# Usability evaluation of a mobile system through a "design-for-all" oriented approach.

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## Abstract:

**This communication restores a research about the validation of the usability of a mobile-information system intended to help the travelers by means of interactions with mobile technologies -mobile telephone, portable computer, PDA, pocket PC…). As this system is developed for all types of users, its usability must be adapted to the greatest possible number of people, otherwise the gap between the users' numerical skills is just to be amplified. With the objective to guaranty a high level of human performance, this paper presents evaluation processes which associate techniques of ergonomic inspection based on criteria, on tests in a laboratory specialized in usability and on satisfaction surveys carried out in live situations. These processes also try to integrate the design-for-all prospects to the evaluation. As a whole, the heuristic inspection results carried out by two experts -by means of tests on 60 people and of questionnaires given to 500 users live- emphasize the need to associate these methods in order to create highly adapted systems.**

## 1. INTRODUCTION

The development of the mobile systems such as PDAs (Personal DIGITAL Assistants), pocket PCs and 3rd-generation telephones has contributed to develop the problems induced in the field of visualisation, of the continuity in service and more generally in that of the human-machine interaction. With these systems, the environment is more and more seen as a means of getting a source of information by way of a wireless network. As for the user, he is considered as being the agent of an interface system which enables him to be connected, work, play, get information or purchase while interacting from afar with a complex network of systems.

These systems are nonetheless meant for everybody, including people with specific needs who -by their ages, their experiments, their impediments- are not accustomed to such devices. It is indeed a major issue to try to adapt mobile systems to everyone because it refers to both technical and ergonomic aspects but also to social and political dimensions concerning the role these people play in our society. Thus, this communication aims at introducing and debating upon an evaluation-correction procedure concerning a mobile device which was presented to samples of highly contrasted users (elderly people, beginners, experts). The procedure is based on a simple idea: a device is said to offer satisfactory conditions of use if it can be used by people with specific needs as well as by experts.

In order to develop this idea, we will first of all present a theoretical framework focussing on the evaluation of the usability of mobile systems for everyone. We will then specify the problem tackled here and the methodology hence developed. Eventually, the result analysis -carried out both live and in a laboratory- will bring us to debate on the interest of a validation procedure about the usability of mobile systems through a design-for-all approach.

## 2. THEORETICAL FRAMEWORK: EVALUATION OF THE USABILITY OF THE MOBILE SYSTEMS

Generally speaking, the research undertaken on the evaluation of the uses of mobile systems insisted either on the contents of the difficulties met by the users or on proposals for evaluation procedures. Let us quickly present these two complementary positions.

### *2.1. Contents of the evaluations of the usability of the mobile systems*

So far, mobile technologies were evaluated from various points of view. Some research works dealt with the problems of the user's movement coordination [1, 5], others with that of the use of multimode supports to restore information [3], and some others only studied interactions with the system [2]. In fact, these studies showed that the user's expectations towards these mobile tools were important. The multiplicity of supports and the increasing number of the possibilities for services explain why these new technologies are meant for categories of population with very different profiles as for age, technical experience or specific needs. This diversity in the users forces us to conceive efficient and easy to use systems [4] which will enable the greatest number of people to get easy and fast appropriation. To this purpose, some research works dealt with the coordinated management of movement and thus with the interaction capacities with tools which often require the use of a stylet [1]. Other works dealt with navigation in a physical space [4]. If it is often an easy task to point at a menu while not in motion

(at home), it can become quite awkward in the case of chaotic movements or travels -like on a bus. This extension in the user's space [2] or its modification -according to the time of day- is one of the characteristics which have led to developing the mobile terminals. The management of the interactions of such systems shows that the interface and the management of dialogue take a dominating or even fundamental place in the development of a communication with mobile devices.

A first series of researches tried to specify the conditions of acceptance or rejection of such devices: They explained the difficulties in their use by indicators of complexification in the interaction situation, as compared with the motionless situations. These studies emphasized the importance of the constraints linked to the geographical limitations of use (residence, bus, car, street, etc), to the services availability (diversity, limited or long opening hours, etc) and to the users' profiles.

