Perception of Wearable Computers for Everyday Life by the General Public: Impact of Culture and Gender on Technology

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Abstract. This paper examines the perception of wearable computers for everyday life by the general public, in order to foster the adoption of this technology. We present a social study that focuses on sensors, actuators, autonomy, uses, and privacy. Carried out in 2005, it considers gender and cultural disparities in two dissimilar groups: French (115 males, 59 females) and Japanese (61 males, 54 females) citizens. Acknowledging that exposition to wearables can alter perception about them, we designed a garment-shaped prototype to check our results, estimate shifts of perception, and define guidelines for equipment and services. We describe our prototype, and future experiments dealing with face-to-face contacts, community awareness, and relaxing environments.

1 Introduction

Current trends show that our environment is continuously being filled with new electronic systems. Although the technologies have matured, it remains unclear whether people will accept them willingfully and how we can facilitate their adoption. Wearables, for example, have been developped but their use remains marginal. To understand this situation and provide hints for related technologies, it is critical to examine social factors.

So far, research in wearable computing focused on experts and on technical aspects. We consider here the general public, its perception of wearables, needs, and requests. Because of the diversity of possible wearables, we cannot take people to laboratories and generalize their feedback. Therefore, we decided to begin with questionnaires. We oriented them on cyberclothes [4]: garments possessing special features that can be used as social markers or tools, and possess some autonomy. This was appropriate for laymen because garments are a natural part of their life, and because enhanced clothes are easy to imagine. Results were gathered in 2005, mainly in France and Japan, which allowed the identification of cultural convergences and divergences.

Studies on mobile phones show that perception of a device can vary after acquisition [11]. Although our questionnaire provides an *a-priori* perception of wearables, it provides limited hints for design, and does not reveal all pitfalls.

As a consequence, we decided to also carry out experiments with prototypes focusing on problematic aspects revealed by the questionnaire. Feedback enabled us to check initial results, and define guidelines. This hybrid approach, combining the width of scope covered by questionnaires and the depth reached with experiments, favors reliable results.

Our paper is organized as follows. We present related works in section 2 then discuss our social study. In section 4 we describe the concept of cyberclothes. In section 5 we introduce our prototype, and planned experiments. In section 6 we discuss results and propose guidelines. Finally we conclude with future works.

2 Related works

Diverse wearables were developed, providing functions of desktop computers (e.g. email, calendar, notes), or novel features such as help for navigation in urban spaces, recognition of persons encountered, and display of physiological data. These computers looked like boxes, accessories, or even garments. Digital accessories include jewelry [10], gloves that react to their wearer's stress [12], and badges displaying messages [2] [6]. Enhanced garments were mainly designed for experts [9] [13] [14]; *France Telecom*'s tee-shirt, which displays graphics, is a rare example of model dedicated to the general public.

The evaluation of several prototypes has led to the definition of metrics and guidelines for the design of wearables regarding comfort [1] [7] [8] and social interactions [14]. However, there are few studies on the perception and adoption of wearable computers. In 2001, a user study was planned to evaluate usability and acceptance of digital jewelry [10] but has not been carried out yet [1]. Studies of other devices, such as mobile phones, are of little use because their characteristics are so different: wearables can have any number and type of sensors, actuators, and can be used for a wide range of services.

3 Social study about perception of wearables

The goal was to gather surface information about the general public's perception regarding wearable computers. Because people are not familiar with wearables, we focused on enhanced garments that respondents could easily imagine for uses in everyday life. This choice reduced the time required to answer questionnaires, and avoided confusion. We considered clear families of items (hardware, intelligence, information, uses), and everyday life situations. Therefore the questionnaire provides hints for wearables in general, and to a certain extent for other ubiquitous systems.

Our results reveal a significant effect of gender and culture on the perception of cyberclothes. Analyses show common interests (comfort, safety) and concerns (display of emotions) between the French and the Japanese. However they also indicate important divergences (e.g. system autonomy).

[1] E-mail exchanges with Christopher S. Campbell, IBM Almaden Research Center, 02-May-2005.

