

A User-Centered Approach to User Modeling

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Abstract. Generally, user modeling concerns a person interacting with a standing console. This scenario does not represent the *HyperAudio* system in use: a visitor freely moves in a museum, gathering information from an adaptive and portable electronic guide. To provide designers with presumptive user behavior, data about visitor profiles and visit styles were collected through a questionnaire. The study pointed out unpredicted situations (e.g., the importance of social context) and confirmed some working hypotheses (e.g., the relevance of visit span). This paper reports on this experience, describing how to go from designer questions to guidelines for user modeling, making the best use of empirical data.

1 Introduction

The design of information systems is more and more user-centered: final users are involved from the very beginning of the planning stage. Early involvement of users has the potential for preventing serious mistakes when projecting innovative systems. Indeed, it compels designers to think in terms of utility and usability. Benefits of the user-centered approach are mainly related to time and cost saving during development, completeness of system functionality, repair effort saving, as well as user satisfaction (Nielsen, 1993). Involving users from early stages allows basing the system core on what is effectively needed. It is acknowledged that approximately 60-80% of interaction difficulties, including lack of facilities and usability problems, are due to poor or inadequate requirement specifications. Even if late evaluations are useful to assess the usability of final systems, it is unrealistic to expect that these results bring about a complete redesign.

Despite its importance, the motto *know the user* seems to be somehow neglected when planning how the system is to interpret user actions. As soon as user-modeling technology moves from research labs to real field usage, the need for a precise idea on how the interaction will evolve becomes increasingly important. The user model can manage only some dimensions (e.g., knowledge or interest) of that complex universe the human being is. Thus, these dimensions have to be the most meaningful and representative of users and uses. Moreover, an advanced sketch of the user is a key point when designing adaptive systems for completely new scenarios, such as computer augmented environments and mobile devices. This paper discusses the usefulness of a user-centered design for user modeling and reports the experience gathered in the HyperAudio project, where empirical foundation were sought to start-up an adaptive and portable electronic guide to a museum.

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2 Know the User: Why and How ¹

To be effective in use, an information system has to be faithful to the real context. This implies that the system has to be in keeping with the employment the final users will make of it. Unfortunately, “users have infinite potential for making unexpected misinterpretations of interface elements and for performing their job in a different way than you imagine” (Nielsen, 1993). In other words, “a designer’s best guess is not good enough”. To cope with this, the Human-Computer Interaction community developed methodologies to design systems incrementally, in order to reach the implementation step with a design that is worth succeeding.

Adaptive systems have been proposed as a solution for usability problems (Benyon, 1993). Nevertheless, even if they greatly improve interaction, their effectiveness and their correspondence to user needs are not straightforward (Dieterich et al., 1993). Well-founded hypotheses are fundamental for a successful interaction, because they represent the basis for system reaction to user behavior. We claim that a user-centered approach enhances the probability that the model to be implemented will satisfy user needs.

Designing with a user-centered approach requires that the user be involved from the very beginning. The relative engagement and influence of users on the final design suggest splitting the approach into two classes depending on the user’s role. *Consultative design* leaves decision-making power to technicians: users are simply sources of information with little to no direct influence. Designers turn to users to test their ideas and receive specific hints on the system being developed. On the opposite, *cooperative design* strongly involves selected users giving them the possibility of affecting the final system. Users have an active role: they have to understand problems and to propose solutions. A big effort is needed to create a common background, as well as to organize and lead design sessions. Here consultative design is discussed; interested readers in cooperative design can refer to Communication of the ACM, June 1993.