### *2.2. The approaches of the evaluation of mobile system usability*

In order to develop a usability mobile technology, other kinds of studies considered that an effective usability evaluation method is fundamental. According to [19, 20, 21, 22], various usability evaluation methods have been developed, like laboratory-based usability testing which gives high-quality usability data with actual users. But the effectiveness of such assessment can dramatically vary, depending on who takes part in the tests, on what data are collected and on how they are analysed.

In recent years, Lee, Hong and Smith-Jackson [18] presented a systematic methodology called SEM-CPU (systematic evaluation method) to evaluate cell phone user's interfaces in laboratory-based usability testing. SEM-CPU aims at guiding usability engineers when integrating five empirical methods (scenario-based task performance, questionnaires, think aloud retrospective, after-task interviews, and user observation) in a laboratory to discover valid usability problems, and to generate proper design specifications. The whole of the SEM-CPU procedure -in terms of data collecting, analysis and integration- was described to give a frame in organizing usability evaluation for mobile systems. On the same point of view, [23] suggested a method to help interactive software reengineering: They suggested a common study support between Software Engineering and Human Factor specialists. This method explicitly combines Petri Nets and ergonomic criteria.

Although integrated approaches of usability evaluations are specifically designed in particular fields (medicine, mobile phone, PDA…), the validation of mobile systems on a large scale of users is not achieved yet. The problem of the validation of a mobile interface for everyone is still up-to-date. And the question is: how can we make sure that a system originally meant for young users is useful, efficient and easy-to-use for elderly ones with special needs?

### *2.3. Integrating the design-for-all aspect to the evaluation*

Designing a product for everyone means taking into account a maximum of users in a maximum of contexts of use at the time of its conception. This definition well applies to the mobile systems (even if some of them, like the PDAs, are still of limited use) which now widely belong to the usual everyday objects –like mobile telephones- owned and used by all the social classes. The design-for-all approach tends to combine two antagonistic procedures: One consists in designing a product meant for an ordinary individual, and one aims at meeting the needs of people with specific impediments (either physically or mentally handicapped). Adding to the ethical question about the reduction of the numerical gap, Newell and Gregor [15] consider the design-for-all approach as a means of showing that people with specific needs are not necessarily at odds with those labelled as "normal". They consider that there is a continuity space in which every individual can one day or the other, under particular circumstances and to differing degrees, find himself with the same specific needs.

Designing for all forces us to develop this idea: The slighter the difference between the performances among contrasted populations, the better the product for everyone.
In other words: The tighter the test results between different populations, the lower the increase in the numerical gap between the users -especially if some of them are with specific needs.

## 3. PROBLEM AND METHODS

### *3.1. General approach*

The development of the citizens' mobility involves major challenges in adapting the systems to every user, or else certain citizen rights will be restricted to some parts of the population. The mobile systems, in particular those dedicated to transports, must thus have a quality of use to make them easy to use for everyone. The researches here before presented first emphasized problems about the system's ergonomics and their interactive characteristics. They secondly focussed on the

importance of the mobile system evaluation structuring in order to guaranty the validity of the results thus obtained. But thirdly, these two perspectives do not show that the mobile system evaluated is adapted to a broad part of the population. So, can we suggest a validation procedure which would be based both on the results obtained with systematic methods and on integrated procedures of evaluation, and which would also take into account the validation of use on heterogeneous populations?

In order to tackle this general question, our central idea is to think about a validation procedure which:

- First inspects the ergonomics of the system according to tested criteria [16, 24];
- Then carries out usability tests in a laboratory on contrasted groups, so as to see whether the skilled subjects are more successful than the other people. If there are few differences to be found, then it would mean that the system shows a relatively wide facility of use, i.e. that it is by extension adapted to everyone.
- Thirdly carries out a real life survey in order to evaluate the user's overall level of satisfaction whatever his category.

This research aims at debating on the hypothesis according to which the skilled users' performances are decidedly the target to be reached by every individual.

