USING PLEASURABILITY TO COMPARE WRISTWATCHES AND IOT SMARTWATCHES: PROVIDING NOVEL INSIGHTS INTO UX DESIGN

Lin, Zidong (1);
Ahmed-Kristensen, Saeema (2);
Hall, Ashley (1);
Sommer, Bjorn (1)

1: Royal College of Art, London, UK;
2: INDEX, Department of Science, Innovation, Technology, Entrepreneurship, University of Exeter, London, UK

ABSTRACT

The emergence of the Internet of Things (IoT) has brought more challenges for designers to fully understand networked objects and develop pleasurable user experiences (UXs). Due to the radical change of products when they are connected, traditional experience design theories may not be applicable in this new context. Based on two well-established UX design theories, this paper presents a survey study that investigated the pleasurability of IoT devices by comparing a representative IoT device (i.e., the smartwatch) and its conventional form (i.e., the wristwatch). An online questionnaire was deployed to gather feedback from parallel wristwatch and smartwatch users. Their experiences using both types of watches were quantitatively and qualitatively compared by data analysis. The results highlighted the differences in UXs between smartwatches and wristwatches in three types of pleasure and five psychological needs. The study revealed design opportunities to improve the pleasurability of smartwatches and provides novel design insights informing the development of pleasurable UXs for future IoT devices.

Keywords: Experience design, Design methods, Design informatics, IoT, Smartwatch

Contact:
Lin, Zidong
Royal College of Art
United Kingdom
zidong.lin@network.rca.ac.uk

Cite this article: Lin, Z., Ahmed-Kristensen, S., Hall, A., Sommer, B. (2023) 'Using Pleasurability to Compare Wristwatches and IoT Smartwatches: Providing Novel Insights into UX Design', in *Proceedings of the International Conference on Engineering Design (ICED23),* Bordeaux, France, 24-28 July 2023. DOI:10.1017/pds.2023.377

1 INTRODUCTION

With the flourishing of material capitalism and mass production, people's lives in the developed world are dominated by commercial products, fuelled primarily by the commercialism of the tech industry and the consumer desire to purchase gadgets that is stronger than ever (Sterling, 2005). Since the beginning of the 21st century, product designers have strived to move beyond basic functionality and usability to create products that offer pleasurable experiences, which attract customers and generate profits. They are aware that, as psychologist Frijda (2009) argued, a pleasurable experience can bring physical and psychological comforts to consumers and cause them to continue their present interaction with an object, making a product more addictive. In the past two decades, several successful methods have been developed for designing pleasure (Jordan, 2002), positive emotions (Desmet, 2012) as well as positive psychology (Desmet and Pohlmeyer, 2013). These theories have addressed the psychological impacts of products and informed the importance of pleasurability in user experiences (UXs). Lazar et al.'s study (2015) shows that pleasurable UXs of smart devices can encourage users to keep them for a longer time rather than abandon them. Creating pleasurable UXs can be helpful in increasing the lifespan and improving the sustainability of new gadgets (see the full definition of pleasurable UXs in Section 2.1).

The emergence of ubiquitous computing (Weiser et al., 1999) has led to new variants of many products that have envolved into Internet of Things (IoT)-related (Ashton, 2009) devices, which are no longer isolated from each other but are instead interconnected via the Internet. We refer to *IoT devices* in this paper as products that connect to the Internet while sensing and exchanging data with a certain level of agency. Designing IoT devices challenges designers to unify interaction design, device design and service design, thereby increasing the complexity of designing UXs (Kuniavsky, 2010). However, pleasurability still plays an important role in the UX design of these IoT devices. Designers can benefit from understanding a user's emotional responses to a product so that they can devise explicit and meaningful objectives when they design an interaction system (Hassenzahl, 2010). Väänänen-Vainio-Mattila et al.'s study (2015) showed that most existing Human-computer interaction (HCI) research on the design of ubiquitous computing has focused on engineering rather than UXs. Although a limited number of studies have explored UXs, they only explored pragmatic qualities but ignored hedonic and eudaimonic qualities. Koreshoff et al.'s review (2013) on IoT literature in HCI observed that the existing three categories of research were useful for design ideas, exploring systems and technical components but there was no special focus on UXs. As a result, methods and principles of designing UXs for new emerging IoT devices need to be further explored.

In our study, drawing inspiration from existing works, we aimed to explore detailed pleasurable UXs of a representative IoT device: the smartwatch by comparing its UXs with the non-IoT product it evolved from - the traditional wristwatch, in order to inform the UX design of IoT devices that have evolved from a non-IoT products. To compare the pleasurable UXs of smartwatches to that of wristwatches, we designed a questionnaire survey that included UX metrics to quantify users' responses to both types of watches. In the age of IoT, technical requirements, performance, user needs and desires all become more complicated and thus designers are facing more challenges. The value of this paper lies in contributing new insights into improving the pleasurability of UXs for smartwatches and designing pleasurable UXs for new emerging IoT devices that are evolving from their traditional forms in an increasingly complex world. This study also extends current research methods and frameworks within UX design for IoT devices.

