

ACCEPTANCE BY THE USERS OF SERVICES INTEGRATED IN THE HOME ENVIRONMENT

Michele Cornacchia, Vittorio Baroncini

Fondazione Ugo Bordoni, Via Baldassarre Castiglione, 59 - 00142, Rome, Italy

Stefano Livi

Facoltà di Psicologia 2, Università degli Studi "La Sapienza", Via dei Marsi, 78 – 00185, Rome, Italy

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Abstract: Whether or not ICT represents the most important vehicle to transform the society seems to be out of discussion. The point of interest diverts from how people do really feel with these services and from the way they perceive the advantages as acceptable to improve the quality of life and work. It is matter of fact that the technical innovation is characterized by a certain risk, the problem of how to implement the technology for sure and, ahead of this phase, the problem of predicting its influence on the social, working and private life in view of the high costs effort to produce. This study applies a predictive model for the acceptance to a services integrated home environment properly set-up in a special laboratory. A class of users was selected from the employees of the company which hosted the trial in order to participate at the evaluation sessions. The tasks were designed to point out the main innovative features of the services presented. The questionnaires were suitably designed and submitted to collect the end-users opinions. The analysis was carried out to assess the performance by the side of the real users and to predict their intentions of use.

1 INTRODUCTION

The study here presented is part of the work carried out in order to investigate the user perception of the ePerSpace (EPS, IST Project N° 506775) personal services for the Home and Everywhere that were set up at the laboratories of a big telephone company, partner in the project.

The general aim was to measure the quality of the delivered services, by verifying the usefulness and ease of use as perceived by the real users, then the amount of added value provided by each service, even in a high technology reproduced environment. The basic references given by the Unified Theory of Acceptance and Use of Technology (Venkatesh et al, 2003) were applied to define a model to forecast the user acceptance (intention as predictor of usage) and arrange the scales (questionnaires) to measure the performance constructs.

2 THE ACCEPTANCE MODEL

Information Technology represents today a primary way of transforming society but each application is assumed to achieve specific benefits. The new technologies actually can be applied to achieve a wide variety of benefits (e.g. improve quality of the life, of the work, etc.) and have influences in the organisational change (e.g. improve productivity, enhance work, effectiveness, etc.).

Because any kind of technical innovation is characterized by a certain risk, there is the problem of how to implement the technology and, ahead of this phase, the problem of predict its influence (in a short: “success or failure?”) in view of the high costs effort to produce. If we look at some evidence about the success or failure rates of information technology projects, we firstly see that is very difficult to attain data as the high complexity and variability of the whole socio-technical system to

consider (Eason, 1988). The ordinary criticisms are that the technology is being oversold (Cornacchia, 2003) and that it is regularly subject of changes within short periods of time. Nevertheless, there are some studies, named in the following, that give an indication of the scale of the problem and the nature of the possible outcomes. These studies are aiming to support those organisations that accept risky investment decisions for instance in order to get a better competitive position. Many examples of the emerging information technologies have been publicized with consistent investment market projections, but they remain strongly fastened by a broad alone of uncertainty as for their effectiveness. At the last, the most important questions rising up the mind of the decision makers are about which of these technologies will succeed and what the useful applications have to be.

In the history the relevant literature describes the development of several models of technology acceptance (by the users) and many extensions to the basic constructs (Malhotra & Galletta, 1999; Venkatesh & Davis, 2000), mostly built with the behavioural elements (Ajzen, 1996) of who is forming an intention to act (Bandura, 1986) and the inclusions of some kinds of constraints (limited ability, learning and usage (Bagozzi et al, 1992), time, environmental, organisational, unconscious habits, and so on) which influence the individuals actions (Compeau et al, 1999; Pierro et al, 2003).

