Questions to Improve Quality of Life with Wearables: Humans, Technology, and the World

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Abstract

Existing wearables mainly benefit to specialists and patients however they could also benefit to the general public, improving quality of life. To reach this goal, strategies for the development and implementation of wearables must be chosen based on careful consideration of interaction between humans and computing technologies, from multiple perspectives including cultural, economic, political, and ecological points of view. This paper takes up some of those perspectives by asking the following questions: What needs can wearables help fill? How do people perceive these technologies? What is the relationship between technology and human needs, and how can its understanding inform development strategies? What are the most promising services? What are the apparent difficulties? How do we design products? What can various demographic perspectives tell us? How do we ensure future-viability? Drawing on psychological theories—such as Maslow's hierarchy of needs—as a framework for analyzing human factors our discussion presents results of interviews, questionnaires and experiments with prototypes, and raises questions for future research.

1. Introduction

Wearables, as small computers continuously worn by their owner, are excellent candidates to support human activities and improve quality of life. Wearables incorporating sensors and actuators acquire various information about wearers and their environment, and then provide the services for which they were designed.

Although products have already been marketed and current research is promising for the creation of garments with embedded components, it is still unclear whether the general public will rapidly benefit from these advances. One problem is to properly target the research and development, then to disseminate systems in a form that people will accept and appreciate.

We propose to focus on improving quality of life, which can be defined as a satisfaction level for everyday life, related to immaterial rather than material elements. A good starting point is Maslow's hierarchy of needs, which identifies five fundamental needs.

The hybridity of wearable computing, and to a lesser degree ubiquitous computing, is evident in people's relationship to their body, to each other and to the environment. They blur the boundary between what was conceived as discrete domains: human, tool, and environment. Therefore technology designers must take into account notions of identity, values, control and sustainability. This is a complex and emergent problem for future generation computer systems: wearables, smart artifacts, intelligent environments, and robots. Here we focus on wearables but the same questions can–and should–be asked for all related fields.

In this paper we link technologies to quality of life, looking at human needs and diversity, the environment and future (figure 1). We ask: What needs can wearables help fill? How are these technologies perceived? What is the relationship between technology and human needs, and how can an understanding of this relationship inform development strategies? What are the most promising services? What are the apparent difficulties? How do we design products? What can demographic perspectives tell us? and How do we ensure future-viability?

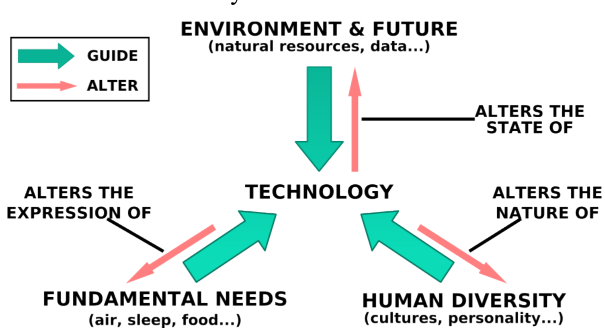

Fig. 1: Influences between humans, technology & the world

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2. What needs can wearables help fill?

To improve quality of life, we consider people's needs. This approach, to be comprehensive, should be complemented with theories of choice. Maslow's needs are one way to analyze human motivations as well as deep needs. After presenting Maslow's hierarchy, we consider the specific case of garments and accessories.

2.1 Human fundamental needs

Abraham Maslow is the American psychologist at the origin of the humanistic movement. Focusing on healthy people rather than on mad ones, he identified 5 fundamental needs [20] that explain human behavior (figure 2): physiological, safety, belonging, esteem, and self-actualization needs. Later, the hierarchy was extended with a level for spiritual needs. Maslow stated that these fundamental needs are universal and hierarchically ordered. He added that some behaviors are unmotivated, corresponding to expressions of one's personality and past rather than to a need.