2 BACKGROUND

2.1 Applying existing UX design theory to IoT devices

Our study employed two UX design theories as guiding principles: Jordan's (2002) four types of pleasure and Hassenzahl's (2010) six psychological needs. Jordan's hierarchy of consumer needs considers pleasure as the highest level beyond functionality and usability, where a product is perceived as life-enhancing through emotional, hedonic, and practical benefits. Jordan's approach borrows four types of pleasure that could be relevant in the context of products, namely physical, social, psychological and ideological from the framework in Tiger's *The Pursuit of Pleasure* (2000). Table 1 provides a description of each type. Jordan's framework was developed with the purpose of helping to

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

"design pleasurable products". His approach and the underlying pyramid structure have been used by various researchers, including Lidwell et al. (2003) in their design hierarchy of needs, Perez Mata et al. (2017) to understand how aesthetics influence user perceptions, and Yang et al. (2019) to identify the factors that influence user's affective responses to conversational agents. Hassenzahl's (2010) alternative perspective posits that pleasurable products must fulfil one of ten psychological needs, which were categorised based on Sheldon et al.'s work (2001). In later work (Hassenzahl *et al.*, 2015), he identified six types of psychological needs which are fulfilled by interactive products (see Table 2). We adopted these six types of needs to develop our questionnaire. By combining the two UX theories, we defined *Pleasurable UXs* as user experiences that make people feel pleasant by eliciting one type of pleasure or fulfilling one psychological need. Our study applied these theories to explore detailed pleasurable UXs of smartwatches and traditional wristwatches to inform the design of emerging IoT devices.

Table 1. Four types of pleasure in Jordan's framework (2002)

Pleasures	**Description**
Physio-pleasure	Relates to the body and pleasures derived from the sensory organs. Includes those connected with touch, taste and smell, as well as feelings of sensual pleasure.
Socio-pleasure	Enjoyment derived from relationships with others, e.g., relationships with friends and loved ones, with colleagues or with like-minded people.
Psycho-pleasure	Pertains to people's cognitive and emotional reactions.
Ideo-pleasure	Pertains to people's values.

Table 2. Hassenzahl's six psychological needs (2010)

Needs	**Description**
Relatedness	Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared of.
Meaning	Feeling that you are developing your best potentials and making life meaningful rather than feeling stagnant and that life does not have much meaning.
Stimulation	Feeling that you get plenty of novelty and stimulation rather than feeling bored and under-stimulated by life.
Competence	Feeling that you are capable and effective in your actions rather than feeling incompetent or ineffective.
Security	Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances.
Popularity	Feeling that you are liked, respected, and have influence over others rather than feeling like a person whose advice or opinion nobody is interested in.

2.2 IoT mediated experiences in design practices

IoT devices formed a new type of human-object relationship when they evolved into an IoT form; humans are no longer users but wranglers as they wrangle with IoT devices using their personal data (Sterling, 2005). Cila et al.'s study (2017) also revealed the complex relationship within the social network that forms between connected objects and suggested that the increasing agency of networked objects also influenced people's perceptions. Lin et al.'s recent study (2022) proposed that designers need to consider various types of interactions within an IoT system which can be effective tools for shaping UXs. Interaction designers and HCI researchers have utilised IoT devices as research tools in their design practices to mediate human experiences. Pschetz et al. (2017) developed an IoT coffee machine as a probe to communicate information from coffee bean supply chains to users to collect their choice and explore their attitudes towards data gathering and sharing in an IoT system. Marenko and van Allen (2016) created animated IoT objects to create new forms of interactions between a person and objects while using search engines, which examined the role of nonhuman agents in shaping experiences. Rebaudengo et al. (2019) designed IoT toasters that competed with other toasters in the user network by attracting their host to use them though digital interactions. These existing examples show that human experiences can be mediated in many ways by IoT devices especially with their features of sensing and communicating data with users, unlike their traditional forms. There is potential for designers to add IoT features to traditional products for delivering radically different,

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

more pleasurable UXs. To investigate whether this is possible, our study specifically explored how an IoT device (i.e., the smartwatch) elicits four types of pleasure and fulfils six psychological needs in contrast to its traditional form (i.e., the wristwatch).

