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Fast, low resource, head detection and tracking for interactive applications

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ABSTRACT

This paper presents a real time, low resource, head tracking system. This system is used for a broad range of applications, the simplest being the control of a car in an arcade racing game. Another use of this system is the improvement of the gameplay of an adventure game. A more advanced application is the detection of the player's attentional state using a simple attention model in an attention aware game framework. This state is then used to adapt the game unfolding in order to enhance user's experience and improve the game attentional attractiveness. The experiments conducted on these different games showed that even if using head as a simple input device for explicit game control can improve the player's immersion, its full potential can only be exploited when adapting or building new gameplay.

Keywords: *Head-based interaction, gameplay, low resource, low cost, head tracking*

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1. Introduction

Providing good human-computer interactions is an important point in the development of interactive software (Barr, Noble, & Biddle, 2007). In the field of games, it is a way to increase immersion in the virtual world of the player. Classical interactions with mouse, keyboard or gamepad, are limited in comparison with the reality of graphics displayed. Indeed, a growing trend is to concentrate on new kinds of interfaces between the player and the virtual world. For example, some approaches are using a headpiece device to detect head movements in order to change the game camera direction. Another example is the use of the interactions between human

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bodies as a core gameplay element illustrated at the EPIDEMIK exhibition, November 2008 Paris, France, http://www.cite-sciences.fr/epidemik. There we describe a fast low cost head tracking system which is used to experiment new kinds of gameplay and improve the player's experience.

We present four prototype applications that have been developed or modified in order to use head direction as input. These applications have an increasing level of integration of head tracking in the gameplay. The first two are a Tetris and a racing game where head direction is simply used as an input to directly control the game. The third application is an adventure game in which user's head direction helps modifying the game scenario in order to try to make the game more immersive and fun to play. The last one is a pedagogical game in which information about the user's attention (derived from head direction) is used to adapt the game unfolding in order to refocus the player's attention. It is used as a tool for pedo-psychiatrists working with children with autism in the pedo-psychiatric hospital of La Rochelle, targeting the objective of improving children's attention.

In chapter 2, we describe the low cost head tracking system that we have developed. In chapter 3, we show how this system can be used as an explicit way to control a game. Then in chapter 4, we describe a more advanced software architecture that uses gaze tracking in order to detect the players' attentional state and update the game unfolding accordingly.

2. Low cost, fast head tracking

Many face detection algorithms have been published over the last 15 years. A survey of many of these systems can be found in (Yang, Kriegman, & Ahuja, 2002) and (Hjelmås, 2001). Face or head tracking is also a very active research area. See for example (Erik Murphy-Chutorian & Mohan Manubhai Trivedi, 2009) for a recent survey of the existing systems. However, many of these systems are conceived for performing either face detection or tracking and are not real-time capable. Recent work (Murphy-Chutorian & Trivedi, 2008) proposes a robust and real time system (30fps) for head detection and tracking, but this system uses the GPU in order to be real time. As a consequence, the system uses most of the CPU and GPU resources of the computer and no interactive application can be run in parallel.

To overcome these limitations, we propose a low-resource head detection and tracking algorithm, which allows running an interactive application (even a 3D game) in parallel on the same computer.

2.1. Constraints

As our system is designed to be used by a wide range of applications and users (from educational games for children with autism to adventure games for "common gamers"), some constraints have emerged:

- non invasive material: users should be able to forget the presence of the tracking device and concentrate on the interactive application;
- low cost: the system must use affordable, off the shelf, hardware;
- single user: the system should detect and track only one person at a time. If multiple persons are present in front of the camera, only one of them will be tracked.
- recordable information: the algorithm should output tracking information that can be easily stored or exploited by another algorithm (ex: attention model).
- standard computer: the system should run smoothly on a standard mid-end computer, with no additional or specific hardware.
- unconstrained environment: our algorithm should be able to work without any additional lighting.

The system is based on a low cost (ieee-1394 or USB) webcam connected to a standard computer. Despite its low cost, this type of camera captures video frames of size 640x480 at 30 frames per second which are suitable characteristics for both accurate face features localization and efficient face features tracking. Depending on the application, the system can use a color or grayscale camera. The choice of a grayscale camera instead of a more common color camera will be driven by the environment of the aimed application. Indeed, in some environments (mainly indoor), the amount of light available is often quite low. As grayscale cameras usually have better sensitivity and have a higher image quality (as they don't use Bayer filters) they are more suitable for these environments. Grayscale cameras may also be used with infra-red light and optics that don't have infra-red coating in order to improve the tracking performance by the use of a non invasive more frontal and uniform lightning. During our experiments we have only used (so far) color or gray scale cameras with no additional infrared lighting.

2.2. Architecture

The tracking algorithm is built upon four modules which interoperate together in order to provide a fast and robust face tracking system. The algorithm contains two branches: the first one for face detection and the second for face tracking. At run time, the choice between the two branches is made according to a confidence threshold, evaluated in the *face checking and localization* module. In the following paragraphs, we detail the algorithms used by each modules of Figure 1.

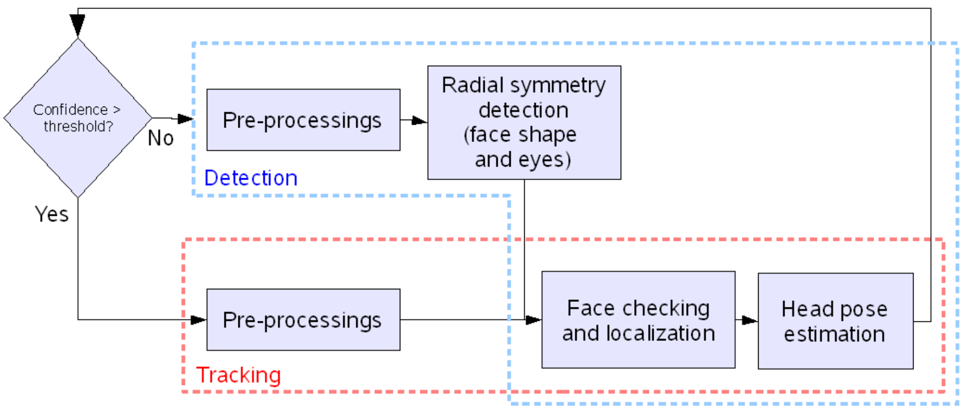

Figure 1. Architecture of the face tracking and pose estimation system.

Pre-processing. Before face or radial symmetry detection, the input image must be pre-processed in order to improve face and face feature detection performance. The main pre-processing steps are:

- image rescaling; the input image is rescaled so that low resolution data is available for radial symmetry detection algorithms;
- (in case of color camera) skin hue detection, using a commonly used histogram-back-projection (Zaqout, Zainuddin, & Baba, 2005)
- lighting correction, also called contrast normalization which consist in adapting each pixel intensity according to the local mean intensity of its surrounding pixel. As this task is naturally performed by human's retina, several complex models have been developed to mimic this processing (Beaudot, 1994).

Since our system needs to be real-time, we have chosen to approximate this retinal processing by a very simple model which consists in the following steps:

- For each image pixel, we build a weighted mean $M_{x,y}$ of its surrounding pixels. In our implementation we used first order integral filtering (Bartlett Filter) in order to achieve fast filtering. Note that first order integral filters are an extension of the commonly used zero order integral filters (box filters). For more information about generalized integral images see (Derpanis, Leung, & Sizintsev, 2007).

- Then we calculate the normalized pixel intensity: $I_{x,y} = \frac{S_{x,y}}{M_{x,y} + A}$ with S the source image, I the normalized image, and A a normalization factor.

Figure 2 shows the result of our simple contrast normalization algorithm on a side lit scene.

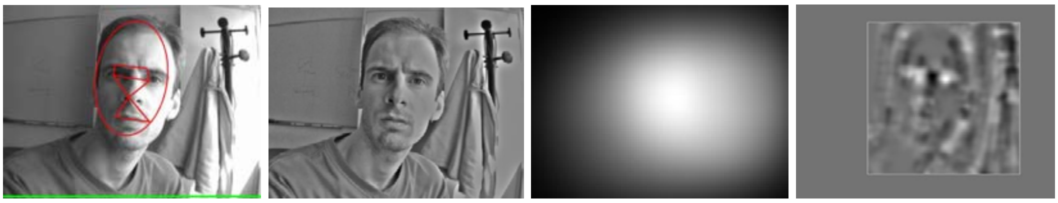

Figure 2. a) Tracking result of a side lit scene. b) Source image after lightning correction. c) Result of face ovoid detection. d) Result of eyes detection.

Radial symmetry detection for space shape and eye detection. Once the image is pre-processed, we use a set of radial symmetry detectors in order to localize a candidate face region that will be further checked by the *face checking and localization* module. Once again our real-time constraint guided the choice of the algorithms we used.

Face ovoid shape is detected in a low resolution version of the input image (typically 160x120, since we don't need much precision for this step) using an optimized version of the Hough transform (Figure 2.c) whereas eyes are detected using an optimized version of the Loy and Zelinsky (2003) transform (Figure 2.d). In order to speed up both transforms, the following improvements have been made: only pixels with a gradient magnitude above a pre-defined threshold[1] are processed; the algorithms vote in only one accumulator for all radius and accumulators are smoothed only once at the end of the processing.

Using these two symmetry maps and a set of face geometry based rules, we define the face candidate area.

Face checking and localization. This module serves two purposes:

- When called from the face detection branch, it checks if the face candidate area really contains a face and outputs the precise localization of this face.

[1] Defined empirically.

- In the case of face tracking, it only finds the new position of the face.

In both cases, the module outputs a confidence value which reflects the similarity between the interface face model and the real face image.

Face checking and localization is based on the segmentation of the face candidate image into several blobs, determined as follow: the source frame is first filtered by a difference of Gaussian (DoG) filter; the result image is then adaptively thresholded. The resulting connected components (blobs) are then matched on a simple 2D face model in order to check and localize the face.

Once the face is localized, the 2D face model is deformed to adapt to the detected face features. These deformations are kept from one tracking step to the other in order to improve tracking performance. Since we are performing continuous tracking at 30 fps, changes from one image to the other are quite small, hence we do not use any king of prediction (ex: Kalman filtering).

Head pose estimation. Similarly to previous research we use triangle geometry for modeling a generic face model. For example, (Kaminski & Shavit, 2006) resolves equations derived from triangle geometry to compute head pose. Since we favor speed against accuracy, we use a faster and simpler direct approximation method based on side length ratios (Nikolaidis & Pitas, 2000).

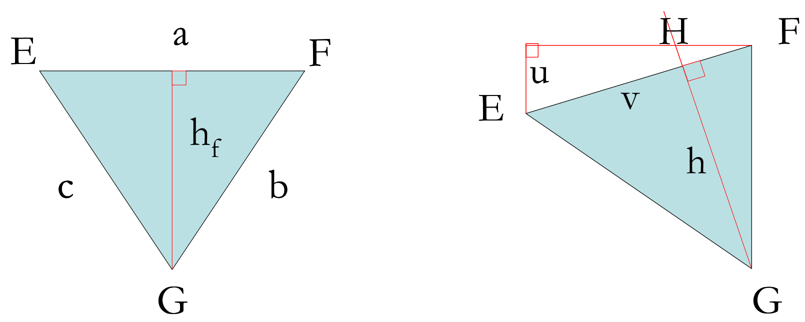

Figure 3. Features used for head pose estimation.

Continuous values for pan, tilt, roll as well as x, y and z position are processed using simple triangle geometry. The considered EFG triangle is built from the respective position of left eye, right eye and nose tip. We hypothesize that for a frontal view, this triangle is isosceles.

$$a = b = c \quad et \quad h_f = \frac{a\sqrt{3}}{2}$$

When the face is rotated we can determine the following values easily:

$$yaw = \frac{v - \frac{a}{2}}{a} \qquad \text{with} \qquad v = \left\| \overrightarrow{EH} \right\| = \frac{\overrightarrow{EF}.\overrightarrow{EG}}{\left\| \overrightarrow{EF} \right\|}$$

$$pitch = \frac{h}{h_f}$$

$$roll = \frac{u}{a}$$

2.3. Performance and robustness

Processing time. We measured the processing time of the algorithm on a laptop PC equipped with a 1,83GHz *Intel Core Duo* processor. We obtained the following mean processing times:

Algorithm	**Processing time per frame**	**CPU load**
Face detection[2]	30 ms	50% (100% of one core)
Face tracking	16 ms	25% (50% of one core)

Table 1. Processing time of the detection / tracking algorithms.

Processing time include all processing steps, from pre-processing to head pose estimation. Since image capture is done at 30fps and the algorithm is using only one of the two processor cores the algorithm is fast enough to enable running a game in parallel on a standard middle-end computer. Please note that we have not used any GPU acceleration in order not to slow down any 3D graphics in the target interactive application.

Robustness. As can be seen from the tracking example shown on Figure 4, the algorithm can handle a broad range of head orientation and distance, as well as different people. The contrast normalization step also allows the algorithm to run under different illumination conditions.

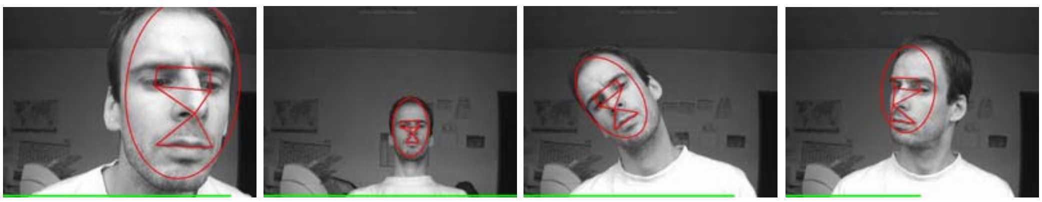

Figure 4. Result of the tracking algorithm for different face distances and orientation.

[2] First detection or detection after tracking failure.

However, this algorithm is designed to be fast, as a consequence tracking performances still need to be improved under some lightning conditions (backlit scene, directional lighting casting hard shadows, etc.) and head pose (Figure 6). When using a color camera and skin color detection algorithms (as in Schwerdt & Crowley, 2000) or (Séguier, 2004) the face detection and tracking robustness are improved. This modification however prevents us from using infra-red light to improve the algorithm performances under poor lightning conditions. A possibility would be to add an infra-red lightning and adapt the current algorithm to this new lightning in order improve the robustness of the system.

Figure 5. Result of the detection / tracking algorithm for different participants.

Lastly, the algorithm is not designed for occlusions handling: if the face is masked by any object, tracking is lost (but quickly recovered at the end of occlusion). Fortunately, occlusions are very rare when the system is used with interactive applications.

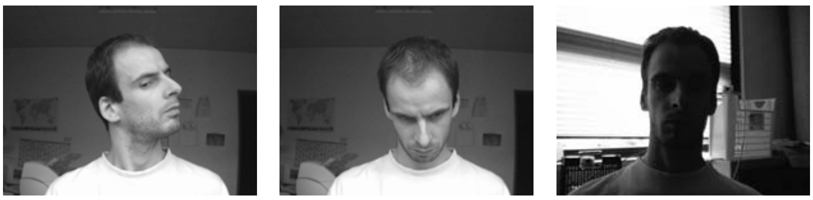

Figure 6. Examples of detection/ tracking failure. Left and middle: face pan and tilt are to important. Right: backlighting is too strong.

2.4. Gaze tracking

Some of the applications described below require information about user's gaze. Since eyes are a feature extracted for our face model, it should be quite easy to use their position to (in conjunction with head orientation) estimate eye gaze. However, considering the large freedom of movement allowed to users, extracted faces can be as small as 48 x 57 pixels. In this case, it is difficult to compute an accurate and reliable estimate of gaze direction.

To overcome these problems, we propose to use head direction as an approximation for gaze direction. Although it may look simplistic, in practice, it provides enough information for the simple attention monitoring tasks described in chapter 4.

The algorithm described above has been integrated into several games / interactive applications. In the next chapter we describe the experiments conducted on these applications.

3. Explicit control of games via head tracking

3.1 Head as a simple input device

Our first experiments consisted in modifying two classic games: a Tetris and a racing game (which are both public domain Microsoft XNA Game Studio game samples) in order to connect them with our head tracking system. We chose these games because any casual gamer knows how to play them, which shortens the learning phase. Moreover, racing game players tend to naturally roll their head when the car is within curves; head movements seemed therefore good candidates for an alternative way to control the car. Once the games modified, we were able to use head movements like any other input device.