Information technology acceptance research has applied many competing models, each one with different sets and very often overlapping of the acceptance determinants (Davis, 1989). In their paper Venkatesh and colleagues (2003) compared eight competing models that were applied in order to understand and predict user acceptance: Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), Combined TAM and TPB (C-TAM-TPB), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), Social Cognitive Theory (SCT). Those models were originated from different disciplines mostly connected with the behaviour prediction (Ajzen & Fishbein, 1980) or specialized for the technology use, from psychology to information system literature. As a result, research on user acceptance appear to be fragmented in different methods and measures (Venkatesh & Davis, 1995).

For this reason the authors empirically compared those concepts in order to formulate a Unified Theory of Acceptance and Use of Technology model (UTAUT) with four core determinants of intention

and usage, and up to four moderators of key relationships (Figure 1): Performance Expectancy, Effort expectancy, Social Influence and Facilitating Conditions as well as other moderators variables (such as Gender, Age, Experience and Voluntariness of Use).

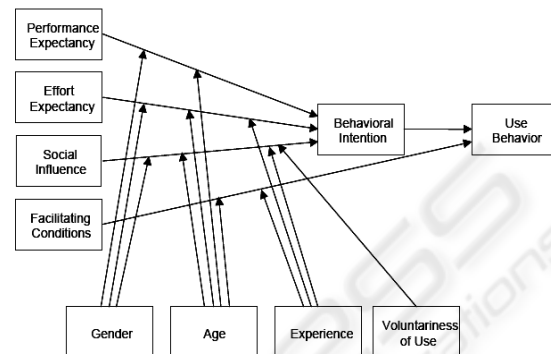


Figure 1: Theory of Acceptance and Use of Technology model (UTAUT) from (Venkatesh et al, 2003).

Applied to the tested system, the **Performance Expectancy** is defined as the believes that using the new services will help him to attain gains in the behavioural objectives. For the ePerSpace aim, this variable will be made operative through the Perceived Usefulness construct, relative advantage of using the innovation compared to its precursor, and outcome expectations.

The **Effort Expectancy**, defined as the degree of ease associated with the use of the new system, has as operative constructs the general perceived ease of use as well as the perceived complexity of the system.

The **Social Influence**, defined as the individual perception of how individual social network believes that he or she should use the new system, has as operatives constructs Subjective norms, Social factors and Social image and Identity similarity.

Finally, the **Facilitating Conditions**, are represented by construct by Perceived Behavioral control, general facilitating conditions (such as objective environment factors) and compatibility with existing values and experience of the potential adopters.

One of the basic concept underlying the model of user acceptance states that, in the domain of “consuming the emerging technology”, the actual use of information technology is influenced by the intention to use and by the individual reactions to using. And so, the greater are the positive reactions, the greater is the intention and therefore the possibility to engage in the use.

3 METHOD

3.1 Measurement Scales

The measurements scales of the acceptance applied to the design of the questionnaire instrument are mentioned in the following. All the scales were tested and successfully used (high degree of adaptability, high Cronbach alpha to denote the consistence of the constructs, high variance explained to denote independency of variables) in several contexts or technological environments and for different classes of users.

It is nevertheless important to call attention to the fact that the questionnaires were adapted to the tasks and that each subject participating to the evaluation got first confidence with the innovating technology. Said that, each questionnaire was referred to a specific task and there were included, when required, additional lines to purposely measure the usability aspects of some significance (SUMI, 1998). Therefore, besides the central constructs of the acceptance, the questionnaires included also other high reliability scales, either for usability (namely on efficiency, affect and control) either for the identity-similarity or motivations (Perugini et al, 2000).

The results by the submission of such scales in the evaluation provided the empirical evidence of a large effect of personal identity on different behavioural intentions. As for the home services tested, the consumer behaviours may had a symbolic meaning beyond their practical and objective features and consequences. For example, buying a certain equipment/system could have been an associated behaviour with an image of “idealized people” or with the “prototype” of the persons who perform these behaviours.