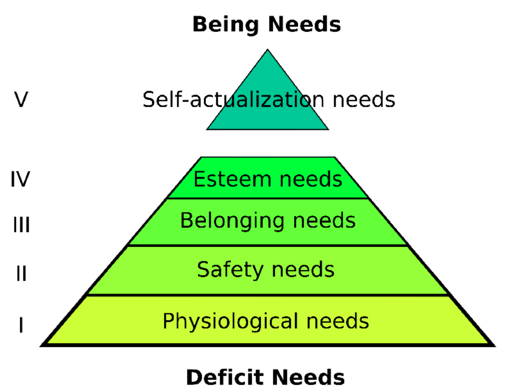

Fig. 2: Maslow's hierarchy of needs

Physiological needs target homeostasis (food, sleep, air, heat). *Safety needs* target physical (no illness or war) and mental (freedom, stability) security. *Belonging needs* deal with emotional relationships (family, coworkers, etc.). *Esteem needs* have an external and internal component: respect (from others) and self-esteem (achievements, skills). *Self-actualization needs* are the highest; they incite us to fulfill our potential.

Lower needs have priority over higher ones; when a need is satisfied, higher needs become salient. However full satisfaction of a need is not required before the emergence of higher needs: priorities evolve gradually. Alternatively, lower needs can come back into focus: when facing a crisis (job loss, divorce, etc.), a person can drop to a lower level that reflects needs of what was lost. Salient needs impact on our current perception of the environment and future, which can lead to a crisis due to the underestimation of lower–currently satisfied–needs.

2.2 Usual role of garments and accessories

Historically, garments and accessories were designed to support some human fundamental needs. They have two important dimensions: functionality and aesthetics. The former supports fundamental needs (table 1) and can be easily extended with wearables. The latter is mainly related to unmotivated behaviors (expression of personality).

For clothes, functions include protection and object container. For accessories, functions include protection (lucky charms), correction of defects (e.g. glasses), and container (e.g. medicinal powder in closed tubes). The functional aspect deals with physiological processes, comfort, belonging needs and esteem needs. Aesthetics is directly related to belonging and esteem.

Garments support physiological processes because they participate in homeostasis. One of their role is to stabilize temperature and protect us from the elements. Reinforced materials also provide a limited protection against injuries from spikes, animals or other humans. All this, as well as the direct feeling of some materials such as silk, contributes to the amelioration of comfort.

Besides wearing uniforms or clothes similar to other people's highlights belonging to specific groups [7]. It reinforces feelings with insiders and creates gaps with outsiders; for example police uniforms can inspire respect or disdain to members of other groups. The apparent cost of attires also impacts owners' reputation [7].

Table 1: Examples of roles of garments & accessories

Source	***Impact***	***Accessories***	***Garments***
Unmotivated	Aesthetics	Earrings	Tee-shirt, dress
Physiology	Temperature Wounds	Scarf Gloves	Pull-over Jeans, military
Safety	Bad luck Sensing	Talismans Glasses	Religious garb -
Belonging	Similarity Contacts	Wedding rings Cell-phone	Uniform Mini-skirt

Accessories, including electronic equipment such as hearing improvement devices and cell-phones, fulfill similar functions: they improve safety and human relationships. Traditional or modern, garments and accessories already participate to the gratification of people's fundamental needs. Wearables therefore also naturally possess the potential to fulfill this important role.

3. How do people perceive wearables?

There are 3 complementary approaches to evaluate the general public's perception of wearable technologies: interviews, questionnaires and experiments. Interviews indicate first elements of reflexion and reveal people's motivations. Questionnaires reveal broad but superficial information. Finally, experiments provide information based on concrete experiences.

3.1 Interviews

Both laymen and specialists should be interviewed. Laymen would provide their practical and naive view about wearable computers, and professionals a more enlightened and technical knowledge. To ensure the usefulness of the process, interviewees should include a diverse sample including people from a variety of demographic categories such as age, culture, profession, education, and technological literacy.

