# Considering Personal Profiles for Comfortable and Efficient Interactions with Smart Clothes

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**Abstract.** Profiles describing the abilities and specificities of individual wearers enable smart clothes to fundamentally and continuously personalize their behavior, suggesting or selecting useful, comfortable and efficient services and interaction modes. First, we suggest foundations for the design of personal profiles for the general public based on perception, bodily characteristics, culture, language, memory, and spatial abilities. Then, we sketch reactions towards profiles for oneself and one's family based on a 2008 pilot study in Japan. Accordingly, we discuss the creation, update, use and dissemination of profiles, and finally perspectives for future social investigations.

**Keywords:** General public, Interaction, Smart clothes, Sociology, Ubiquitous computing, Personal Profile, User profile.

## 1 Introduction

Individuals may benefit daily in private, public or semi-public places from services proposed or adapted based on personal profiles describing users' specificities, because our past differentiates us, ubiquitous services diversify [1], and contacts with personal, shared and public systems affect quality of life. For instance, partially sighted people may access guidance systems of little use to fully sighted people; terminals may offer sound along with altered graphics to compensate color deficits. Young children may navigate digital encyclopedias through associative links while adults access logical links. Tourists may hear explanations adapted to their culture in a familiar language. Considering activities, aging and disabilities, profiles would benefit most people sooner or later, possibly with mobile networked devices handling local services.

With accepted well-thought standards, designers worldwide could greatly enhance systems and favor universal access in a single year, exploiting simple profiles stored in contact cards. Moreover, using detailed profiles in cellular phones or smart clothes (clothes containing computers), designers could bring singular services to challenged

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as well as non-challenged individuals on a time-scale contingent on the technology concerned. Smart clothes are most challenging because their size, shape and location allow for more numerous and more diverse sensors and actuators as well as for novel services such as health monitoring based on bio-sensors. Knowledge about the wearer appears necessary to mitigate the resulting complexity, e.g. by suggesting inputs and outputs to ignore or prioritize. Advanced smart clothes may thus paradoxically simultaneously provide and require personal profiles.

Profiles make sense for the general public since computer users diversified (e.g. kids and elders), access to shared systems spread (e.g. terminals in train stations), and affordable mobile devices emerged (e.g. Apple's *iPhone*); the commercialization of smart clothes worn most of the time will strengthen these three motivations. However, standard personal profiles to share information through time, between devices or services appear non-existent. Computer users can barely adapt operating systems to their abilities and needs: accessibility features are static patches with limited options, linguistic choices exclude proficiency levels, and personality and intellect are ignored. On top, local applications are secretive about users, and online services request data to improve business rather than interaction. Only e-learning commonly exploits profiles but they are usually tightly linked to systems themselves, and usually lack sensory, linguistic and psychological dimensions.

As multiform ubiquity exists [1] and as huge sums were invested in it worldwide for a decade, one may expect at least embryonic research on all fundamental issues, including profiles. However, the community pursued a monolithic agenda suggested by Weiser's vision [2], focusing on context awareness: systems were to adapt to the user's location, access to devices, identity of bystanders, etc. Personal profiles were systematically ignored although, ironically, they could promote the humane face of Weiser's vision called "calm technology" [3] by uniquely shaping information to provide at the center and periphery of a given person's perception.

Outside ubiquitous computing, the creation of profiles was probably hindered by the intuitive difficulty of cheaply gathering and maintaining reliable sensori-motor and psychological information, accordingly adapting systems, and respecting privacy. To these inherent obstacles, we may add the excessive focus on technology and the over-specialization of scientists; for example works abound to adapt Internet services to various screen sizes *independently* of users.

Finally, some may argue that instead of creating personal profiles to adapt systems we should improve general usability and, when necessary, create dedicated devices. This would be unsatisfactory for the modeled majority of users as improving general usability cannot lead to an optimal design: different users may have conflicting priorities. This would also be unsatisfactory for others as they may not obtain smart clothes–even remotely–appropriate to their specificities, especially if concurrent conditions affect them. Besides, adaptive garments may be very valuable when situations quickly change, for instance when one breaks her leg or when aging degrades senses. Thus, we should simultaneously pursue personalization and improvements in usability.