The constructs used in the assessment were: *Performance Expectancy, Effort Expectancy, Social Influence, Facilitating conditions, Attitudes toward Using Technology, Attitudes (towards home environment solutions), Intentions, Identity-Similarity, Usability.*

They corresponded to the questionnaire sections:

- A - Perceived Usefulness in the home environment
- B.1 - Perceived ease of use
- B.2 - Complexity
- B.3 - Ease of use
- C.2 - Social factors
- C.3 - Image
- D.1 - Perceived behavioural control
- D.2 - Facilitating conditions
- D.3 - Compatibility

- E.1 - Attitudes towards behaviour
- E.2 – Intrinsic motivation
- E.3 – Affect towards use
- E.4 – Affect
- F - Attitudes towards EPS solutions
- G – Intentions

3.2 The Home Services Evaluated

The home environment services evaluated by the users were selected from those that were set-up within the Home Platform Portal. An outlook of the services portal made available is shown in the following Figure 2.



Figure 2: The home page to access the ePerSpace services at Home and Everywhere.

The Home platform services available in the portal are exposed in the Table 1.

Table 1: Home platform services of ePerSpace.

HOME PLATFORM SERVICE	Indoor elements	Outdoor elements
Appliances, actuators and white appliances management	Residential Gateway, home automation networks, home devices and white appliances, personal devices for service interface (PDA/smart phone/PC/TV)	Service and network provider
Alarms Handling	Residential Gateway, home automation networks, personal devices for service interface (PDA/smart phone/PC/TV), network cameras	Service and network provider
Access control	Residential Gateway, RFID reader; RFID personal cards, home automation network, smart phone/PC/TV	Service and network provider

The control of the automated home appliances and devices includes the management of:

- Lonwork actuators and sensors over twisted pair: lights, water valve, blinds, canopies, door lock, fire/gas/water detectors, etc.
- Lonwork white appliances over power line: oven and washing machine.
- Actuators and sensors: lights and small motors attached to a demo panel.
- Network cameras.

3.3 The Tasks

A set of tasks was properly designed for the class of users profiled for the trial and the services to evaluate. The services were accessed by the user from any PC or PDA wired or wirelessly connected to the LAN of the home. In both cases, the user started the browser of the access terminal to initially authenticate him/herself by username and password. After that, the user was admitted to the home portal and enabled to select from the list of the personal services.

In case of being using the **web access**, a map of the house displayed icons representing the home appliances that can be actuated, as well as its current state (i.e., on/off). At the user click on each icon a menu of the possible actions appeared. For example, in the case of a light, currently on, the user was offered to switch it off and adjust the light intensity. In case of using the **PDA access**, instead of a map of the house, the user found a list showing the rooms in the house. At the user click on one of the rooms, the list of automated devices to be controlled in that room displayed. The running was similar to the web access, but the graphical interface was more simple to adjust to the limited screen size.

3.4 Set-Up of the Test Bed

All the HAN of the test-bed were connected to the RG (Residential Gateway) which run an OSGi (Open Services Gateway initiative) framework over which the home platform services are managed and activated. A Personal Computer or Laptop or a Personal Digital Assistant (PDA), inside the house, were used either to access the web interface of the services and also to provide the I/O for the tasks planned to be accomplished by the users in the assessment. The PDA was connected to the HAN via WiFi in the house for the demonstration. A Set Top Box (STB) was connected to the TV set and could run also home environment services, controlled by the RG Middleware.

Basically the automated control for the house domestic devices from the PC in web interface services of the Home Platform were evaluated. The user accessed the options from a list of services directly through the main page. The procedure to carry out the evaluation followed a prearranged scheme. Each subject was received in front of the house door, informed about the overall session and the services to be evaluated by means of questionnaires. The questionnaires were arranged in a labelled sequence, then submitted to the subject. About 60 questions over the total amount of 193 were answered by each subject in the section of the local services for the home (Figure 3).