Because of our focus on wearables, interviews of laymen should begin with questions on garments and accessories. The identification of usual and exceptional uses, then of elements critical to their acceptation should be attempted before moving to electronic devices like cellphones. To stimulate laymen's imagination, sketches of wearable projects could be provided at the middle of the interview. On the contrary, specialists should first define the scope of the field then discuss their main interests. After indicating main issues to create services, they should describe uses in everyday life in a real-world setting.

As a first step, we interviewed a pilot group of 26 students and researchers in psychology and computer science, chosen for their ability to rise human and technological issues [9]. They were Japanese and French aged 20-37 year old. Because specialists in wearable or ubiquitous computing have not been interviewed yet, some critical issues have probably been overlooked in this pilot study. However, these first interviews allowed us to design exploratory questionnaires investigating the general public's perception of wearable computers.

3.2 Questionnaires

Questionnaires allow the acquisition of vast amounts of data in short time, without issues related to accessibility and distances. Although lacking the depth of interviews, they are appropriate to gather superficial information. Ideally random samples of the public would fill the questionnaires. Unfortunately this is expensive to achieve. Because answers can vary with cultural and ecological specificities, investigations must be carried out in several countries. Short of an international coordinated effort, only *pseudo*-randomness can be achieved (choosing people in public places then eventually normalizing the data).

Our group accordingly provided questionnaires in public places (cafés, bars and train stations) on weekdays and weekends, and in electronic form. Focusing on garment-shaped wearables, we prepared 2-pages self-completion questionnaires that were filled by 174 French and 115 Japanese respondents [10]. This quantity appeared appropriate for an exploratory study. Similar patterns emerged: support for health, well-being and some relationships appeared attractive. However slight cultural and gender effects exist, sometimes for critical elements like the extent of control by artificial agents. Beside deepening our understanding of specific features, we should dedicate other studies to digital jewelry and other wearables.

3.3 Experiments

Experiments with prototypes or commercial devices allow the acquisition of information on specific issues, based on concrete experience from respondents. Due to a lack of diffusion of wearables, experiments are currently the best way to know "How do people interact with the technology?". Requiring time and co-location, experiments should validate results from other sources, clarify motivations or get feedback on issues arising from practical use. Also long-term field tests in authentic settings are preferable.

Recently we exposed people to prototypes to clarify rejections detected with questionnaires and to get feedback to implement solutions satisfactory to users [11]. We found that using concrete wearables improved the acceptance of dubious features (table 2) and that the rejection of emotional displays is related to a perceived danger (see section 6.1 for details).

Table 2: Shift in ratings due to the use of prototypes

	Before	**After**	**Shift (pt)**	**Shift (%)**
Display graphics	4.0	4.8	+ 0.8	+20%
Useful with strangers	3.5	4.5	+ 1.0	+ 29%
Disclose profile	3.2	4.2	+ 1.0	+31%
Emotions display	1.8	2.3	+ 0.5	+28%

Another finding is that laymen overestimate some capacities of proposed technologies. For example, all respondents considered the efficiency of emotion evaluation based on physiological sensors to exceed 50%. Research in affective computing is far from yielding such accuracy [24] in detecting e.g. happiness or anger.

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4. How does technology match needs?

Wearable computers are exceptional because they follow their user in most places and can exploit body-related features (e.g. physiological monitoring). They are therefore particularly well-suited to assist humans in their everyday life. Currently, we find wearables that deal with deficit needs but not being needs. Designing wearables for being needs is more difficult because it implies the discovery and integration of one's nature and motivations. Most devices appear on lower levels of the hierarchy of needs, and are perceived as most useful, which is logical because they deal with survival. Notable problems include inadequate interfaces, and a need to coherently group and integrate these devices.