Hereafter, we suggest foundations for the design of personal profiles based on perception, bodily characteristics, culture, language, memory, and spatial abilities. Next, we sketch reactions towards profiles for oneself and one's family based on a 2008 pilot study in Japan. Accordingly, we discuss the creation, use and dissemination of profiles. Finally, we conclude on perspectives for future social investigations.

## 2 Current Knowledge Suffices to Create Partial Profiles

To firmly found personal profiles for the world general public, we cover aspects relevant to everyday life with smart clothes. Some additional aspects are discussed in section 4.1. For more information on impairments and functional abilities, see [4].

Deep knowledge of vision and hearing was successfully applied to design cinemas, glasses and cochlear implants [5]. Complex, touch is underexploited by still emerging technologies. We omit smell and taste because the former is badly understood and the latter of little interest in clothing. Beside human senses, bodily features are critical for clothes, culture and language for global markets and mobile users, and memory and spatial abilities for proper uses of most computers.

### 2.1 Vision

We can characterize vision with contrast sensitivity (to distinguish light and dark), visual acuity (to discriminate details), visual field, and color perception, which all affect human-computer interactions [6]. A significant part of the world population is partially sighted, and suffers from important disadvantages when compared to sighted people (e.g. 50 times slower to select icons [6]).

Contrast sensitivity may be assessed with a Pelli-Robson chart, visual acuity with a Snellen or Bailey-Lovie chart, the visual field with standardized automated perimetry, and color vision with the Farnsworth D-15 color vision test [6]. The human visual field approximates 200 degrees but disabilities may modify it, affecting everyday life and immersion in data spaces provided by e.g. semi-transparent glasses. Similarly, inter-ocular distance and data about an eye disease or loss helps manage stereovision.

### 2.2 Hearing and Speech

We can characterize hearing with frequency-specific auditory thresholds (in dB) from which a sound is heard; important to notice and identify sounds, and to evaluate the distance to their source. The average intensity required to hear pure tones at 500, 1000 and 2000Hz could provide a unique reference [4]. Head-Related Transfer Functions (HRTF) also characterize hearing; describing the behavior of sound within a listener's body, especially at the outer ears, they provide spatial clues [7] useful for stereophonic music and some augmented-reality services. Diseases, drug consumption, exposure to loud sounds, and genetic expression may degrade hearing [5].

We may easily characterize speech by its impairments based on audibility, intelligibility, and functional efficiency [4] but such data is difficult to effectively exploit. Age typically alters speech, elders multiplying repeats and restarts in sentences.

### 2.3 Touch

Complex, touch informs about pressure, vibration, temperature, pain, and position thanks to cutaneous and kinesthetic systems. Fully profiling it seems unrealistic as numerous various receptors heterogeneously cover the body; interfaces exist even for the inside of the mouth [8]. Dedicated research is here necessary to establish the data to gather and standard measurements, taking into account bodily differences (e.g. fat, gender) and the influences of age on the short- and long-term.

### 2.4 Bodily Characteristics

Anthropometric information such as citizens' height and arm length is typically gathered by textile/clothing organizations to evaluate their market or by governments to evaluate the health and evolution of the population. These measurements provide a basis to profile the body of users of smart clothes but should be complemented with dynamic information regarding e.g. joints or excess fat during movements (useful to select or tune interaction algorithms). Besides, data on dominant and non-dominant hands could help adapt interfaces.

Finally, age may be a useful proxy for missing information (in or beyond the scope of a profile) because it allows assumptions about users' abilities; for instance, children, young adults and older adults fatigue at different rates. Recommended interaction and navigation techniques may change according to the developmental phases of children and potential problems of elders.

### 2.5 Culture and Language

Culture affects abilities, common sense, preferences, and world views. In the broad sense of the word, we all simultaneously belong to several cultures, related or not to a national identity. Standardizing classifications of non-regional cultures is a challenge but, as a starting point, one may easily be defined by the culture of her citizenship.

Linguistic abilities can be defined by a list of spoken/written languages, associated to proficiencies characterized by the knowledge of vocabulary, semantic structures, usage patterns, and writing features. A common standard lacks but independent ones exist for several languages (e.g. Test Of English for International Communication, Japanese Language Proficiency Test).