Figure 7 show screenshots of both applications. Video demonstrations are also available on YouTube[3].

We conducted some experiments with a small set of five persons aged from 23 to 35 (all were casual gamers). Each person was shown how to play the game for 5 minutes. Then, they could play on their own for 15 more minutes. Lastly, they were interviewed in order to know what they thought about this new kind of interaction. These experiments showed that:

- Gaze control is not suited to all kinds of games. Moving and rotating Tetris bloc with head movements is quite unintuitive and requires some training. On the contrary driving with gaze is quite easy to learn, and quite fun.
- Robustness is a key point for a good gaming experience. If tracking is lost during the game (because of extreme head positions or bad lightning condition as described in section 2.3), all immersion improvements are lost. However, the system need also to be fast, if the system's responsiveness is low immersion improvements are also lost.

[3] http://www.youtube.com/watch?v=e8VGafkN4RQ and http://www.youtube.com/watch?v=91F9VnBa7Wo

- The gameplay of head controlled games needs to be adapted in order to be really intuitive. For example, gamers found it difficult to control the Tetris game with their head. Additionally, they obtained lower scores when controlling the game with their head than when controlling it using the keyboard. For the racing game, although head control was easier and fun, users sometimes had difficulties controlling throttle. A solution would be for example, mixing mouse (throttle) and head tracking (steering) in order to propose a more natural gameplay.

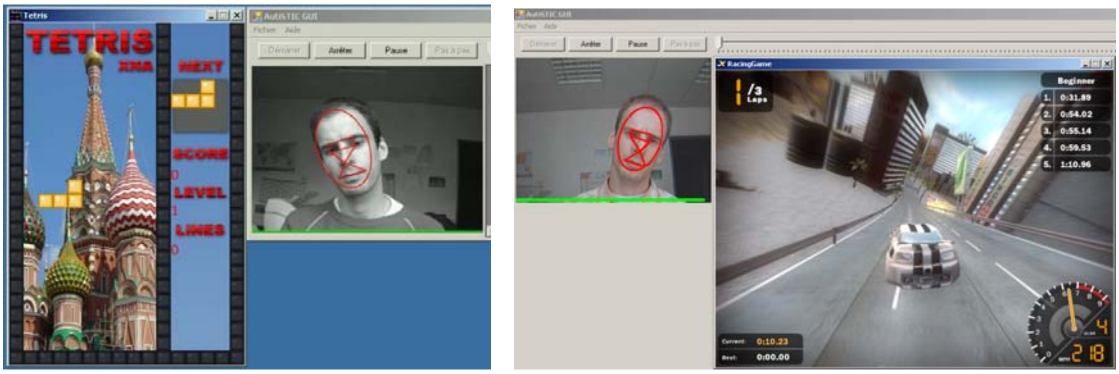

Figure 7. Left: screenshot of the gaze controlled Tetris game. Right screenshot of the gaze controlled racing game.

To further exploit the potential of gaze in games we have decided to add head controlled sequences in an adventure game prototype developed by students of the ENJMIN[4] School: L3iLife. This time we don't replace an input modality by another. Instead, we introduce new gameplay elements which were created for head based interaction.

3.2 Head as a new gameplay element

We have developed an adventure game based on the visit of a virtual world that represents the computer science laboratory (L3i) of the University of La Rochelle. The player has to explore the laboratory by opening doors and visiting rooms. Figure 8 shows a screen capture of the prototype that has been developed with the Unreal Engine editor[5].

The game concept is the following one. The player is a student that has a fixed delay to give a work to his teacher. He is in direct competition with an *evil* student that tries to

[4] Ecole Nationale du Jeu et des Médias Interactifs Numériques
[5] http://www.unrealtechnology.com/

prevent the player from reaching his goal and with a *little pest* that tries to steal his work and give her own work first to the teacher.

We propose to give to the player a maximum amount of interactivity while keeping a robust and interesting narrative framework. The approach of emergent narrative consists of a particular architecture that increases the player's freedom of action and produces a dynamic control of narrative quality. A challenge is, for example, to detect the player's behavior in order to dynamically modify the scenario.

Interested readers will find more details about the architecture of the game in (Champagnat, Prigent, & Estraillier, 2005) and (Perreira Da Silva, Courboulay & Prigent, 2007).

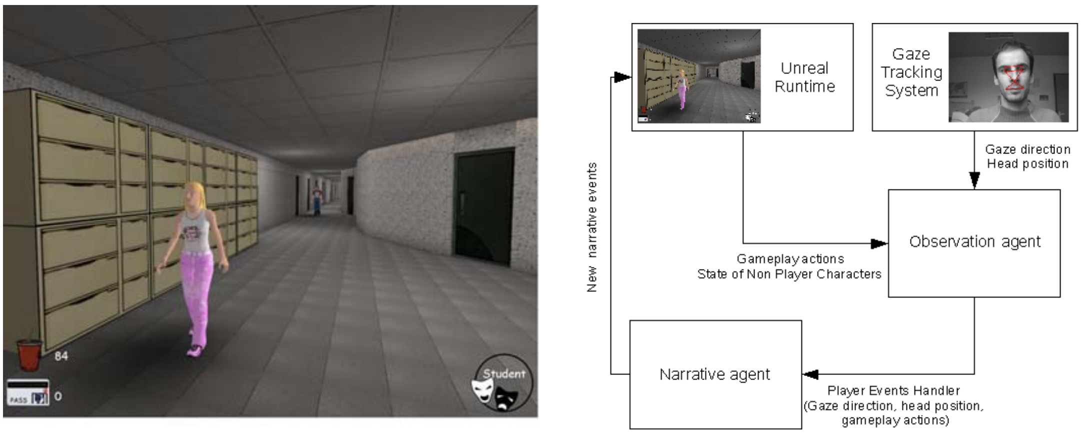

Figure 8. Left: A screen capture of the prototype game (L3iLife). Right: Overview of the narrative based game architecture.

Game/head interaction. During our first experiments (conducted with the same protocol and participants as in section 3.1), we only took into account a few explicit players' behavior:

Firstly, we focused on the interaction with the non player character of the *little pest*. She tries to steal the work of the player. The player can interact with the girl by doing a wink[6] to the camera when he is in front of the girl. Then, the girl will give his work back to the player if she has stolen it to him.

Secondly, we allow the player to protect himself against the *evil* student by looking down. Indeed, if the evil student arrives near the player, this one will put his head down and then the *evil* student will go on without stealing his work.

[6] Since the player's eyes are already localized by our face tracking algorithm, blinks are detected by a simple frame subtraction.

Figure 9. Gaze controled sequence of L3iLife. Left: The evil student is about to catch the player. Middle: The player gaze down in order to show his submissiveness. Right: The evil student does not catch the player: game is not over!

During our first experiments we have observed that this new kind of interaction improves the players' immersion in the virtual world of the game. Moreover, it also increases its interest for the game because the gameplay is richer and the game more fun to play. These observations will certainly be confirmed once our framework will include the observation of implicit behavior as we will have more real-time feedback on the user's gaming experience.

We are currently working on the integration of more complex kinds of behavior into the interactive game framework. Gaze tracking could be used to observe the level of attention of the player. For example, if the player stops watching at the screen, a particular game action can be launched to refocus his attention. In L3iLife for example, in this kind of situation, the adaptive architecture can modify the unfolding of events, and make the *evil* student run after the player to steal his work. It is a stressing action that can bring some interest back to the player.

This implicit behavior system is not yet implemented in L3iLife, but we conducted some similar experiments with an educational game aimed at autistic children. We describe this system in the next section.

4. Implicit control of games via head tracking

Usually, computer software has a very low understanding of what the user is actually doing in front of the screen. It can only collect information from its mouse and keyboard inputs. It has no idea of whether the user is focused on what it is displaying, it doesn't even know if the user is in front of the screen.

One of the first steps to making computer software more context-aware is to make it attention aware. In (Roda & Thomas, 2006) attention aware systems are defined as «Systems capable of supporting human attentional processes.»

From a functional point of view, it means that these systems are thought as being able to provide information to the user according to his estimated attentional state. According to (Roda & Thomas, 2006), one of the best ways to estimate user's attention is using gaze direction. Consequently, building good adaptive attention aware system requires estimating reliably user's gaze.

Many high accuracy commercial gaze tracking systems are currently available (Ould Mohamed, Perreira Da Silva, & Courboulay, 2007). Most of them use dedicated or costly hardware in order to estimate user's gaze with the desired precision. Moreover, these systems are designed to be used with cooperative users (most of the time disabled users or attention studies participants) in a constrained environment. A choice needs to be made between gaze tracking precision, equipment cost and user's freedom of movement. As our attention aware system only needs to know whether the user watches the screen or not, we propose to use head pose as an estimator for gaze direction.

But before closing this, let's have a closer look on what attention is.

4.1 Attention

Attention is historically defined as follows (James, 1890):

«Everyone knows what attention is. It is the taking possession by the mind in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought...It implies withdrawal from some things in order to deal effectively with others»

Thus, attention is the cognitive process of selectively concentrating on one thing while ignoring other things. In spite of this single definition, there are several types of attention (Ould Mohamed, Courboulay, Sehaba, & Menard, 2006): awakening, selective attention, maintained attention, shared attention, internal or external absent-mindedness and vigilance. For an interactive task, we are mainly interested in selective and maintained attention. The analysis of the first one allows knowing whether people are involved in the activity. The second one enables us to assess the success of the application.

It has been proven that the same functional brain areas were activated for attention and eye movements (Corbetta et al., 1998). Consequently, the best attention marker we can measure is undoubtedly eyes and gaze behavior. A major indicator concerning another type of attention, vigilance, named PERCLOS (Dinges & Powell, 1998) is also using such markers. (Horvitz, Kadie, Paek, & Hovel, 2003) presents different models for integrating attention into an Attentional User Interface. But the models are mainly focus on attention, without any clear link with gaze. On the contrary, Peters, Pelachaud, Bevacqua, Mancini, and Poggi (2005) present how gaze direction can be used in order to improve the behavioral plausibility of an Embodied Conversational Agent. But the models described have only been used in a simulated environment.

In continuity of such studies, we based our markers on gaze behavior, approximated by head pose, to determine selective and maintained attention. A weak hypothesis is that a person involved in an interesting task focuses his/her eyes on the salient aspect of the application (screen, avatar, car, enemy, text...) and directs his/her face to the output device of the interactive application (screen). Nevertheless, if a person does not watch the screen, it does not necessarily mean that he/she is inattentive; he/she can be speaking with someone else about the content of the screen (Kaplan & Hafner, 2006). However, the more time users spend not watching the screen, the more probable is their inattention. Consequently, we have decided to adopt the following solution: if the user does not watch the screen during a time *t*, we conclude to inattention. In the following subsection, we present how t is determined. If inattention is detected, we inform the application.

A simple model of human inattention. The goal of this model is to define the delay after which the application tries to refocus the user on the activity. Actually, we easily understand that in this case, an interactive application does not have to react the same way if people play chess, role player game or a car race. Until now, this aspect of the game was only directed by the time during which nothing was done on the paddle or the keyboard.

We based our model of what could be named inattention on two parameters:

- the type of application;
- time spent using the application.

The last parameter depends itself on two factors:

- a natural tiredness after a long time
- a disinterest more frequent during the very first moments spent using the application than once attention is focused, this time corresponds to the delay of *immersion*.

Once the parameters are defined, we propose the following model in order to define the time after which the application try to refocus the player who does not look at the screen.

Potential of attention. As we mentioned, potential of attention depends mainly on two parameters, tiredness and involvement. We have decided to model arousal (the opposite of tiredness), or potential of attention, by a sigmoid curve parameterized by a couple of real number β1 and β2. β2 represents the delay after which the first signs of fatigue will appear and β1 is correlated to the speed of apparition of tiredness (Figure 10).

$$P_{arousal} = \frac{\exp^{-\beta_1 t + \beta_2}}{1 + \exp^{-\beta_1 t + \beta_2}}$$ where β_1 and β_2 are two real parameters.

For the second parameter, we have once again modeled involvement, or interest probability, by a sigmoid. We started from the fact that activity is a priori fairly interesting, but if the person is involved after a certain time ruled by α2, we can consider that interest is appearing at a speed correlated to α1 (Figure 10).

$$P_{\text{int}\,erest} = \frac{1}{1 + \exp^{-\alpha_1 t + \alpha_2}}$$

For our global model of potential of attention, we couple both previous models in order to obtain:

$$P_{attention} = P_{\text{int}\,erest} \times P_{arousal}$$

Delay of intention. Once this model is defined, we are able to determine the time after which the software has to react (if the person still does not look at the screen). Here, it is an arbitrary threshold γ determined by experience, which characterizes each application. The more the application requires attention, the higher this coefficient is. Under the hypothesis that attention follows an exponential decay, the equation we have adopted is an exponential function which models the time after which attention reaches its activity switching threshold.

$$D_{game} = \exp^{\chi(t) \times P_{attention}}$$

γ is a function of time because we have estimated that it can exist several tempo in an application (intensive, stress, reflection, action ...).

As a conclusion, we can summarize our model of inattention by the two following steps (Figure 11):

- depending on the time elapsed from the beginning of the application, we estimate the potential of attention $P_{attention}(t)$;

- depending on this potential and the application, we estimate the delay $D_{gamma(t)}(P_{attention}(t))$ after which the software has to refocus the inattentive player.

Please note that this model was validated on only five children and still need to be validated on more people. Nevertheless, the first tests are quite promising.

This model of inattention has been used in conjunction with our real time gaze tracking system in an educational game. This game is part of a project called the *AutiSTIC Project* which we describe in the following section.

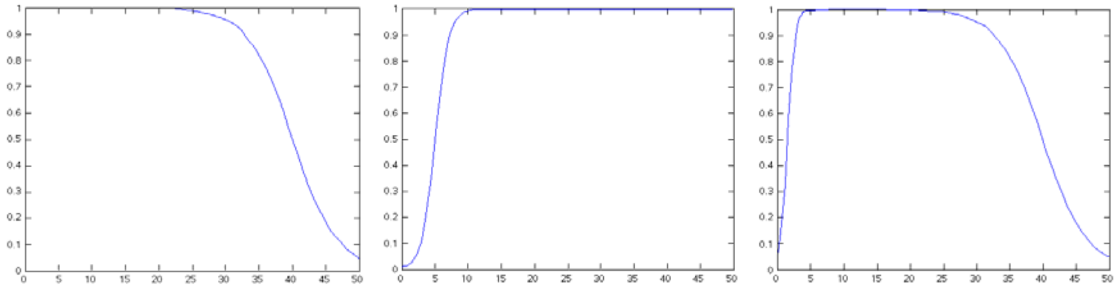

Figure 10. Left: model of tiredness evolution. Middle: model of interest probability. Right: model of potential of attention. Abscissa represents time in minutes (α1=1, α2=3, β1=0.3, β2=12).

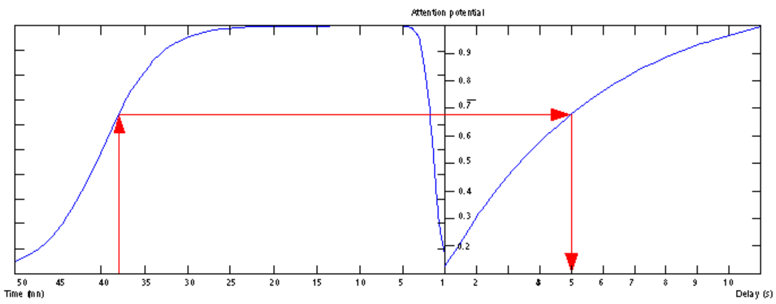

Figure 11. Curves used to determine the delay of software interaction.

4.2. The AutiSTIC Project

The AutiSTIC Project tends towards implementing a system that can help autistic children during the rehabilitation process. The role of such a system is to provide the child with personalized activities in the form of educational games. During a session, the system collects through various devices (camera, touch screen, mouse, and keyboard) actions and attention, in order to understand her/his behaviour and responds to it, in real time, by adequate actions considering directives. These directives concern rupture, avoidance, stereotype gestures... For instance, the system may attract attention by displaying an image on the screen, or by launching a characteristic music. It is impossible to generalize activities or reaction without precaution; we have to favor the adaptability of a system to take into account the specificity of persons. It is important to locate and interpret carefully these intrinsic behaviors as eye and gaze orientation, in order to help him/her to rehabilitate. We do not have to perturb the child when he/she is working; misinterpreting his/her attention may deeply perturb him/her because of his/her monotropism (Murray & Lawson, 2005).