3.1 Method followed and scales

We designed the questionnaire with a pilot group, which led to rephrasing, and addition of an introduction. To enable quick answers, we limited the questionnaire to 2 pages with seven closed-ended questions and an open-ended one. For closed-ended questions, **participants rated assertions using a scale going from 1 to 5**: 1-strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree, and 5-strongly agree. We considered that **a mean below 2.5 indicated a significant trend for rejection while a mean above 3.5 indicated acceptance**. Besides, we considered the existence of a significant gender effect when the difference between genders' mean values was superior to 0.5. The questionnaire was produced by native speakers in English, French, and Japanese.

Due to cultural and ecological specificities, answers can vary between populations. Therefore, we focused on two dissimilar cultures, while collecting other data worldwide for comparison purposes. A sample of 333 laymen (199 males, 134 females) ranging in ages from 9 to 67 replied in 2005. Respondents came from 25 countries, with two core groups (table 1) from France and Japan. First results for France were previously introduced in [3]. To reflect populations' heterogeneity, the questionnaires were provided in public places and over Internet. Respondents included artists, designers, librarians, reporters, students, teachers, researchers, engineers, secretaries, salesmen, managers, housewives, retirees, medical staff, soldiers, preachers, etc.

	French Male	French Female	Japanese Male	Japanese Female
Number	115	59	61	54
Age Range	14 - 67	14 - 58	19 - 54	14 - 45
Age Mean (S.D.)	26 (09)	25 (09)	29 (08)	30 (07)

Table 1. Respondents (France and Japan).

3.2 Perception of wearables in France

Sensors and stimulators. As shown by scores between 3.7 and 4 (figure 1), French respondents are ready to accept garments that adapt their temperature to the environment, or analyze the air (smells, pollution, humidity, temperature). Results for recording graphics or sounds indicate a significant gender effect: French males are more attracted than females by the possibility to record graphics and sounds. Results for other features are not significant. Figure 2 indicates a high acceptance (3.6-4.4) of physiological monitoring to contact emergency services, evaluate sports performances, and adapt environments to users' needs. However, it shows an opposite trend for the disclosure of emotions (1.4-2.7), especially for women. There is a marked gender effect for physiological monitoring to adapt video games, females rejecting it whereas males remain neutral.

Attractive usages. Participants showed interest for three situations: in potentially dangerous situations (3.8-4.1), to communicate with disabled persons (3.6-3.9), or on trips (3.5-3.6). However figure 3 shows that enhanced garments are rejected for more common situations such as meeting new people. Besides, respondents rejected the ability to provide data about surrounding people (1.8-2.6). Getting information about ongoing tasks was not significantly appreciated (only 3.3). Comments expressed concerns about privacy.

Autonomy of the garments. Gender effect is strong, with males having a significant better acceptation of several features proposed. Respondents, especially women, indicated their will to own a system as much as possible under their direct control. This is shown on figure 4 by the rejection of full control by artificial agents (1.9-2.4), partial acceptance of limited artficial intelligence (3.3-3.5), and significant acceptance of full user control (3.5-3.9). The main reason indicated in comments highlighted a fear that the system might harm the wearer, with no possibility for her to fix the problem. Finally, respondents neglect the possibility for garments to learn from wearers' reactions (2.9-3.4) or to coordinate their actions (3.0 for women).

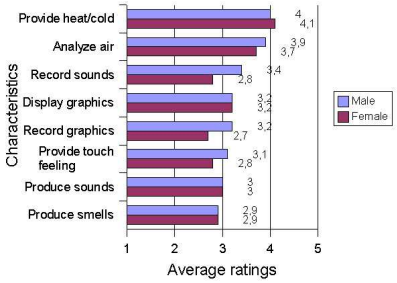

Fig. 1. Acceptance of perceptual sensing and stimulation (France).

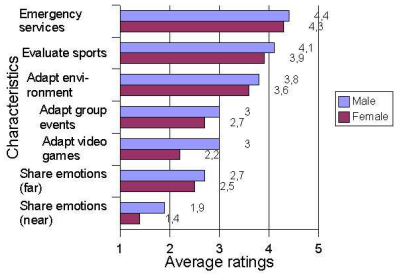

Fig. 2. Acceptance of physiological monitoring (France).