### 2.6 Memory and Spatial Abilities

Memory can be divided into sensory, short-term/work, and long-term [4], respectively dealing with immediate sensory information, items for 20-30 seconds, and generic permanent storage. Interacting with computers usually mainly involves short-term memory, easily evaluated by the number of items a person can remember for 20-30 seconds. Smart clothes may promote sensory memory due to their actuators, as well as long-term memory linked to new communication and interaction patterns.

Spatial abilities cover spatial perception, spatial cognition, navigation, movement, and manipulation in three-dimensional spaces (e.g. mental rotations), and can notably be evaluated with subsets of Intelligence Quotient (aka I.Q.) tests.

## 3 Reactions of the Public in Tokyo Suggest Acceptable Designs

We gathered surface information about the general public's perception of potential everyday life uses of personal profiles with paper self-completion questionnaires, and clarified results with informal interviews in Tokyo (Japan) from March to November

2008. 84 citizens from Japan and 11 other countries, aged 11-75, including as many males as females, participated to this pilot study. Accessible and featuring leading edge technologies, Tokyo was appropriate to evaluate people's interest in personal profiles for ubiquitous services, and collect sufficient quality information to prepare big scale investigations planned for 2009-2010.

Background information of interest included problems experienced in everyday life with familiar systems. Core issues were feelings about physical or mental profiles for oneself and for one's family, differences in reactions for private, public and shared systems, wishes for services and practices.

We designed a 6-page questionnaire, including 4 series of background questions, 17 series of core closed-ended questions, and one open-ended question. We revised it based on comments from a test group, and provided checked versions in Japanese and English. For core questions, participants rated assertions on a 5-point scale: 1-strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree, and 5-strongly agree.

Respondents were not shown screenshots, photos or videos to avoid bias. A short text introduced the study as research to *evaluate existing information systems*, and *design future devices and services for use by the general public in everyday life*. Systems were defined as *any computer equipment, electronic device or software*. Questions evoked familiar technologies, wearable computers, smart spaces and robots.

We clarified the collected data with interviews to establish hypotheses for future studies. We limited statistics to medians, the most simple but least controversial measure for opportunity-based sampling, which provides weak data. The reactions of respondents from diverse cultures expressed a clear pattern presented hereafter.

### 3.1 Familiar Everyday Devices Already Pose Problems

Example of assertion to rate: *I already experienced movements problems (example: accurately and quickly use a mouse or type on a keyboard) when using cell-phones or computers.*

Cellular phones and computers raise interaction-related problems in everyday life. Most respondents experienced significant difficulties with systems due to movements (median: 4), and sometimes to language (median: 3) and spatial abilities e.g. difficulty to find appropriate menus or icons (median: 3). However, respondents think they had no problem due to vision (median: 2), hearing (median: 1) or memory (median: 2).

### 3.2 Profiles Seem Useful for Personal Systems Used by One's Self and Family

Examples of assertions to rate: *It would be useful to adapt my children's systems to their ability to see, hear, feel objects, and move and To automatically adapt public systems (for example when buying train tickets or getting guidance in shopping malls), I would provide information about my vocabulary (example: meaning of software menus).*

As seen on Figure 1, respondents feel it would be useful to adapt their systems to their vision, hearing, movements, spatial abilities, memory, and vocabulary (median: 4 all). However they are ambivalent about providing information on their cognitive abilities (median: 3).

Although respondents think adapting public systems is also useful, they refuse to provide information for it (medians: 1.5 to 2.5) except for vision (median: 3).

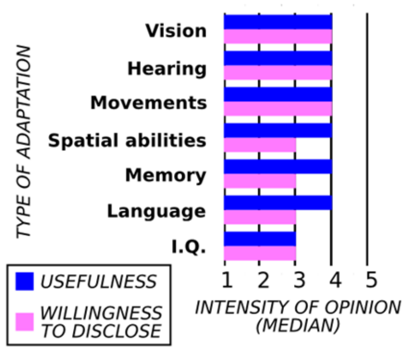


**Fig. 1.** Perceived usefulness of adaptations, and perceived willingness to disclose information, for use with one's personal systems

Finally, most respondents feel it would be useful to adapt their children's and older relatives' systems to their perception, spatial abilities, memory, language, (median: 4 all) and possibly to their Intelligence Quotient (median: 3). Questionnaires being long, we omitted questions on profiling relatives to adapt public systems and on disclosing information to profile relatives.

