected experience, immediate experience and long-term experience[2]. Law pointed out that the construction of user experience model is the basis of evaluating user experience, he believed that user experience evaluation should focus on the distribution of index weight and the evaluation of overall user experience[3].

2.2. Summary of mobile phone user experience research
For the user experience of mobile phone, Luo Shijian et al. put forward a user experience design method which based on usage scenarios, and validated the method by taking the design of mobile phone interface as an example[4]. By collecting the factors of satisfaction and dissatisfaction in the use experience of smart phone users, Si Yaqing et al. put forward that the results of user experience are reflected in emotions, satisfaction and intention of continuous use, and expounded the psychological changes of users when there is a difference between users psychological expectations and their actual use feelings[5]. Li Ding studied the modeling design of mobile phone based on user experience, pointed out the changing psychological needs of users, and promoted the innovation of mobile phone design concepts[6].

To summarize, although scholars' research on user experience has been relatively consummate, there is still a lack of research on the changing law of user experience satisfaction.

3. Brief analysis of the factors influencing the satisfaction of mobile user experience

3.1. Sorts and analysis of factors
User experience satisfaction mainly refers to the gap between users' psychological expectations of products or services and actual experience. The smaller the gap, the higher the satisfaction. Through investigation and analysis, this study divides the factors affecting the satisfaction of mobile user experience into four aspects: formal factors, economic factors, performance factors and humanistic factors. Formal factors refer to the form, color, quality and other external manifestations of the mobile phone, which is the most direct feeling of the product to the users; economic factors refer to the price, value of the goods before and after the purchase of the mobile phone and the impact of the relationship between the two on the user experience; performance factors mainly refer to the performance indicators provided by the mobile phone, reflecting the overall operation of the mobile phone; humanistic factors mainly refer to the cultural background and consumer psychology of consumers.

3.2. Establishment of hierarchical diagram
For mobile phones, formal factors mainly include the shape, color, material, weight and wear of the mobile phones; economic factors mainly include the brand, price and potential advantages and disadvantages of the mobile phones; performance factors mainly include the network performance, battery performance, storage space and operation speed of the mobile phones; and the humanistic factors include the user's cultural background, class background, consumer psychology and so on.

The hierarchical diagram is shown in Figure 1, it was established by assorting and extracting factors that affecting user experience satisfaction of mobile phone. Moreover, it can provide a preliminary theoretical support for further exploring the attenuation law of user satisfaction with mobile phones.
4. Construction and hypothesis of model

4.1. Proposal of satisfaction computing method
The products themselves have the characteristics of functionality, economy, humanity and aesthetics, which together determine the overall satisfaction of users for a product. However, the importance coefficients of each factor of different products are different. According to the use status of products, they can be divided into durable products, value-preserving products and general products. Furthermore, general products also include learning products, maintenance products and accidental damage products. Mobile phones belong to general products. At the same time, they have the characteristics of maintenance products and accidental damage products.

Based on the above analysis, this study proposes a calculation method for user experience satisfaction:

Assume each factor's satisfaction: performance factor's satisfaction is \( F \), brand factor's satisfaction is \( B \), price factor's satisfaction is \( P \), and aesthetic factor's satisfaction is \( A \).

Assume importance coefficient: performance factor is \( K_1 \), brand factor is \( K_2 \), price factor is \( K_3 \), and aesthetic factor is \( K_4 \).

Comprehensive cumulative satisfaction:

\[
MP = K_1 F + K_2 B + K_3 P + K_4 A \quad \text{Eq.1}
\]

Considering the mutual influence of various factors, if any aspect is seriously dissatisfied, the product will not be selected. Then list the satisfaction product coefficient as:

\[
MT = FBPA \times 10^{-8} \quad \text{Eq.2}
\]

Comprehensive satisfaction is the product of cumulative satisfaction and product coefficient:

\[
M = MP \times MT \quad \text{Eq.3}
\]

Because of different users having different experiences on various factors of the product, their satisfaction is not the same. So the order of the results may also be different.

4.2. Mobile phone user satisfaction model construction
On the basis of a large amount of literature research, this study uses the main idea of the User Satisfaction Index Model (CSI)[7] to construct a mobile phone user satisfaction model, as shown in Figure 2.
4.3. Research hypothesis

After factor analysis, this study conducted user interviews with a number of users, selected the mobile phone usage time as an indicator to reflect the overall decline of mobile phone user experience satisfaction, and selected battery loss, damage degree, running stuck degree, storage space size as four key factors, and put forward research hypothesis.