2.3 Comparing smartwatches to wristwatches for design purposes

A *smartwatch* is a connected computer that is in the form factor of a wristwatch, and is a typical category of Hardware Sensor Platforms in the IoT ecosystem (Swan, 2012). It differs fundamentally from their predecessors- *traditional wristwatches* that are analogue or digital quartz. Previous design research has compared the designs of smartwatches and traditional wristwatches to gain new insights. Martin's study (2002) revealed parallels between the development of traditional watches and wearable computers in terms of wearability, user interface and cultural impact. Cecchinato, Cox and Bird's study (2015) interviewed early adopters of smartwatches and found that they cannot entirely replace traditional watches, as users have different preferences regarding the aesthetics of smartwatches. Lyons (2015a, 2015b) examined the usage practices of traditional digital watches (also described as "dumb watches" by him) to inform the design of smartwatches and reveal design implications of the evolvement from digital watch to smartwatch. In the former (Lyons, 2015a), he found that the aesthetics of digital watches could impact the design of smartwatches; the wearing habits of digital watch users had implications for the power sources of smartwatches, and the usage scenarios of digital watches could influence the purposes of applications designed for smartwatches. In the latter (Lyons, 2015b), he found that the relationship between digital watches and smartphones informed the future relationship between smartwatches and smartphones, which could potentially change users' perceptions regarding smartwatch capabilities. In our study, we compared the influences of smartwatches and wristwatches on pleasurable UXs. We were interested in these two products as their development 1) might share common development goals with other products (Martin, 2002) (e.g., smart fridges, lamps or kettles, etc.), 2) represents a successful product widely accepted and adopted by diverse user groups and industry, and 3) could potentially serve as a model for the development of future products. The relationship between smartwatch and wristwatch revealed that an IoT product and its conventional form might have similar meanings for end-user and the usages of the latter can inform the design of the former. Ultimately, our study aims to inspire novel insights into UX design for future IoT devices.

3 METHODS

For comparing UXs of wristwatches and smartwatches, an online questionnaire was chosen as the method for our study to collect quantitative and qualitative data. To transform qualitative experience data into quantitative data, we designed UX metrics based on Jordan's four types (2002) of pleasure and Hassenzahl's six psychological needs (2010). Design researchers often use UX metrics in studies to measure different components of experience for comparative purposes (Tullis and Albert, 2013). For example, Perez Mata et al. (2017) deployed a survey to quantify user perceptions of geometric features of vases. Desmet (2012) applied UX metrics to measure the degree of 25 positive emotions in human-product interactions, and Hassenzahl et al. (2015) qualitatively applied UX metrics to identify the relationship between need fulfilment and UX. By transforming descriptions of experiences into numerical data, researchers can easily compare the UXs of two products. In this paper, we borrowed experiences from previous empirical studies and compared the pleasurable UXs of smartwatches with those of traditional wristwatches.

This questionnaire survey included one questionnaire devoted to parallel smartwatch and wristwatch users. Previous work by Lin et al. (2021) was based on two separate questionnaires for either smartwatch users or wristwatch users and prevented the researchers from investigating the impact of parallel experiences. To avoid this limitation, the survey herein was conducted with participants who had experiences using both types of watches. In the questionnaire, participants were asked about their experiences in terms of the four types of pleasure and six psychological needs (see Section 2 Background). The questionnaire was divided into three parts. The first part included closed questions regarding the participants' basic information (gender, age group, nationality, country of residence, watch model), which might influence their perception of pleasurable experiences. The second part of the questionnaire asked about pleasurable UXs of using smartwatches and wristwatches. This part of the questionnaire comprised rating-scale questions, thus creating UX metrics to measure experiences.

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

We applied Osgood's semantic differential (SD) scale (Osgood, 1957) to evaluate respondents' affects and cognitions in our questionnaire. The SD scale was a seven-point scale (−3, −2, −1, +1, +2, +3) between bipolar, contrasting adjectives (extremely unpleasurable, very unpleasurable, slightly unpleasurable, slightly pleasurable, very pleasurable, extremely pleasurable) and a neutral zero point (0, neither pleasurable nor unpleasurable). The third part of the questionnaire asked participants to compare their experiences of smartwatches to that of wristwatches. They were asked which type of watch they were currently using after having experienced both and which type of watch had provided them with a better overall UX. There were also open-ended questions in this section, allowing participants to indicate the reasons for their responses. After acquiring the approval from the ethics committee of the Royal College of Art, the participants were recruited by posting the questionnaire on Reddit and by sending it to students' university email addresses. Reddit is an online forum that has a vast number of communities covering a wide range of topics. We posted our questionnaire under the topic "smartwatch". The flow diagram of applied methodology is presented in Figure 1.