First of all, a user-centered approach requires understanding reality: who will use the system, where, how, and to do what. Then, the system is designed iterating a design-implementation-evaluation cycle. In this way it is possible to avoid serious mistakes and to save re-implementation time since the first design is based on empirical knowledge of user behavior. To collect it, many different techniques can be applied, among them direct observation, interviews and questionnaires. *Direct observation* is the most reliable and precise method, especially valuable for identifying user classes and related tasks. Moreover, it allows identifying critical factors, like social pressure, that can have a strong effect on user behavior when the system will be used in the field. Unfortunately, direct observation is very expensive, because it requires experimenters to observe each user individually. For this reason, it is useful when a reduced number of observations is enough to generalize behavioral predictions or when hypotheses have to be tested rather than generated. *Interviews* collect self-reported experience, opinion, and behavioral motivations. They are essential to finding out procedural knowledge as well as problems with currently used tools. Interviews cost a bit less than direct observations, because they can be shorter and easier to code. However, they still require skilled experimenters to be effective. By contrast, self-administered *questionnaires* can be handed out and collected by untrained personnel allowing to gather a huge quantity

¹ Here fifteen years of HCI are summarized. It is impossible to give references. Interested readers can refer to the valuable commented list of current HCI literature by Andrew Sears (“An HCI Reading List”, SIGCHI Bulletin, Jan. 1998, vol. 30, n. 1) available at <http://www.acm.org/sigchi/bulletin/>.

of data at low cost. They allow statistical analyses and stronger generalizations than interviews. Questionnaires provide an overview on the current situation as well as specific answers. Which combination of these methods is worth applying depends both on requirements and budget. The ideal situation, where all of the above are used as in Vassileva (1996), is rarely justified. Nevertheless, as described in this work, the cheapest solution can give rise to interesting results.

Elaborating the outcome of the knowledge phase, designers define a first version of the system. At this stage, design techniques (e.g., task centered or scenario based) and expert reviewing (e.g., heuristic evaluation or cognitive walkthroughs) do provide satisfying solutions. Among the many methods used in HCI, probably the most suitable for systems that have a user model is parallel design. The goal is to explore different design alternatives before settling on a single proposal to be further developed. Possibly, in this way designers will propose different solutions (what to model) and different interaction strategies (what the user can control).

Then, one or more solutions can be tested with users. This step, called *formative evaluation*, aims at checking some choices and getting hints for revising the design. Techniques like paper mock-ups, prototyping and Wizard Of Oz simulations can be applied. *Paper mock-ups* are the cheapest: pieces of the system interface are drawn on paper and the interaction with a user is simulated by an experimenter. Despite its trivial appearance, this technique allows collecting reliable data which can be used for parallel reviewing. *Prototyping* allows testing some functionalities in depth (vertical prototyping) or the whole interface (horizontal prototyping). Both paper mock-ups and prototyping can be empowered by methods like focus group (i.e., many users solve a task together) or think-aloud (i.e., the user expresses verbally what he/she is doing), that clarify user behavior and understanding. They also succeed in finding misunderstandings and false presuppositions. Since no system is needed, they can be valuable tools in user modeling early testing. They can easily test the relative advantage of system self-adaptation versus user controlled adaptation (Dieterich et al., 1993), or user general understanding of interface dynamic changes. By contrast, *Wizard Of Oz simulations* require a sophisticated system to help the wizard perform as the final system will do. This technique is expensive and is justified only when a corpus of reliable interactions has to be collected (e.g., for future training or testing in dialogue systems).

At the end of the design cycle, *summative evaluation* are run. They concerns the test of the final system with effective users performing real tasks in their working environment. Therefore, a summative evaluation should be considered as the very last confirmation of the correctness of the hypotheses stated during the design process.

3 A Quick Overview of HyperAudio

The basic idea of HyperAudio arose upon observing that each museum can be coupled with a hypertext the visitor might wish to explore during the visit. Each exhibit corresponds to a sub-net. For example, a stuffed crocodile can be described by general features, evolution, life cycle etc. Entering the reptile room, approaching the crocodile, visitors explore the hypertext through their movements. Combining portable computers and physical exhibitions, coupling exhibits and hypertext structure, HyperAudio provides a new way of navigating information:

- moving in the physical space, approaching a case, the visitor implicitly selects a node of the hypertext as relevant;

- as in a “traditional” hypertext, the visitor can explicitly explore the sub-net connected to the current node (i.e., the object the visitor is facing) before moving in the physical space towards a new object.

In this way, the visit becomes a path among physical sites (rooms, objects) and semantic sites (descriptions, contents).

