Universal Design for Mobile Phones: A Case Study

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Abstract
In this paper we describe a case study of Universal Design applied to mobile phone physical devices. Using a user-centered design process, we tried to integrate visually-impaired, hearing-impaired and elderly peoples' needs to design mock-ups adapted in terms of usability and design style.

Keywords
Universal Design, user-centered design process, disabled people, mobile phone.

ACM Classification Keywords
H5.2. Information interfaces and presentation: User Interfaces – *ergonomics, user-centered design*.

Introduction
Today, more than 20% of the world population is equipped with a mobile phone (this rate exceeding 50% in most of industrial countries), and many people consider their mobile phone as an essential accessory of their everyday life. However, the devices provided by the current market remain unsuitable for some of us. In the present study, we investigated the issue of adapting mobile phones' physical device to people with visual, hearing or dexterity impairment. For such a goal, we had to study and take into account multiple

individual specificities in the design process in order to obtain a product usable by as many people as possible. This process closely related to Universal Design enabled us to design devices resembling everybody's phone and thus to avoid the stigmatizing effect of products labeled "for disabled people".

Universal Design

The design of products for people with disabilities or impairments should care not only about usability dimensions but also about the image and values conveyed by the products, in order to make them acceptable in our social environment. If the product displays the idea of disability, it is likely to be rejected by the users it is intended for. For example, mobile phones with no screen, especially designed for blind people, may not necessarily meet market success. Conversely, the present study is grounded on Universal Design recommendations, which specify that a product should not be specialized for any particular population but may be suitable for most users. "The intent of universal design is to simplify life for everyone by making products, communications, and the built environment more usable by as many people as possible at little or no extra cost. Universal design benefits people of all ages and abilities" [3,5].

Global design process

The process we followed in this study is presented in Fig. 1. We studied user needs both on usability (functional dimension) and design trends (stylistic dimension). This served as a basis for creativity sessions, which resulted in new concepts that we materialized into mock-ups to be user-tested.

Our target users were: (1) visually-impaired to blind people, (2) hearing-impaired to deaf people, and (3) elderly people, who may have declining visual, auditory and motor capacities (limited dexterity).

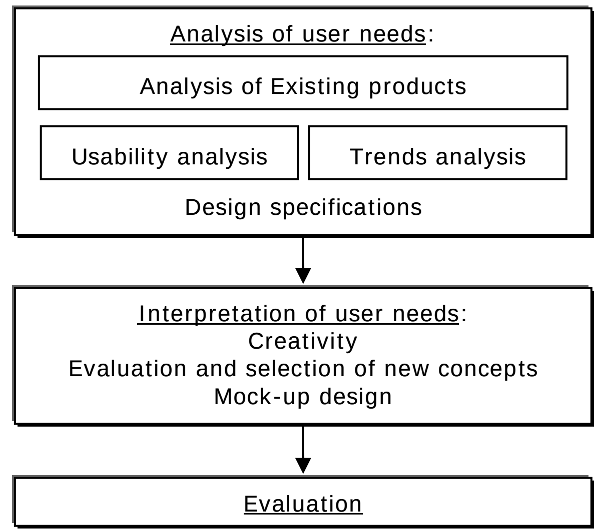

figure 1. Design process.

User needs analysis

This phase consisted of three studies described below.

Analysis of existing products

We benchmarked solutions, products and services for impaired people. Some mobile phones are designed specifically for people with disabilities (Fig. 2), e.g. with large keys or Braille interface, but these products are usually expensive and socially discriminating – moreover, most of blind people do not read Braille. Besides, telecommunication companies generally offer some services (e.g. vocal servers) to improve accessibility of mobile communication whatever the device actually used, but these services sometimes remain unknown to the users.

figure 2. Device with Braille interface (left), screenless phone with text-to-speech (middle) and large keypad (right).

