User Requirements of Wearable Technology for Activity Tracking

A Comparison Between German and Chinese Users

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Abstract. Wearable technology has been enjoying a growth of market since it first caught attention of the public in 2010. More than 400 wearable devices have been developed and 60 % of them are activity trackers. China has a great market potential for wearable devices due to the high acceptance of wearable technology in Chinese users. It is important and necessary for designers to understand the specific user requirements and preferences of wearable devices for activity tracking and specify the different preferences among China and other countries. In this study, we collected both qualitative and quantitative user requirements of Chinese and Germans then compared the result to elicit practical design instructions. Semi-structured interviews were conducted firstly on ten Germans and ten Chinese to obtain qualitative requirements. A quantitative questionnaire was designed based on the findings of the interviews and a total of 158 respondents participated the survey (52 from Germany, 97 from China and 9 from other countries). Descriptive statistics were summarized and non-parametric tests were used to compare the requirements between Chinese users and German users.

Keywords: Wearable technology · User requirements · Cultural differences · Activity tracker

1 Introduction

Wearable technology has been enjoying a growth of market since it first caught attention of the public in 2010. It was estimated that the Compound Annual Growth Rate would vary between 24.56 % [1] up to as high as 154 % [2] from 2013 until 2017, which would increase the market size to up to $50 billion in 2018 [3].

Wearable devices referred to electronic devices attached and/or embedded in clothes and accessories, which could be worn comfortably on the body [4]. As defined by [5], three distinct characteristics should be included in wearable devices: (1) they integrate seamlessly with the user's fit; (2) they allow for sensory input; and (3) they

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are connected with other devices. More than 400 wearable devices have been developed by worldwide corporations as well as startups [6], among which 193 devices are capable for fitness use and 253 devices are related with lifestyle. These activity trackers were proven to be the most successful among all the wearable devices and accounted for over 60 % of all wearables on the market [5, 7].

Though few studies addressed user requirements for activity trackers, studies revealed how users accepted mobile/wearable technologies. A series of four studies in University of Illinois revealed that (1) there was a strong influence of the perceived maturity of a technology on the adaption. At the same time, the familiarity of the technology impacted the user perceived ease of use [8]; (2) functionality, portability, performance, usability and network were five important features during design of wearable devices [9]; (3) the mobility of a mobile technology was not necessarily geographical moveable but the devices should "roam freely" among different user scenarios [9].

Specifically, preliminary experimental studies pointed out several requirements of wearable devices. In [10], 26 participants used wearable devices in their daily life and indicated two key concerns: (1) data capture and analysis of current technology need to be improved; and (2) privacy problems should be carefully handled. Privacy concerns were also discovered in [11, 12]. "Persistent identity" which meant to identify the identity of a specific user was appealing to users [2, 13]. Other key characteristics of wearable devices included data accuracy, appealing design, ease of use and independency from smartphone. Furthermore, sensor analytics and mobile payments were two promising applications for wearable devices [2].

It is believed that China would become a great market potential for wearable devices with a growth from 420 million to 1 billion in 2015 [14]. Chinese might contribute a significant higher share than western countries based on the results of an online survey with 24,000 respondents in 2014 [15]. Cultural differences between Chinese users and the worldwide designers [16] might challenge the adoption of the designed wearable devices (specially, the activity trackers). It is important and necessary for designers to understand the specific user requirements and preferences of wearable devices of activity tracking and specify the different preferences among China and other countries.

Aimed at figuring out the specific requirements of wearable devices for activity tracking of Chinese users and comparing the findings with those of western countries (German as a representative), preliminary interviews and semi-structured interviews were conducted to collect qualitative requirements. A quantitative questionnaire was designed based on the findings and a total of 158 respondents participated the survey (52 from Germany, 97 from China and 9 from other countries) answered the 39-question survey. Descriptive statistics were summarized and non-parametric tests were used to compare the requirements between Chinese users and German users.