4.3.1. Mobile phone usage time. With the increase of the use time of a mobile phone, the stability of various performance will change, and to a large extent affect the satisfaction of users. Just as the satisfaction of users for devices is the highest when new a mobile phone are purchased, with the passage of time, the satisfaction will vary. As a result, we propose the following assumptions:

Hypothesis 1 (H1) Mobile phone usage time is positively correlated with overall satisfaction decline of user experience.

4.3.2. Battery Loss. With the use of mobile phones, the total battery capacity will be irreversibly attenuated, which will have a great impact on the experience of mobile phone users. Whether the mobile phone's battery life is outstanding is also one of the reasons why users consider changing their mobile phones. As a result, we propose the following assumptions:

Hypothesis 2 (H2) Mobile phone battery loss is positively correlated with user experience satisfaction attenuation.

4.3.3. Degree of Damage. Daily use of mobile phone will inevitably occur wear and tear, different degrees of wear will have different degrees of impact on mobile phones: light to affect the appearance, serious to different parts of the damage directly affects the use of mobile phones. Therefore, the degree of wear and tear of mobile phone will affect the satisfaction of user experience to a great extent. As a result, we propose the following assumptions:

Hypothesis 3 (H3) The degree of mobile phone damage is positively correlated with the decline in user experience satisfaction.

4.3.4. Degree of running stuck. With the increase of mobile phone usage time, the hardware of the mobile phone will experience different degrees of loss. Application updates have higher requirements for mobile phone hardware performance. These will cause the phone to be stuck in different degrees. The slow running speed of mobile phones greatly affects the user's mood and seriously affects their satisfaction. As a result, we propose the following assumptions:

Hypothesis 4 (H4) The degree of mobile phone running stuck is positively correlated with the attenuation of user experience satisfaction.
4.3.5. **Storage space size.** Storage of photos, applications, system information and so on all shall occupy the storage space of mobile phones. With the increase of data and files, the storage space will gradually decrease. When the mobile phone space is too small to download applications and files, or the frequent prompt storage space is insufficient, it will seriously reduce user experience satisfaction. As a result, we propose the following assumptions:

Hypothesis 5 (H5) The size of storage space of mobile phone is positively correlated with the decline of user experience satisfaction.

5. **Questionnaire design and data collection**

5.1. **Questionnaire design**

This study uses a questionnaire survey method to guide users to fill out questionnaires based on their actual experience. From the purchase to the replacement of a mobile phone, the process of satisfaction change is a potential variable that cannot be measured visually. Therefore, it is necessary to obtain or estimate the useful data required for the study by observable and descriptive variables. The questionnaire mainly investigated and analyzed the factors such as mobile phone damage, battery capacity, running stuck, storage space, etc., and interviewed some users to get more data needed for this study.

5.2. **Data collection**

Questionnaires are conducted online and offline. Online surveys use the "Questionnaire Star" online survey website to collect questionnaires. Offline surveys are mainly completed through paper questionnaires. The subjects of the survey are mainly students, teachers and the general public. It is generally believed that the number of survey samples should be 5-10 times the number of survey items. There are 20 questions in this questionnaire, 164 questionnaires were collected, 160 valid questionnaires, the effective recovery rate is 97.6%, which meets the research requirements. The data of valid questionnaires and the corresponding question items of hypotheses are counted by Excel table. Some of the questions are listed in Table 1.

| Hypothesis | Source issues |
|------------|---------------|
| H1         | Mobile phone usage time&Overall Satisfaction |
| H2         | Standby time of mobile phone、Percentage of battery loss |
| H3         | Damaged part、Mood after breakage |
| H4         | Sorting the Importance of the Reasons for Changing Mobile Phones |
| H5         | Sorting the Importance of the Reasons for Changing Mobile Phones |

5.3. **Data Reliability Test**

Reliability refers to the degree of consistency of the results obtained when repeating measurements on the same thing, reflecting the stability and reliability of the measurement tool and the true degree of the measured features[8]. In this study, the SPSS 20.0 tool was used to test the reliability of the questionnaire data using Cronbach’s Alpha coefficient and split-half reliability coefficient, which were shown in Table 2.

| Reliability index                      | General questionnaire |
|---------------------------------------|-----------------------|
| Cronbach’s Alpha coefficient          | 0.722                 |
| Split-half reliability coefficient    | 0.762                 |

After testing, the overall Cronbach’s Alpha coefficient of the data in the questionnaire was 0.722, and the split-half reliability coefficient was 0.762, indicating that the questionnaire had good reliability.
6. Model Verification and Analysis of Satisfaction Attenuation Law

6.1. Hypothesis 1 (H1) Mobile phone usage time is positively correlated with overall satisfaction decline of user experience.