In other words:

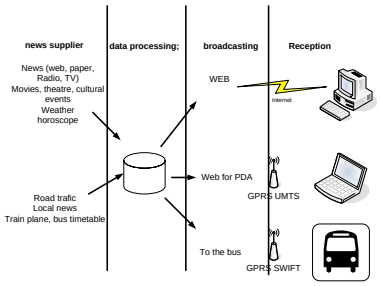
- We arbitrarily postulate that –with relation to the context- the performances in the expert category are the best possible ones (provided the ergonomic criteria are satisfied).
- We suppose that the experts' level of performance must be an objective to reach for all the other users (elderly, beginners, etc), and thus that the systems must enable the other people to achieve this objective.
- We also suppose that tight results between experts vs seniors and between experts vs beginners is an indicator of the good usability level of the technology involved.
- We finally suppose that if experimental measurements aiming at group comparison- show a relative proximity between the groups, then life-size ecological measurements will give results that are acceptable for all people.

### *3.2. Field work: ECIM: Communication Environment for mobile information.*

Today, technology enables people to have continuous access to data whatever their nature (video, mail, local news), the support (telephone, PDA, Pocket, computers), the place, the surroundings and the time of day. Thus, when the people's surroundings start communicating, when objects become partly interactive or when a bus changes into a media support, the usability evaluation methods of a mobile system have to be revised. It is a major issue to deal with the validity of the analyses obtained, and this represents the majority of the studies on remote evaluation. Though it was raised years ago, this question is still a current issue as it involves results that are sometimes contradictory.

ECIM is a European project concerning information-mobility, a part of which concerns transport by bus in the city of Metz. Figure 1 shows the principle of extraction and automatic working of information. The use of information technologies is a means of supporting the coherent use of the various means of transport because it immediately provides practical, relevant and detailed information.

FIGURE 1: EXTRACTION WORKING CHAIN AND INFORMATION BROADCASTING ON THE BUSES IN METZ.




The project was developed in order to make the mobile information chain reliable and to come up to the users' various expectations. ECIM gives access to information in an interactive way on private terminals. It offers consultation services for local information on private supports, all this as a take over or as an addition to the already existing services on fixed and embarked supports. These services are accessible on already marketed and widely used supports (mobile telephones and personal assistants). Here are the consultation services offered: data (texts and pictures) in a connected mode (wap, imode, HTML), request services, SMS alarms and audio services.

If people want to have full use of their mobile devices, then we must make sure that the usability of the services offered is in keeping with their tasks and their psychological characteristics, or else the systems will be insufficiently and badly used.

### *3.3. Methods*

Different researches have showed the necessity to collect data from the users. In this evaluation, the following data should be collected:

- A heuristic inspection (expert walkthroughs) performed by two ergonomists with a guideline developed from [16, 24]

- A video recording of the user's interaction with the mobile technologies; Four scenarios were followed by each user in a usability laboratory.
- Task performance data (task completion time and error rate)
- Verbal protocol data,
- Audio recording of post-task interview session,
- Usability questionnaire ratings during a survey; It consists of a short trip on a bus equipped with mobile technologies; 500 end-users were questioned.

Each part of the result presentation will develop the specific methods used to produce and collect the data.

## 4. ANALYSIS OF THE MAIN RESULTS

Evaluating the usability of a mobile system aims at determining the capacity of the device to cooperate with any user. The procedure consisted in setting up three kinds of evaluation, as follows:

- an ergonomic inspection carried out by two expert ergonomists;
- tests performed in a usability laboratory on three groups of 20 users each;
- and eventually a satisfaction survey directly made in real-life situation.

The presentation of the results will follow these three points.

### *4.1. Ergonomic inspection of the PDA site.*

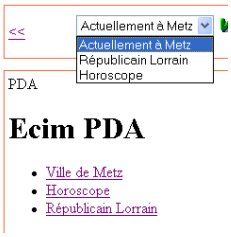
The analytical evaluation methods of user interfaces (as opposed to the empirical evaluation methods like test users) are not directly based on the users' performances or opinions when collected in real-life situation or in a laboratory. They are based on the examination, which is more or less directed and more or less automated, of specified and simulated or operational interfaces. All this derives from theories, from formal models of the man-computer interaction, from guides, from checklists or from heuristics. A subset of these methods can be labelled as "methods of ergonomic inspection". These are methods of interface examination made by specialists (expert evaluation) or non-specialists, with various inspection techniques primarily based on certain dimensions of usability

Broadly speaking, the results show that the site does not respect many of these criteria: bad categorization in the data, informational overloading, legibility problems, sometimes unsatisfactory human-task compatibility …

The heuristic inspection also noticed a great number of navigation menus and real inconsistency in their organization.