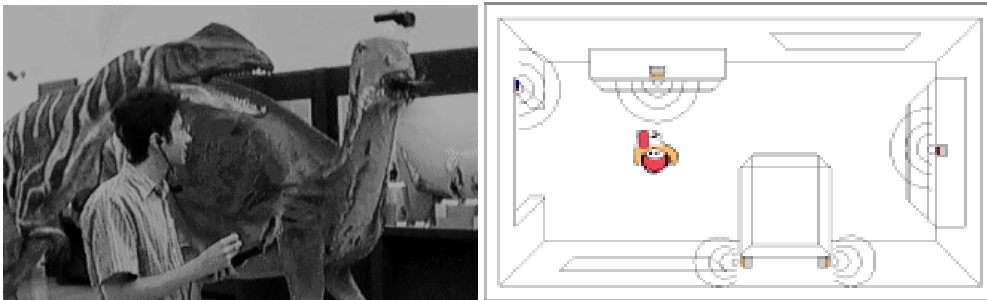


Figure 1. A visitor equipped with a palmtop computer and headphones in the augmented museum.

HyperAudio stands where location aware systems and adaptive systems overlap. Exploiting position data, it provides personalized information to a user carrying a palmtop computer. The system follows the moving user and provides information at the right time (Figure 1). HyperAudio adapts to a single user, who is following a personal path in a physical context². Each of these three facets (the visitor, the actual visit, and the museum) influences the process of dynamically building presentations in different ways and with different strengths (Not and Zancanaro, 1998, and Petrelli et al., 1999). A presentation is created on the fly. It is composed of an audio message (generated by assembling pieces of messages), a set of potentially interesting links, and a map or a picture valid for the discussed object. A presentation can vary in terms of: (i) the selected content; (ii) the proposed links; (iii) the language used (style and form); and (iiii) the system initiative (ranging from a fully guided tour to delivering information only upon explicit request). Selecting the proper content and links, using the most suitable language, and proposing the right level of visiting support depend on the guesswork the system makes observing visitor behavior. As described above, physical and hypertextual steps compose a visit path. The system has to interpret both steps as user input. While the link selection using a pen on the palmtop screen is explicit, moving towards, stopping, and moving away from an exhibit are signs of visitor’s attitudes, but they are not straightforward. They have to be interpreted.

² HyperAudio is at the basis of a richer scenario that is being exploited, jointly with other partners, in HIPS, a European project of the Esprit I3 program, (<http://marconi.ltt.dii.unisi.it/progetti/HIPS/>). The HIPS consortium includes: University of Siena (Italy, coordinating partner), CB&J (France), GMD (Germany), ITC-IRST (Italy), SIETTE-Alcatel (Italy), SINTEF (Norway), University College Dublin (Ireland), and University of Edinburgh (Scotland).

4 Getting Off on the Right Foot

Good initial hypotheses are instrumental when the interaction is far from the well-known direct manipulation paradigm. When the HyperAudio project team tried to imagine visitor-system interaction, they did not receive any support from the literature, nor from previous experiences. Moreover, the peculiar scenario further complicated the task. In a museum, the attention of a visitor is mainly focused on exhibits. Therefore, the time spent interacting is possibly low and distributed all along the visit. This means that HyperAudio guesses have to be based on a few details: a moving, a stop, and a single click. Thus, a reliable profile is vital. To overcome the gap between current knowledge and design needs, a case study was planned. An interdisciplinary group, involving people with background in psychology, human computer interaction, and artificial intelligence, was set up. Applying a consultative design methodology, a survey study was planned. Requirements were of preliminary data on visitor's attitudes toward and behavior in museums. In that case, reliable results required a broad sample of observations. Thus, the questionnaire was selected as the more suitable tool to collect relevant information on visitor profiles.

The aim of the study was to get a precise idea of how people visit museums and of what their feelings are. The final goal was to draw stereotypes (Rich, 1983) identifying the major dimensions affecting visitor behavior, feeling and attitudes. The study was not intended to be a survey of museum visitors, describing for instance the average age or profession. On the contrary, here personal data are of interest if (and only if) they match a typical behavior. Age, for example, may explain variations in attitude towards technology if elderly visitors prefer human guides, while younger ones enjoy using computer guides. This information would affect interaction preferences, a major aspect of the initial user profile. Accordingly, the system is set for a completely guided tour or, alternatively, it proposes a highly interactive visit.