In the application context, our architecture aims to bring flexibility and modularity in the individualized rehabilitation of children with autism. In the next section we present a part of our platform which observes children and analyses their visual attention.

The hello hidden game. This interactive game, which was developed within the context of the AutiSTIC project, is characterized by simplicity in order to not perturb the autistic child, often sensitive to complex environments. This is why the game has a static background, contains few objects and is easy to use. Nevertheless, each object has several behaviors in order to allow the control of execution according to the behavior of each child. The goal of the game is to allow autistic children to reach by interactive manipulation the competences of perception, motor function, spatial and temporal representation. Figure 12 shows the game interface of "hello hidden". This game allows using one or more balls of various colors on the screen. These balls appear in a frame that is displayed in full screen.

There are two kinds of balls:

- The small ball, called cursor, which the children can handle by applying a pressure on a touch screen.
- Big balls of various colors which remain motionless. The interaction between the cursor ball and the big balls contains two possibilities: Either the cursor ball disappears when it becomes near big ball and reappears when it goes away, or it stops its progression when it arrives at the periphery of a big ball and joins with it.

The objectives of this game vary according to various situations which occur. In the case of the presence of only the cursor ball, its elementary use allows the child to establish a relation between a direct motor action (to touch the screen) and the effect produced (movement of the object). In the case where one or more big balls are present on the screen and the cursor ball disappears when it moves near big ball, the objective is to analyze the capacity of the child to represent hidden objects and to act to make the cursor visible.

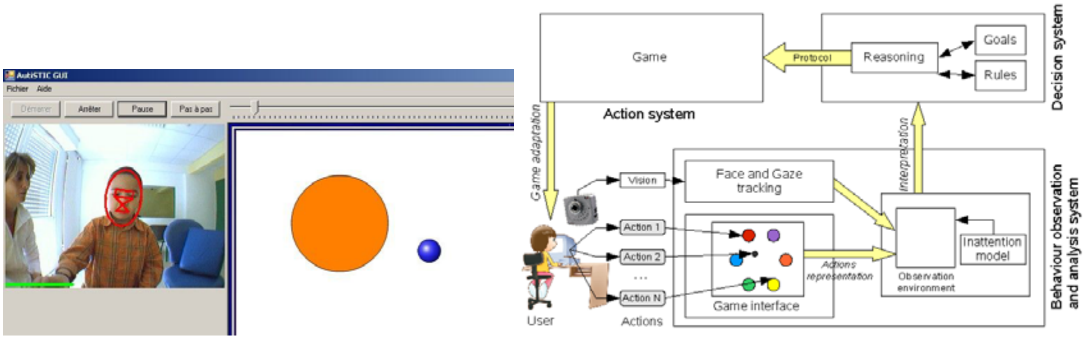

Figure 12. Left: Screenshot of the "hello-hidden" game. Right: General architecture of the adaptive software platform.

More details about the architecture of this interactive application can be found in (Sehaba, Courboulay, & Estraillier, 2006). In this application, head orientation is used to estimate whether the child is watching the screen or not. When he is not watching the screen, we use our inattention model to decide when to play a sound to refocus him.

Results. Our platform can use, in real time, information concerning the explicit behavior of the child (mouse and keyboard events) and his/her implicit behavior (movements of the face, gaze...) in order to estimate the degree of carelessness of the child and to adapt the activity as well as possible. We use these annotations, done using video annotation software (L3iAnnote), in order to make automatic measures and to validate our model of inattention. Our software, installed both in academic and in medical sites, has allowed us to confront our model and the reality of children in front of a computer. Preliminary results obtained with children who took part to our study (three) are very interesting and promising, but the number of participants should be significantly increased and the model also needs to be validated on people without autism. Yet, it is very difficult to find children for the experimentations, because of the reserve of parents and the small number of children in the medical structure. Currently, we have tested our model on ten ordinary players in our laboratory, and the first results confirm those obtained with children with autism. We will continue the workshops with the same children by leaving this time the initiative of the stimuli to the computer, in order to analyze their behavior.

5. Conclusion

In this article we have presented a low resource real-time head tracking system. This system provides a fast and low cost solution for integrating approximated user's gaze into interactive applications. Its precision is not as good as gaze tracking devices and its robustness is not as good as slower head tracking systems. However, it provides a good tradeoff between cost, resource consumption, precision, robustness and freedom of movement. Ideally, one would like a more precise and robust system; but providing a precise system with great freedom of movement or a more robust one with low resource consumption is still an unsolved issue.

This system has been successfully integrated into four different games: a Tetris game, a racing game, an adventure game (L3iLife) and an educational game part of the AutiSTIC Project. The experiments we conducted on these different games showed that even if using head as a simple input device for explicit game control can improve the player's immersion, its full potential can only be exploited when adapting or building new gameplay. This can be accomplished by the following ways:

- Do not try to use full head based control. Mix *classical* input devices and head control in order to provide the best ergonomics.
- Insert head controlled sequences in games only when necessary. For example in L3iLife, head controlled sequences were launched only in defined situations (interaction with non-player character).
- Do not change the way the game is controlled, but use head tracking as a gaze tracking approximation in order to monitor user's attentional state. These data can then be used to modify the game's unfolding.

Lastly, we have proposed a simple model of inattention, which provides an original solution for processing the attentional state of person from its eye or head tracking data.

6. Acknowledgments

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Designing Effective Feedback of Electricity Consumption for Mobile User Interfaces

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ABSTRACT

This paper illustrates the approach of Energy Life, a pervasive household sensoring and feedbacking system aimed at improving the energy conservation practices of the inhabitants. The concept of EnergyLife takes into account state-of-the-art knowledge of what makes a feedback intervention effective, which – at this stage of its development – can be synthesized into two main features. First, knowledge and action are to be synergically addressed by visualizing electricity consumption on the one side, and providing conservation tips on the other. Second, the design should be centered on the users and undergo iterative usability tests. A more detailed description of the literature-based requirements informing the design of EnergyLife is offered at the beginning of the paper. The way in which they are embodied in the features of the mobile interface, epitomized by its intuitive 3D carousel, is then described. Finally, the rationale and results of the first usability evaluation are reported, describing the responses to a satisfaction questionnaire and the types of breakdowns that occurred during the users' interaction with the device. These results will guide the next development phase and the release of a new prototype.

Keywords: *energy awareness, feedback, mobile interface, breakdown analysis.*

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1. Introduction

The potential for saving energy relies on the involvement of consumers in conservation and waste reduction. Current solutions often pay limited attention to usability and engagement, which are prerequisites for the sustained impact of any feedback system. These are challenges for interaction design, namely to propose solutions to engage consumers and turn them into active players in order to develop energy conservation practices. Such challenges can be faced by considering their social and psychological aspects, together with state-of-the-art approaches to user interfaces.

The system presented here – called EnergyLife – tries to accept these challenges and deals with them by capitalizing on past attempts at improving energy conservation via the provision of feedback, and on their reported strengths and weakness. It also relies on current advances in technology, which make pervasive digital feedback systems tailored to consumers widely accessible. This system can be implemented in familiar tools, which do not require any special measures or learning process in order to be mastered by their users. The paper describes the requirements of this system, connecting them to the literature; it then illustrates the mobile user interface developed on a touch-enabled smart phone using 3D widgets; finally, it recounts the method and results of the usability tests.

1.1 Awareness tools

The identification of the requirements for EnergyLife started with a series of interviews with people who are assumed to possess wide experience in increasing energy awareness because of their position, job, or personal commitment. The interviews were integrated with a literature review of more than 70 scientific articles, which reported the results of interventions to reduce energy consumption by way of various feedback systems. The review allowed the characteristics of the interventions that proved more effective and that are worth being implemented to be singled out.

A total of nine Finnish and Italian stakeholders were interviewed according to a common protocol; in both countries, the stakeholders included prominent activists in environmentalist associations, members of governmental agencies, and house appliance producers. The interviews revealed the stakeholders' idea of consumers' energy conservation practices. According to them, consumers' knowledge barely consists of the bill they pay. Details, such as the amount of kW/h spent or the cost of a kW/h, escape regular consumers. In addition, people lack some basic knowledge of the proper use of an electrical device (e.g. the meaning of the term power class), or embrace wrong beliefs (e.g. switching on and off fluorescent bulbs any time they leave a room for a short while). According to the stakeholders, consumers lack information about the long-term impact of their behaviors, about the energy production process (e.g. energy re-use, when the energy generated by one appliance is used to feed another one) and about invisible consumption (e.g. devices in stand-by state), while the perception of the energy consumed can be based on superficial or misleading cues (e.g. usage time).[2]

Since the interviewees shared these concerns coherently, an intervention to increase consumers' awareness then seemed a necessary companion to the feedback system planned for EnergyLife. While the feedback was meant to depict the actual energy consumption, awareness tips could facilitate the acquisition of knowledge about electricity conservation practices with everyday home devices; this knowledge would allow consumers to interpret the feedback appropriately and to adopt effective countermeasures to improve energy conservation. This resolution was corroborated by the literature analysis, which highlighted the fact that any feedback must rely on a clear comprehension of the goal to be pursued (goal setting, e.g. McCalley & Midden, 2002; Becker, 1978; McCalley, 2006) and of the way to achieve it (task motivation level and corrective feedback, Kluger & DeNisi, 1996). Therefore, consumption feedback and awareness tools became two synergic pillars of EnergyLife.

Some ways to provide information have been reported as problematic, since advice tips and information packages did not improve performance with respect to sole feedback (Ueno, Inada, Saeki & Tsuji, 2006; Hutton, Mauser, Filiatrault & Ahtola, 1986; Wood & Newborough, 2003). A different solution could rely on contextualised and tailored information, coherent with the feedback provided, yet separated from it. There are indications that tailored information is sometimes effective (Abrahamse, Steg, Vlek, & Rothengatter, 2007). This solution will be attempted in EnergyLife through specific tips and quizzes and the scores deriving from them and customized to the users' behavior.

[2] More details on these interviews and their results can be found in Chapter 2 of the BeAware Projet Deliverable 2.1, available at: http://www.energyawareness.eu/beaware/uploads/deliverables/BeAware-D2.1-UNIPD-20081031.pdf

1.2 Consumption Feedback

Regarding consumption feedback, it cannot consist of the kind of consumption information that users are currently offered and that is often ignored, such as pure kW/h, which is not immediately translatable into a conservation step other than simply cutting electricity use; it must be related to the conservation goal selected (McCalley & Midden, 2002; Becker, 1978; McCalley, 2006) and tailored to the household's actual consumption (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Midden, Meter, Weenig, & Zieverink, 1983). On the one side, it should be as close as possible to the users' actions: it is easier to affect specific behavioral intentions than general ones (Van Raaij & Verhallen, 1983; Painter, Semenik, & Belk, 1983), and the user needs to understand which steps would fill the gap between their actual state and the targeted one (Kluger & DiNisi, 1996). Therefore, BeAware will provide consumption feedback device by device, appliance by appliance. On the other hand, feedback on the overall household consumption should be provided as well, since it could discourage a rebound effect, where the electricity saved with one device is spent on another new device and then the adoption of energy conservation practices does not lead to a final decrease in the overall energy consumption (Dillman, Rosa, & Dillman, 1983; Haas, Auer, & Biermayr, 1998; Herring, 2006). Finally, the information provided by the feedback must be remembered when needed (Ilgen, Fisher, & Taylor, 1979) in order to orient the prospective actor, and should be accessed at the same place where it is used without additional steps (e.g. such as turning off a dedicated terminal, as in Ueno, Inada, Saeki, & Tsuji, 2006). This is why no dedicated device will be proposed by EnergyLife, but rather the augmentation of ones that already exist.

All these aspects can be realized through well-designed information technology: sensors and algorithms can provide consumption data for specific devices, as well as the household; the feedback algorithm can express the information on the basis of several parameters, including the conservation goal; networks created between sensors and a server can update the feedback in quasi-real time on the basis of the usage of the individual devices in the household; awareness tools can be implemented in the system and exploit the electricity measurement in order to be tailored to the household.

Other recommendations on the type of consumption feedback can be distilled from the literature on energy conservation. First, historical feedback has proved to be more effective than a comparative type, in which the household's consumption is compared to that of others (Midden, Meter, Weeenig, & Zieverink, 1983; Schultz, Nolan, Cialdini, Goldstein, & Griskevicious, 2007; Kantola, Syme, & Campbell, 1984). This could be due to the fact that comparative feedback selected a term of comparison that was not relevant to the consumer, or because the comparison generated a boomerang effect: a consumer who saved more electricity than the other users might lose the motivation to improve further. Second, the feedback must be sensitive to small savings: interviews with 20 Finnish users who loaned the meter were carried out within the BeAware project revealed that meters made the energy consumption of a single appliance at any given moment appear too negligible to motivate any need for energy conservation practices (Liikkanen, 2009). Third, and contrary to common opinion, monetary feedback should be avoided: using financial savings as a motivator is not effective in the long run, since it is too closely connected to low incomes and financial crisis (Neuman, 1986; Monnier, 1983; Pfaffenberger et al., 1983; Black, Stern, & Elworth, 1985). In order to appeal to all types of households, especially those with the highest saving potential, the feedback system should appear as a nice piece of technology, serving efficiency and well-being,

In synthesis, historical, sensitive, and aesthetically attractive feedback is more likely to be effective. Table 1 shows the requirements examined in this section

Requirement	**Description**	**Relevance to User Interface**
Positive and negative habits	Feedback must encourage good habits, not just discourage bad ones (Kluger & DiNisi, 1997).	Important to include both rewarding and penalizing feedback
Feedback related to specific behaviors	It is easier to affect specific behavioral intentions than general ones (Van Raaij & Verhallen, 1983; Painter, Semenik, & Belk, 1983).	The feedback needs to allow the effects of specific behaviors to be learnt (Kluger & DiNisi, 1996)
Sustaining the impact	Trials must run for a long time in order to be effective (Van Raaij & Verhallen, 1983; Henryson et al., 2000; Wilhite, 1997)	The interface should be able to evolve in order to sustain the interaction
Accounting for variations in energy use	Amount of energy use and adoption of energy conservation practices are not directly related (Dillman, Rosa, & Dillman, 1983; Haas, Auer, & Biermayr, 1998; Herring, 2006).	By keeping a measure of general energy consumption in the household, one can verify if there is a rebound effect
Context-dependent feedback	Relevant data on households and geographical area must be inputted into the system to tailor the feedback to the user (Midden, Meter, Weening, & Zievering, 1983; van Houwelingen & van Raaij, 1989).	Corrections to energy use must be added to the algorithm for the production of the feedback (based on weather, appliance, region)
Tailored feedback	Tailored feedback and sometimes feedback plus tailored information are effective (Abrahamse, Steg, Vlek, & Rothengatter, 2007); individually tailored feedback is more effective than comparative feedback (Midden,	The feedback must be tailored to the actual consumption of the user, and to his/her profile

	Meter, Weenig, & Zieverink, 1983).	
Historical detailing	Historical feedback is more effective than comparative (Midde, Meter, Weeenig & Zieverink, 1983; Schultz, Nolan, Cialdini, Goldstein, & Griskevicious, 2007; Roberts, Humphries and Hyldon 2004; Kantola, Syme, & Campbell, 1984).	The feedback must be a historical index, not merely a cumulative calculation, and must be calculated so as not to show excessive variations
Format of feedback	Financial savings are not a long-term motivator compared to efficiency (Neuman, 1986; Monnier, 1983; Pfaffenberger et al., 1983; Black, Stern, & Elworth, 1985).	The main feedback should not express energy conservation in monetary units, but as efficiency or conservation

Table 1: Requirements for Consumption Feedback

1.3 Usability requirements

In addition to the above remarks, any feedback system should be usable in the sense that it should be easy to understand and adopt, and that it should support energy conservation practices effectively and efficiently. For instance, too much information on different appliances might lead to overload and drop-outs (Ueno, Inada, Saeki & Tsuji, 2006); thus, tests must ensure that the information provided and the functions displayed do not confuse the user. Additionally, computerized feedback is more effective than other methods (Brandon & Lewis, 1999), but should not require the inspection of too much data and long log-in procedures. Making sure that EnergyLife is usable facilitates the achievement of its final goal, which is not just to be adopted by the users, but to modify their habits.