2 Method

2.1 Qualitative Interviews and Findings

The first step of the study were qualitative requirements elicitation interviews. Five preliminary interviews were conducted to understand attitudes towards using wearable

devices for activity tracking. Then semi-structured interviews were conducted with ten German and ten Chinese participants to collect information for questionnaire design. The interview consisted of six sections: (1) "previous experience with wearable devices"; (2) "functional requirements"; (3) "physical appearance"; (4) "battery"; (5) "robustness"; and (6) "data".

The main findings of qualitative requirement elicitation were summarized below. These functions and attributes were used to design the user survey questionnaire.

- A **long battery life** (mentioned by all the 20 participants) was expected though not exact duration could be concluded.
- The preferred **location** of wearing the devices were head and wrist.
- Users thought the **interaction between the wearables and other devices** were important and all of the interviewees agreed the connection to smartphones.
- **Upload activity data** to social network caught interests of the respondents and they expected to gain motivation from the activity share.
- The **privacy and data security** should be guaranteed, especially for the German users (7 out of 10 mentioned the concern).
- Every participant described **desired appearance** of a wearable activity tracker. Frequently mentioned styles included: (1) a conventional watch; (2) jewelry; (3) designs that were outstanding/technical/futuristic; (4) simple design.
- More than two third participants expected a **waterproof** wearable device.
- The **functions** of a wearable devices for activity tracking should include step count, GPS tracking, sleep monitoring, calories burned, cellphone handling capability, conventional watch functionality, and biodata monitoring.

2.2 Requirements Elicitation Survey

The user requirement elicitation surveys were designed based on the results of the interviews. The questionnaire was made up by three sections. The first (1) section was "the participant's personal information". This section comprised the participant's age, their nationality and the familiarity of the user with wearable devices. The second (2) section was "general preferences for wearable devices for activity tracking". In this section, we asked the preferred location of the wearable device, preferred method to unlock the wearable device and preferred appearance of the wearable device. For these three categories, participants could check as many options as they thought appropriate. Multiple choices questions collected the expected battery lifetime, data display, independence of the device and the extent connected to social networks. Then seven items regarding the characteristics of wearable activity trackers were rated using 7-point scale ("1: very important" to "7: not important"). The last section (3) contained 21 functions collected from market research and interview results. Using a 7-point scale, participants rated their perceived usefulness of the functions ("1: Must have" to "7: useless").

The questionnaire was designed in English to avoid misunderstanding caused by interpretation. Online questionnaires were distributed on campus of Tsinghua University.

Descriptive statics were summarized, Mann-Whitney independent non-parametric tests were used to compare the requirements of Chinese and Germany users.

3 Results

3.1 Participants

The questionnaire was answered by 158 respondents (Male = 93, Female = 65), in which 52 were Germany, 97 were Chinese and 9 were from other countries. The age distribution is listed in Table 1. Regarding the previous experience of using wearable devices, up to 54.43 % (86 respondents) did not use wearable devices, 22.78 % (36 respondents) wore the devices sometimes, 7.59 % (12 respondents) wore the devices more than three days a week, 8.86 % (14 respondents) used the devices every daytime and the remaining 6.32 % always wore a wearable device.

Table 1. Age distribution of the participants

Age (years)	<18	18–25	26–30	31–35	41–50	51–55	56–60
Count	1	134	16	2	2	2	1
%	0.63 %	84.81 %	10.13 %	1.27 %	1.27 %	1.27 %	0.63 %

3.2 Location of Wearing the Devices

As illustrated in Fig. 1, the "wrist" was chosen as preferred location by more than 40 % (43.67 %) respondents, regardless of the culture background of the users. The second and third preferred locations were "arms" and "fingers", chosen by 37.34 % and 29.11 % participants, respectively. "Chest", "torso", "legs" and "feet" were only preferred by around 15 % or less respondents, which suggested the designers to avoid these positions.

