Wearable Services Adoption Study from a Perspective of Usability

Zhongwei Gu[1] and June Wei[2(✉)]

[1] Shanghai Dianji University, Pudong, Shanghai, China
zwgu@qq.com
[2] University of West Florida, Pensacola, FL, USA
jwei@uwf.edu

Abstract. This paper explores the adoption of wearable services from the perspective of usability. Firstly, three factors influencing the usability of wearable services are proposed, namely device characteristics, APP characteristics, network characteristics. Secondly, we put forward an adoption framework based on usability of wearable service. The empirical analysis results from the structural equation model analysis show that device characteristics, APP characteristics and network characteristics have significant impacts on the usability of wearable services, and usability significantly affected use intention. It indicates that the characteristics of wearable devices are very important and consumer satisfaction needs to be improved urgently. The conclusions of the study can provide references for the usability and adoption of wearable services, and point out the direction of product development for wearable device manufacturers.

Keywords: Wearable service · Usability · Device characteristics

1 Introduction

Wearable service refers to a new service model that comprehensively utilizes various wearable devices, wearable apps and related technologies (sensors, cloud computing, big data and wireless network etc.), and has the capability of scenario computing and natural human-computer interaction, so as to be applied in healthcare, entertainment, social commerce and other fields. At present, the world is entering the era of 5G plus Internet of Things (IoT), which indicates that wearable services will definitely enter a period of rapid development. Wearable devices market is expected to reach 500 million dollars in 2021 [1]. However, due to the limitations of wearable devices, the backward of APP software and the imperfect of communication network, the adoption of wearable services will bring certain negative effects. These factors include wearables' comfortability, beauty, durability, size, input/output efficiency, store capacity, connection and transmission speeds etc. These disadvantages are determined by the characteristics of wearable devices, APP, communication network etc. which will affect the usability and thus the adoption of wearable services.

Traditional adoption studies are mostly based on classic technology adoption theories such as TAM, but the main factors of TAM model are subjective rather than objective description of technology itself. Therefore, the TAM model has a limited role in guiding the research on wearable service adoption. Compared with perceived usefulness (PU) and perceived ease of use (PEOU) factors in TAM model, usability is a more objective concept. The research of many scholars has shown that usability is an important factor in the success and wide adoption of mobile services [2, 3]. Wearable services are similar to mobile services, so this paper hopes to study the adoption of wearable services from the perspective of usability, propose a wearable service adoption model based on usability and carry out empirical analysis. It is hoped that it can provide reference for the research on factors influencing the usability of wearable services and the adoption of wearable services, and provide guidance and suggestions for the product R&D and design of wearable device manufacturers.

2   Conceptual Model and Hypotheses

2.1   Conceptual Model

Combined with the above literature and research on wearable manufacturers, this article finally builds a wearable service adoption model based on usability (Fig. 1 below). Among them, five variables will be evaluated, including device characteristics, network characteristics, APP characteristics, usability and use intention.
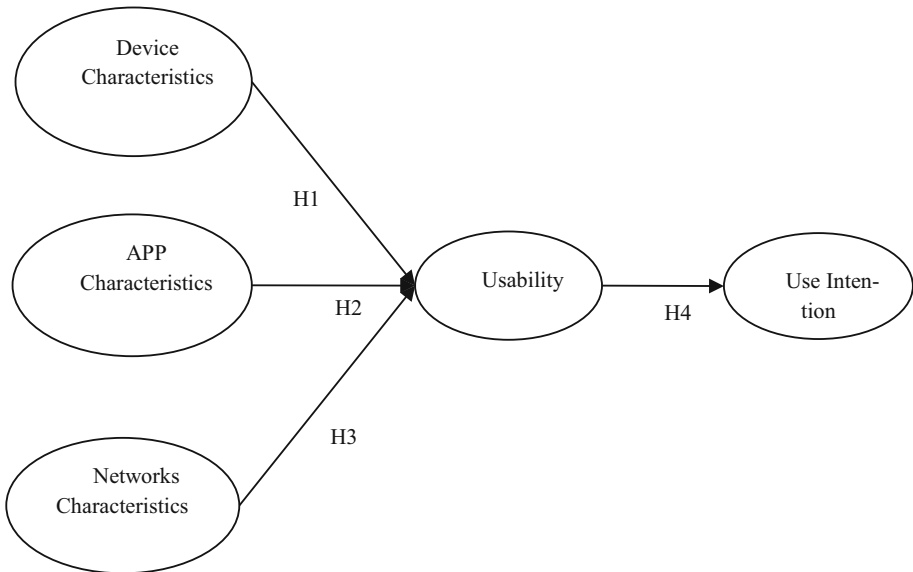
Fig. 1. Conceptual model of wearable adoption