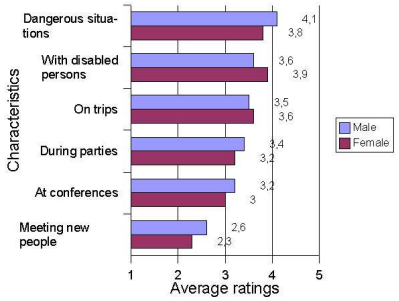

Fig. 3. Interest in usages (France).

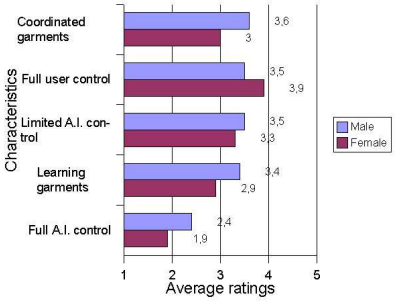

Fig. 4. Wishes for autonomy (France).

3.3 Perception of wearables in Japan

Sensors and stimulators. Gender effect is significant for features related to perception. As shown on figure 5, respondents look forward (3.5-4.2) garments that adapt their temperature to the environment, analyze the air, or record graphics. Males also consider acceptable to record sounds and display graphics on clothes; they reject the production of smells while females reject the generation of touch feelings. Figure 6 indicates a high acceptance (3.7-4.3) of physiological monitoring for emergencies and sports. Males are interested in the adaptation of their environment to fit their needs (3.6). However, there is an opposite trend for the disclosure of emotions (1.8-2.6). Females highly reject (2.2) physiological monitoring to adapt video games, while males remain neutral (3.0).

Attractive usages. Figure 7 shows that participants are attracted by proposed uses, except to meet new people (2.5-3.0). There is a gender effect for *meeting new people* and *parties*; female reject them strongly. Respondents reject the provision of data to surrounding people (2.5) but not for ongoing tasks (2.7-3.4).

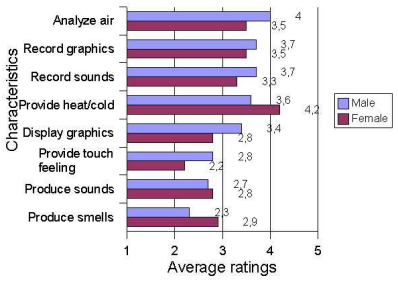

Fig. 5. Acceptance of perceptual sensing and stimulation (Japan).

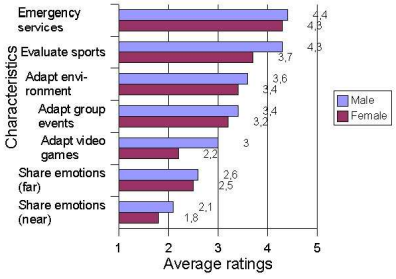

Fig. 6. Acceptance of physiological monitoring (Japan).

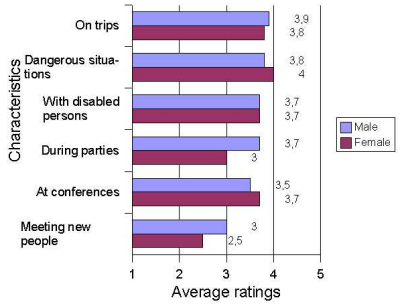

Fig. 7. Interest in usages (Japan).

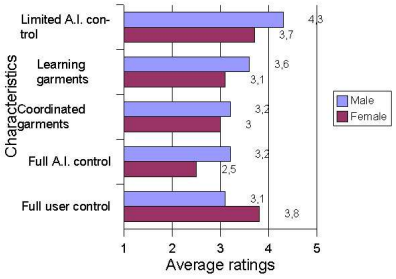

Fig. 8. Wishes for autonomy (Japan).

Autonomy of the garments. As shown on figure 8, women reject full control of enhanced garments by artificial agents (2.4). Partial or full user control appears

more attractive, women preferring full control (3.8), and male limited A.I. control (4.3). These aspects indicate a strong gender effect. The capacity to learn from wearers' reactions is attractive to males (3.6). Results for coordinating actions are not significant.