Comparing the preference between Germans and Chinese, we found that although "fingers" seemed to be a good position, the percentage of Chinese who preferred "fingers" was as twice as that of Germans. Another position that Chinese respondents liked more was "waist", but we thought this difference was caused by the misread on the word "waist" as "wrist". Positions that Germans preferred more than Chinese were "feet", "torso", and "chest", but they were not popular choices for all the participants.

3.3 Unlock Mechanism

As shown in Fig. 2, unlock the wearable devices by fingerprint was the most popular choice (overall percentage 58.23 %). PIN was preferred by nearly 40 % (39.87 %) respondents, which came as the second popular unlock mechanism. An interesting point to notice was that fingerprint was preferred by 65.98 % Chinese while only 46.15 % Germans checked this mechanism. Inverse result occurred in PIN, 55.77 %

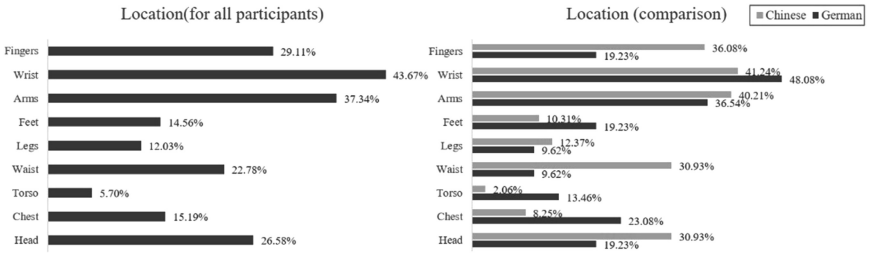

Fig. 1. Preferred location of wearing the devices

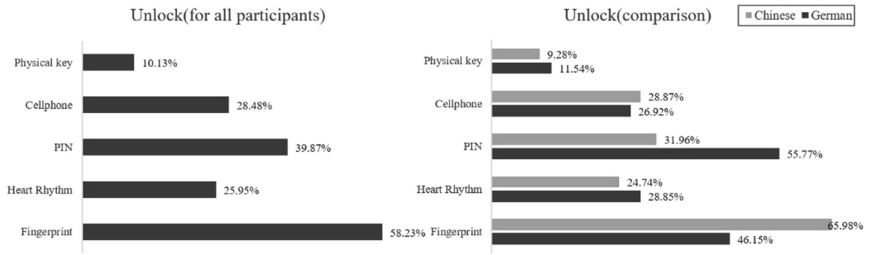

Fig. 2. Preferred unlock mechanism for the devices

Germans chose this option while only 31.96 % Chinese checked the item. We inferred that there was a difference in the preferred unlock mechanism between Chinese and Germans, and suggested unlock by fingerprint for Chinese and by PIN for the Germans.

3.4 Appearance

The top 2 chosen design styles for the wearable devices were "simple design" (60.13 %) and "as a conventional watch" (47.47 %) (See Fig. 3). But "simple design" was much more popular in German users than in Chinese users with a great gap between the percentages (German: 75.00 %, Chinese: 51.55 %). This difference was consistent with the finding that Chinese users enjoyed "outstanding (20.62 %)" and "futuristic (28.87 %)" appearance more, compared with a relatively low preference on these two styles in German users ("outstanding": 5.77 %, "futuristic": 17.31 %). We inferred that although simple design was preferred by most users, the designers also need to integrate outstanding and futuristic features to the devices for the Chinese users.

3.5 Battery Lifetime

The distribution of expected minimal battery lifetime had two peaks (See Fig. 4). More than half participants stated their minimal battery lifetime to be either 1 or 3 days. Due to a relative high selection frequency on the duration "1 week", we would suggest a