This is embodied by a series of usability requirements, which are synthesized in Table 2.

Requirement	**Description**	**Relevance to User Interface**
Designing to avoid information overload	Too much information on different appliances might lead to overload and drop-outs (Ueno, Inada, Saeki, & Tsuji, 2006)	The information displayed should be self-explanatory; merely decorative elements should be avoided; the information must not be presented all at once, but on successive levels of detail.
Situated feedback	Feedback must orient the prospective actor and needs to be accessed at the same place where it is used and without additional steps	Feedback should be easily accessible on a mobile device that is always at hand and present actionable information (clear time span, advice on how to improve).
Non-intrusive	Sensors should not disrupt everyday family habits by requiring additional measures just to cope with them.	When feedback from the ambient and mobile interface is presented, its message should be communicated in a way that does not prevent the user's intended activity.
Intuitiveness	The interaction with the system is	Every interaction method should

	easy and intuitive	encourage the correct user input without the need for a manual.

Table 2: Main usability requirements

To these, we added two requirements that improve the system's credibility and trustworthiness (Table 3).

Energy efficiency	The feedback system should be energy-efficient (Darby, 2006)	A mobile device is always on; it should require less energy compared to a dedicated device or PC.
Privacy	The system should not be perceived as threatening to the users' privacy	Mobile devices with personal access give the opportunity to personalize the feedback and to protect privacy at the same time.

Table 3: Additional system requirements

The next section describes the way in which the requirements and remarks listed in this section are implemented; the results of the usability test follow.

2. EnergyLife

2.1 General concept

As anticipated, the system developed within BeAware, and called EnergyLife, bases its persuasive potential on two pillars, awareness tips and consumption feedback. Awareness tips are meant to increase the users' knowledge of the consequences of their electricity consumption in general and of that of specific devices; consumption feedback makes the actual energy consumption visible to the users in terms of the updated distance from the selected saving goal. The two kinds of information together would help the users to monitor the quality of their conservation practices, and would enable them to know what to change in these practices in order better to achieve their goal. Both types of information are tailored to the actual consumption of individual devices and of the whole household.

The resources provided by EnergyLife are meant to constitute a whole system that pervades the household and connects the different aspects of the use of electricity from the perspective of the user: from electricity consumption (lights dimming and the mobile interface), to the information that helps to modify the consequences of consumption (tips), to the verification that the information has been acquired (quizzes).

In order to create a coherent, familiar, and attractive rationale for the use of EnergyLife, the pursuit of the saving goal follows a game-like rationale: awareness and consumption (saving) are expressed in scores; goals are divided into sub-goals connected to different levels of the game, so that the fulfillment of the objective on one level gives access to a higher level; higher levels have greater difficulty and richer functionalities; the saving activity can be discussed with other people participating in the same program; knowledge is tested through quizzes and improved though contextualized tips, all of which contribute to increasing the awareness score.

This interface meets some of the basic usability requirements highlighted above; the system does not need the user to do anything special in order to access the feedback, since it can be received on the same mobile device s/he uses for telephone calls; or, even s/he does not want to turn on his/her mobile, minimal feedback is provided anyway by the lights in the house, which dim when switched on when the goal is not met. The input system is also very easy, consisting of touching the screen in ways similar to the action one would perform on the actual object: rotations, pressures, ticks.

2.2 The main interface metaphor: the Carousel

The idea of adopting a carousel as a closed-loop menu to select items is not new. Those of us that were playing video games in the ’80s on the Neo Geo arcade machine might remember that a lot of these games used such a carousel to ask the best players to enter their initials and appear on the high scores screen. An example of a more recent carousel can be seen in Microsoft’s Encarta 2004. As Wang, Poturalski, and Vronay (2005) explained, the carousel design provides a straightforward and great-looking layout, its mechanism is easy to understand, the 3D visualization enables its users to spot the selected item easily, and the rotation effect is engaging.

Such models are now widely used on web pages in order to display fancy image galleries or menus. With recent browsers it is possible to use different tools and languages to implement them, such as JavaScript, Adobe Flash, or Microsoft Silverlight. But even if these solutions are great options to display our 3D carousel on a desktop browser, they are not suitable when we use browsers on mobile devices because of technical restrictions. On the iPhone, using 100% “classic” JavaScript would be way too slow and Flash and Silverlight are not even supported by Safari for iPhone. In addition, these examples do not include any touch and movement recognition.

3D carousels have also been used in multi-touch installations. The Citywall project (Peltonen et al., 2008) used two 3D rings (one vertical and the other horizontal) to allow users to represent “time travel” and to display pictures taken in a specified period of time. Fingertapps (http://www.fingertapps.com) provides a software platform for delivering commercial multi-touch solutions. They implemented a 3D carousel menu for Lexus, very close to the one we made, to navigate between the different options to customize a virtual car. Once again, the technologies used by these installations cannot be used on the iPhone.

Even if some applications on the iPhone also have components that can be described as carousels, like the vertical rotating menu that is used to set up the alarm clock or the timer, they are among the native applications. As we did not want users to have to install anything on their mobile phone, we could not use this solution either.

2.3 Overview of the mobile Application

The EnergyLife application client is a Web application adapted for touch screen-enabled mobile devices. The current platforms are iPhone and iPod Touch, since they support the new web standards (HTML5, CSS3 with 3D manipulation) used in the application. The application client communicates with a server that delivers the data present in the application. The server is connected wirelessly via a base station to a variety of plug sensors in the households that send instantaneous power continuously with a lag of 1 to 2 minutes.

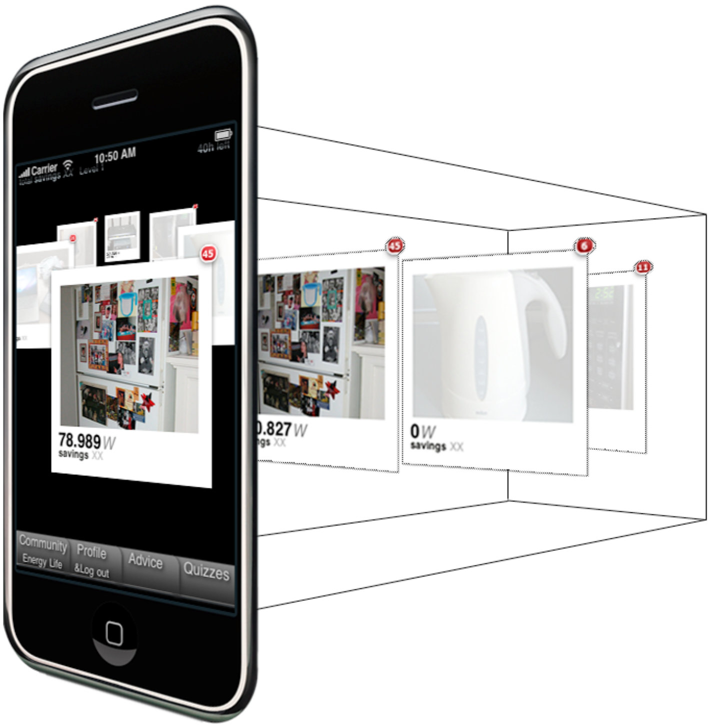

Figure 1: The 3D carousel

The carousel is part of an Energy Awareness application that displays the detailed power consumption for each appliance (Figure 1). Therefore each card in the carousel represents an appliance or electrical device in the house. In addition, the card can be tapped on and turned to offer additional information and functionality for the given appliance. The user interface and the 3D carousel component run in the client browser powered by JavaScript.

The EnergyLife application has the structure shown in Figure 2.The main screen shows the main menu Carousel Menu 0.0. The other main views show main menu 1.0, “Profile Setting”, main menu 2.0 “General Advice & Quiz”, and main menu 3.0 “Community Access”.

By tapping on one card, several sub-screens become available (see Figure 4): sub-menu 0.1 Historic Analysis displays the consumption history of the device; sub-menu 0.2 shows Advice tips – all the advice on that specific device; sub-menu 0.3 is the Quiz, sub-menu 0.4 the Tools, and sub-menu 0.5 the Settings.

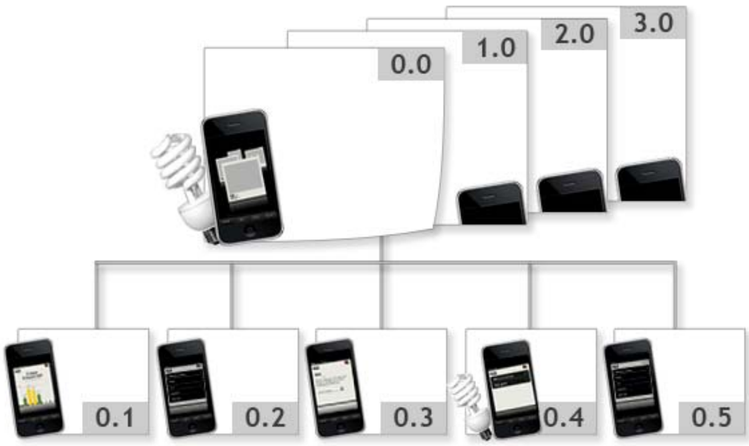

Figure 2: The main EnergyLife screen (up left) and its submenus (bottom)

2.4 The cards and blinking effects for overconsumption

Each card has a front and a back. The number of cards created for the menu varies in this application, according to the data that are fetched from a server. In the application that was developed, the cards represent the electrical appliances in the household. When a card is tapped, it flips around and shows a menu for that device.

When the circle is initialized, each card is created and positioned in an elliptical circle level to the plane. They are distributed around the circumference of the circle with their fronts facing the user. Each card is a div element consisting of two child div elements. They are placed in the same position, but one of them is rotated 180 degrees around the y-axis. In this way each card has a back and a front. Their container gives the impression of being a two-faced card.

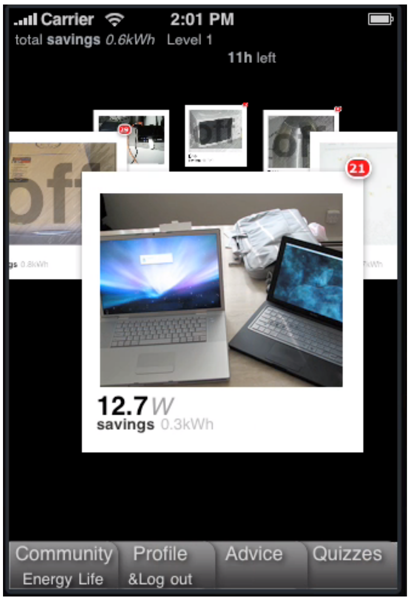

Figure 3: The main EnergyLife screen with the carousel

The fronts of the cards show a picture of the appliance, its current electricity consumption, and how much electricity the appliance is saving in relation to the average consumption from the beginning of the game. In order to help the user conserve energy and gain awareness, the system provides advice at certain times. The amount of unread advice is indicated with a small number in the corner of a card.

If an appliance is consuming too much, the ambient interface installed in the house will react. When the user turns on the light that is dedicated as an ambient interface it will slowly dim instead of instantly coming on. The mobile interface lets the user know which appliance is consuming too much by dimming the image of the appliances in a similar way to the ambient interface.

Figure 4: Front (left) and back (right) of one card in the carousel.

We now return to the requirements on feedback and on mobile interfaces. Table 4 shows how we addressed most of the requirements in Energy Life, although most are planned features that are not included in the usability trial.

Requirement	How it was addressed and improvements needed	Status
Positive and negative habits	At the time of testing the negative feedback was given via the dimming of cards, indicating a lack of energy conservation. The positive feedback was a high saving percentage. Later prototypes include the ability to gain awareness and saving points, allowing the user to gain levels.	Addressed
Feedback related to specific behaviour	The feedback relating to user behavior in the tested prototype is the dimming of cards in relation to a specific device. For the next release smart tips will be introduced that are triggered in response to the energy consumption of the appliances being measured.	Addressed
Sustaining the impact	This requirement will be considered in the future by adopting principles from games and accompanying the users through 3 levels of rising complexity, each with different goals, ending with open-ended goals.	Planned
Accounting for variations in energy use	In the prototype the variations in energy use were not accounted for. This is something that needs to be introduced into the design.	Missing
Context-dependent feedback	Context-related feedback needs to be improved in order to satisfy this requirement.	Planned
Tailored feedback	Tailored feedback is currently not supported and needs to be addressed,	Planned
Historical detailing	After this study a new historical analysis component was developed that shows the consumption historically and allows the user to examine the consumption history.	Planned
Format of feedback	Additional feedback formats are needed that allow the user to understand his/her habits and their effects on the environment and electricity consumption. The current methods show the user's savings in terms of a percentage deviation from the average at the beginning of the game. In future versions a balance sheet giving a breakdown of electricity consumption in different sectors is to be introduced.	Addressed for improvement

Table 4: Feedback content

Table 5 analyses the requirements for the user interface solution. All the requirements are addressed, while some can still be improved. The table also summarizes the added value of using a mobile and device and intuitive interfaces such as multi-touch.

Requirement	How it was addressed and improvements needed	Status
Energy efficiency	The energy consumed by the mobile device is small compared to that of a PC.	Addressed
Privacy	Each user has their own login and cannot access the private data of other households.	Addressed

Designing to avoid information overload	The information is not presented “all at once” and the user is given the ability to browse for the desired data. An additional level of abstraction would be needed for the advice in order for the system to know if advice has been read or not.	Addressed
Situated feedback	Feedback relating to energy consumption is present on the device cards and available tips and quizzes are notified via visual cues. The mobile device (iPod touch) can be carried in the pocket and consulted any time; however, a smart phone with a GSM connection could work anywhere.	Partially
Non-intrusive	All feedback from the system is presented in a way that neither interrupts the user, nor prevents any ongoing activity. The iPod touch solution is an additional device. By using an iPhone, for example, the solution would not require the user to carry an additional device.	Partially
Intuitiveness	The application has been designed with intuitiveness in mind. One thing that might need an additional affordance is the feature of tapping on a card to flip it. The interface paradigm is intuitive; users had conceptual issues with the labels.	Partially

Table 5: System usability and user interface

3. Usability Evaluation

To refine the interface and the feedback offered by EnergyLife, and make it simpler to use, usability tests were performed on the prototype. They cover four dimensions of usability, i.e. effectiveness, learnability, efficiency, and satisfaction, relating to the requirements reported in Tables 1 and 2.

3.1 Method

The evaluation procedure is based on a series of simple tasks similar to the basic tasks that the user is supposed to perform with the help of the interface. After some piloting the procedure and equipment were defined. Users sign an informed consent and sit comfortably on a sofa in a user experience lab. They are handed an iPod showing the actual electricity consumption recorded in an instrumented house, where sensors and a base station were installed weeks earlier. The house is monitored every day by the research team, so that any technical problem preventing the tests from taking place is reported right away. After signing the informed consent, the user is shown a video illustrating the elements of the interface and their meaning. The user can ask more questions and require clarifications; when s/he is ready s/he can start the actual task series (Table 6). The task instructions are read out by the experimenter, task by task.

TASK NAME	INSTRUCTIONS
Log in	*Start the EnergyLife application (turn the device on, start the application, complete the log-in)*
Finding the microwave	*Find the microwave in the card carousel*
Counting the devices	*Rotate the carousel and count the devices*
Navigating the carousel	*By rotating the carousel, go 1 card forward, go 3 cards back, go 1 card forward, go 1 card back*
Over-consuming devices	*Which devices are over-consuming?*
Devices off	*Which devices are off now?*
Fridge consumption	*How much energy is the fridge consuming now?*
Highest consumption	*Which device is consuming the most energy?*
Saving washing machine	*How much energy did the washing machine save?*
Negative value	*Consider device x; is it saving energy? How much? (using a device that has a negative saving value)*
Horizontal view	*Rotate the iPod touch from a vertical to a horizontal position. How much is the fridge consuming? How much energy did the fridge save?*
Log out	*Log out from Energy Life*

Table 6: Tasks.

Afterwards, users are asked to rate their experience with the EnergyLife interface by expressing their level of agreement with a series of written statements on a questionnaire on a scale ranging from 1 to 6 (1 = “totally disagree”, 6 = “totally agree”). The analysis of the responses is carried out through a T-test comparing the average response to each item from all users with the middle value of the response scale (middle value = 3). The 41 items composing the questionnaire are taken from existing repositories (“Practical Heuristics for Usability Evaluation”, Perlman, 1997; “Information Services and Technology Usability Guidelines; Heuristic Evaluation. A System Checklist”, Pierotti, 1994; “USE Questionnaire Resource Page”, Lund, 1998), and some were built especially for this test by the research team. The items allowed the user to assess the interface from some main perspectives, i.e. Navigation, Semantic Comprehensibility, Structural Clarity, Pleasantness, Satisfaction, Learnability, Feedback, Consistency, User Control, and Usefulness. The full list of items is in the Appendix (Section 6).