As a working hypothesis, we assumed that through stereotypes, we could identify visitors categories by analyzing a short questionnaire (10 items at most) the user would be required to fill in at the beginning of the visit. This because we expected that visitors would be easily categorized using "classical" dimensions such as age, profession, education, specific knowledge or background. Such a categorization would allow setting important features in the user profile, such as language style (expert vs. naive), preferred interaction modalities (led by the system vs. the user), verbosity (depending on the available time). As a typical scenario, we imagined an individual visitor, going to the museum to visit it as a whole. We also assumed that the behavior should affect the dynamic part of the user model, i.e., user knowledge and user interest. Thus, jumps, skipping and staying in front of an exhibit would update the interest model, while the request for information would affect interests and knowledge. Finally, the rate of interaction would be a measure of preferred modalities.

5 The Questionnaire and the Case Study

The design of the questionnaire was guided by several constraints arising from field research. In particular, an accurate and quick way to collect reliable, self-reported information from visitors

was needed. Questionnaire topics were defined on the basis of the literature relevant to museums. The five topic areas are listed and commented below.

- **Personal data profile** contains questions about age, sex, education, job, etc. It has the purpose of providing a sketch of the compiler.
- **Museum habits** collects information about frequency of museum visits and preferences (e.g., visiting alone or with a partner). It was introduced to complete the personal profile in the museum visit perspective.
- **Context of the current visit** moves the focus to the visit just finished. Information on general motivations for the visit was collected here.
- **Course of the current visit** was intended to clarify the use of guides (from labels to human guides) as well as the duration and the purpose of the visit.
- **Styles of visit** aims to clarify different dimensions of visiting styles, to say how people behave (e.g., stay with the companion all the time), how they feel after (e.g., afraid of having missed something important), or their attitudes towards guided tours.

The final version, as derived by a pilot study, was composed of 26 items, requiring around 10 minutes to be filled out. A page describing the purpose of the study introduced the questionnaire. For most of the items, participants were required to tick the appropriate answer from a set of given alternatives. In the “styles of visit” section participants had to express their level of agreement with 11 statements describing different behaviors or attitudes. Answers were modulated on a 5-point Likert scale. The survey was conducted from October to December 1997. Data were collected in three museums focusing on topics related to the natural sciences: *Museo Tridentino di Scienze Naturali* in Trento (Natural Science); *Museo Civico di Storia Naturale* in Verona (Natural History); *Museo dei Fossili* in Bolca (Fossil Museum). The heterogeneous sample should increase the external validity of the study, allowing to generalize findings to the class of Natural Science/History Museums. In total, 250 questionnaires were collected: 97 in Trento, 102 in Verona, and 51 in Bolca.

When leaving, visitors were asked to take part in the study by museum staff. This procedure was convenient, on the one hand, because it did not require experimenters to stay at the museum, but, on the other hand, it did not allow for any control over sampling. For instance a bias might affect the sample of Verona where teachers and professors seemed to be a preferred target. Nevertheless, we considered the whole sample reliable since we are not interested in museum statistics: we are interested in finding out if and how personal characteristics are relevant to predicting visitor behavior.

6 From Empirical Results to Briefings

Empirical results pointed out relevant and unexpected aspects that urge designers to rethink the system. In the following the main outcomes are presented and discussed. The focus is on result interpretation and on user modeling guidelines. The experiment and analysis report (Petrelli et al., 1998) is available at <http://ecate.itc.it:1024/petrelli/publications.html>.