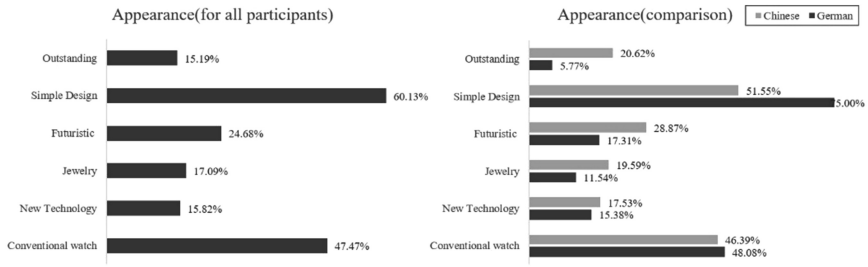

Fig. 3. Preferred appearance of the devices

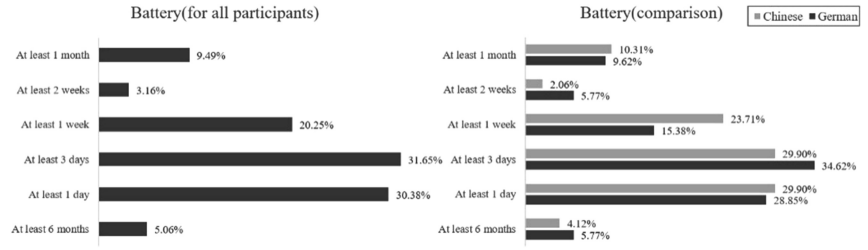

Fig. 4. Minimal battery lifetime of the devices

1-day to 7-day battery lifetime. There was little influence of the culture on the preferred battery lifetime.

3.6 Display

The answer of whether to include a display was demonstrated in Fig. 5. No significant difference was recognized between the Chinese and German respondents. Because more than half respondents (52.53 %) chose to have a display in their wearable devices for activity tracking, we suggested that the device for activity tracking should have a display.

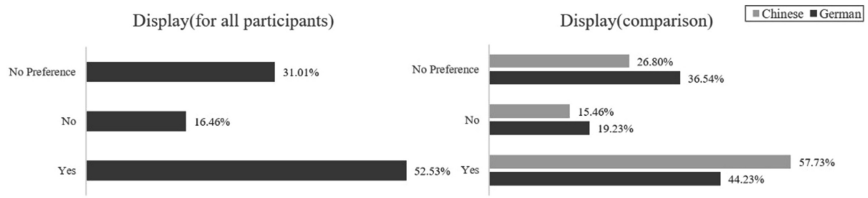

Fig. 5. Should the wearable have a display?

3.7 Dependency on Other Devices

More than 60 % (60.76 %) participants thought their devices should be partially dependent on their smartphones, and cultural difference did not influence the results much (See Fig. 6).

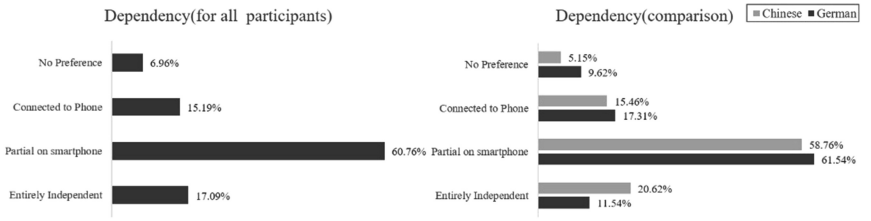

Fig. 6. Should the wearable be used independently from other devices?

3.8 Share Data on SNS

Cultural difference had a great influence on the opinion to share data to SNS (See Fig. 7). Most Germans (69.23 %) stated that they would not share the information on SNS (69.23 %). However, Chinese preferred to share the data (37.11 %) or held a neutral opinion (48.15 %) on whether to share the data to SNS.

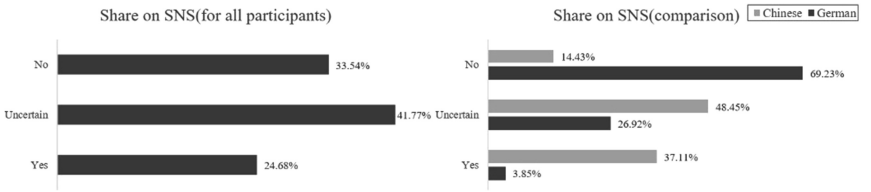

Fig. 7. Would you like to share the data from the wearable in social network?