Regarding the task performance, data were collected by way of two synchronized video cameras that recorded the participant and the mobile device respectively. The video recordings were then systematically analyzed with Noldus The Observer, in order to evaluate the effectiveness and efficiency with which the system is used, and to identify the main issues encountered by the users in the form of ‘breakdowns’. Breakdowns are interruptions or delays in the projected development of the action, which reveal to the user (and the analyst) the inappropriateness of the action possibilities identified up to that moment[3].

In order to perform the analysis quickly, as required from a formative evaluation, a first analysis of the videos identifies a series of these breakdowns; the list is then transformed into a coding scheme for a second and detailed analysis. The coding scheme associates specific categories to stretches of the video, and identifies:

- TASK and its outcome in terms of success, failure, or abandonment;
- BREAKDOWN and its outcome (solved or not solved);
- OPERATIONS carried out to solve the breakdown:

1. TOUCHING. Pressing the finger against the screen on: card/ main menu/ “close” button/ “back” button/ “log in” button/ “log out” button/ iPod “on-off” button/ menu “log in” button/ menu “log out” button/ “undo” button
2. SLIDING a card in one of the following directions: Forwards (the carousel rotates counterclockwise)/ Backwards (the carousel rotates clockwise)
3. ROTATING THE IPOD from a vertical to a horizontal position and back
4. WAITING
5. TALK. The user says something, namely: Help request/ Comments on the interface/ Solution description
6. DRAGGING A CARD
7. DRAGGING THE LAYOUT

The length and occurrence of each event are then counted, and the breakdowns are described and ranked.

3.2 Results

A group of 20 users (mean age = 24.65, SD = 3, 10 women and 10 men) tested the application with the procedure described above. The results of the tests were then reported to the developers and designers.

Questionnaire. In all dimensions the responses are significantly higher than the middle value of the scale (Table 7), showing that the application was positively evaluated, regardless of the specific problems that were found.

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[3] More information on the technique of breakdown analysis and its theoretical foundations can be found in a paper currently under review, whose contact author is Luciano Gamberini. Please contact him if you are interested. A previous work on the subject was by Spagnolli, Gamberini, and Gasparini (2003).

	Mean	SD	t	Sig. (2-tailed)
Navigation	4,26	0,89	6,36	0,00
Comprehensibility	4,22	0,94	5,83	0,00
Structural clarity	3,85	1,33	2,86	0,01
Pleasantness	4,01	1,10	4,11	0,00
Satisfaction	4,00	1,37	3,26	0,00
Learnability	4,44	1,11	5,78	0,00
Feedback	4,65	1,14	6,46	0,00
Consistency	4,73	1,01	7,67	0,00
Control	3,69	1,14	2,69	0,02
Usefulness	4,29	1,47	3,92	0,00

Table 7: Results of the t-test for the rates obtained from the questionnaire (DF=19, p<.05); mean, standard deviation, t value, and significance are reported.

Effectiveness in task completion. Figure 5 below shows the results of each task, identifying how many of the 20 users completed the tasks successfully, how many failed in the tasks, and how many abandoned them after several attempts.

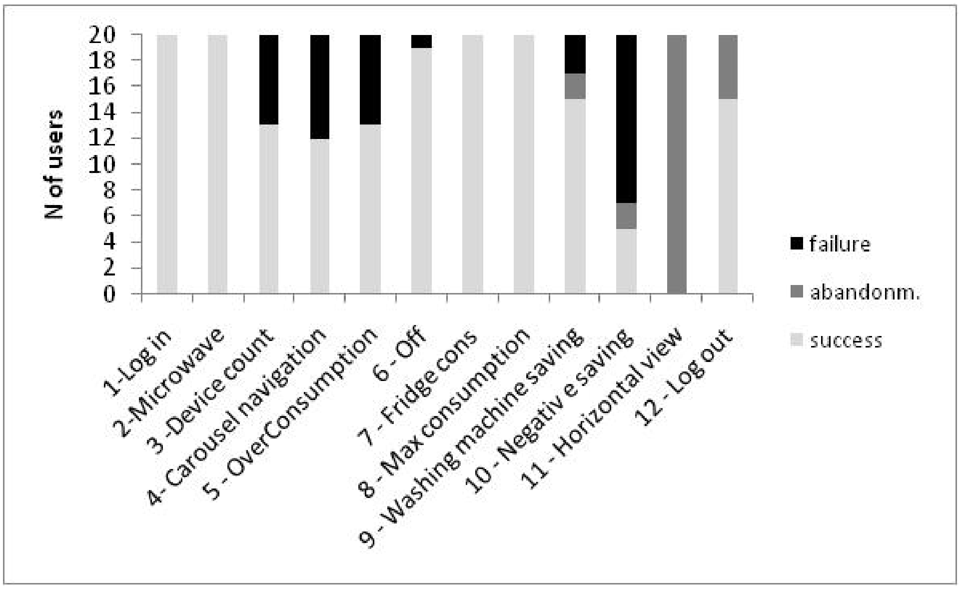

Figure 5: The number of users who completed each specific task with success or with failure or who abandoned it.

None of the participants completed all the tasks successfully; each user completed 8.6 tasks on average. The least difficult tasks were logging in, finding the image of a device, finding the consumption of a device, and identifying the device with the highest consumption. The average number of breakdowns for each task was 18.8, distributed over the tasks as shown in Figure 6. The most problematic seem to be 4 and 11.

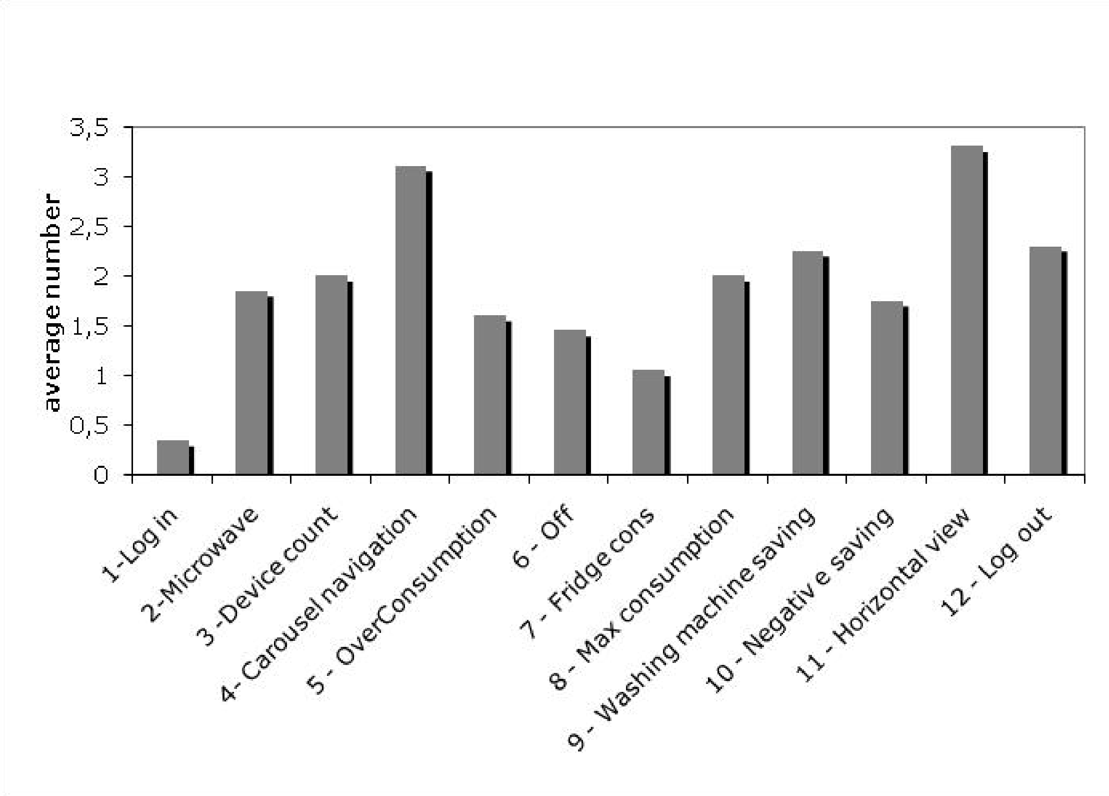

Figure 6: The average number of breakdowns per task

The breakdowns found by the users were the following:

1. Inadvertent opening of main menu: while sliding the carousel, the user inadvertently opened up one of the main menus of the application (setting, help, etc.).
2. Missed recognition of log-out: the user continued to try to log out once s/he had already logged out of the application; the screen became black except for the menu bar at the bottom.
3. No response: the user touched one button of the interface, but the system did not respond to the input.
4. Accidental turning of central card: while performing a task not involving the central card of the carousel, the participant touched the central card by accident, making it turn. Pressing any point of a card made that card flip; so if the user operated in an area close to a card, it was likely that his/her finger might inadvertently touch a portion of the card, making it turn.
5. Excessive carousel rotation: while the carousel was being rotated, it did not stop at the card next to the original one, but at one of the cards past it, since the rotation was greater than expected.
6. Turning a card to one side: the task was focused on a card, but inadvertently the user touched a card next to it, making it turn.
7. Missed recognition of saving: the writing was so light that sometimes it was not spotted by the user.
8. Freezing of a turning card: while a card was turning from the back to the front view or vice versa, the turning process froze.

9. De-centered layout: The margins of the layout appeared de-centered with respect to the screen, either towards the right or towards the left.
10. Layout dragging: When one part of the layout to slide the carousel was touched, the whole layout was dragged in the same direction. The dragging stopped once the finger stopped touching the layout.
11. Dropped Layout: when the mobile device was in a horizontal position, the menu bar covered part of the carousel.

Figure 8 below synthesizes the main indices of severity for each breakdown type. On the basis of the total severity rates, we can rank the breakdowns as shown in Figure 7. This ranking takes into account the various ways in which a problem can hamper the interaction, namely by appearing frequently, by being impossible to solve, and by taking a long while to resolve.

	FREQ	FAIL	ATT
1-Inadvertent opening of main menu	0,9	0,00	1,28
2-Missed recognition of log out	0,2	1,00	0,00
3-No response	1,3	0,73	0,71
4-Accidental turning of central card	2,5	0,06	1,94
5-Excessive carousel rotation	8,4	0,86	1,57
6-Turning of a side card	0,3	0,17	5,40
7-Missed recognition of saving	0,2	1,00	0,00
8-Freezing of turning card	0,3	0,50	1,67
9-De-centred layout	1,6	0,28	7,17
10-Layout dragging	2,25	0,00	2,51
11-Dropped layout	0,85	1,00	0,00

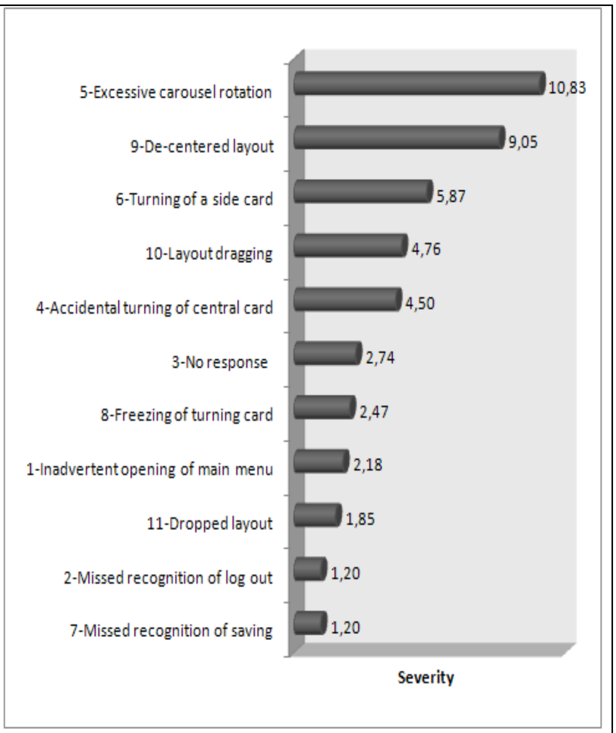

Figure 7: On the left, the data on which severity rates are defined: average frequency per participant ("FREQ"), proportion of breakdowns that are not closed successfully ("FAIL"), and average number of attempts needed to successfully close a breakdown ("ATT"); on the right, the breakdown types ordered according to the resulting severity rate

From the analysis it emerged that there is great potential for this system and that the key elements of the interface design appear to be the right choice. The carousel structure and the navigation interface appear to be excellent solutions that only need some refinement.

Some of the problems are merely technical; others require a redesign because they signal a problem in the input system, a lack of feedback in the operations result, or problems in the comprehension of the meaning of some features.

4. Conclusions

The hallmark of EnergyLife is represented by the emphasis on usage practices. Within an articulated educational process organized into stages within a game-like metaphor, it is meant to support electricity conservation. The system developed within the BeAware project is pervasive in the household through sensor layers and ambient and mobile interfaces; it provides its users with the necessary tools to conserve energy, namely feedback on the consumption level with respect to a target level and tips to facilitate the achievement of the target. These results of the usability evaluation reported here will guide the next development phase and the release of a new prototype. The updates on this process of developing and testing, which will soon also include longitudinal field trials with users, can be obtained from the project website www.energyawareness.eu.

5. Acknowledgements

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6. Appendix: the satisfaction questionnaire.

Answers to all items are expressed on a scale ranging from 1 to 6 (1 = “totally disagree”, 6 = “totally agree”).

A. NAVIGATION

1. E' facile trovare le informazioni di cui ho bisogno [*It is easy to find the information I need]*

2. Sono riuscito a trovare velocemente le informazioni che cercavo [*I was able to find the information I needed rapidly*]

3. In ogni situazione riconosco in che sezione mi trovo [*In each situation I can recognize in which section I am*]

4. La possibilità di tornare alla pagina principale è sempre riconoscibile [*The possibility of going back to the main page is always recognizable*]

5. Le sezioni più importanti dell' interfaccia sono raggiungibili dalla pagina principale [*The main sections of the interface are reachable from the main page*]

6. Il tasto per tornare indietro in ogni pagina è individuabile [*The back button is recognizable on each page*]

7. Le aree cliccabili sono distinguibili da quelle non cliccabili [*Clickable areas are well distinguishable*]

B. COMPREHENSIBILITY

1. Le immagini sullo schermo sono comprensibili [*The images on the screen are comprehensible*]

2. Le informazioni fornite dall'interfaccia sono efficaci nell'aiutarmi a completare il compito [*The information provided by the interface helps me to complete the task*]

3. Il linguaggio utilizzato è semplice e comprensibile [*The language is simple and comprehensible*]

4. I valori che mi indicano la quantità di energia risparmiata sono comprensibil [*The values showing the amount of energy saved are comprehensible*]

5. I valori che mi indicano quanto sto consumando sono comprensibili [*The values indicating how much I'm consuming are comprehensible*]

C. STRUCTURAL QUALITY

1. Le immagini sono ben distribuite nello schermo [*Images are well distributed on the screen*]

2. Le informazioni sono ben distribuite nello schermo [*Information is well distributed on the screen*]

D. PLEASANTNESS

1. Il Design dell'interfaccia è piacevole [*The interface design is pleasant*]

2. Mi sento a mio agio utilizzando questa interfaccia [*I feel at ease while using the interface*]

3. Mi piace utilizzare questa interfaccia [*I like to use this interface*]

4. L' interfaccia ha tutte le funzioni che mi aspettavo avesse [*The interface has all the functions I expected it to have*]

E. USER SATISFACTION

1. In generale sono soddisfatto del sistema [*In general I'm satisfied with the system*]
2. Lo consiglierei ad un amico [*I would recommend it to a friend*]
3. Questa applicazione può cambiare il mio stile di vita in modo soddisfacente [*This application can satisfactorily change my lifestyle*]
4. Questa applicazione mi aiuta a risparmiare energia [*This application helps me to save energy*]
5. Questo prodotto può incentivare comportamenti sostenibili [*This product can enhance sustainable behaviours*]
6. Questo prodotto può contribuire a migliorare le condizioni dell'ambiente [*This product can contribute to improving environmental conditions*]