Usability analysis

This research benefited from a large-scale survey on the way people with impairments use their mobile phone, what their usability problems and preferences are. In early stages, we interviewed a sample of users and conducted scenario-based observations (give a phone-call, write a text message, etc.): we met 4 blind persons and 2 visually-impaired ones, a hard-hearing man and a woman with visual and hearing impairment, 2 elderly users with slight visual, hearing and rheumatic problems. These data enabled us to build a questionnaire which was circulated via French associations, Internet forums and e-mails. A total of 74 users filled out the questionnaire: 27 visually-impaired to blind people (aged 20 to 70), 27 hearing-impaired to deaf people (aged 20 to 70), and 20 elderly users (60 to 80 years old). 70% of this sample actually used a mobile phone.

The questionnaire addressed usability issues related to both the physical device and the digital interface of mobile phones. As the present study focuses on the physical device, we only report results concerning this particular topic.

VISUALLY-IMPAIRED PEOPLE

The way this population uses mobile phones depends on their device and on their impairment. Late-blind people encounter much more difficulties than early-blind persons who could develop more compensating capacities and strategies. Most of blind people have a good mental representation of their keypad. Navigation on the keypad is guided by the raised dot on the number 5. Blind people use both hands to manipulate their phone: one holds the device; the other one explores the keypad with the index finger or with 3 fingers (index, middle and ring finger). Many usability problems are related to hard-to-feel buttons (lack of relief or tactile discrimination). 18% of visually-impaired people use a phone with text-to-speech providing auditory feedback on information appearing on the screen. Speech recognition is also sometimes used to call someone by speaking his/her name.

For people with low vision, the main difficulty is related to the font size on the screen and the keypad, as well as to luminosity and contrasts (e.g. some users better perceive black-and-white contrasts, others are unable to read a too bright screen).

HEARING-IMPAIRED PEOPLE

People with auditory prosthesis generally cannot use their phone on the auditory channel because of interferences with their prosthesis – and volume amplifiers are generally not sufficient to substitute for the prosthesis. Besides, the use of mobile phones as videophone is not widespread yet among people using sign language. Thus, hearing-impaired and deaf people use their mobile phone almost only for text messages. In this respect, usability of the keypad is an important criterion for this population: a usable numerical keypad will sometimes be preferred to full-QWERTY devices which have too small buttons, too close from one another. The possibility to use a predictive text-input system such as T9 is also a key feature for this population. Finally, visual in addition to vibrating alerts are necessary to notify a call or a message.

ELDERLY PEOPLE

This population uses mobile phones mostly for spoken communication. As for visual-impaired people, font size on the screen and keypad has to be large enough. Other frequent problems that were mentioned are: the apparent fragility of mobile devices, the too small key space, and the audio ring volume (insufficient even when set to the maximum).

CONCLUSION

Our user needs analysis (only partially reported here) supported about 75% of the results previously reported by Tomioka et al. [4]. Altogether, the data collected were converted into design specifications for mobile phone devices that would be suitable for impaired people as well as for anybody else.

Design trends analysis

Like many objects and accessories we wear, mobile phones are submitted to design trends which influence e.g. shapes, textures, lines and colors of products. Trends analysis enables to identify and integrate current trends into the design process. Contrary to the usability analysis, our trends analysis did not focus on people with specific needs or impairments but considered the whole market.

figure 3. Semantic map of existing mobile phones. The vertical axis represents the perceived simplicity of the device (up = high simplicity; down = low simplicity). The horizontal axis represents the degree of innovation (left = poor innovation; right = strong innovation). The star shows the position we chose for our product.

The first stage of the trends analysis method [1] consists of a benchmark of iconic content of existing products in order (1) to identify sectors of influence and (2) to position the new product wrt. concurrent products. A team of 6 designers thus collected a large sample of pictures of existing mobile phones and organized them into a semantic map (Fig. 3). The choice of the axes and the distribution of products along them was based on a common workgroup's agreement: the vertical axis represents the perceived simplicity of the device and the horizontal axis represents the degree of innovation. The star on Fig. 3 shows the position of our product: we intended to design a mobile phone with a high perceived simplicity and a moderate innovative design (suitable for as many users as possible).