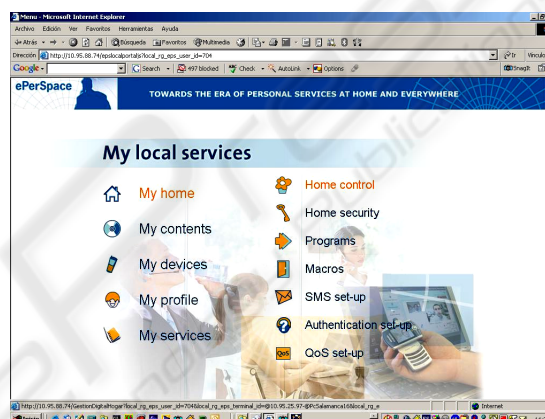


Figure 3: "Home Control" sub-menu.

The evaluation process took place in two weeks in total. The integration work lasted 6 months. The test bed used for the user evaluation gave a configuration and outlook of a real flat (Home).

3.5 The Users Profile

A two steps selection of final 40 users followed some general criteria in order the final class of subjects could be the most homogeneous possible and provide consistent values of judgements.

The subjects selected for this evaluation were chosen among the employees of the company hosting the trial, as close as possible to an ideal type of potential user, open minded enough towards ICT solutions (neither too much enthusiastic neither too much unwilling) and on an average skilled in using electronic digital devices (e.g. the PC or other home familiar devices).

The first step in the definition of a class of users was mainly a rough skimming from a initial set of about 70 individuals, preliminarily contacted in order to be certain that:

1. the subjects characteristics were close to the home services requirements of use;
2. the essential skills and the basic attitudes towards ICT were not unacceptable;
3. the subjects were volunteers.

The second step was a selection of the final 40 users, among the several items relating about each individual, to check whether:

1. the final group were sufficiently represent males and females;
2. the age range (at least) were as narrow as significant to the statistics to apply;
3. the availability to effectively participate to the evaluation sessions were an actual statement.

The emerging final profile shows:

1. a proportion of frequencies about the 23% for females while the 77% for males;
2. evident age crowding in the range 30-39 years,
3. equal occurrence of married and single individuals;
4. medium-high level of education;
5. mostly technicians and engineers (respectively 70% and 15%);
6. high experience accrued with ordinary IT technologies (PC, Email, Mobile, etc.);
7. proximity to household equipment with communication means.

The users participating to the evaluation went through an introduction of the Project and a training session in order for them to use the system almost without assistance in order to obtain valuable and not-biased information from the questionnaires.

3.6 The Data Analysis

The questionnaires were coded and the data properly wrapped up to be analysed by means of the SPSS (Statistical Package for Social Science 13.0). Three main groups of analyses were generated as output:

1. **descriptive statistics** for all cases and outliers identification; the data were grouped in the way that the scores of the home services appeared, for each aspect of the Acceptance.
2. **correlation** study for the Home services relative to the dependant variable “attitudes towards behavior”.
3. **extended correlation** study of the service Home Control in relation to the dependant variables “attitudes towards EPS solutions” and “intentions”.

4 RESULTS

The descriptive statistics (median, confidence interval within $\pm\sigma$, outlier rejection interval $> \pm 2\sigma$) were shortly assembled in the 14 lines of Table 2, as many as the cases were for the Home Control Panel and the home services through it accessed.

Table 2: Descriptive statistics for the Home Services accessed through the Home Control Panel.

HOME CONTROL PANEL	min	max	average	standard deviation	outliers
Perceived Usefulness in the home environment	1.00	5.50	2.81	1.08	0
Perceived ease of use	1.00	5.00	2.24	.88	1>max
Complexity	4.00	7.00	5.74	.86	0
Ease of use	1.00	5.00	1.88	.84	1>max
Social factors	1.00	7.00	3.03	1.69	0
Image	1.00	7.00	3.33	1.64	0
Perceived behavioural control	2.00	6.33	3.56	.81	1<min, 2>max
Facilitating conditions	1.00	7.00	4.17	1.77	0
Compatibility	1.00	6.00	2.38	1.21	0
Attitudes towards behaviour	2.00	7.00	5.79	1.30	2<min
Intrinsic motivation	1.00	7.00	2.56	1.27	2>max
Affect towards use	2.00	7.00	5.54	1.34	0
Affect	2.50	7.00	4.63	.79	1>max
Attitudes towards EPS solutions	2.50	7.00	5.13	.93	2<min, 2>max

4.1 Frequencies

The analysis of the frequencies gathered pointed out that from a broad point of view the services were well accepted by the users, as innovative for the home and access from the elsewhere. The variables used to define the constructs of the acceptance model, all showed a definite tendency in positively comparing the ICT solutions presented in the test-bed with the already available personal services that can be seen as a clear advantage and concrete expectation for the home services to improve the life style of its users.