6.1 Museums are Social Places

The major unexpected result regards the importance of the social dimension. This clearly emerges analyzing either self-reported behavior or preferences. Only 5% of visitors went to the museum all alone. The majority participated in a guided tour (45%), while 20% went to the museum with friends. Moreover a high percentage of people came with children (30%), showing that families are an important target for natural science museums. From these results, it appears that visiting a museum is mainly a ‘social event’, an experience to share with important others. Family, friends and partners play an important role in making the visit a valuable experience. This finding clearly contradicts our hypothesis stating that visiting a museum is mainly a personal experience. As a consequence, the user model has to become a group model too, because needs, expectations and behavior of groups are very different from those of individuals. Indeed, our data confirm Falk and Dierking (1992): persons tend to behave differently when visiting museums with friends or family. When visiting museums with friends, adults are mainly concerned with the nature and the content of the exhibits. Even if discussion is stated as a very important point, their attention is more focused towards what they see than towards their own social group. On the contrary, adults with their family typically focus on their children, on making the exhibition understandable and the visit enjoyable. Before the visit, they are used to gather information significantly more often than adults with friends. This finding has a strong impact on user modeling. Indeed, it is plausible that the family profile has a higher background than the most part of single visitors. Moreover, it is known that family visit depends on what attracts children and that family learning (i.e., when adults and children learn together) derives from family discussions (Borun and Dritsas, 1997). Therefore, the system has to support family discussion besides proposing a standard comment on the exhibit. The content could be organized as question-answer, because this format stimulates discussion and self-exploration. System proposals (e.g., presenting further information when a visitor remains in front of the same object) should be reduced in number and form, so as not to hamper family discussion and exploration. In terms of user modeling, a new attribute of linguistic style has to be introduced (question-answer vs. narrative presentation), and system initiative (i.e., preferred interaction modality) has to be fine-tuned.

Our data suggest also that museums play an important role in pupils learning. In the sample 36% of participants were teachers who came with the class. This experience is very different from that of being taught in a classroom: since exhibits replace the teacher as the central medium of instruction, museum learning is self-directed rather than directed by the teacher. In this context, the main purpose of a guided tour should be to have the pupils stay in the exhibits longer, learn more, and return to the museum frequently throughout their lifetimes (Falk and Dierking, 1992). Moreover, children learn well together. As a consequence, an electronic guide should take most of the group visit. It should stimulate students in working together, have them solve problems in groups, and share their solutions. Therefore, the system should shift from a guiding style to an “informal” tutoring style, proposing quizzes and problems as well as suitable explanation of the exhibits. This is of course a completely new and exciting scenario.

6.2 Guide without Dominating

Another important result is the positive attitude towards guidance. On the average, participants reported to strongly appreciate guided tours. Attitudes were found to be consistent with reported

behavior. More than half of the sample (58%) used a guide during their actual visit. One of the major goals of the survey was to evince factors influencing the decision of using a guide. Such a decision appears to be correlated with familiarity with the specific museum. The more visitors are used to going to a museum, the more they will use a guide. In addition, we found that the major part of people who came to see specific objects used a guide, while people who came to visit the museum in general did not. These results are counterintuitive. Indeed, we expected that familiarity with museums should reflect an autonomous style and self-sufficiency.

Other interesting results regard the number of non-first-time visitors. It is surprisingly high (68%). This variable was found to affect the time of the visit. Contrary to our expectations, those who came to see specific objects stayed in the museum longer than those who wanted to see the museum in general did. Again these results have strong impact on user modeling. They support the idea that each visitor comes to the museum with a personal agenda in mind. Some come to get an overview, others to see specific objects, or to learn, or to relax. An accurate user model has to take these aspects into account because they change the meaning of behavior. For example, when a visitor is not coming for the first time, skipping objects has not to affect the interest model decreasing the weight of the object. Similarly, pondering an object for a long time is a sign of interest, but the system should not interrupt self-exploration with further explanations. A *beep* may be enough to signal interested visitors about available information. First-time visitors have to be considered apart because they have to be motivated and engaged if they want to learn and return. One way to stimulate first-time visitors is to create expectations (Finn, 1985). For this purpose, the system may use the very beginning of the visit, when people spend a few minutes in finding direction, to give a sketch of the possible visit. Then, each visitor would follow his/her preferences adopting a personal path and rhythm for the visit. Some visitors will have a systematic and intensive look, others will select objects to look at, and many will “cruise” the museum (Falk and Dierking, 1992). By monitoring this behavior, the system can identify relevant aspects to modify the user model.