### 3.3 Monitoring of Abilities Seems Fine for Oneself and Elders, Not Children

Examples of assertions to rate: *I would feel comfortable and agree for my systems to monitor my memory and I would feel comfortable and agree for my children's systems to monitor their mastery of vocabulary and grammar.*

Respondents would seemingly quietly let their systems monitor their perception (median: 4), language (median: 3.5), and spatial abilities (median: 4), yet less their memory (median: 3) or Intelligence Quotient (median: 3). Respondents are even more enthusiastic about the monitoring of their older relatives' language and memory (median: 4 both). However, they express mixed feelings for the monitoring of all children's abilities (median: 3 all).

### 3.4 Disrupted Settings Strongly Promote Adaptations

Example of assertion to rate: *I would like services to adapt to me when I am pregnant.*

Respondents indicated strong wishes for adaptations of services in disrupted settings: when pregnant (median: 5), physically or mentally challenged (median: 5 both), ageing (median: 5), or abroad (median: 4). Most respondents also wished adaptations when using other people's devices (median: 4) yet this possibility elicited negative reactions from several respondents.

### 3.5 Profiles Should Be Stored on the User, Not Online

Examples of assertions to rate: *I would feel comfortable with storing a description of my ability to see, hear, feel objects, and move in a card sending information only in contact and I would feel comfortable with storing a description of my intellectual abilities such as finding objects, remembering things, and solving complex problems online with a personal service from e.g. Google.*

As seen on Figure 2, respondents would feel comfortable with storing information about their vision, hearing and movements in a contact-card or cell-phone (median: 4 all) but less about spatial abilities, memory and language (median: 3 all). Although online storage is usually rejected, it is the preferred method of some respondents who consider it the best method, arguing that companies like Google would do their best to protect the data in order to safeguard their reputation.

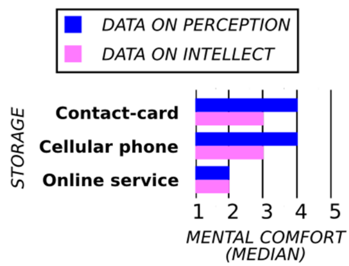


**Fig. 2.** Projected comfort when storing personal profiles according to supports

## 4 Discussion

The actual feasibility of useful personal profiling and its apparent attractiveness to manage everyday systems suggest that smart clothes may successfully store and use a wearer's profile to continuously adapt their behavior and that of nearby devices. How shall we create, update, exploit and promote such profiles?

### 4.1 Practical Creations and Updates Necessitate Much Thinking

Smart clothes typically involve multi-modal interactions, fabric-embedded sensors, and ubiquity. Personal profiles should thus logically cover (1) senses, spatial abilities and memory, (2) bodily characteristics, and (3) culture and language to ensure access to, and understanding of, information, as well as to render wearers' interactions more comfortable and efficient. However, we need research to define standards for culture, language, smell, and touch because they are complex. Although personality and preferences may serve, they would provide weak foundations to personal profiles because their subjective nature favors incompatible standards, and reduces their usefulness to adapt arbitrary services.

Doctors and psychologists may assess elements in section 2 to create or update profiles but this approach is unrealistic due to their busyness and costs. Alternatively, profiles could be initialized from templates then updated, which makes sense for homogeneous (e.g. kids) but not heterogeneous (e.g. elders) groups. Monitoring [9, 10] or evaluations through games [11] by smart clothes are cheap, convenient and enjoyable update methods; the former requires new algorithms [12] but the latter already works. Profile elements may be specifically updated at appropriate moments, taking into account developmental phases for kids [13], risk assessments for elders, cultural events (e.g. rites of passage), policies (e.g. age for English tests), and environments (e.g. noise pollution). Updates should be possible based on context-awareness or on demand to quickly adapt to disrupted settings, a key wish of respondents.

Various creation and update methods should be considered to allow for unequal wealth, technology and expertise worldwide, but also for different levels of patience (e.g. children) or health (e.g. elders).