This important result was first attained by the Perceived Usefulness, and then it was supported by the plain scores gathered by Effort Expectancy (i.e. very high of ease to learning and low perception of complexity) and Social Influence (i.e. the family view coherent and close to a doable real use). At last, the external conditions tested were compatible with the life style of the subjects and as a matter of fact not opposed to the potential adoption, as well as the wide-ranging attitudes towards the new home solutions.

4.2 Correlation

The Pearson correlations were computed to look for significant linear links between the variables of the Predictive Model of the Acceptance, i.e. for the Home Service and the dependent variable (positive) “Attitudes towards behavior” (item of section E1 in the questionnaire), as resulted in Table 3 analysis.

Table 3: Attitudes towards the new solutions for the Home Control.

Valid cases	Attitudes towards solutions for HOME CONTROL
Perceived Usefulness in Home Environment	.35(*)
Perceived ease of use	.17
Complexity	-.19
Ease of use	.06
Social factors	.42(**)
Image	-.05
Perceived behavior control	-.03
Facilitating conditions	.05
Compatibility	.46(**)
Attitudes towards behavior	.53(**)
Intrinsic Motivation	.42(**)
Affect towards Use	.30
Affect	-.01

*. Correlation significant at the degree of 0,05 (2-tails).

**.. Correlation significant at the degree of 0,01 (2-tails).

As given in the Table 3, all values in bold and with one/two asterisks indicate the presence of a high/higher degree of correlation between the variables. Having a look to the links in the picture of the predictive model of acceptance, it means that, for the home services, there were good probabilities that the positive attitude of a user-consumer were influenced by those variables. Taken for example the Home Control “Perceived Usefulness: effectiveness in home activities”, it can be said that: either “the greater is the effectiveness in the home activities the greater is this influence on the “positive attitude

towards solutions”, or it can be said “the significant Pearson correlation provides evidence that the variable “perceived usefulness” stimulates the perception of positive attitude towards solutions”.

4.3 Extended Correlation

The Pearson correlations were computed in order to look for significant linear links between the variables of the Predictive Model of the Acceptance, for the Home Control alone, and the two dependent variables “Attitudes towards EPS solutions” and “Intentions” (respectively sections F and G of the questionnaire). The results are shortened in Table 4.

Table 4: Home Control correlations with “Attitudes towards EPS solutions” and “Intentions”.

HOME CONTROL	Attitudes towards EPS solutions	Intentions
Perceived Usefulness in the Home Environment	.45(**)	.33(*)
Perceived ease of use	.31	.16
Complexity	-.27	-.30
Ease of use	.35(*)	.33(*)
Subjective norms	.33(*)	.40(*)
Social factors	.41(*)	.64(**)
Image	.24	.31
Perceived behavioural control	.29	.13
Facilitating conditions	.14	.07
Compatibility	.54(**)	.47(**)
Attitudes towards behaviour	.62(**)	.43(**)
Intrinsic Motivation	.63(**)	.45(**)
Affect towards Use	.39(*)	.12
Affect	.29	.30

*. Correlation significant at the degree of 0,05 (2-tails).

**.. Correlation significant at the degree of 0,01 (2-tails).

The Home Control extended study was based on the choice of a different (but close to the previous set) couple of dependent variables to be used to compute the Pearson correlations.

As given in the Table 4, all values in bold and with one/two asterisks indicate the presence of a high/higher degree of correlation between the variables. Always having a look to the links figured in the predictive model of acceptance, it mean that, for the Home Control service, the “perception of having intention to use” of the subjects was even more demonstrated to be influenced.