6.3 Technology Must Be Hidden

Results show that the most liked museum visit is guided by a member of the museum staff (53%). Almost 21% of the sample prefer catalogues or books, and 19% to visit museum without any support. Only 7% reports to like using technological devices. These data lead to several important considerations. First of all visit aids are highly appreciated. Secondly, the preferred solution is still represented by human experts. This can be due to the social aspect of the situation and to the possibility of interacting with the source of knowledge to obtain the most appropriate information. It can also suggest that listening to a human guide is the easiest way (i.e. less tiring and constricting) to get information.

To conclude, the low percentage of people who prefer technological devices has to be taken into account. It can be partially explained by the reality of Italian museums, where technology is still underrepresented, or by the comparison with human guides, but it could also reflect a negative attitude towards technology in the context of a museum visit. This suggests that some visitors may never explicitly interact with the system. Thus, the user model has to take into account the possibility of facing a completely passive visitor: the system has to rely on a default setting that actively proposes a visit. This also fits the requirement that systems for public use have to be “walk-up and use”, i.e., no training phase is needed to operate them. However, active users can take the initiative

getting the most from HyperAudio support. For those visitors who like to interact with computers, the system has to adopt appropriate strategies, since the attraction lasts only for few minutes (Serrell and Raphling, 1992). For example, it could propose a game to measure background knowledge, a user characteristic particularly important and that is difficult to self report about.

6.4 Ask Only the Essential

Another unexpected outcome is that personal data, like age, profession, education etc., do not characterize the visitor. For example older people do not show different preferences than younger one; education is high for almost all museum visitors (91%); professional interest does not influence visit behavior. This means that personal data are not as important as expected and should be ignored in the initial questionnaire.

Secondly, a relative dislike for technology suggests reducing the explicit interaction to the very minimum, possibly even eliminating it. Filling out a questionnaire at the beginning of the interaction, a technique widely adopted in user modeling community (Fink et al., 1997, Strachen et al., 1997, Murphy and McTear, 1997 just to mention a few), does not seem to be the best solution in this context. Indeed, the negative attitude towards technology, the strong attraction of the exhibits, the small amount of time devoted to computer interaction suggests limiting system requests as much as possible. Furthermore, the four attributes that explain the most of visit and interaction variability and that the system must know to start can be inserted by museum staff when the HyperAudio guide is handed out. They are:

- **Family, school or adult:** user modeling does not only concern a single person but also has to address groups of people with a common goal. This attribute affects language style (narrative vs. question-answer) and complexity (simple terms vs. complex ones to stimulate discussion) as well as the system reaction level (high initiative of the system vs. user explicit request).
- **First-time visit:** this distinction affects content selection. For first-time visits an overview is proposed, while for following visits a deepening is preferred. This attribute also affects the dynamic part of the user model, mainly the interest, because some behavior does not have the same meaning in the two cases, e.g., skipping objects will not be interpreted as disinterest in follow-up visits, while it is one of the best guesses for a first-time visit. It also has an impact on the next attribute evaluation.
- **Foreseen visit duration:** the more time available the broader the visit can be. It affects system verbosity in terms of numbers of objects proposed or in-depth descriptions.
- **Interaction preferences:** this is an important attribute of the visitor's profile since it is used to describe passive visitors. Unfortunately it does not appear to be related to any personal or visit characteristics. Partially it can be inferred by previous attributes, for example family visitors may prefer a smooth interaction, while adults on their first-time visit could appreciate a very active guide.

Note that this questionnaire does not portray the isolated user but, better, it describes user, visit and context, the three components relevant for an effective usage of the electronic guide.

7 Conclusions

The outcome of this study has demonstrated the high level feedback that a user-centered approach can provide, even with low cost methods. The results incited designers to rethink some basic assumptions. Indeed, the idea of using stereotypes had to be set aside in favor of a broader view, where user, visit, and context were the key points. It is worth noting that no prototype was developed for the study. Hence the whole system could be easily redesigned. A sketch of the current user model implementation is given in Sarini and Strapparava (1999), in the poster section of this volume. Given the very interesting results, we are going to follow the user-centered design approach exploring games to measure background knowledge through paper mock-ups.

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