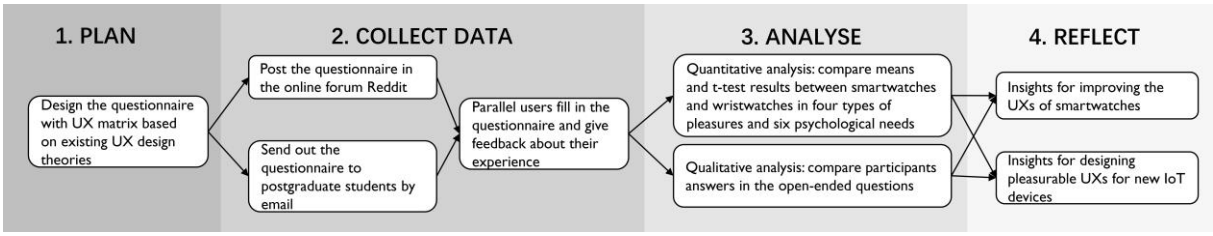

Figure 1. Flow diagram of the applied research methodology

4 RESULTS

The survey received a total of 192 responses. Of those, 130 participants were deemed valid and were selected as the final sample for analysis as they had completed all the questions in the questionnaire and their general response time was all over 3 minutes, ensuring they had not have rushed through the questionnaire. This sample comprised equal numbers of Western (American, Australian, Austrian, Belgian, Bosnian, British, Canadian, Danish, French, German, Greek, Hungarian, Irish, Italian, Mexican, New Zealander, Polish, Romanian, Russian, Slovenian, South African, Spanish and Turkish) and Eastern (Chinese, Malaysian, Singapore and South Korean) participants (65 each) to avoid an influence of cultural bias on the result. The differentiation of countries into Eastern and Western were based on Huntington's theory (1998). The participants' basic information is presented in Table 3.

Table 3. Basic information of participants (n=130)

Gender		**Age Group**		**Length of Using**	Smartwatch	Wristwatch
Female	32.31%	Under 18	5.38%	Less than 1/2 year	26.15%	14.62%
Male	66.15%	18-24	32.31%	1/2-1 year	23.85%	17.69%
Prefer not to say	1.54%	25-39	44.62%	1-3 years	31.54%	7.69%
		40-60	10.77%	Over 3 years	18.46%	60.00%
		Over 60	6.92%			

To analyse UX data, we calculated means for each type of pleasure and each psychological need and created histograms in Microsoft Excel to check the normality assumption of data (see Figure 2). Although the histograms are not perfectly symmetric and bell-shaped, we found no normality violations. Given that experiences can vary widely across individuals, it is not necessary for the data to conform to a standard normal distribution. Next, we performed t-tests to the data for UXs of smartwatches and wristwatches to determine if there is a significant difference between the two groups. To minimize the risk of Type I errors due to multiple comparison, we applied a Bonferroni correction to the significant threshold (alpha).

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

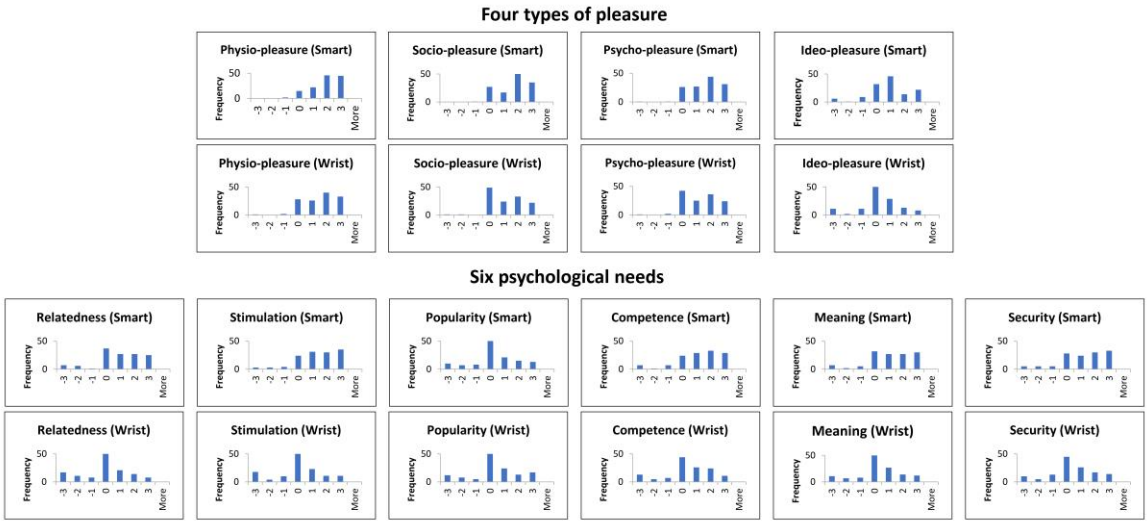

Figure 2. Histograms for checking the normality assumption (n=130)

First, we compared the participants' responses in relation to Jordan's four types of pleasure (introduced in Section 2.1) in the context of using smartwatches and wristwatches (as shown in Table 4). The comparison of means shows that the smartwatches elicited the four types of pleasure better than wristwatches, indicating that participants experienced a higher level of pleasurability from smartwatches. Physio-pleasure was elicited the most, while ideo-pleasure was associated with minimal gain, regardless of the type of watch used. We used the Bonferroni-corrected alpha level of 0.013 to compare the results of the t-tests for four types of pleasure. The results showed that the p-values of physio-pleasure, socio-pleasure and ideo-pleasure were below the threshold chosen for statistical significance (0.013), indicating a statistically significant difference between the three types of pleasure (physio-, socio- and ideo-) experienced from using smartwatches and wristwatches. The results were the reverse of the previous study (Lin *et al.*, 2021), which separated both user groups and where the four types of pleasure of smartwatches were not statistically different from those of wristwatches.