2.2   Hypotheses

Device Characteristics. As a new kind of device, wearable device is quite different from traditional desktop device and handheld device. Many scholars point out that the important factors restricting the development of wearable devices include battery life, input and output mode, storage capacity and so on [4]. Wearable devices are closer to our bodies than handheld or desktop devices. These devices stay with us longer even at night (for example, bracelet used for monitoring sleep). So, the device must have comfortable wearing with higher durability and endurance. For outdoor activities, these devices also need to be beautiful, not too large or too heavy, and in some cases need better waterproof ability. Of course, the capabilities that other mobile devices have, such as processing speed, storage capacity etc., also need to be considered. Now consumers have high expectations for wearable devices and diversified demands, which bring new challenges to hardware manufacturers. To sum up, these factors will directly or indirectly affect the usability of wearable services. Therefore, the following hypothesis can be made:

H1: wearable device characteristics significantly affect the usability of wearable services.

APP Characteristics. Due to the limitation of screen size, the User Interface (UI) design and interaction design of wearable APP have higher requirements. The layout of the content presented in the software's user interface needs to help reduce search time, improve user efficiency in completing tasks, and increase user satisfaction. Hsiao et al. believe that the personalized design of wearable devices will affect consumers' choices [5]. More and more personalized demands require UI design that is not only convenient for users but also customized by users.

In order to improve user experience, the interaction process of the software can be minimized by using voice interaction or visual recognition, such as using the intelligent voice assistant to control the software operation of the wearable device, authentication payment through fingerprint or face scan for identification.

At the same time, due to the limitation of computing power and storage capacity, the APP function of wearable devices will be limited. The software should not be too large and the functions should not be too many. Therefore, the development tools and development process of APP are also different from the development of traditional mobile APP.

In a word, the APP development of wearable devices must be able to keep pace with the development of hardware and make up for the shortage of hardware. The characteristics of APP software for wearable devices are very important factors influencing consumer adoption. Therefore, the following hypothesis is proposed:

H2: APP characteristics of wearable devices significantly affect the usability of wearable services.

Networks Characteristics. Before, due to the immaturity of network communication technology, sometimes users were disappointed with it. The main reasons were the slow speed of data transmission, the instability of network access and the low coverage rate, which greatly affected the efficiency of users to achieve the predetermined target. With the commercialization of 5G, network connection speed and transmission rate will be gradually solved. But the issue of coverage could still constrain the growth of wearables.

Especially in sparsely populated countries, network coverage is a challenge, given the wild or time-critical use scenarios.

At the same time, with the development of the IoT, there are more and more types of wearable devices and more and more complex usage scenarios. In the era of internet of everything, the interconnection and compatibility between various heterogeneous networks are becoming more and more important. If we want to break down the barriers between each device and platform, we need to make the network compatible with each other, so that users can switch easily and freely. Xia et al. believes it is important to make wearable devices compatible [6]. Therefore, the following hypothesis is proposed:

H3: network characteristics of wearable devices significantly affect the usability of wearable services.