F. LEARNABILITY

1. Imparare a utilizzare questa interfaccia è semplice [Learning to use this interface is simple]
2. Imparo a usare questa interfaccia velocemente [*I learned to use this interface quickly*]
3. È facile ricordare come usare l'applicazione [*It is easy to remember how to use the application*]
4. Mi sono sentito subito competente nell'interazione con l'interfaccia [*I immediately felt competent in the use of the interface*]

G. FEEDBACK

1. E' sempre comprensibile ciò che sta accadendo sul display [*What is happening on the display is always understandable*]
2. Riconosco immediatamente quando un dispositivo elettrico sta consumando più del dovuto [*I can immediately recognize when an electric device is consuming too much*]
3. Riconosco immediatamente quando un dispositivo elettrico è spento [*I can immediately recognize when a device is off*]

H. CONSISTENCY

1. Il significato dei termini è coerente con l'informazione ad essi associata [*The meaning of a term is consistent with the information associated with it*]
2. Le informazioni energetiche sono coerenti con l'immagine selezionata [*The energy information is consistent with the selected image*]

I. USER CONTROL

1. Quando faccio un errore usando l'interfaccia, posso riparare facilmente [*When I make a mistake using the interface, I can easily remedy it*]
2. Sono sempre in grado di controllare l'applicazione durante l'interazione [*I'm always able to control the application during the interaction*]
3. È facile annullare ogni mia operazione [*It is easy to undo all my operations*]

4. Riesco sempre a far eseguire all'applicazione ciò che desidero [*I can make the application do what I wish*]

L. USEFULNESS

1. L'applicazione mi permette di avere maggior controllo sulle attività legate alla vita reale [*The application allows me to control the activities of my real life better*]
2. L'applicazione incontra la mia volontà di ridurre gli sprechi energetici [*The application meets my wish for reducing energy wastage*]
3. L'applicazione rispecchia la mia volontà di salvare l'ambiente [*The application reflects my will to save the environment*]
4. Utilizzando Energy Life posso ridurre i tempi necessari per adottare una condotta sostenibile [*Using EnergyLife I can reduce the time needed to adopt sustainable habits*]

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The increase of the experiences of the self through the practice of multiple virtual identities

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ABSTRACT

This paper proposes some reflections concerning the process of creation of multiple virtual identities usually verified in several online social platforms of informal interaction based on textual/synchronous modality. With this intention, it discusses characterization, exploratory possibilities (personal and social-communicative) and reasons which lead users to execute such practice. In addition, it intends to identify possible relations between this procedure and the promotion of a dynamics of relationships distinguished in these computer-mediated communication environments. From this point of view, it defends the idea that there is a favourable context to the exercise of simultaneous social roles, decentred and not hierarchical, associated to more flexible identity constructions and more adjusted to contemporary society settings.

Keywords: *Cyberspace, social interaction, virtual identity.*

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1. Introduction

With the development and popularization of networks, it is observed that the social-communicative processes and behavioural strategies used by people that navigate the various online platforms based on textual/synchronous communication, had their action scope expanded. One of these actions is the possibility of exploring new existential, cognitive and experiential territories through the virtual world. It allows the users to experience different identities, distant from the commonly adopted references

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of the offline world[1], the ordinary world of everyday life. Although it sounds rather simple, this mechanism of identity formation involves a series of layers and adjustments that are necessary and conditional factors in the transitional process between offline and online world. Rituals of initiation are used every time users convey through these points, visibly because of the presence of ceremonial entrance markers (e.g. login), naming strategies, competence and anonymity (Aranha Filho, 1995).

These measures for admission, far from being considered as a set of strictly technical routines or focused only on the cultural ways and conventions, lead to the "immersion" of people in a different social environments, where the references commonly used in the offline world are usually reshaped according to their relevance and usefulness (Klastrup, 2003). These practices, actually, give the users credentials, turning them into carriers of virtual passports, allowing them to move freely through the selected interactional platforms, to develop a sense of belonging, and the recognizance of the user by their equals as a constitutive part of the same social environment and collective experience.

By overcoming the "entrance", through the admission practices, users have at their disposal, due to the peculiarities of the shared-mediated environment, and the practices commonly adopted (anonymity, use of nicknames etc.), a greatly expanded range of possible combinations of features, for the composition of a "personal front" or "social identity" (Goffman, 1974). In a complementary way, they also have enhanced their possibilities to establish a number of relationships with a diversity of “social identities” built up by the eventual users, partners of the experienced social environment.

It is worthy to note that, according to Goffman (1974), the role playing process through the creation of “personal fronts” or “social identities” is performed by the western societies in a way where it does not interfere in the development of a singularity of the self: regardless of the variety of roles required in the contextual situations, there is a rather basic assumption that the biographic characteristics of a supposed “personal identity” is preserved. Following this line of argument, it seems that the comment approximates to the situations experienced in online relationships established in interactional platforms based on textual/synchronous communication,

[1] Although controversial in the conceptual point of view, due to the ease of its association with a possible technical view of reality, the use of the terms "online" and "offline" - to characterize and differentiate, respectively, the "experiences" located in the virtual environment and those experienced in the three-dimensional environment of the physical world - is maintained in this paper, since there is a wide use in the academic area.

since the "personal identity" would be reflected and maintained in identity experienced by the users in the offline world, while the various "social identities" would be represented by multiple virtual identities created to navigate these mentioned online environments.

According to what Goffman (1974) points out, in face to face (FTF) situations there is the possibility that people develop a deeper identification, in some circumstances and due to most different reasons, between their “personal identity” and a specifically role played, what could alter the structure of individual personality. Likewise, such fact would also occur in the online world of the platforms based on textual/synchronous communication, where some users may have experiences so vivid that the characteristics of virtual identities would gradually be embedded on one’s offline life. In extreme situations, this would cause an equivalence perception concerning the two relational spheres, as pointed by Turkle (1995, p. 13), quoting one of the researcher’s interviewee discussing the variety of “windows” of his life: “I split my mind. I’m getting better at it. I can see myself as being two or three or more... I go from window to window... And then I’ll get a real-time message and I guess that’s Real Life. It’s just one more window. Real Life is just one more window and it’s usually not my best”.

As can be seen in the transcription above, there is clear allusion to an increase of interest on online experiences, as much as a derogation of the importance given to the “window” related to real life.

2. The identity formation process in the contemporary world

How can these new social settings be discussed, considering the fact that the very idea of identity shows itself in the process of re-evaluation of its applicability in the contemporary culture, as some researchers points out to highlight a possible “plural structure of the subject" (Turkle, 1995; Jenkins, 2008)? The famous sociologist Max Weber, for example, already foreshadows this issue, stating that the identity, of the point sociological view, it is just a relative and floating state. Mead (1934), through his famous book *Mind, Self and Society from the Standpoint of a Social Behaviorist*, had already engendered a theory concerning human interaction and the development of personality, which posited the malleable and dynamic natures of the identity, alongside with its tripartite composition (the "I", the "me" and the "generalized other"), as well as the use of different situational roles.

Hence, this paper upholds the idea that it has been experienced a transitive moment characterized by a transformation concerning the idea of identity – deeply rooted in modernity – and its evolution to the idea of identification – typically related to the post-modernity, where it should be regarded the presence of a self in a continuous process of construction – through a succession of temporary interchangeable identifications, adjusted by the diversity of demands and variables present in the lived contextual situations – instead of the notion of a single identity, self-contained, closed, built up on a solid and stable basis. Following this point of view, Maffesoli (1990), French sociologist, points out that it would be better to adopt the concept of a person than the individual to characterize the present moment, given that he falls into a more relational, shifting, as it presents itself in a more permanent and more suited to contemporary social reality.

On a second basis, in analyzing the identity formation process and its relationship to historical paradigm changes affecting our society, Hall and Du Gay (1996) point toward the presence of three different notions of identity: the (1) first one related to the enlightenment, characterized basically by the existence of an autonomous individual, integrated to the core of society, centred both on reason and unity; (2) the second one would be related to the “sociological subject” in which its composition would be formatted from the interactive relationship between the self and the institutions derived from modern society, that, although complex, would allow the identification with stable structures; (3) the third – regarding the “post-modern subject” – would present itself committed to the perception of an essentially dynamic, multiple, malleable and fragmented self where the institutions would show themselves within an unstable configuration. Hall and Du Gay (1996) highlight a gradual transition from the idea of a “centered” model of identity - forged during the Age of Enlightenment - to the one characterized by the "decentered” model of identity, more fit for the idea of contemporary world.

In the process of building this historical route, some authors point out, properly, the relevant role of communication technologies. Meyrowitz (1985), North American professor of communication and sociology, for example, explores the influence of electronic media on the identity references and their relationship to changes in social behaviour. Thus, people, not being anymore limited to the circumstances and social situations located in the geographical nearby spaces, would have their range of experiences expanded through the knowledge and contact with other realities, values and beliefs. Thompson (1996), in a similar point of view, highlights the growing availability of forms and mediated symbolic models, brought in by the development of the media, as an essential factor in people understanding of the world beyond the places where they immediately live and – consequently – in the production of necessary situational references to express their various facets of identity.

For the purpose of this paper, the exhaustive discussion about the most appropriate and most accurate terms to portray the presence of the phenomenon of multiple identities in the contemporary scene (no longer focusing on a uniform and final perspective) is dispensable. What interests us is not only the perception of the existence of a set of mutant referential frames that enables the emergence of such events but also, the recognition that advances in the field of communication technologies have become a key part in shaping these frames.

3. The practice of multiple virtual identities

Given the set of peculiarities observed in contextual situations promoted by interactional platforms based on textual/synchronous communication, an intriguing aspect comes to light: the occurrence of social exchanges is the main source for promoting the existence of virtual identity. Even though, this situation is observed in a similar way in the offline world, as postulated in social-interactionist theories, the originality resulting from it, is derived primarily from two aspects: (1) the first one is that this process is produced in an essentially permissive environment, where there is great potential for discovering new facets of personality and behavioural practices (Gackenbach & Von Stackelberg, 2007); (2) the second one is shown in socially shared environments, where the emission and reception of information about the identities created and exercised at the time are made largely through the exclusive use of textual language (Wood & Smith, 2001). That is, the interaction, fostered by a succession of repeated statements and answers exchanged between the participants in the written form, is what allows the identities created, to actually come into existence. In fact, they are constructed not only as elements directly derived from the exchange that happen in the communicational environment, but also, from a complex set that contains, besides the interaction process accomplished with the other participants, the interactions made with the machines (computers) and with their softwares (Ribeiro, 2003).

Even with the presence of a greater flexibility and a wider set of experimentation possibilities, the identity built virtually also needs recognition from others so that it does exist. Thus, the users need that there are cooperation and complicity on the part of the partners, to allow it to become, through the created identity and roles represented, whom they wish to be at that moment and in that environment. It is necessary that the other gets into the "social game" intended by the user, to be able to exercise the characteristics and chosen behavioural practices. However, the issue becomes more complex, when one recognizes that the others are not merely passive complementary being, but active subjects that are probably exercising and exploring new existential, cognitive and behavioural possibilities (either in a ludic way or not).

Without physical referential provided by the tactile contacts, users experience a space of possibilities, breaking the "bonds" derived from the presentification of the actual body. Having a wide range of experimentation options, with other forms of construction of their social contacts, in a "culture of simulation" (Turkle, 1995), they have the opportunity of creating in a fragmented manner, several imaginary subjects, potencializing the expression "decentered" of the identity configuration, becoming more distant from references previously used, such as the sameness, the continuous and evolutive character of the unique identity, and the gradual building of it, based on one's life history from a linear perspective.

As a result, there is the creation of characters who may or may not correspond with parts of the identity created from the offline world, and will act in accordance with the features selected, and will connect with other virtual beings that travel in the same environment. Being protected by the anonymity, the users can design fantasies and desires that will meet their most intimate needs, maintaining ephemeral contacts or even lasting contacts with other subjects. In other words, in the interactional platforms based on textual/synchronous communication the users become one or more of the possible identities, moving freely in accordance with the contingencies and their own will, experiencing new and different situations through a quick and exchanging succession of aspects and features of themselves. So, there is the possibility for the user, without obligations, and in a playful way, to experience a kind of relaxation from vigilance and constant monitoring that comes from the "disciplinary power", pointed out by Michel Foucault (1977), and experience a temporary removal of the representational attributes and characteristics, usually associated with the identity experienced in the offline world.

Interesting to note that this feature set closer to the description of Augé (1995, p. 103) on the experience possible the subject in a "non-place": “Subjected to a gentle form of possession, to which he surrenders himself with more or less talent or conviction, he tastes for a while - like anyone who is possessed - the passive joys of identity-loss and the more active pleasure of role-playing”. Thus, there would be a certain “pleasure", even if temporarily, in the fact of "letting go the chains" of identity references built and supported by biological experiments, historical and social experiences in the offline world.

There would be, in this sense, the experience of a process of "controlled depersonalization", verified in the construction and experience of online identities as the pure expression of ludic and pleasant exploratory experiences, which could prove to be extremely beneficial both in the sociological sense, as claimed by Augé (1995), as in the psychological sense, as recommended by Laing (1969).

> “One should know the social risks if one makes a break with social reality: if one begins deliberately to make a systematic attempt not to be the *self* that everyone takes one to be, to escape from this identity by playing at not being there, by being anonymous, or incognito, adopting pseudonyms, saying one is dead, saying one is nobody because one´s body does not belong to oneself” (Laing, 1969, p. 37).

It is noteworthy, that the words of Laing (1969) mean a prescription, seeking the psychological well-being of the individual.

Another aspect to be highlighted is that a brief excursion into the scientific literature[2] shows that these perspectives seem to reflect the issue of multiple identities as a phenomenon that would have its manifestation mainly caused by something that falls outside the control and the will of the individual. Whether it is a response to traumatic issues deeply rooted in the labyrinths of personality, or for purely social determinants, such visions reinforce the idea that the various facets of possible experiences were being imposed "from outside to the inside", considering the individual, in principle, in a situation of passivity.

So, what is seen is the evidence of circumstances in which the individual "would give" or "would lend", most often unconsciously and unintentionally, his bodily constitution to be inhabited and used, temporarily, by other identities. Conversely, the users of the interactional platforms based on textual/synchronous communication are placed in an

[2] Let us see what the Diagnostic and Statistical Manual of Mental Disorders (4th edition DSM-IV) says, about the topic (300.14) - Dissociative Identity Disorder (formerly multiple personality disorder): “[...] Each personality state, may be experienced as if it has a distinct personal history, self-image, and identity, including a separate name. Usually, there is a primary identity that carries the individual's given name, and is passive, dependent, guilty, and depressed. The alternate identities frequently have different names and characteristics that contrast with the primary identity (for example, are hostile, controlling, and self-destructive). Particular identities may emerge in specific circumstances and may differ in reported age and gender, vocabulary, general knowledge, or predominant affect”. As we can see, there is clearly the idea of lack of control by individuals in these demonstrations.

extremely active position, as these developments are not only made otherwise through the creation and insertion, in a conscious way, of the various possible identities in the online environment. Thus, it is not their bodies that are occupied by other autonomous identities, but the users overtake and use other bodies (built virtually) to exercise other behavioural possibilities, and this is done in a consciously and controlled way.

In parallel, we can also think that, in the dynamics observed in the real environment, the performance of various roles would be predetermined and closely entwined, where the user is "tied up" and impelled to follow them and represent them in sequence (for example, the role of father, son, uncle, teacher etc.), fitting, in most cases, their behaviours in certain social circumstances and the expectations created by these respective roles. The ideas carried out for Goffman (1969) give support to this specific understanding:

> “When an actor takes on an established social role, usually he finds that a particular front has already been established for it. Whether his acquisition of the role was primarily motivated by a desire to perform the given task or by a desire to maintain the corresponding front, the actor will find that he must do both. Further, if the individual takes on a task that is not only new to him but also unestablished in the society, or if he attempts to change the light in which his task is viewed, he is likely to find that there are already several well-established fronts among which he must choose” (Goffman, 1969, p. 27).