4 Wearables for the general public: a humane philosophy

Focus on technics limited the development of wearables dedicated to the general public. With *cyberclothes*, we hope to replace human beings at the locus of attention. Creating this concept clarifies our goals, provides an alternative for the design and adoption of wearables on a wide-scale.

We define cyberclothes —in a nutshell— as garments that have special features improving a person's well-being, awareness, and sociability. This definition takes its roots in Maslow's hierarchy of human needs, usually represented as a pyramid, displaying the most fundamental needs at the bottom. Its five main levels are physiological, safety, belonging, esteem, and self-actualization needs. Based on this theory, a wearable that fulfills a person's needs should sustain in priority physiological needs, safety needs, and belonging needs.

Physiological needs include food, water, air, and sleep. Safety needs include physical and psychological security (e.g. health, comfort, absence of danger, good familial situation). Belonging needs are related to relationships with people at large, in clubs, at the office, etc. Informal interviews we carried out in France and Japan indicate an interest for wearables that can monitor the evolution of the body condition: calories absorbed and used, sleep duration, etc. The study presented previously also indicates an interest for wearables that increase comfort and safety. These results indicate that the orientations chosen for cyberclothes are pertinent.

Cyberclothes improve a person's well-being, which encompasses physiological and safety needs. This can be achieved with garments that monitor physiology and contact emergency services, provide guidance, adapt to the environment or adapt the environment to the user (temperature, light). They can also maintain peace of mind by conveying comforting news (kids, lover).

Cyberclothes improve a person's awareness, which help take good decisions and feel secure. Using sensors and Internet, cyberclothes can provide information about the user herself (movements, biosignals), other people (availability of coworkers), or the environment (pollution level).

Cyberclothes improve a person's sociability, sustaining mainly belonging needs. With actuators, garments can become a medium of communication. For example garment could change their shape, modify graphics on their surface, produce smells, process speech, compare profiles of wearers, etc. Uses include easing communication with deaf persons and finding people with similar interests.

5 Experiments proposed to check our first findings

To complement our social study, we also experiment with prototypes. Our applications deal with *face-to-face contacts*, *community awareness*, and *relaxing environments*. We chose these to investigate privacy, relations with the environment, and full control by artificial agents, as well as the apparent rejection of emotion sharing and support for first contacts.

5.1 Prototype to investigate belonging and safety needs

We developed a prototype (figure 9) consisting of a jacket that processes data, accesses wireless networks, displays graphics, renders sounds, and acquires biosignals (skin conductivity, heartbeats). The two displays were placed to support conversations, and inform passersby about the wearer. The biosignals equipment aims at identifying the body condition, stress, calm, and intense emotions.

Fig. 9. Support for social events.

5.2 Experiments: contacts, awareness, and relaxation

Face-to-face contacts. Using JAVA and XML, we developed a system in which prototypes dynamically generate and display personalized slideshows of photos corresponding to common interests of surrounding wearers. Based on [5], we plan to check the interest of the service, evaluate controls for the system, and investigate private displays to inform wearers about their displays.

Community awareness. Belonging to a community implies keeping in touch and strengthening links with other members, which can be difficult due to temporal or spatial constraints. Our prototype can convey information and represent

it with a *night sky* metaphor: it displays a sky where each star represent a community member, colors and intensities representing feelings (based on biosignals or manual choices). We are particularly interested in reactions of users regarding privacy and disclosure of emotions.

Relaxing environments. To improve people's life, we propose to use garments to generate healing, relaxing environments. We still have to develop this system, but we plan to use biosignals as input, to control music, light, and scents around the wearer. This should help us both evaluate environments and generate relaxing ones.

6 Results and guidelines

The results of our social study in France and Japan show common interests and concerns regarding cyberclothes, in two dissimilar cultures. Using these as a basis, we established guidelines to design wearables. Besides, the creation of our prototype and preparation of experiments raised social and technical issues.

6.1 Results: cultural convergences and divergences

French and Japanese people show similar perceptions of wearable computers concerning the hardware and services. However, there are important differences about the control of the system, especially concerning the amount of artificial intelligence considered acceptable.