Table 4. The four kinds of pleasure compared between smartwatches (n=65) and wristwatches (n=65)

Pleasures	**Physio-pleasure**		**Socio-pleasure**		**Psycho-pleasure**		**Ideo-pleasure**	
Watch Type	Smart	Wrist	Smart	Wrist	Smart	Wrist	Smart	Wrist
N	130	130	130	130	130	130	130	130
Mean	1.900	1.538	1.700	1.162	1.569	1.262	0.854	0.238
SD	1.055	1.202	1.104	1.219	1.154	1.211	1.453	1.430
t-test (p)	0.011		0.0002		0.037		0.001	

Second, we compared the participants' responses to the six psychological needs (introduced in the section 2.1) fulfilled by smartwatches and wristwatches (see Table 5). The means of the six psychological needs suggested that smartwatches fulfilled all these needs better than wristwatches, except for the psychological need of popularity. In agreement with the results from the aforementioned study (Lin *et al.*, 2021), popularity was the only need more strongly met in the wristwatch user group than the smartwatch user group. Most of the psychological needs were seen as positively met in relation to wristwatches, at a level just slightly above neutral (0). While for smartwatches, they were identified as at or above the 'slightly fulfilled' level (1). The participants' psychological needs for relatedness and stimulation were barely fulfilled by wristwatches. We used the Bonferroni corrected alpha level of 0.008 to compare the results of the t-tests for six psychological needs. The tests produced the p-values below the threshold chosen for statistical significance (0.008) for all the psychological needs except popularity. Thus, it appears that the users' levels of fulfilment of the five psychological needs by smartwatches were significantly different from those of wristwatches. In the previous study (Lin *et al.*, 2021), smartwatches only fulfilled the need of stimulation significantly differently compared to wristwatches.

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

Table 5. The six psychological needs compared between smartwatches (n=65) and wristwatches (n=65)

Needs	**Relatedness**		**Stimulation**		**Popularity**		**Competence**		**Meaning**		**Security**	
Watch Type	Smart	Wrist	Smart	Wrist	Smart	Wrist	Smart	Wrist	Smart	Wrist	Smart	Wrist
N	130	130	130	130	130	130	130	130	130	130	130	130
Mean	0.938	0.062	1.362	0.046	0.292	0.338	1.169	0.392	1.085	0.277	1.177	0.377
SD	1.608	1.655	1.441	1.656	1.557	1.668	1.571	1.635	1.595	1.565	1.602	1.586
t-test (p)	0.000001		0.0000000001		0.818		0.0001		0.00005		0.00007	

Third, we compared the overall UX of smartwatches and wristwatches. Over half of the participants (54.61%, n=71) were exclusively using smartwatches when they responded to the questionnaire. Roughly one-third of the participants (33.85%, n=44) were using both smartwatches and wristwatches, and just over one-tenth (11.54%, n=15) were using only wristwatches. An open-ended question in the questionnaire asked why users abandoned a type of watch (if they were only using one type). Of 50 participants who had abandoned their wristwatches, 38 (76.00%) claimed they had made this decision because smartwatches produced better UXs because of their extended functionality. For example, participant 17 stated, "I prefer the greater functionality of smartwatches. Moving to the Apple Watch LTE allowed me to go out without my phone. I missed the days before we were all lugging around a phablet and it's nice to be free from it"; and participant 129 noted that "my smartwatch monitors the changes of my body index which is suitable to wear for exercising. The functionality of the wristwatch is simple, which makes it more suitable to use at work." Meanwhile, 9 of 15 participants (60.00%) who had given up smartwatches mentioned that the inconvenience of charging had decreased pleasurable experiences. Participant 15 complained that "only downside I've found in smartwatch is needing to charge it so frequently"; and participant 16 stated, "I do not use smartwatches anymore because I always forgot to charge them which was annoying".

In terms of the overall experience, 72.31% of the participants (n=94) believed that smartwatches delivered a better UX than wristwatches. When combined with the current watch they were using, the result indicated that approximately 15.38% of the participants (n=20) were still using both kinds of watches, even though they thought the UX of smartwatches was more pleasurable. In the open question section, 10.77% of participants (n=14) stated that they used both type of watches on different occasions. For example, participant 75 explained, "I mainly use smartwatches except when I'm in a place where I cannot use them (e.g., exams)" and participant 88 mentioned that "I have to wear wristwatch when meet some important people". Additionally, 6.92% participants (n=9) mentioned the pleasurability of smartwatches due to their IoT features such as connectivity, sensing and uploading data. Participant 11 said "The smartwatches I have owned have expanded my capabilities when it comes to interacting with my other devices or friends and family as they offer new features to speed up day-to-day tasks and give me new methods of interaction." Participants also highlighted how smartwatches and traditional wristwatches offered pleasurable UXs in different ways. Participant 41 stated, "I take pleasure in the mechanics of wristwatches. I am aware of the various movements, design history and so forth. Smartwatches please me in capability, and the spectacular amount of technology they bring to bear on daily activities." Notably, two participants expressed a desire for a combination of both watch types. Participant 1 said "I love a traditional watch. I don't like radiation. I just need a sleep and step and maybe heart tracker in one. The elements of a traditional watch are irreplaceable but can be innovated".