The main difference from the other table is in the availability of the “intention” as direct dependant

variable. This availability makes the accuracy of the measure higher. As seen by simply comparing the columns of the “attitudes towards EPS solutions” in both Table 3 and Table 4, more accuracy made possible the detection of more correlations.

As concerning the Home Control service, the interpretation of the correlations is the same than in the previous table. Taken for example the Home Control “Perceived Usefulness: effectiveness in home activities”, it can be said that: either “the greater is the effectiveness in the home activities the greater is this influence on the “intention of using”, or it can be said “the significant Pearson correlation provide evidence that the variable “perceived usefulness” stimulates the perception of having intention to use”. The Table 4 also provide a direct read of the correlation to the intention in the second column.

4.4 Gender Differences

In order to evaluate the differences between Male and Female perception of the Home Control Panel, was compared the mean of each sample and performed an Analysis of Variance (ANOVA) to verify if those differences were statistically significant.

Results showed that, overall, male and female perceived user acceptance in the same way for almost all the dimensions explored. The only noteworthy exception was pointed out for the “Perceived Usefulness in The Home Environment”, where females, differently from males, stated that using the Home Control system would enhance their job performance ($F(1,37)=6.10$; $p<.05$).

In the following Table 5 there are the results for the mentioned variable.

Table 5: Gender differences for the Perceived Usefulness in the Home Environment.

Perceived Usefulness in the Home Environment HOME CONTROL PANEL			
Male	Mean	N	Standard deviation
	2.62	30	.98
Female	Mean	N	Standard deviation
	3.56	9	1.08
Total	Mean	N	Standard deviation
	2.83	39	1.07
ANOVA: $F(1,37)=6.10$; $p=.02$			

5 CONCLUSIONS

The new home services as provided in the trial were on the whole accessed by the subjects with high curiosity and interest. The adoption of a controlled interactive session to present the services and their innovative features was able to give to each single participant the time necessary to understand and quickly build a personal judge about.

Then the repeated sequence task-questionnaire to gather data demonstrated to be appropriate in catching the impulsive ideas about the added values given by each service in comparison with the actual home possibilities, as well as the possible adoption in the own life. This is an excellent consequence of the methodology proposed for the evaluation, then proved by the reliable data obtained.

As for the acceptance items, this is a composite variable that can be carefully expressed by combinations of different results (and different constructs).

Therefore, by considering the “perceived usefulness” (Questionnaire Section A), the users class received a positive feeling from the services. This result is strongly powered by looking at the values of the Questionnaire Sections B.1, B.2, B.3, which indicate the clear easiness to operate and the low perception of underneath complexity, even not really so (this is an excellent result from the usability point of view, better evident for the Home Control).

The social factors (Questionnaire Sections C.2, C.3) confirmed how the subjects view was also shareable with the family and the close neighborhood.

The facilitating condition “having the resources/knowledge necessary to use the system” (Questionnaire Sections D.1, D.2) resulted about neutrally considered in relation with the acceptance, while it was very encouraging the perception of the “compatibility” (Questionnaire Section D.3), actually close to the idea of lifestyle at home.

The rest of the items in the questionnaire directly checked the attitudes of the subjects towards both the service idea and the actual usage possibility at home. The resultant Questionnaire Sections E.1, E.2, E.3, E.4 scored high positive values, indicating that there were clear intrinsic motivations in the thought of acquiring these services for the home.

Finally, the last variable (Questionnaire Section F) of “attitudes towards EPS solutions” in a straight line confirmed that the users should be willing to introduce the new solutions at home, as they were desirable, important, useful and agreeable.

The ANOVA applied to find differences of behaviour between males and females, pointed out no statistical differences except one: the females perceived differently the “usefulness at home” of the services.

The analysis on the data gathered of course didn't investigate the cause of this “social” difference, nonetheless, it is spontaneous to think at the actual different condition of the women at home in different countries and the different perception of “the usual staying at home” they may have with respect to the men.

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