3.9 Attributes and Features

In Table 2, we listed the importance scores for seven design features of wearable devices for activity tracking. The mean scores for each item were shown with standard deviations given in blankets. All the listed features got a mean score of less than 3 points, indicating that all the features were important. Mann-Whitney independent test was used to determine whether the answers of the Chinese and Germans had statistically significant differences. The bolded score meant significantly more important (significantly lower score). “Good appearance” and “Easy to put on and off” were regarded more important for the Chinese while “Physical robustness” was rated more important for the Germans.

Table 2. The importance of the attributes (1: very important to 7: not important)

	Attributes	All (N = 158)	German (n = 52)	Chinese (n = 97)	p-value
A01	Good appearance	2.36(1.4)	2.85(1.65)	**2.09(1.22)**	<0.01
A02	Easy to put on and off	1.80(1.15)	1.98(1.08)	**1.7(1.18)**	<0.05
A03	Small size	2.22(1.13)	2.1(0.93)	2.25(1.23)	
A04	Low weight	1.86(1.14)	1.96(0.97)	1.79(1.26)	
A05	Device is waterproof	2.08(1.39)	1.88(1.17)	2.14(1.51)	
A06	Physical robustness (e.g. shatterproof)	2.01(1.12)	**1.65(0.9)**	2.22(1.19)	<0.01
A07	Privacy and data security	1.85(1.29)	1.67(0.98)	1.91(1.42)	

3.10 Functions

In Table 3, we listed the mean score and standard deviation (in blankets) for 21 functions. A less than 3.5 point meant that the function was useful. From a comparison of the ratings using Mann-Whitney test, we concluded that the preferences varied between Chinese and Germans. The significantly more useful (lower score) were bolded.

Useful functions selected by both cultures were: GPS tracking, alarm clock, intelligent alarm, sleep monitoring, calories burned, watch, blood pressure measurement, find the device, charging by induction, and inform the incoming call.

Some functions were thought as useful only by the Chinese: mobile payment, wireless key, step count, activity identification, and temperature measurement, monitoring audio data, illness detection, calendar, voice control, and display test message. Mann-Whitney test results showed that except for the "monitoring audio" function, all the differences between the Chinese and Germans were significant at 95 confidence level.

Table 3. The usefulness of the functions (1: must have to 7: useless)

	Functions	All (N = 158)	German (n = 52)	Chinese (n = 97)	p-value
F01	Mobile payment (ability to pay with the wearable device)	3.86(1.82)	4.71(1.82)	**3.38(1.69)**	<0.001
F02	Wireless key (opens car/house doors wirelessly, unlocks the cellphone, etc.)	3.33(1.7)	4.02(1.82)	**2.92(1.55)**	<0.001
F03	Step count (calculates the steps taken every day)	2.99(1.69)	3.67(1.99)	**2.62(1.42)**	<0.01
F04	GPS tracking	2.37(1.35)	2.46(1.49)	2.28(1.29)	
F05	Alarm clock	2.83(1.54)	3.10(1.61)	2.72(1.52)	

(*Continued*)

Table 3. (*Continued*)