4.1 Level I: Physiological needs

Several wearables dealing with physiological needs were designed for experts and specific uses; they help find vital resources, monitor their quality, and sustain good body conditions. Models developed for soldiers help find resources with GPS, magnetic compasses and digital maps [39], and provide partial ballistic and laser protection [39]. Others are created to cool soldiers in deserts [33] or detect and protect against chemicals and biohazards [28]. Similarly, firefighters can benefit from clothes like the *LifeShirt* [35], which monitors posture and physiological state, or from embarked sensors combined with wireless to inform on-site members and command centers [16]. Cheap sensors assess environments (temperature, oxygen, toxicity) as well as firefighters' location and health status, which is vital for them and for people to rescue. Other models include suits for survival in arctic spaces [26], notably supporting body's thermoregulation. Dedicated models are easily adopted because they reduce wearers' risks.

For professionals and the general public, we find a medical jacket [15] that prevents fatal heart problems, with electrodes to acquire ECG data, a unit comparing data to a personalized profile, and a transdermal drug delivery component to inject nytroglycerin in wearers' body when required. Such vests are useful to people moving in hazardous places and to a non-negligible number of citizens suffering from heart problems. The *SmartShirt* [1] also takes advantage of various sensors.

Systems beneficial to the general public include watches that monitor sleep [1] and highlight anomalies revealing e.g. *sleep apnea*. Poor awareness about such vital issues certainly hampers their acquisition. Another device is the *GlucoWatch* [32], designed for diabetics. *Lifewatcher* [23] tracks food intakes, medicine use and activities, with services on mobile devices. To maintain good health with appropriate diets and exercise, sensor-based (movements, temperature, ultraviolet or heart-beats) support systems [5][19] can be used.

Although related to both physiological and safety needs, no wearable is dedicated to environmental or ecological issues. The closest work is that of Kaur et al. [18], who combined an ultrafine particle detector with a video camcorder to measure and visualize exposure to pollutants in transport microenvironments. This device is portable but not yet wearable.

4.2 Level II: Safety needs

Diverse wearables are dedicated to health, comfort, freedom from danger and peace of mind, providing novel features such as help for navigation in town and recognition of persons encountered. Enhancing security at the entrance of military sites [27], some can be adapted for the general public, for example to help people suffering from Alzheimer's disease. Sending photos of scaring situations to trusted people, the StartleCam [14] supports physical safety. Technology embedded in cell-phones and mobile terminals offer 3D information to find escape ways in case of natural disasters such as earthquakes [4]. Kids are not forgotten, with wearables that detect dangers on the way back home then appropriately inform children and parents [31]. Creative devices include clothes that produce smells to relax wearers [2], which helps fight against depression.

4.3 Level III: Belonging needs

Standard functions satisfying belonging needs include e-mail and phone. A good example of novel applications is the *galvactivator* [25], which emits light according to its wearer's arousal, hinting at stress levels. Other devices include badges that display messages [12], inform people about relationships within their community and help people know each other in more depth [6]. Devices that exchange digital cards when shaking hands facilitate interactions and help keep in touch [17]. Garments displaying graphics, like *France Telecom*'s tee-shirt, support communication and community belonging. As previously indicated, aesthetics must also be considered. Fashion shows (e.g. by *Team Tsukamoto* [3]) proved that technologies can be embedded but highlighted limitations when functionality is to be simultaneously achieved.

4.4 Level IV: Esteem needs

Finally, some wearables support everyday and work tasks, including digital jewelry [22].

5. What are the most promising services?

According to Maslow, physiological and safety needs are the most critical. If not already gratified, they are therefore most likely to be requested and accepted by the general public. Our investigations with questionnaires confirm this theory. A complementary interpretation is that the availability of novel services alters the expression of our fundamental needs. For example, the possibility to continuously monitor heartbeats and automatically prevent fatal problems modifies current needs to include this possibility.