5 DISCUSSIONS

5.1 Improving pleasurable UXs for smartwatches

Our survey found that battery life is one of the key issues leading to less pleasurable UXs which supported the hypothesis in Lyons' study (2015a, 2015b). Compared to wristwatches which are not necessary to be charged on a regular basis, the charging of smartwatches affects convenience. Designers and technology firms should focus on extending battery life and reducing the charging frequency in future smartwatches. Despite the improved battery life in some of the latest products like Apple Watch Series 8 (declaring 72-hour battery life) (Apple Inc, 2022), it is still not comparable to that of wristwatches. Our participants' responses showed that wristwatches tend to have a greater diversity of appearances, whereas smartwatches are more similar in their form factors. This is in

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

agreement with arguments presented by participants 1 and 41 in section 4, where some parallel users appreciated the appearances of wristwatches, and they wanted a combination of a smartwatch and a wristwatch. The UX metrics in our study showed that wristwatches better fulfilled users' psychosocial need for popularity than smartwatches. Cecchinato, Cox and Bird (2015) and Lyons (2015a, 2015b) also argued that smartwatches cannot completely replace wristwatches because their appearances were not competitive. Thus, smartwatch designers might borrow the design languages from wristwatches to improve the diversity of their aesthetics to meet users' demands. Such an improvement will also be helpful in increasing pleasurable UXs of smartwatches.

Considering smartwatches as IoT devices in a network can be the direction of their future development. From comparing the means and p-values from the t-test in our survey and integrating participants' answers in open-ended questions, we saw that the extended IoT features of smartwatches can facilitate eliciting pleasure and fulfil psychological needs. In the UX design of smartwatches, designers may need to change their perspective to see these products. Rather than seeing them as individual devices, they may need to consider them as devices in a network with a special concern to their roles and how they can influence the ecology of connected objects, as suggested by Cila et al. (2017) on the design of products in the IoT age. Lin et al.'s study (2022) has suggested the influence of the agency of actors and various types of interactions in an IoT network on pleasurable UXs. Designers should further utilise these unique features of smartwatches to create more novel interactions, and mediate among the agency of smartwatches, users and other IoT devices in order to elicit pleasure and fulfil users' psychological needs in effective ways.

5.2 Insights for designing pleasurable UXs for an IoT device that evolved from a traditional form

By comparing smartwatches to wristwatches, our study indicates insights for designing pleasurable UXs for an IoT device that evolved from a traditional form. First, our study demonstrated how to use UX metrics in a questionnaire to help designers understand the differences in UXs between an IoT device and its traditional form. Unlike the previous study (Lin *et al.*, 2021) which compared the UXs of two products for separate user groups, in this study we conducted the comparison within the same user group. This approach led to contracting results and effectively emphasised the distinctions between UXs of an IoT product and its conventional form. Second, designers should consider the hedonic qualities of an IoT devices. Our survey found that smartwatches presented advantages in eliciting pleasure and fulfilling psychological needs because their features expand beyond the inherited function of wristwatch (i.e., telling time). The hedonic qualities of smartwatches were the source of pleasurable UXs. Hassenzahl et al.'s study (2015) also revealed psychological needs were directly related to hedonic qualities but not to the pragmatic ones. To transform other products into IoT forms, it is important to consider the hedonic qualities beyond their pragmatics quality. For example, what can an IoT dish washer do besides washing dishes?

Third, for the products like wristwatches that have the strong attributes of luxury and decoration, designers need to consider their aesthetics when transforming them into IoT devices. Our study found that wristwatches have strengths in their build quality, appearance, and sense of luxuriousness but these strengths disappeared in smartwatches along with the pleasure users gained from these elements. Martin's study (2002) argued that a wristwatch was occasionally a symbol of identity and social status but this attribute was lost after it evolved into a smartwatch. However, for mundane domestic IoT devices such as smart kettles, smart heaters or smart fridges, this principle might not be applicable. Last, some existing UX theories are still relevant to new emerging IoT devices. Our study demonstrated that Jordan's four types of pleasure (2002) and Hassenzahl's six psychological needs (2010) can be identified in pleasurable UXs of smartwatches. Designers can attempt to apply other design theories to their IoT design practices or explore further needs beyond the ones applied in the context of this work.