Figure 2 shows an example where two menu zones are on the same screen with pieces of information that are classified in a different order.

FIGURE 2: MULTIPLICATION OF THE NAVIGATION OPTIONS




This inspection technique enabled us to come next to the limits of the Web developments on the mobile systems. The size and the screen resolution force us to completely reconsider the organization and the presentation of information. A user does not easily admit that he cannot find all the richness (image, organization.) of a conventional Web site. Hence some recommendations deriving from this study in order to improve the usability of the system.

### *4.2. Usability test for a PDA site, in a laboratory*

In order to evaluate the facility of use through a design- for-all approach, the population on test was divided into three categories of 20 people each. The first category was called "beginner" and it included subjects which had never used mobile terminals of the pocket PC type. The second category was labelled "expert" and was made up with people who had been PDA users for more than 6 months. The last category consisted of "senior" individuals, i.e. of people over 60 years old who knew how to use the Web but did not own a PDA.

These three categories were asked to follow four scenarios:

The first one (SC1) was the search for two horoscopes on the site. The second one (SC2) was the search for indoor spectacles on pre-established dates. This information was not categorized. The third scenario (SC3) aimed at looking for local information taken from a daily newspaper. The last (SC4) scenario was simply to go back to the home page.

As a starting point, we assumed that the experts were to prove more effective and more efficient than the beginners and the seniors in following the whole of the scenarios. Is their mastering of the system an advantage for them? Or on the contrary, are the interfaces designed so as not to leave anyone behind?

The table below shows for the four scenarios the success rates in the expert, the beginner and the senior categories.

FIGURE 3: COMPETITIVE ANALYSIS OF THE RATES OF SUCCESS

| | | EXPERT | | | beginner | | | SENIOR | |
|---|---|---|---|---|---|---|---|---|---|
| | Success | Part | Fail | Success | Part | Fail | Success | Part | Fail |
| SC1 | 20 | 0 | 0 | 19 | 0 | 1 | 18 | 1 | 1 |
| SC2 | 1 | 14 | 5 | 0 | 12 | 8 | 0 | 6 | 14 |
| SC3 | 20 | 0 | 0 | 15 | 0 | 5 | 15 | 0 | 5 |
| SC4 | 18 | 0 | 2 | 14 | 0 | 6 | 15 | 0 | 5 |

Figure 3 shows that, as expected, the experts get the best scores including in scenario 2 which was more difficult than the others. Added to this, the difference in success between experts, beginners and seniors is nonsignificant in terms of effectiveness. The average calculation of success shows that the three categories have tight results though the experts have an advantage.

FIGURE 4: COMPETITIVE ANALYSIS CHART OF THE AVERAGE TIMES (IN SECONDS) AND THE NUMBER OF ITEMS SELECTED, WITHIN EACH OF THE 4 SCENARIOS.

| | expert | | beginner | | seniors | |
|---|---|---|---|---|---|---|
| Average | time(sec) | nbclics | time(sec) | nbclics | time(sec) | nbclics |
| **SC1** | 67 | 11 | 59 | 7,5 | 83 | 8,1 |
| **SC2** | 375 | 33 | 345 | 26 | 475 | 24 |
| **SC3** | 78 | 9,2 | 157 | 11 | 91 | 6 |
| **SC4** | 23 | 4,4 | 22 | 2,5 | 19,5 | 2,1 |

The analysis of performing times and of the number of mouse-clicks necessary to carry out the various tasks (figure 4) does not put forward significant difference between the experts and the two other groups which could be considered as "backward" (beginners and seniors). Except for scenario 3, the experts have performing times that can be compared with the beginners'. We also notice that the number of interactions is quite higher in the expert group. Would this mean that they have a penalizing exploratory strategy? Indeed, they do not hesitate to temporarily leave the objective aside to navigate in unexpected sites and pages.