In a less dramatic way, ubiquity allows for the first time real service personalization taking into account specificities of an individual's obesity, blindness, allergies, light exposure (impacting on our biological clock and thus on sleep). Physiology and safety-based services also appear most promising because they directly benefit users, without needing to reach a diffusion threshold (on the contrary to services dedicated to e.g. human networks).

5.1 Physiological and Safety needs

Results of questionnaires on physiology and safety (figure 3) indicate that related wearables are perceived positively. Respondents were asked to rate assertions such as “It would be acceptable for me to wear clothes that analyze the air (smells, pollution, temperature)” and “I would agree to use garments that monitor my condition (heartbeats, movements) to adapt my environment to my needs (temperature, light, music)”.

Fig. 3: Enthusiasm for well-being

The French and the Japanese both give high ratings to garments that adapt their temperature to the environment or analyze the air. Physiological monitoring is considered positively to adapt the environment to users' needs, evaluate sportive performances or inform emergency services.

5.2 Belonging needs

Results of questionnaires on belonging (figure 4) indicate mixed feelings: some services are well accepted and others rejected. Respondents were asked to rate assertions such as “Enhanced clothes would be useful to communicate with disabled people” and “I would agree to use clothes that monitor my condition (movements, heart) to reveal my emotions to surrounding people”.

Fig. 4: Mixed results for relationships

There was good acceptance for communication support in disrupted settings (with disabled people or for trips). However several services are considered negatively, in particular support for first encounters and emotional disclosure. Emotion disclosure was described as the evaluation of wearers' emotions with physiological sensors then their display to surrounding people.

From the point of view of service creation and technology diffusion, the most promising services deal with physiological and safety needs. From a long-term perspective however challenges lie in support for belonging needs, notably with the identification of factors of rejection. These factors should not be neglected even now because they might prove critical for the actual success of all wearables dedicated to well-being. Additional investigations could take into account the extended Technology Acceptance Model [34].

6. What are the apparent difficulties?

Difficulties are related to both technological and human (physical, psychological, social) factors. The latter require much care due to the weakness within computer science to handle current social and cultural theories.

6.1 Human factors

The first difficulty is related to human diversity: people's needs may be similar but ways to satisfy them vary from an individual to another, a culture to another. Also, it is difficult to create sensor-based devices for kids, because they easily break them. For older people problems change: some want to hide handicaps (and thus supporting devices) to acquaintances, to avoid being ostracized. Reactions of some Japanese elderly to exoskeletons [29] are encouraging but it is doubtful that they can be generalized abroad or within Japan.

Apparent difficulties might be linked to cultural and environmental issues, as shown by preferences regarding controls for wearables (figure 5). One should also remember that, depending on socio-economic settings, technological solutions to problems might not be the most suitable. Producing vaccines might be preferable and more accepted by a population than acquiring wearables that monitor health condition.

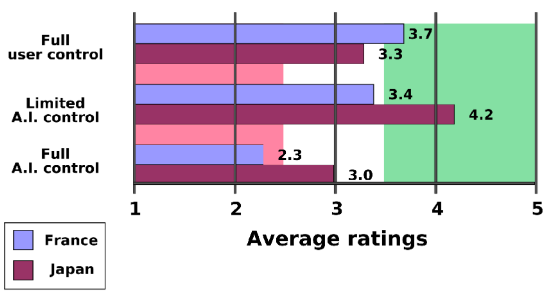

Fig. 5: Problems with different forms of control

With questionnaires and experiments we identified design issues like the rejection of *artificial intelligence* in wearables (figure 5). Although adaptive learning systems and autonomous agents are necessary for some services, people are afraid to loose control and part of their identity. Technologies like *emotional displays* create similar problems. For this latter, a solution is to focus on family settings, seen as most useful and least harmful (figure 6). Surprisingly *physiological monitoring* is not rejected for private use. However investigations are required for professional uses. A predictable difficulty is that using and sharing physiological data may be governed by national laws.