This semantic map was also used to identify sectors of influence in order to create trend boards [1], a tool highlighting coherence in a perceptual field, harmony between shapes, textures and colors, related semantic field and social values. 5 trend boards were created (see an example in Fig. 4).

figure 4. Example of a trend board.

Finally, we integrated previous results about stylistic preferences of users [2], which showed e.g. that mobile phones should display the idea of softness (e.g. curves, asymmetry, ellipses, large screen…).

Results

A creativity session based on usability specifications and trends analysis resulted in multiple concepts of mobile phone devices. We selected 4 of them (Fig. 5) to be materialized into mock-ups (polyurethane foam or Stratasys® ABS). The form factors are classical, consistent with the position chosen on the semantic map (Fig. 3), and the styles were guided by the trend boards (e.g. the example shown on Fig. 4 partly influenced the A and D concepts). Regarding usability, Table 1 lists the main design features of theses concepts.

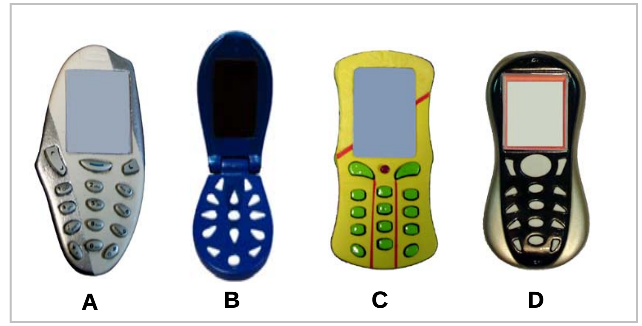

figure 5. The 4 physical mock-ups.

Criteria	Description
Sufficient size of the device	Important for grip of the device and size of the keypad.
Sufficient size of the keypad and the buttons	Usability of keypad and sufficient font size on buttons.
Limited number of buttons	14 to 18 maximum to have an easier mental representation.
Marker on key 5	1 or 2 raised dots.
Organization of the keypad	Convex alignment of buttons (A, C, D concepts) to facilitate tactile exploration by the 3 middle fingers.
Space between buttons	Improves tactile discrimination and usability of keypad.
Button shape	Rounded shape on the top for better tactile discrimination. Shape varying according to the position (B and D concepts).

Button texture	Soft, different from the texture of the device body. Possibility to use different textures for different buttons.
Button relief	Sufficient relief to feel force feedback and to facilitate tactile exploration.
Visual feedbacks	To notify a call or a message.

table 1. Design features.

The A concept also uses asymmetry to improve grip (both for right- and left-handed users): the small bump on the left can either guide the left thumb or be placed between middle and ring right fingers. Moreover, asymmetry was shown to be appreciated by users [2].

The B concept has the minimal number of buttons (14): the numerical pad is also used for navigation and validation. The shape of buttons 2, 4, 6, 8 indicate directions (↑, ←, →, ↓). The 5 button is round to indicate the center of the pad and the validation action.

Conclusion

This study was grounded on Universal Design recommendations applied to mobile phone physical device. For this purpose, usability specifications were based on special needs of people with disabilities, but stylistic specifications were based on general design trends. The resulting mock-ups now have to be user-tested in order to validate these two aspects as well as our whole design process. One limitation of our study may be the stylistic dimension, since we had no graphic designer in the team: the stylistic design consisted in non-expert formalizing the trend boards. However, we may emphasize that our mock-ups do not look like existing products for disabled people (Fig. 2) and thus may meet our goal of harmonious integration into our social environment. Finally, this study provides a few ways of improvement (needs analysis and design specifications) potentially useful for mobile phone manufacturers.

With a similar process, the next step of this project will be to use the remaining data from the needs analysis to design a digital interface (phone menu and functionalities) for universal mobile phones.

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