5.3 Limitations of the study

The explorations outlined in this review presented several limitations in terms of design, execution, and analysis. The questionnaire was sent to postgraduate students at a particular university and posted in the online forum Reddit, but there was no question in the survey that asked about identities and all the participants were anonymous. This means that we could not determine the proportions of the participants from the university and from Reddit. However, the university cohort is a diverse mix of culture from potentially over 65 nationalities, gender diversity and disciplines across design., creative industries,

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

sciences and engineering. In terms of the analysis, the sample was selected to include an equal number of Western and Eastern participants. However, there was not a widely-accepted standard to differentiate between Western and Eastern participants. We chose one that we believed resulted in two groups that were representative of each, but it may not have fully eliminated the cultural influences on our results.

6 CONCLUSION

This research compared the UXs of smartwatches and wristwatches using a questionnaire survey with UX metrics to provide novel insights for designing pleasurable UXs for IoT devices that evolved from a non-IoT product. The study reveals the complexities of this type of IoT research, and benefits not only UXs of smartwatches but also that of future IoT products. We incorporated existing UX design theories into our questionnaire and found significant differences between pleasurable UXs of smartwatches and wristwatches. The study revealed how unique features of smartwatches may provide a more pleasurable UX by eliciting three different types of pleasure and fulfilling five psychological needs. We recommend the improvements to the UXs of smartwatches by 1) increasing the battery life, 2) borrowing design aesthetics from traditional wristwatches, and 3) considering smartwatches as part of an IoT network while designing them. Our study also suggests that when designers attempt to developing a new IoT device from a traditional product, they need to A) compare UXs with metrics within the same user group, B) consider hedonic qualities, C) determine whether aesthetics should be inherited and D) apply existing design theory where appropriate. The research contributes to understanding how we can extend existing theories for IoT devices, especially those that have evolved from non-IoT products. IoT and smartwatch product designers can gain value from this research via the UX design theories applied to traditional watches and smartwatches and decipher how this uncovers new creative pathways for IoT devices.

ACKNOWLEDGMENTS

We would like to thank all the participants of the questionnaire survey for their time, feedback and insights.

REFERENCES

Apple Inc. (2022), “Apple Watch Series 8”, Apple (United Kingdom), available at: https://www.apple.com/uk/apple-watch-series-8/ (accessed 21 November 2022).

Ashton, K. (2009), “That ‘internet of things’ thing”, RFID Journal, Vol. 22 No. 7, pp. 97–114.

Cecchinato, M.E., Cox, A.L. and Bird, J. (2015), “Smartwatches: the Good, the Bad and the Ugly?”, Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, pp. 2133–2138, https://dx.doi.org/10.1145/2702613.2732837.

Cila, N., Smit, I., Giaccardi, E. and Kröse, B. (2017), “Products as Agents: Metaphors for Designing the Products of the IoT Age”, Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, pp. 448–459, https://dx.doi.org/10.1145/3025453.3025797.

Desmet, P. (2012), “Faces of Product Pleasure: 25 Positive Emotions in Human-Product Interactions”, International Journal of Design; Vol 6, No 2 (2012).

Desmet, P.M.A. and Pohlmeyer, A.E. (2013), “Positive design: An introduction to design for subjective well-being”, International Journal of Design, 7 (3), 2013, Chinese Institute of Design.

Frijda, N.H. (2009), “On the Nature and Function of Pleasure”, Pleasures of the Brain, Oxford University Press USA - OSO, New York, UNITED STATES, pp. 99–112.

Hassenzahl, M. (2010), “Experience Design: Technology for All the Right Reasons”, Synthesis Lectures on Human-Centered Informatics, Morgan & Claypool Publishers LLC, Vol. 3 No. 1, https://dx.doi.org/10.2200/s00261ed1v01y201003hci008.

Hassenzahl, M., Wiklund-Engblom, A., Bengs, A., Hägglund, S. and Diefenbach, S. (2015), “Experience-Oriented and Product-Oriented Evaluation: Psychological Need Fulfillment, Positive Affect, and Product Perception”, Int. J. Hum. Comput. Interact., https://dx.doi.org/10.1080/10447318.2015.1064664.

Huntington, S.P. (1998), The Clash of Civilizations and the Remaking of World Order, Touchstone, London.

Jordan, P.W. (2002), Designing Pleasurable Products: An Introduction to the New Human Factors, 1st edition., Routledge, Boca Raton London New York Singapore.

Koreshoff, T.L., Robertson, T. and Leong, T.W. (2013), “Internet of things: a review of literature and products”, Proceedings of the 25th Australian Computer-Human Interaction Conference: Augmentation, Application,