In short, the tests carried out in a usability laboratory emphasize that there is no statistical difference between the expert group and the groups with short or no experience (beginners) or with elderly individuals, both in terms of effectiveness and of efficiency. Thus the results follow the idea according to which there is an similitude between the performances of the individuals accustomed to the use of mobile devices and the neophytes'.

For our study, the age factor does not seem to be determining when dealing with the ability to simply carry out a research on Web sites. The information restitution format (a PDA screen) and the interaction mode (a stylet) do not act as impediments for the senior category at all. We even noticed that this group had slightly better results in time and interaction number on scenario 3 and, to a lower degree, on scenario 4.

### *4.3. Ecological tests: Satisfaction survey in real-life situation.*

First of all, the evaluation through ergonomic criteria enabled us to bring out recommendations for improvement. Then the laboratory tests emphasized that there is a relative proximity in the uses made within the three groups. The point is now to know whether the positive aspects of the initial evaluations will come up again in a life-size evaluation with a large public (500 people).

In order to know whether the life-size evaluation confirms previous evaluations, 500 questionnaires – relating to information broadcast on the bus screens- were given so as to evaluate the users' satisfaction degree [17] over a 2-month period. People were asked about general ergonomics (screen size, site, legibility), on the relevance of information, on their overall perception of the service and the developments they hoped for. Half of the questionnaires were collected in the morning and the other half in the afternoon. This study helps us to complete indirectly the validation tests carried out in the laboratory, since it only evaluates one satisfaction rate of the system.

This reveals that 68% of the people questioned have a good perception of the service and 83% are in favour of its development. It is noticed that the level of satisfaction is also dependent on the time of day, with sometimes difficulty to access to information after midday because of the higher number of people on the bus. Accessibility to information is on the whole satisfactory (the character size is only mentioned 5 times whereas the person's location or position on the bus is mentioned 52 times). The relevance of the broadcast contents is quite satisfactory even if the users seem to be asking for intermodal information, for example like regional city traffic, car park vacancies, schedules or transport connections.

## 5. DISCUSSION - CONCLUSION

The effectiveness and the efficiency in the use of the system enable categories of disadvantaged individuals (beginners, seniors) to reach performance levels that are close to those obtained by experts. The tool shows usability characteristics which enable the greatest number of people to handle easily the whole of the functionalities offered by the system. It appears to be adapted to various populations and, therefore, is adapted to a large public. The use tests that we carried out in a laboratory on the mobile systems (which were a reproduction of the contents offered on the buses

plus with an access to the Web) showed that it is important to set up connexions between the various information systems and to make them available via the Web. A priori, the studies we undertook before augur well of a good level of satisfaction in the use of the system. In short, we may think that the device offers important guaranties of adaptation.

Beyond these results, this experiment offers a type of particular reasoning on the validation of usability. Let us resume it here after:

1. There are ergonomic characteristics which, once integrated into the system, make it possible to have systems that can be adapted to the greatest number of people.
2. These ergonomic characteristics are based on a scientific and methodological corpus, i.e. ergonomic recommendations and criteria.
3. The integration of the ergonomic characteristics must really induce an easier and better use of the system for "handicapped" individuals or for people with specific needs.
4. There is a means of measuring the ergonomics contribution to the use of the system: it is to compare in a laboratory the performances between expert groups and specially chosen populations (in our case: elderly people because they take the buses, and beginners because they just use mobile telephones).
5. If the performance variations between the groups are small, then we may imply that the system can be used by most of the people. Hence the relevance of the satisfaction evaluation in real and life-size situation.

In fact, this communication aims at developing forms of usability validations according to which the similarity in the performances between the different groups is an indirect indicator of the adaptation of the technical systems. Consequently, the groups with handicaps or disadvantages give comparison indicators that are useful for the creation and the evaluation of the technical systems. These groups offer a real potential for the validation of uses.

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