However, in online interactional platforms based on textual/synchronous communication, there wouldn´t be, initially, predetermined roles to be followed, since, conversely, the user would be the one who would determine and format the different roles (linked to the chosen identities), and its insertion sites on the web, constructed within the social virtual spaces. Thus, what emerges is a sort of expansion of opportunities to experience the multiplicity of selves, either by the acceleration of the change of experienced roles, by the simultaneity of the "parallel existences," or by the stronger awareness of their roles representations. Hence, this paper proposes an extension of the concept of “successive identifications”, appointed by Maffesoli (1990) to characterize the situation (common in contemporary times) of the frequent change of the faces of the self to the notion of "parallel identifications”, which in this paper is regarded as more appropriate to capture the experiential practices outlined.

Another question becomes relevant here: why such users feel stimulated to create multiple and alternative identities that bring characteristics apart from those present in their everyday offline lives? Considering as a most ordinary answer, it happens simply because they can do it, or because there are a number of social and technical factors (possibility of living the experience anonymously, lessening of social-behaviour demands, relativisation of space-time references, freedom to choose nicknames and representative features) promoted and made available by the communication environment that, to some extent, suggests that practice. At the same time, we can assume that the facility provided by the environment for the representation of multiple roles, according to the will or desire of the users, would, in principle, have the feature of enabling and promoting the learning of the various aspects linked to the attributes of the chosen identity, since the human symbolic ability allows the acquisition of predictive information, without going through the learning processes by direct and real experience. In this sense, those users who, for example, had shy and introverted behaviours and characteristics, could exploit, in an instructive way, characters and a more acceptable way of acting socially.

Thus, the features chosen to compose the virtual identity can provide elements that help the users to deal with difficult situations in the offline world, in which they often encounter. This creation may seek an “improved version of themselves”, where certain attributes are emphasized to compensate or complement psychologically existing aspects of their daily lives, especially those related to a weakened sense of self-image, as claimed by the studies of Sherry Turkle (1995), in her famous book “*Life on the screen*”.

Through these created identities, and the relationships built from them, users have the opportunity to experience and deal with the events in a less traumatic way, promoting the possibility of an increased self-esteem. It is implied that the expressive nature of the online environment may encourage some people to develop some social skills (for example, experience social dialogue with other people, face anxiety of social situations, practice social rituals of approach, departure, etc) and - in specific situations - to provide even the first experiences of these behaviours in a social arena.

The possibility of exploring new social and behavioural aspects, of "seeing certain situations with new eyes”, is another evident reason to create virtual identities, and undergo experiences, that would make it difficult one to have access to. The practice of experiencing fantasies in the most diverse ways, without barriers and social judges routinely present in the social life offline, fosters a unique situation, and at the same time favours learning, as a result of the lens enlargement, and the focus of analysis on the various situations. Thus, the easiness for the expression of transgressive acts may represent, for some users, the unique possibility of experiencing "the opposite" of their daily behavioural habits, as manifested, for example, moving from a personality structure characterized by a few practices, to a personality structure characterized by the excess of these same practices, as claimed by Maffesoli (1993).

However, the users are not always deliberately, seeking to exercise and uncover repressed aspects of personality, or learning new social skills, or "procedures" of behaviour, necessary for their development and personal growth. There are those situations where the composition of the virtual identity is only intended to give the opportunity to experience the entertaining aspects of the situation, leading, thus, to an indirect form of learning, not reflected, not deliberated.

In general, what is perceived is that the experiences derived from the creation of alternate identities - that travel around online platforms based on textual/synchronous communication - give users an expansion of the emotional and perceptive universe, associated with the offline world, beyond the occasional occurrence of existential concerns and personal transformations. Thanks to the multiple levels and perspectives - made possible by these experiences - the users have the opportunity to understand a little of the psychological and social dynamics, that comes up (1) in the assumption of certain postures, or (2) behavioural procedures practiced and experienced from the adoption of different roles. Of course, this aspect is not exclusive of these interactional online platforms, but can be expressed in a less threatening, and more manageable way, by the users who will experience it in this environment.

Finally, considering another way of analysis, an assumption could be considered: that the different identities would act or behave according to the expectations about them. Thus, for the identity built with aggressive characteristics, for example, one would usually believe that - in virtual relations - gestures or hostile behaviour would be performed; which would show, in a sense, a stability of behavioural tendencies, and consequently a similarity and regularity in the representation of the roles created, using those experienced in FTF relations as comparative benchmarks. Otherwise, we may think that the practice of creating multiple identities (and their representations) would not be limited to a simple appropriation of certain styles of conversation using the network, since they could acquire their own characteristics and borders, close or not to the FTF identity references.

4. Final Thoughts

According to the above reflections, this paper verifies that the online environment, somehow, increases the possibilities of expression, of performance and control of the roles played by the users in the "many lives" represented by the variety of built up identities. This situation, indeed, is not displaced from the offline world, since the possibility of experiencing multiple virtual identities is regarded as inserted in the practice of multiple roles in the various aspects of everyday life. However, the point is that the subject plural structure would be characterized and accentuated its expression, not only by the representation of different roles accomplished in a sequential manner - agreeing to the variety of scenarios and lived moments, through a continuously ebb and flow on the attribute characterization process - as commonly found in FTF contacts, but also by the chance to experience different roles (with their respective characterizations) simultaneously, decentralized and not hierarchical, increasing, thus, the exploratory experiences of the self.

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Usability studies: to meet or not to meet intrinsic motivation

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ABSTRACT

Controlling the users' motivation can significantly improve the efficiency and prognostic value of usability studies. The distinction between the extrinsic and intrinsic motivation plays a decisive role in computer-related activities. A well-developed theory of flow experience, introduced by M. Csikszentmihalyi within the school of positive psychology, is intimately related to intrinsic motivation. Researchers intensively explore flow experience in various types of human-computer interaction. The authors' earlier results referring to computer hackers' motivation are discussed, and the model of hackers' motivational development is presented. These findings suggest productive hints on software users' motivational development, and can be applied in usability studies. Longitudinal usability research projects prove to be reliable in acquiring information about long-term use of newly-developed or updated software products. Specifically, longitudinal research projects would benefit, if the Experience Sampling Method is used. Methodology is discussed, aimed at development of software products which facilitate users' flow experience, and possibly long-term use of these products.

Keywords: *usability, software development, motivation, intrinsic motivation, emotion, longitudinal study, flow experience, hackers' motivation, experience sampling method.*

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1. Software Developers and Consumers in Conflict

Creators of competitive software products have at least two main goals: to attract the target group of users, and to “hook” them, i.e. to make them stick to these products. User Experience teams do their best in assisting software developers to achieve these goals. In some cases, while they are successful with the first goal, the second goal is harder to reach. Is it because usability is still “a craft, but not a science” (Spool, 2004) ? Probably not, although usability teams differing in expertise, methodology, the number of participants in usability assessment sessions tend to detect diverse usability problems, and the lists of problems have only few overlaps (Molich, Ede, Kaasgaard, & Karyukina, 2004).

The traditional explanation of such diversity refers to time limits: in many cases the particular user research had to be “done yesterday” (Courage & Baxter, 2005, p. 158). The software market is highly changeable. When a new project is being developed, that means that marketing teams have found a niche for the immediate use of the new product. Marketing and user research is targeted on those who would install and use the product the next day after it was purchased, and the updated versions of a niche product will be set precisely to the interests of a would-be customer. Thus, almost any alpha (beta) version is only tentative, not yet customer-tailored.

We suggest that one of the main causes of usability efforts failure lies in traditional testing procedures which are oriented primarily on cognitive and operational components of target-group users’ behavior, while emotional and motivational aspects of human behavior are underestimated, if not totally misrepresented. The latter is often responsible, we believe, for failures of usability team efforts, even in case of thorough research. Indeed, users are looking for personalized interfaces and software products to do tasks automatically; this is conceptually close to the ideas of universal design and universal usability (Shneiderman, 2000). Having got universal and personalized software products, users would enjoy applying them for a long time and wouldn’t like to face the need to switch to another product in a year or two. Here is a place where a conflict arises between the users’ needs and the results of marketing- and usability-oriented work. We can suggest two likely explanations of the origins of this conflict. The latter one will be extensively discussed in the paper.

2. Usability in Time Perspective

2.1. Wanted: Time Machine

A usability team has not too many chances to learn how a user will be interacting with a new product (feature, gadget, etc.) in the future. The reason of this limitation of usability testing procedure derives from the fact that participants in usability studies are mostly novices, at least novices for this particular software product. Even experienced computer users face the application (or a new feature in a product) for the first time during usability testing. Indeed, trying to address questions to those who are already competent in using this particular software product looks odd. Thus, even when users are already familiar with a company's software products, they are given to test the entirely new features, the ones they have never used before. In usability practice there are almost no procedures tailored for experienced users.

As time goes by, users get more and more familiar with the features and options, and their requirements and expectations change very often, partly due to their experience with some competitors' products. Thus, a conflict arises between the users' needs and the characteristics of software. In a longitudinal study (Kjeldskov, Skov, & Stage, 2005) it was shown that after 15 months of working with the particular software users revealed a significant number of usability problems they could not discover when testing the same product for the first time. The authors suggest to invite both novice users and expert users for usability testing, because such testing helps identify serious usability problems.

"Telescoping" is aimed at getting full knowledge of the ways the product is likely to be applied in the future (Kuniavsky, 2003). The method includes recruiting study participants having various experience with the use of the product, from newbies to long-time experts: "By keeping track of the problems and perspectives that people have based on their experience level, you can deduce the kinds of changes that people are going to go through as they use your product for long periods of time" (Kuniavsky, 2003, p. 393). With a totally new product, however, the "time machine," be it telescoping or an alternative methodology, would not work.

2.2. Motivation Is the Key Issue - but Motivation Related Studies Face Problems

The second reason of usability failures is of motivational nature. In attempts to learn users' motivations, though, usability researchers have to successfully pass traditional traps. As it has been stated in case of focus groups, "participants just lie" (Gross, 2003). Close to this extreme statement, Zaltman wrote in the book *How Customers Think*, that "the correlation between stated intent and actual behavior is usually low and negative" (2003). People often verbalize socially desired statements instead of their actual feelings or perceptions; usability practitioners find that deceptive statements are often culture-influenced: for example, status inequality, gender and age differences, plus an ethnic background determine the readiness of many participants, for example of Eastern origin, to give socially desired replies or give preference to neutral statements (Gould, 2009). It is also well known, that User Research teams have to filter out money-seekers as respondents, since they are known to tell lies, cheat, and pretend to take any position in the imagined continuum of competencies starting from the total lack of competence, and up to being over-competent, depending on the usability team's current needs. For this purpose, user researchers keep databases of people coming to a lab, check their identity, carry out structured phone interviews containing elements of testing, and even practice "face control": candidates sometimes change their names and addresses to participate in a paid study (Courage & Baxter, 2005).

The validity and prediction value of self-reports, given in a lab study setting, is questionable, too. Even if researchers ask the usability study participants, whether they are interested in using a product or a feature, the participants' reports on their "would-be behaviors" might not fully reflex their intentions. There are good chances that the actual behavior will totally differ from the self-reported "would-be attitudes". That is why researchers prefer to complement the user metrics with eye-tracking studies or physiological methods to get more objective data (Bruneau, Sasse, & McCarthy, 2002). Thus, organization of motivation related studies faces human-related problems (Cooper, 1999).

3. Understanding Users' Motivation

3.1 Emotional Design and Users' Motivation

While sometimes criticized (Hollnagel, 2003), principles of emotional design (Norman, 2002; 2004) as well as affective computing (Picard, 2003) is being widely advocated. A promising example seems to be the Emotive Alert, designed by Zeynep Inanoglu and Ron Caneel at the Media Lab, MIT: the new product labels messages according to the caller's tone of voice, and is aimed at helping to identify urgent messages (Biever, 2005). The behavioral role of Emotive Alerts is in a way close to what Minsky (2006) called “alarmers,” or resources “interrupting higher-level processes” of problem solving and information processing due to the need to react immediately (p. 338).

While the status of affects in thinking and semantic processing have been underestimated for long time, nowadays the role of emotions in cognitive processing is widely recognized. Studies of emotional intelligence (Goleman, 1998) represent one of the most promising directions of current psychological research. In accordance with this line of studies, Norman notices that good design is also “emotional”, and our perception of “nice and beautiful” comes from our emotions and past experience: emotions simply “code” and store any information about positive, negative, or neutral elements in the environment (Norman, 2002; 2004).

Emotional aspects of design are not alien to the usability researchers. For example, Weinschenk (2007) insists on using PET methodology, which means measuring (“scanning”) and designing processes such as “persuasion, emotion, and trust”. In recent studies (Lindgaard, Fernandes, Dudek, & Browñ, 2006; Tractinsky, Cokhavi, Kirschenbaum, & Sharfi, 2006) it is shown that users tend to form immediate aesthetic impressions of the web pages they observe quite quickly, namely, in just 50 milliseconds, and these impressions are stable.

At the same time the motivational components of design are not yet widely investigated (Markus & Keil, 1994). Why so? Maybe due to the fact that by “motivation” usability researchers most often mean their own intent for providing the study, but not the investigation of the reasons of users’ interest in certain products and services (Cooper, 1999). Describing the users’ “wants and needs analysis,” the researchers warn that the study participants “don’t always know what they really would like and are not good at estimating how much they will like a single option” (Courage & Baxter, 2005, p. 373). At the moment, the methods of investigating users’ motivation include mostly statistics of web-site hits, and form a part of users’ requirements studies (Fuller & de Graaf, 1996).

This context is, to our mind, long way from current motivational research. Understanding users’ real motivations, i.e. their “drive” to use this or that particular application is among the most important tasks for the new generations of user researchers. As Shneiderman (2002) formulates it, “workers of the old computing … want objective and even automatable metrics. Advocates of the new computing often seek subjective measures and apply ethnographic approaches to conduct evaluations. They observe and interview users while they are doing their work or enjoying their entertainment. The results are not numbers but understanding, not percentages but insights" (p. 238). Motivation seems to be in the crossroad of qualitative and quantitative ways of analysis.

3.1.1 Usability Field Study

In order to investigate prospective users' workflow, tasks, motivations, and problems, User Research gurus highly recommend to conduct field studies (Dumas & Redish, 1999; Nielsen, 1999; Shneiderman, 2002). Conducting field studies might help practitioners understand their users' and customers' behavior patterns: the ones that the users are not able to keep trace of and thus cannot report. Moreover, it is pointed out that field research is prospective in addressing longitudinal issues, while quantitative methods are not (Wixon et al., 2002).

Since field studies are believed to be too expensive and time consuming, whereas in many cases user research had to be "done yesterday" (Courage & Baxter, 2005, p. 158), the usability engineers only rarely have a chance to conduct them. Many companies benefit from logging the users' activities on the websites or other online applications. But not all of them; the ones who need this information the most, often have no access to such data. Another opportunity to conduct a "field" study, not stepping outside one's office is "scraping" the blogosphere content, specifically, Twitter posts. Kuniavsky (2003) recommends, alongside with the log analysis, to collect, organize by coding and tabulating, and analyze comments. Google is exceptional, since it keeps logs of everything the Google users look for (Meyer, 2005). Thus, researchers have full access to very useful data: for example, it was discovered that when as many as two notifications of wrong spelling appear in front of the users' eyes (in the form: did you mean {correct spelling}), 20% of users never notice such notifications and keep complaining that there is no spell checking service in Google (Meyer, 2005).

3.2 Extrinsic and Intrinsic Motivation

There are two major types of motivation: extrinsic motivation depends on bonuses: money rewards, gifts, and positive feedback; intrinsic one depends on human beings' interests and challenges: tasks and trials are taken for their own sake (Deci & Ryan, 1985). The latter one is severely underestimated when new software products are released and tested. While in fact intrinsic motivation is of special interest in the field of human-computer interaction, especially in usability studies (Berkun, 2001; Malhotra &

Galletta, 2004; Voiskounsky, 2008).

Of course, the use of applications and services can be driven by either extrinsic or intrinsic motivation, or their combination. When a person does not use an application, a feature, or a service due to its special value, but appreciates it as a tool for obtaining an outer goal, then the motivation might be called extrinsic. Alternatively, when a person is fond of experiences with a feature, an application, or a service due to his or her particular interests in manipulation with this piece, and/or challenges connected with it, then this case is indicative of an intrinsic motivation.

Inviting study participants to the lab, usability engineers restrict the testing procedures with only one sort of motivation, i.e. extrinsic one: a participating user is encouraged to complete the given task and/or is paid to do so. Since sessions are videotaped, participants feel concerned with “not loosing face”. If they are unable to complete tasks, it is a signal of serious usability problems; the absence of serious problems does not mean easy life: even if participants successfully completed the tasks it does not mean they are going to use this product in the future, not mentioning overcoming small difficulties or cosmetic usability problems. While in most cases user researchers ask participants, if they are likely to use particular features or new software product, the reliability of these self-reports is undefined.