### 4.2 Designers May Easily Enhance Wearers' Comfort and Efficiency

With profiles, designers may easily select interaction modes e.g. vision for fully sighted wearers but touch for the blind, or adapt stimulations e.g. size/color of icons, loudness/type of alarms, pattern/location of vibrations for immersive games or affective telepresence. Knowledgeable designers may enhance interactions based on bodily features by correcting the results of accelerometers due to fat, on memory by applying memorable lengths to messages, and on spatial abilities by switching menu styles. Smart clothes may define referenced words and concepts to children and travelers based on their linguistic proficiency. The Intelligence Quotient is a natural–weak–proxy for memory and spatial abilities; age may similarly serve for homogeneous cohorts (using e.g. developmental phases [13]), before old age. Integrating data from separate domains, smart clothes may enrich face-to-face communication with displays on their surface of visual metaphors adapted to an interlocutor's age and culture. Finally, staff in game and shopping centers may check profiles to suggest simulators or new smart clothes.

Smart clothes should be carefully exploited for medical, psychological, social, and legal reasons. We need research on the effects of body-wide stimulations and continuous adaptations, especially for children and elders, and during pregnancy; meanwhile, designers should diversify stimuli. Besides, providers should acknowledge erroneous and incomplete profiles because updates may lag, wearers may be cautious towards e.g. public systems, and uses may be rejected (e.g. touch for women [14]) or taboo. Finally, online storage should be avoided as international privacy laws may restrict its use, which matches the public's apparent concerns and preferences.

### 4.3 Ubiquity May Spread Profiles before Smart Clothes Become Mainstream

To avoid familiar problems, respondents are open to adapting ubiquitous services with personal profiles for themselves, their children and older relatives, especially in disrupted settings. This family-friendly view should foster adoption as parents equip their children and sometimes also their own parents. Monitoring by personal systems is a key enabler for up-to-date profiles so worries about children's monitoring should be investigated and, if possible, alleviated; other predictable concerns should also be researched to save this confidence capital from risky or inappropriate first products.

Embedding perceptual profiles in contact cards or cellular phones seems a first step with few drawbacks; cognitive elements may spread later, after they prove valuable to e.g. stimulate young and elder first adopters. However, adding the Intelligent Quotient seems dangerous. To deal with distrusted services, users should be able to prevent access to their profile, provide a vaguer version or a common archetype.

Profiles may be adopted on a larger scale in populations that are heterogeneous (due to aging, pollution, healthcare) or share devices (due to cost or availability), and in environments where diverse networked mobile services are available. Considering initial reactions and the potential of smart clothes equipped with profiles, early adopters may be travelers, challenged people, children, elders, and pregnant women.

## 5 Perspectives

Personal profiles already appear feasible and acceptable to the public. Exploring their creation, update, use, and adoption, we suggested bases for comfortable and efficient interactions in *ubiquity-enabled* countries, notably with smart clothes as daily support from youth to old age.

We will check, deepen and extend our hypotheses with big-scale studies in Seoul in 2009-2010 using better sampling and various methods to study variations due to age, gender and culture, e.g. drawings and scenarios with children. As proof of concept, we will also define XML descriptions of personal profiles to adapt the behavior of smart clothing prototypes from the *Smartwear Research Center*.

Considering uses, we may ask: When are profiles thought useful for children and elders, and why? What are influential fears, hopes and values? What risks do personal profiles raise? How shall we provide affordable reliable profiles worldwide?

Considering design, we may ask: What tools would help design regarding memory, spatial abilities, language, culture, and concurrent disabilities? How shall we combine profiles about users and about garments? How shall we test and validate adaptations?

Besides, we may ask: How will gender, culture and spirituality shape standards and the adoption of personal profiles, considering the symbolic role of clothes, body images, perceptions of technology, and the importance of individualism? How will body implants, contact cards, cellular phones and smart clothes relate to each other? What will be the energy costs and benefits? How important would integrated profiling be to enable advanced smart clothes?

Finally, although beyond the core scope of technological research, we must consider the potential for abuse or misuse of information created by ubiquitous transfers of so far unavailable personal detailed information, leading to e.g. oppression of human rights with impacts on denial of dignity, risks to personal security or to the ability to shape one's own future. On the contrary, personal profiles could support cultural diversity and reduce wasted (human) potential.

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