![Figure 3](image1.png)

Figure 3. Attenuation curve of overall user satisfaction.

According to the data of the mobile phone usage time (x) and overall satisfaction (y) in the questionnaire, through the conversion and processing of some data, the coordinate scatter plot is drawn by Excel spreadsheet, and the trend line is generated, as shown in Figure 3. With the increase of mobile phone usage time, the overall satisfaction of users shows a gradual downward trend, and the decline of satisfaction shows a gradual upward trend. Therefore, the usage time of mobile phone is negatively correlated with the overall satisfaction of users, and the usage time of mobile phone is positively correlated with the decline of the overall satisfaction of users.

6.2. Hypothesis 2 (H2) Mobile phone battery loss is positively correlated with user experience satisfaction attenuation.

![Figure 4](image2.png)  
![Figure 5](image3.png)

Figure 4. Percentage change curve of battery performance attenuation.
Figure 5. Lithium ion discharge capacity decay curve.

According to the data of mobile phone usage time (x) and the attenuation degree of mobile phone's standby time (y) in the questionnaire, the coordinate scatter plot is drawn by using Excel table through the transformation and processing of part of the data, and the trend line is generated, as shown in Figure 4. As can be seen from the figure, for different users, with the increase of mobile phone usage time, the battery life is shortening, battery performance is declining, the attenuation of standby time (%) of mobile phone shows a gradual upward trend, which reflects the continuous decline of user experience satisfaction. At the same time, according to Yang Peng's research on capacity decay of lithium-ion batteries, the capacity of lithium-ion batteries reduces with the increase of charge-discharge cycle numbers, as shown in Figure 5[9]. Therefore, the number of battery cycles is positively correlated with battery loss (%).

6.3. Hypothesis 3 (H3) The degree of mobile phone damage is positively correlated with the decline in user experience satisfaction.

This hypothesis involves four questions in the questionnaire: the wear and tear of mobile phone, the place of breaking, the impact on performance after breaking and the mood after breaking. The mood
after breaking indicates the decline of user experience satisfaction from the side. According to the statistics of the broken part and the mood after the breaking, 42.31% and 30.77% of the users expressed "a little unhappy" and "relatively uncomfortable", while 26.92% of the users chose "indifferent" and "very uncomfortable". According to the analysis of the user's mood changes based on the broken part, 43.75% of the users chose "more uncomfortable" after the smash screen, which was the highest proportion. However, after the corner, border and back of phone are broken, the change of user's mood is "a little unhappy", which is the highest proportion. Therefore, mobile phone breakage leads to a decline in satisfaction, especially screen breakage, which has a greater impact. The data and results of this analysis are presented in the form of pie chart, as shown in Figure 6.

![Pie chart of user's mood change after mobile phone breakage.](image)

6.4. Hypothesis 4 (H4) & Hypothesis 5 (H5) The degree of mobile phone running stuck and the size of storage space are positively correlated with the attenuation of user experience satisfaction.

According to the question item of “importance ranking of reasons for changing mobile phones” in the questionnaire, after data integration and processing, the importance ranking “running stuck > insufficient storage space > broken down > battery durability > wear > slow network speed > other”. The user chooses to change the mobile phone, which means that the experience satisfaction has reached or will reach the lowest point, and the data indicates that the slow running speed and insufficient storage space are the primary factors for the user to change the mobile phone. So the degree of mobile phone running stuck and the size of storage space are positively correlated with the attenuation of user experience satisfaction.

6.5. The general rule of mobile phone user experience satisfaction decline

It can be seen from the above analysis that the user experience satisfaction decreases with the increase of the use time of the mobile phone, and the key factors for the slow decline of satisfaction are battery loss, running stuck, damage, and insufficient storage space. At the same time, the sudden breakage and maintenance of mobile phones, which can also cause a sharp decrease or rise of the user experience satisfaction.

7. Conclusion

This study used the methods of user interviews and questionnaires to analyze the influencing factors of user experience satisfaction and establish the key influencing factors. Then the satisfaction calculation method was proposed, the satisfaction model was constructed and the model was validated by the questionnaire data. The results of this study can guide enterprises to improve products in a targeted manner, thereby improving user experience satisfaction and ensuring the sound development of products. At the same time, the satisfaction calculation method proposed in this paper will provide academic and theoretical support for researchers in related fields.

There are still some shortcomings in this study. Firstly, the sample size of the questionnaire survey is small, because the mobile phone user group is very large, 160 valid questionnaires are not enough to represent all users accurately; secondly, this study does not consider the impact of gender, age and
occupation on the research results, and will continue to study in the future to obtain more accurate and complete research results[10].

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