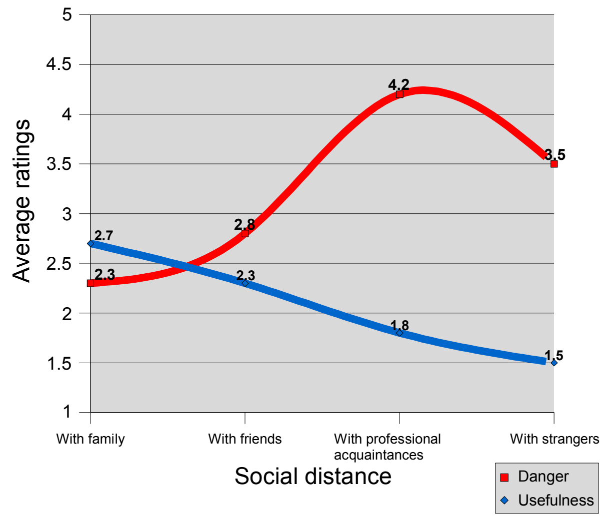

Fig. 6: Problem with the perception of emotional displays

As shown in table 2 acceptance of wearables can vary after experiencing them. This influence can be negative, however our results only showed positive shifts so far. These shifts render design difficult.

6.2 Technological factors

Persistent technological problems include battery life: many services must be continuously usable during work time (8 hours as a target), personal time (including transportation, lunch and evening), or both (e.g. health monitoring). This requires a breakthrough or very smart solutions. Then there is also the problem of privacy, of security, of services requiring a permanent connexion to the web (especially for life critical situations), and of the extraction of meaning from biosignals for specific services. Considering that these issues are currently being actively researched, we will not detail them here. However we will insist on the necessity to find identification measures for users that are not time-consuming. Because wearables will store highly private data and may be used continuously, this is imperative.

Small wearables, such as digital jewelry [22] add few problems; the main one being communication with other wearables (when applicable). On the contrary, enhanced garments add 4 specific problems: embedding components in textiles, washability, data transfer between clothes when changing of attire (daily or when lending to an acquaintance), and simultaneous integration of gender and cultural technological preferences in addition to usual issues of garments design. The two first problems are being actively researched however with the two latter ones we enter into virgin territories.

7. Prototypes and industrial products?

We propose guidelines to design wearable computers that improve quality of life then discuss form, behavior and final product issues.

7.1 Proposed design guidelines

Based on Maslow's theory and on our results so far, we propose eight guidelines that still need to be experimentally validated:

A – Wearables should improve the body condition, comfort and safety of their wearer, and possibly of surrounding or distant people.
- A1 – Full control by artificial agents should be avoided.
- A2 – Emotional disclosure based on physio logical data should be avoided, especially for non-anonymous public displays.

B – Support for communication should focus on disrupted settings (e.g. with disabled persons, or on trips) rather than on standard situations.

C – Design should be gender and culture oriented.

D – Communication with other entities, and suggestion of behaviors based on knowledge about wearers should be possible.
- D1 – Wearers should receive feedback about their wearable's activities.
- D2 – Surrounding persons should receive feedback about wearables' activities when they are concerned.

Personalization should be coupled with *simplicity*, taking into account the variety of personal needs' expression. We recommend thematic interviews to design specific services, identifying demands and experiences based on a use context (e.g. the family).

7.2 Form and behavior

Form-factors available to create wearables include garments, accessories, and miscellaneous shapes. As shown in table 3 garments are good to embed numerous elements: sensors, actuators, etc. However they pose the problem of daily changes in attire. For everyday uses, some functions might therefore be embedded in all garments of a given wearer, or embedded in accessories. For the time being, this latter solution is the most realistic.

Table 3: Main features of different form-factors

	Garments	**Accessories**	**Others**
Body contact	High	Low	?
Surface, volume	High	Small	?
Everyday use	Difficult	Easy	?