Wearables related to comfort and safety are perceived very positively; several respondents even proposed additional applications related to health: sleep monitoring, stress feedback, and support for diets. The French and Japanese give high ratings (3.5-4.2) to garments that analyze the air (e.g. pollution) and adapt their temperature to the environment. In addition, physiological monitoring is considered positively (3.4-4.4) to adapt the environment to users' needs, evaluate sportive performances, and inform emergency services. Finally, respondents had **interest in wearables for situations involving safety and fundamental communication abilities**: on trips (3.5-3.9), to communicate with disabled persons (3.6-3.9), or in potentially dangerous situations (3.8-4.1). There is little variation here between males and females.

However, the **perception of wearables for standard social uses is negative**, and results highlight a gender effect. French and Japanese respondents strongly reject the use of physiological monitoring to reveal emotions to distant or surrounding people (1.4-2.7). Comments indicate that respondents did not want to disclose their emotions because they considered it as private information, and potential harmful, especially if revealed in real-time. Besides both consider that support for meeting new people is not interesting (2.3-2.6). Females have significantly more negative views than males on these issues. In addition, respondents reject the ability to provide data about individuals present at a gathering (1.8-2.6). Finally, French people also reject the possibility to get information about the group as a whole whereas Japanese keep a neutral stance on this issue.

Cultural differences are most visible when considering the control of wearables. The preferred choice for the Japanese would be to use limited artificial intelligence (3.7-4.3) whereas French people prefer full user-control (3.5-3.9). In both cultures, full control by an artificial agent is seen very negatively by women (1.9-2.5); males have a more open attitude but it remains negative in France (2.4) and neutral in Japan (3.2). As highlighted during interviews, the French and the Japanese are both afraid that mistakes of an artificial agent might harm them socially or physically, with no way to fix the problem quickly.

These results confirm that focusing on human fundamental needs is a good approach to foster the adoption of wearable computers. However they also indicate a significant gender effect, and possible difficulties raised by the presence of artificial agents to control the equipment.

6.2 Universal guidelines for the adoption of wearables

Because French and Japanese cultures are very different, the similar trends revealed point to guides valid worldwide:

1 - Wearables should improve the comfort and safety of their wearer, and possibly of surrounding or distant people.
2 - Wearables should be able to communicate with other devices, and to suggest them a behavior based on knowledge about their wearer.
3 - Support for communication should focus on disrupted settings (e.g. on trips, or with disabled persons) rather than on standard situations.
4 - Design should be gender-oriented, taking into accounts the specific concerns of males and females.
5 - Full control of the system by an artificial agent should be avoided, and the autonomy and intelligence of the system should be selected based on cultural preferences.

6.3 Issues raised

Our results raised two main issues: control of wearables, and privacy. The experiments planned raise additional questions about services specificities.

People feel unease with artificial intelligence. Respondents rejected full control of wearables by artififical agents. Interviews and comments gathered with the questionnaire show that people are afraid that wearables would harm them physically or socially. Examples include selecting a wrong temperature for the heating system, or displaying unappropriate pictures at the office.

Requirements for privacy can hamper services. The use of personal information (e.g. emotions, condition, and location) is the subject of numerous research and needs to be investigated further before reliable guidelines can be produced.

Each service will raise new problems. Wearables allow the creation of diverse services and designs. Therefore various issues arise. For example, the display of photos reflecting common interests requires content and context annotations. Other problems include asymmetry of services, displayers unaware of what viewers see on them, or people ignoring the meaning of public display metaphors.

7 Conclusions and future works

In this paper we studied the perception of wearable computers for everyday life by the general public. Our hybrid approach combines social studies and experiments with prototypes. We found common interests (comfort, safety) and fears (control by an artificial agent) in France and Japan, revealed a gender-effect, and highlighted cultural differences. We introduced the concept of cyberclothes, a prototype, and future experiments. Finally we proposed design guidelines for the adoption of wearables, and raised related issues. From now on, we will carry our experiments to validate further our results, and acquire more insights regarding the design of wearable and ubiquitous systems.

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