Usability. Usability is an important variable that affects users' willingness to adopt it. Coursaris et al. summarized 45 empirical research literatures on mobile usability. Efficiency will have an impact on usability, and then the usability of the whole system [7]. In the same way, the effectiveness and high satisfaction to users will make users feel that the system has good usefulness, thus increasing users' intention and adoption of the system. These three essential attributes of usability also apply to wearable services.

This article adds wearablity to the usability concept defined by ISO 9241-11. That is, usability includes efficiency, effectiveness, satisfaction, and wearablity. The biggest difference between wearables and mobile devices is wearablity. The term "wearablity" refers to the capability to provide services through dress or wear without the need for handheld or manual operation.

Of course, wearablity, as one of the core characteristics of wearable devices, is a key attribute that constitutes the usability of wearable services. Wearablity will determine whether people can comfortably use wearable devices, which will largely affect people's PEOU of wearable services, thus influencing users' adoption of wearable services. Therefore, through the above analysis, the author believes that usability will have a critical impact on the adoption of wearable services by users. So, the following hypothesis is proposed:

H5: usability significantly affects use intension to adopt wearable services.

3   Research Method

This paper developed some new measurement items for questionnaires, and adopted 7-point Likert method. We conducted a small sample pre-survey. Preliminary investigation had chosen 50 persons with a wearable device or mobile device using experience. Finally the concrete measurement item and the literature sources are shown in Table 1.

The questionnaire respondent were selected from undergraduate students, graduate students and IT professionals in China. A total of 330 questionnaires were collected, of which 269 were valid. Men accounted for 52% and women make up 48 percent of the population. The majority of respondents were between the ages of 18 and 35 (84.8%). The total proportion of students is 37.9%. Among the students, 82.9% have a bachelor's degree or above, 34.9% have a monthly income below 3,000 yuan, and 37.1% have a monthly income between 3,000 and 6,000 yuan. All of them are Chinese citizens, so the

questionnaire respondent were selected in line with the current research requirements of wearable devices in mainland China.

Table 1. Improved measurement scale

Variable		Indicators	Index content	Source
1	Device Characteristics (D)	D1	Wearable devices must be durable, waterproof and dustproof	Literature [8]
		D2	Wearables should be comfortable to wear	New item
		D3	Wearable battery life is important	Literature [4]
		D4	The information input of wearable devices should be more convenient	Literature [9]
		D5	Wearables have more computing power and are faster	Literature [9]
		D6	Wearable devices should have the right storage capacity	Literature [9]
2	APP Characteristics (A)	A1	UI layout design of wearable device APP is very important	New item
		A2	Interactive process design of wearable device APP is very important	New item
		A3	I hope my wearable device can customize the UI interface and functions	New item
3	Network Characteristics (N)	N1	I think compatibility between networks is important	New item
		N2	I want my wearable device to connect to other devices quickly	New item
		N3	I want the wireless Internet to download as fast as possible	Literature [12]
		N4	I hope the signal on the wireless network is stable	Literature [12]
		N5	I hope wireless coverage can be higher	Literature [12]
Usability (U)		U1	Wearables should be comfortable to wear.	New item
		U2	Wearable services can improve my productivity.	Literature [11]
		U3	Wearable services can improve my work.	Literature [11]
		U4	I'm happy with the wearable service	Literature [11]
Use Intension (UI)		UI1	I'm willing to buy wearables and try out some apps	Literature [10]
		UI2	I am willing to provide necessary personal information to wearables providers	Literature [10]
		UI3	I will try to use wearable devices in the future	Literature [10]

4   Data Analysis and Results

4.1   Reliability and Validity Analysis

First, the Bartlett sphericity test was performed using SPSS24.0. The results showed that the KMO value of the sample data was 0.894. Four factors were extracted from principal component analysis, the variance interpretation rate was 74.696%, and the load values of each index's corresponding factors were all greater than 0.5, while the factor load values of the cross variables were all less than 0.5, indicating that the samples had good convergent validity and discriminant validity.

Through confirmatory factor analysis the mean variance extraction (AVE) of all variables is greater than 0.6, indicating that the scale has good convergent validity, and the composite reliability (CR) is higher than 0.8, indicating that the scale has good reliability.