Psychological knowledge can also influence design, especially regarding systems' *humanity*. Should systems be as human as possible to create an emotional bonding with the wearer, and to ensure proposed advice will be followed? Leaving aside ethical considerations, this includes reflexions about wearables that think (independently of abilities to act), speak [13], have emotions [24], or are socially-aware. The ability to forget can also be stressed as positive[1] because it avoids burdening users with bad memories, which have psychological and social weights.

Another way to see *humanity* in wearables is to provide each wearable with a personality, using a role model (human people, animals, or fictitious characters) chosen by the owner. Such a personality could impact on task priorities and interaction styles. It might then evolve based on users' decisions and on environments.

7.3 In the real world

In Japan, fashion-conscious works by *Tsukamoto Team* [3], Wakita et al. [37], and Tsukuba teams [29] reveal the diversity of reactions to final or semi-final products. Reactions to *Tsukamoto Team*'s fashion shows demonstrate the attractiveness of (almost) non-functional but aesthetic wearables. Reactions to works by Wakita et al. show similar effects for garment-shaped wearables establishing faint human contacts, simple presence and dim contacts. Reactions to work in Tsukuba shows an attraction for very functional (but initially non-aesthetic) wearables.

To create real-world wearables, however, more than aesthetics and functionality is required: there are rules to create digital jewelry and enhanced garments [21]. Besides wearables cannot include all functions: choices are done by creators and customers. Design should therefore also be based on theories of choice.

Finally the real world is a good place to test and improve wearables. They can be evaluated for both their *quality* and *added-value*. The spread of wearables will mean opportunities to collect feedback and, at last, to carry out long-term studies.

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1 Liam Banon (University of Limerick), panel session at ISIE 2006.

8. What can demographic perspectives tell?

Taking various demographic perspectives, we can evaluate the existence of patterns and the nature of differences. We propose here two first views, one opposing French people to Japanese people, and one opposing males to females. Because these groups have different habits and behaviors; we can expect variations on needs and favored solutions. Cultural and national variations depend on several factors, notably nature (climate, natural disasters), the importance of individuality, technological availability/dynamism and acceptability. Our social investigations confirm variations but we still have to clarify underlying factors that lead to specific differences.

8.1 French vs. Japanese

Comparisons of results for the French and Japanese respondents of our questionnaires showed a few significant divergences in opinion (figure 7). An analysis with *t*-test for unpaired samples (2-tailed) shows significant differences with a statistical confidence of 95-99%.

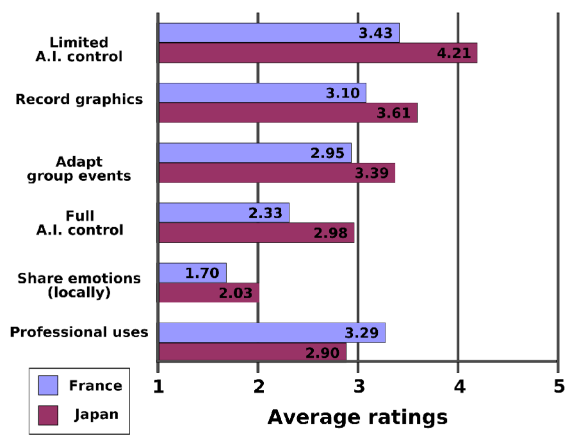

Fig. 7: Main differences between French and Japanese

Although the roots of the differences need to be investigated, we propose two explanations. Higher acceptance of artificial intelligence in Japan might be due to higher technology availability and dynamism: rapid evolution of cellphones, robots used at reception desks of some companies, etc. Another view is religious, opposing Shintoist values and beliefs (objects have souls) in Japan to Christian ones (only god should create life) in France. To test the importance of technological settings and of religion, we could do a dedicated cross-cultural study.

Finally higher acceptance in Japan of services adapting group events was expected due to the relative importance of individuals in France and groups in Japan.