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press

Innovation, Collaboration, Association for Computing Machinery, New York, NY, USA, pp. 335–344, https://dx.doi.org/10.1145/2541016.2541048.
Kuniavsky, M. (2010), Smart Things Ubiquitous Computing User Experience Design, 1st edition., Morgan Kaufmann Publisher, Amsterdam; Boston.
Lazar, A., Koehler, C., Tanenbaum, J. and Nguyen, D.H. (2015), "Why we use and abandon smart devices", UbiComp 2015 - Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing, Association for Computing Machinery, Inc, New York, New York, USA, pp. 635–646, https://dx.doi.org/10.1145/2750858.2804288.
Lidwell, W., Holden, K. and Butler, J. (2003), Universal Principles of Design, Rockport Publishers, Gloucester, Mass.
Lin, Z., Hall, A. and Sommer, B. (2022), "Designing experiences for IoT products: A case study testing existing UX frameworks", DRS2022: Bilbao, Design Research Society, Bilbao, Spain, https://dx.doi.org/10.21606/drs.2022.593.
Lin, Z., Sommer, B. and Ahmed-Kristensen, S. (2021), "IoT Product Pleasurability - Investigating the Pleasurable User Experiences Between Conventional Products and IoT Products Through Watches", in Brooks, A., Brooks, E.I. and Jonathan, D. (Eds.), Interactivity and Game Creation, Springer International Publishing, Cham, pp. 394–408, https://dx.doi.org/10.1007/978-3-030-73426-8_24.
Lyons, K. (2015a), "Using Digital Watch Practices to Inform Smartwatch Design", Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, pp. 2199–2204, https://dx.doi.org/10.1145/2702613.2732719.
Lyons, K. (2015b), "What can a dumb watch teach a smartwatch? informing the design of smartwatches", Proceedings of the 2015 ACM International Symposium on Wearable Computers, Association for Computing Machinery, New York, NY, USA, pp. 3–10, https://dx.doi.org/10.1145/2802083.2802084.
Marenko, B. and van Allen, P. (2016), "Animistic design: how to reimagine digital interaction between the human and the nonhuman", Digital Creativity, Vol. 27 No. 1, pp. 52–70, https://dx.doi.org/10.1080/14626268.2016.1145127.
Martin, T.L. (2002), "Time and time again: parallels in the development of the watch and the wearable computer", Proceedings. Sixth International Symposium on Wearable Computers, presented at the Proceedings. Sixth International Symposium on Wearable Computers, pp. 5–11, https://dx.doi.org/10.1109/ISWC.2002.1167212.
Osgood, C.E. (1957), The Measurement of Meaning, edited by Suci, G.J. and Tannenbaum, P.H., University of Illinois Press, Urbana.
Perez Mata, M., Ahmed-Kristensen, S., Brockhoff, P.B. and Yanagisawa, H. (2017), "Investigating the influence of product perception and geometric features", Research in Engineering Design, Springer London, Vol. 28 No. 3, pp. 357–379, https://dx.doi.org/10.1007/s00163-016-0244-1.
Pschetz, L., Tallyn, E., Gianni, R. and Speed, C. (2017), "Bitbarista: Exploring Perceptions of Data Transactions in the Internet of Things", Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, pp. 2964–2975, https://dx.doi.org/10.1145/3025453.3025878.
Rebaudengo, S., Aprile, W. and Hekkert, P. (2019), "Addicted Products: A Scenario of Future Interactions Where Products Are Addicted to Being Used", Zenodo, 24 March, https://dx.doi.org/10.5281/zenodo.2604816.
Sheldon, K.M., Elliot, A.J., Kim, Y. and Kasser, T. (2001), "What is satisfying about satisfying events? Testing 10 candidate psychological needs", Journal of Personality and Social Psychology, American Psychological Association Inc., Vol. 80 No. 2, pp. 325–339, https://dx.doi.org/10.1037/0022-3514.80.2.325.
Sterling, B. (2005), Shaping Things, MIT Press, Cambridge, MA, USA.
Swan, M. (2012), "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0", Journal of Sensor and Actuator Networks, Multidisciplinary Digital Publishing Institute, Vol. 1 No. 3, pp. 217–253, https://dx.doi.org/10.3390/jsan1030217.
Tiger, L. (2000), The Pursuit of Pleasure, 1st edition., Transaction Publishers, New Brunswick.
Tullis, T. and Albert, B. (2013), Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics: Second Edition, Elsevier Inc.
Väänänen-Vainio-Mattila, K., Olsson, T. and Häkkilä, J. (2015), "Towards Deeper Understanding of User Experience with Ubiquitous Computing Systems: Systematic Literature Review and Design Framework", in Abascal, J., Barbosa, S., Fetter, M., Gross, T., Palanque, P. and Winckler, M. (Eds.), Human-Computer Interaction – INTERACT 2015, Springer International Publishing, Cham, pp. 384–401, https://dx.doi.org/10.1007/978-3-319-22698-9_26.
Weiser, M., Gold, R. and Brown, J.S. (1999), "The origins of ubiquitous computing research at PARC in the late 1980s", IBM Systems Journal, presented at the IBM Systems Journal, Vol. 38 No. 4, pp. 693–696, https://dx.doi.org/10.1147/sj.384.0693.
Yang, X., Aurisicchio, M. and Baxter, W. (2019), "Understanding Affective Experiences with Conversational Agents", Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, pp. 1–12, https://dx.doi.org/10.1145/3290605.3300772.

https://doi.org/10.1017/pds.2023.377 Published online by Cambridge University Press