4.2   Structural Model: Hypothesis Testing

This article uses LISREL to test the model's hypotheses, as shown in Table 2. Data analysis results showed that all the hypotheses were significant at the p < 0.05 level, with H1, H3 and H5 being significant at the p < 0.001 level.

Table 2. Hypotheses testing results and path coefficient

Hypothesis	Testing results	Path coefficient
H1	Supported	0.44***
H2	Supported	0.15**
H3	Supported	0.34***
H4	Supported	0.95***

5   Discussion and Conclusion

Discussion. Data analysis results show that wearable device characteristics, APP, network characteristic and usability all have positive significant effect. The device characteristic's influence on usability is the largest, the path coefficient of device characteristics is 0.44. This shows that consumers still pay great attention to the special value brought by wearable hardware products. Consumers have high expectations for wearable device characteristics, such as durability, endurance, size and comfortability. This also indicates that the gap between device characteristics and consumer ideal is the most obvious in the process of wearable services at present. Secondly, the path coefficient of network characteristics is 0.34, indicating that good network communication is a necessary condition for the use of wearable services, and consumers are well aware of this. Thirdly, the path coefficient of APP characteristic, 0.15, also significantly affects the usability of wearable services, indicating the importance of APP, which can be adapted to hardware, bring personalized customization functions to consumers, and improve the efficiency, effectiveness and satisfaction of wearable services.

The hypothesis that the usability of wearable services has a significant impact on consumers' use intentions has also been verified, with a path coefficient of 0.95, indicating that improving the usability of wearable services is the best way to fundamentally improve consumers' use intentions.

Conclusion. This paper proposes a new attribute of wearable service usability, namely: wearablity. This new attribute is put forward for the first time on the basis of integrating all kinds of literature in academia and business circles. Although the adoption of wearable services has been mentioned in the previous research literature, the number of literatures is small, and the perspectives are different. Studying the adoption of wearable services from a usability perspective is a useful attempt.

References

1. Gartner: The forecast of global wearable device shipments in 2015–2021. Forward - Industry Research Institute, Gartner (2017)
2. Han, J., Pei, J., Yin, Y.: Mining frequent patterns without candidate generation. ACM Sigmod Rec. **29**(2), 1–12 (2000)
3. Pasquier, N., Bastide, Y., Taouil, R., et al.: Efficient mining of association rules using closed itemset lattices. Inf. Syst. **24**(1), 25–46 (1999)
4. Liu, D., Cai, S.: Research on influencing factors of wearables user adoption behavior based on the comparative analysis of iWatch and xiaomi. Prod. Res. (11), 68–73, 6 p. (2016)
5. Yang, J., Wang, Q.-P., Hu, H.-N., et al.: New progress in wearable device endurance research. Micro Nano Electron. Technol. **53**(7), 425–430 (2016)
6. Hsiao, K.-L.: Android smartphone adoption and intention to pay for mobile Internet. Libr. Hi Tech **31**(2), 216–235 (2013)
7. Integration technology of smart home and wearable devices. Hunan Normal University (2015)
8. Coursaris, C., Kim, D.: A qualitative review of empirical mobile usability studies. In: AMCIS 2006 Proceedings, p. 352 (2006)
9. Gu, Z., Xu, F., Wei, J., et al.: The empirical study on the influencing factors of consumers' initial trust in wearable commerce. J. Manag. Rev. **27**(7), 168–176 (2015)
10. Buchanan, G., Farrant, S., Jones, M., et al.: Improving mobile internet usability. In: Proceedings of the 10th International Conference on the World Wide Web, pp. 673–680 (2001)
11. Nielsen, J.: Usability Engineering. Morgan Kaufmann, Burlington (1994)
12. Hung, S.Y., Ku, C.Y., Chang, C.M.: Critical factors of WAP services adoption: an empirical study. Electron. Commer. Res. Appl. **2**(1), 42–60 (2003)