8.2 Male vs. Female

Answers to the questionnaires also show differences between males and females' feelings towards wearables (figure 8). An analysis with *t*-test for unpaired samples (2-tailed) shows significant differences with a statistical confidence of 95-99%.

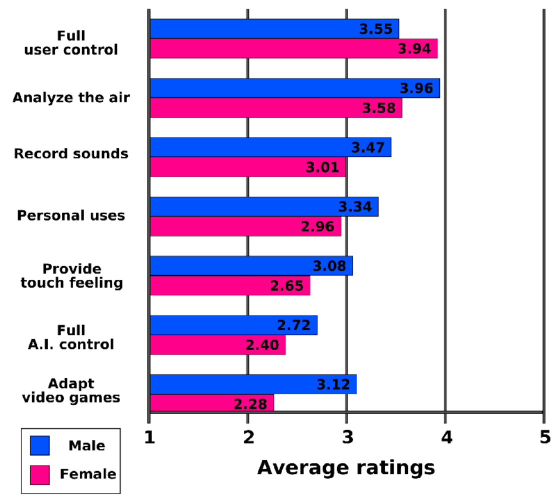

Fig. 8: Main differences between males and females

Here again, the roots of the differences need to be investigated. However higher acceptation of the technology by males is in accord with the literature [8][36] and was expected. This influence is so marked that the only item for which females score higher than males is a feature restricting the technology (*provide full user control*, as opposed to using artificial intelligence).

Of particular interest is the item *provide touch feelings*. First because it elicited much reactions from female respondents. Second because it is related to the hybrid nature of wearables, interface between wearers' body and the world (both physical and social). Although unremarkable during cultural comparisons, we expect this feature to require special care. While important in some countries (e.g. France), body contact is avoided in others (e.g. Japan). Besides it is a local act requiring a direct confrontation with the person touched. Altering this setting, wearables providing touch feelings might create unexpected situations, especially if abused by some users.

9. How do we ensure future viability?

Making wearables future-viable involves three main issues: reusability, ecology and technology diffusion.

9.1 Reusability

To ensure the coherent and sustainable development of wearables, reusable software is required, including common frameworks, APIs and components. Besides services should use common algorithms, for example to interpret data provided by physiological sensors. Light frameworks should be considered due to resource constraints; with possible benefits on energy-consumption. Open source would ease access and improvements.

9.2 Ecology

An ecological way to create wearables is to focus on recyclable materials and on modularity. Besides modularity will facilitate repairs, upgrades and support international interoperability, which should not be neglected considering existing problems with cellphones.

Environmentally friendly wearables should use as little energy as possible; as clean as possible (e.g. wind, sun, body [30]). Energy savings are also attractive due to the limitations of batteries. Choices of technologies and materials (e.g. embedded screens) must take this issue into account.

9.3 Technology diffusion

Technology diffusion allows knowledge transfers and symbiotic interactions. Knowledge transfers allow findings in wearable computing to benefit other fields and vice-versa. The similarity of issues of wearables and intelligent environments can lead to both faster developments and to better quality.

Such exchanges can also allow technologies to co-exist and develop symbiotic relationships; for example wearables with robots or intelligent environments. In such symbiotic environments, wearables have two undeniable advantages: they can provide permanent interfaces for other devices [38] and personalization for external services.

10. Future works and Conclusion

This paper asks questions that must be answered in depth to ensure the usefulness of research in wearable computing, the appropriateness of industrial products, and the respect of human specificities, notably cultural. It also casts light on issues related to the improvement of quality of life with wearable computers.

We will carry out more investigations with interviews, questionnaires and experiments. We also plan to develop prototypes with industrial partners. Interested in long-term issues and in use by everybody (general public, culture, gender), we must go as far as develop very practical prototypes tested in real-world everyday life settings. Besides we will create and evaluate scenarios, and collaborate with design or visual art schools to create sketches to show to the general public.

Finally we will simultaneously study intelligent environments to see how these technologies can interact.

11. Acknowledgments

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