	Functions	All (N = 158)	German (n = 52)	Chinese (n = 97)	p-value
F06	Intelligent alarm clock (wakes the user up in phases of light sleep within a preset timeframe. This improves the users sleep quality)	2.80(1.58)	3.27(1.83)	**2.56(1.41)**	<0.05
F07	Sleep monitoring (keeps track of the time slept and deep sleep periods)	2.90(1.64)	3.35(1.84)	**2.66(1.46)**	<0.05
F08	Device calculates the calories burned	2.84(1.73)	3.48(2.04)	**2.45(1.43)**	<0.01
F09	Substitutes a watch, (i.e. displays time conveniently)	2.40(1.27)	2.42(1.41)	2.31(1.13)	
F10	Activity identification (the device can tell, which activity is performed, e.g. tennis, football, office work, driving a car.)	3.27(1.74)	3.94(1.95)	**2.91(1.58)**	<0.01
F11	Blood pressure measurement	2.92(1.45)	2.98(1.43)	2.78(1.42)	
F12	Body temperature measurement	3.09(1.46)	3.52(1.61)	**2.8(1.32)**	<0.01
F13	Monitoring of audio data	3.53(1.77)	3.9(1.98)	3.29(1.63)	
F14	Monitoring of video data	4.00(1.74)	4.83(1.72)	**3.57(1.6)**	<0.001
F15	"Find the device function" (wearable device can be found by with the user's cellphone or personal computer)	2.42(1.33)	2.88(1.49)	**2.12(1.18)**	<0.01
F16	Illness detection (the device detects the health status of the user)	2.99(1.72)	3.75(1.74)	**2.56(1.58)**	<0.001
F17	Induction charging (the device can be charged by induction)	2.59(1.35)	2.85(1.49)	2.45(1.29)	
F18	The device includes a calendar	3.31(1.67)	3.73(1.73)	**3.08(1.64)**	<0.05
F19	Voice control (the device can be controlled by voice commands)	3.18(1.78)	3.85(1.98)	**2.77(1.56)**	<0.01
F20	Display of text messages from smartphone	3.22(1.77)	3.67(1.91)	**2.96(1.68)**	<0.05
F21	Inform user about incoming call	2.81(1.68)	3.15(1.97)	2.58(1.47)	

4 Discussion

Among all the features and functions rated in the questionnaire, we found the biggest difference between Germans and Chinese was on whether to share the activity data to the social networks. Chinese users supported the opinion to share data to SNS while most Germans denied this idea. The different preference regarding the connection to social networks was also reflected in the results of the semi-structured interviews.

This difference could be partially explained by the different use patterns of social networking services [17]. Chinese had a share of 61.6 % of mobile users amongst the users of social networking services [18]. A survey in Germany on the other hand revealed that in 2013 only 18 % of German participants regularly used their mobile devices to access social network services [19]. The difference in behavior did also manifest in the spread of different types of social networking services in China and Germany. In 2014 Facebook had a market share of 71 % in Germany [20], while the social networking services in China did focus more on mobile use, as for example WeChat, which was used by 73 % of the Chinese online population [21].

Another noticeable item was "mobile payment". It was rated second highest (second important) by German participants (4.71, not important) as well as Chinese (3.38, a bit important) with an average rating for all participants of 3.86 (not important). The result was not in conformity to previous surveys [2] which stated that mobile payment was one of the "killer features" of wearable technology. One of the causes was a perceived security risk of mobile payment from the users. Consumers were also concerned about the device and the network reliability. Furthermore, users feared of too complex data input formats, codes and service numbers, complex registration procedures, and management of separate accounts [22].

The above findings suggested that wearable devices designed for Chinese should include the data sharing function but had to exclude this function when designed for Germans. Security of data privacy and simplification of payment procedure need to be carefully considered and guaranteed.

There were limitations to the results of this paper. Firstly, only 158 participants took part in the survey and they were mainly college students recruited on the campus of Tsinghua University. The college students did not represent the potential users of wearable devices. Secondly, the survey and the interviews were conducted in English to minimize the translation errors of responses but none of the participants was a native English speaker. This might negatively affect the results due to the misunderstanding of the questions. Lastly, cultural differences in response style might lead to a bias of the results. A more extreme response style (ERS) of the Germans and a more acquiescence response style (ARS) by the Chinese might influence the comparison of the answers between two countries.

5 Conclusion

In this paper, we collected the user requirements of wearable devices for activity tracking and compared the results between Germans and Chinese to address the influence of cultural difference. The requirements and differences on user requirements would guide

the development of wearable devices for activity tracking. The different preferences between Chinese respondents and Germany respondents suggested the designers to include different functions and features in wearable devices for activity tracking.

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