Outside the usability trial sessions, the would-be users of new software products act on their own risk, their needs and drives are not that urgent, losing face is not a problem: to sum up, without any external support the existing level of extrinsic motivation might turn out to be inadequate for overcoming problems connected with the new software product – and the intrinsic motivation has not yet been formed. In this case, if would-be users cannot rely on supporters and help-givers, they may give up using the problematic software. Each trainer and consultant can recall the cases when someone asks them “just tell me, which buttons should I use, and after that I will work on my own”. That means that the extrinsic motivation is too low for fighting against an unknown unfriendly interface without any external help, which is close to losing the slightest interest in completing the task.

We thus state that motivation is crucially important for making choice of software applications for work, communication, entertainment, and education. It is even more important for “hooking” customers to use these particular applications, possibly – for long-time use.

3.3 Flow as a "Hook"

Theories and models of intrinsic motivation are not too numerous; the most well developed ones are the self-determination theory (Deci & Ryan, 1985) and the flow theory (Csikszentmihalyi, 1975). Our research is based on the latter theory, since we believe that the flow theory is elaborated enough and can be widely applied to usability. First we briefly describe the origins and the current status of this theory of intrinsic motivation.

The theory was proposed by M.Csikszentmihalyi (1975). It rests on an observation that many people report the state of flow while engaging in diverse activities like favorite sports or hobbies, doing creative work or just washing dishes and vacuuming the floor. Flow is an experience of deep involvement into a certain activity, with the feeling of being competent: a new action freely follows the previous one, and there is no need to push oneself to keep performing an activity that is too boring or too difficult. Usually, in flow individuals do not notice time passing by. A person experiences flow as "a unified flowing from one moment to the next, in which he is in control of his actions, and in which there is a little distinction between self and environment, between stimulus and response, between past, present, and future" (Csikszentmihalyi, 1975).

The main antecedent of flow is matching of someone's skills and task challenges. If task challenges are too high for ones' skill set, a mismatch leads to the anxiety and negative emotions. If, vice versa, the skills are too high, the consequence is boredom. Flow occurs at the cutting edge of person's skills, and it is a moving target. Increased skills should lead to an increase of challenges, if the precise matching is to be preserved, and the choice of greater challenges demands an update of skills. Feedback, interactivity and the match between one's skills and current challenges are the main characteristics of flow (Novak & Hoffman, 1997; Voiskounsky, 2008).

Feedback and interactivity, inherent to computer-related types of activities, are quite rapid and up-to-date, compared to many other kinds of daily routines. For that reason flow is known to be experienced while playing video/online/computer games (Choi & Kim, 2004; McKenna & Lee, 1995; Voiskounsky, Mitina, & Avetisova, 2004), interacting via instant messaging, e-mailing or chatting (Finneran & Zhang, 2002; Trevino & Webster, 1992), web shopping (Hoffman, Novak, & Duhachek, 2002; Huang, 2006), hacking (Voiskounsky & Smyslova, 2003), web learning (Heidman & Sharafi, 2004; Pace, 2004), and other types of behaviors. Comprehensive reviews have been recently published (Hoffman & Novak, 2009; Voiskounsky, 2008); interested readers may derive the needed references from these sources.

In spite of rapid feedback and high interactivity, computer users do not experience flow all the time. Flow is dependent on special features and characteristics of the interface and the software pieces. Even the best imaginable piece of software enables limited periods of flow experience which are inevitably interrupted by periods of boredom, or anxiety. In our previous study of computer hacking we described a model of hackers' motivational development, based on flow experience paradigm. We discovered that one group of our participants has been "following the flow", i.e. choosing only that projects, which the participants felt could be completed fast and accompanied by flow for much of the work's duration (Voiskounsky & Smyslova, 2003). Let us describe this phenomenon: it might be helpful for understanding the origins and development of intrinsic motivation characterizing the users' behavior while engaging in usability testing.

4. Hackers' Motivation Research

4.1 Description of the Study and its Results

The hypothesis of the study on hackers' motivation was that the likelihood of experiencing flow increases with the increase of hackers' competence in the use of IT products. An online research was administered within the Russian-speaking community of hackers (N=457). The participants of the study were self-selected hackers (peer recommendations were also available for part of the sample, otherwise they were active users of HackZone web-portal). One group in our study consisted of the least competent participants (in more detail, with small number of known programming languages, software products and less IT experience) and reported to experience high level of flow. In a second group highly competent participants (with the high variety of known programming languages and software products, and the highest duration of IT experience) reported, too, high level of flow. Cluster analysis of the research data (Voiskounsky & Smyslova, 2003) revealed the third group: moderately competent participants (in more detail, with moderate variety of known software products and moderate duration of IT use). The members of this group experienced very low level of flow. We can state that the moderately qualified participants reported a gap (a sort of a crisis) in the hackers' flow experience. Thus, the straightforward hypothetic correlation was not confirmed: the relationship between hackers' competence and the flow experience turned out to be more complicated. Our subjects appeared to experience both periods of flow and periods of flow crisis (i.e., no flow: we can suggest that it was either boredom or anxiety feelings), followed again by periods of flow renovation. A model that could explain the observed hackers' motivational development is presented at Figure 1.

The model (shown by solid arrows) is partly supported in our empirical study, and is partly hypothetical (shown by dashed arrows). The model is based on a balance between the level of IT skills and experience (but not specifically hacking skills) and the level of challenges (or task choices) in hacking. Most of the people start at the point of low skills and challenges. Flow, experienced at this stage, can keep hackers interested and drive them to master some skills or try different environments. A hacker can stay at this level of knowledge, or else he can progress in at least three ways. The first is a step-by-step progress both in challenges and skills – first to turn into a moderately, and then into a highly experienced hacker – in such a way that challenges and skills are balanced at every developmental stage (it means keeping flow experience).

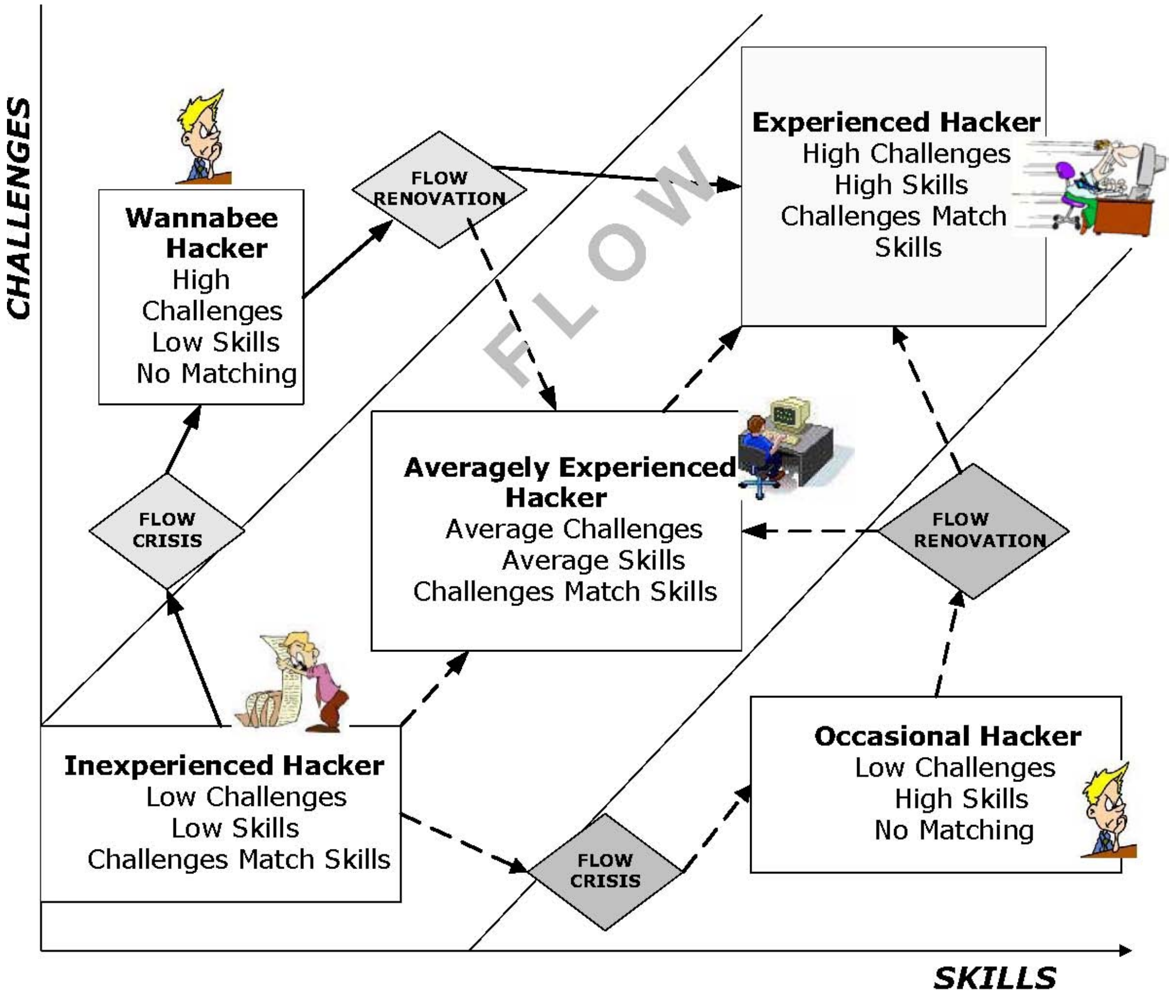

Figure 1: Model of hackers' motivational development (see: Voiskounsky & Smyslova, 2003)

Two other ways of a newbie hacker progress mean, first, that a hacker gains new skills and lacks the correspondence of new skills to non-updated challenges, or, vice versa, forwards or accepts new challenges without adequate skills to balance them. These two ways of a hacker's progress lead to periodical dropouts of the flow range, and the hacker periodically loses the flow experience. At the next stage the hacker might manage fine correspondence of skills and challenges anew and acquire the flow experience at a higher level of his/her progress in hacking.

4.2 Development of Hackers' Motivation

According to the model, the hacker's motivational development might be presented in the following way. Beginners are often heavily using the "how-to" and FAQs; supposedly, they are aware mostly of extrinsic rewards. Some hackers use the advantage to get "live" support via chats or instant messaging, thus forming what might be called online hacking Labs: distant members of these Labs exchange pieces of code and knowledge, help each other and support the advance of numerous individual and group projects (Nuwere & Chanoff, 2002; Yar, 2005). Thus the motivation for hacking can be supported by means of hackers' joint interest in within-group communication.

On a certain step of his/her professional development a beginner (i.e., a newbie hacker) might run into a balanced combination of challenges and get flow experience in hacking-related activity. This point is of crucial importance: flow experience is accompanied by positive emotions, with the feelings of competence and power. Strengthened by this kind of feeling, the flow motivation might become the dominant, desired and welcomed type of motivation. Such a "fixation" on flow while hacking may motivate novice hackers in their future hacking career.

While some hackers might stay at the stage of a beginner for years, others make progress. Their progress might take place in at least three ways, as described in the previous section. The most pleasurable and complicated one is a step-by-step progress both in challenges and in skills, which takes place in such a way that challenges and skills keep matching at every developmental stage. This means that a hacker experiences flow all the time during his or her working sessions. The possibility to keep this delicate balance of skills and challenges seems to be beyond reach, but we can accept it as a hypothetical way of hackers' development. The variety of the available hacking tools, e.g. decompilers, handbooks for beginners, universal standards of programming languages makes a "step-by-step" type of learning truly enjoyable and flow-facilitating. With the appearance of screencasting software, Youtube video tutorials became popular in education (Young, 2008).

4.3 Post-Experimental Data: Differences in Task Choice

Useful results were gained in post-experimental online interviews. Questions were sent out to subjects who were close to the centroids of their respective groups, the outcome being 37 completed replies. We are going to discuss here the participants' replies to only one question, related to the specifics of the task choice. They reported two major mechanisms of task choice while hacking: the step-by-step and the "interests-driven" choice.

First we briefly discuss replies given by reportedly incompetent participants experiencing flow. For example, Sergei wrote: "*Actually, all the problems could be solved. I mean I can see the solution, all steps of it. But sometimes I have not enough experience with the software products I need for the project. If I choose the project to complete I try to estimate the time. Do I have time to learn new programs or not?*"

Or M.G**.** wrote: "*Big projects are not enjoyable for me. On a certain stage it becomes boring, because there is no result… Now I am doing only those projects, which I hope to complete quickly. Some time ago I did not understand why I was so interested in it, why it was so enjoyable to break the copy protection of software products… Later I understood that it was just fast results… It was faster than to complete my own project*".

The task choice mechanism reported by Sergei and M.G. might be called a step-by-step choice. Possibly, this mode of task choice promotes the balance of skills and challenges on every step, and thus the flow experience is maintained. On the contrary, hackers who are reportedly highly competent and experience low level of flow choose their next tasks or projects within the hacking field according to their interests and do not coordinate it with the difficulty of the chosen task.

Here is the reply given by Yuri: "*Everything depends on my temper and weather ;). Today I may want to work on free mail service; tomorrow I may begin to create an accounting service for Linux. And the day after I would not do anything…Everything is up to me. Today it's interesting, tomorrow it's not*".

As we can see from Yuri's words, he chooses the tasks by himself. Projects he mentioned are complicated enough; other programmers or teams have already developed some of them. The projects would take a lot of time and effort to be realized.

Y.K. says the same: "*I always feel lack of knowledge, because I have a lot of ideas about different projects... and for realizing them I need a lot of information and knowledge. I choose only those projects which are interesting for me and don't pay attention to their complexity*".

Two moments need to be emphasized. First, the step-by-step task choice often leads to close correspondence of challenges of the task and of available skills, which is one of the main conditions of flow experience. And second, the task choice is regulated by intrinsic motivation of cognitive nature, which leads to full involvement and engagement with the actual project. But if the task complexity overruns the available skills, the resulting actual motivation might be far from the flow experience.

5. Flow in Usability Testing

5.1 Hints from the Earlier Studies

Strategies of task-choice described in the previous section show that flow might determine the hackers' choices of software products, operating systems, and programming languages. The hackers, who are competent software users, might both keep using the same software products for a long time, or try different operating systems in order to complete their projects effectively.

Some suggestions have been already presented in the literature. For example, Johnson and Wiles (2002) classify particular game design elements which either facilitate flow experience or interfere with it. Not restricting the analysis with the gaming environments, Bederson (2004) and Rettie (2001) report certain factors which inhibit flow experience or, alternatively, facilitate it. In attempts to promote the design of computer interfaces which would keep the users "in the flow" Mistry and Agrawal (2004) explore heuristics targeted to support the flow-oriented design and apply it, under the name "functional metaphoric approach", to the development of an electronic diary service. Two technological characteristics, namely perceived ease of use of a technology and perceived challenge, as well as two psychological characteristics such as skill efficacy and focused attention, are suggested as specific mediators which would impact flow experience, if measured correctly (Phau & Gan, 2000). All the mentioned above suggestions have been referred to in a recent paper (Voiskounsky, 2008), which is not, unlike the current paper, limited to usability studies.

Lazarro, psychologist working in the gaming industry, admits that she uses the flow paradigm in game design and testing (Lazarro, 2005), while Chen (2007) insists that flow experience is an exceptionally important element in game design. In a thorough empirical study, Korean researchers (Choi & Kim, 2004) investigated parameters of online gamers' customer loyalty (a marketing term meaning a customer's tendency to use repeatedly the same product, or a product of the same company). The parameters found include flow (structured as expressions of interest, fun, curiosity, control over the game, high absorption and the absence of distractions while gaming), as well as an ease of social interactions with other players, including a common virtual space with communication media (for example, a chat line or a community bulletin board), and an established feedback (called personal interaction) from the gaming environment, including available artifacts and instruments, adequate responses to gamers' actions, and appropriate goals to be achieved. Resulting on a large-scale survey, the customer loyalty model has been approved; moreover, developers of numerous online games made their proposals aimed at practical realization of certain interaction parameters of the model. The latter include the embodiment of 3D technology and true color graphics, design of artifacts to differ from real entities, and provision of correct information about the gamers' gender and occupation.

Though this study is restricted to online gaming, Choi and Kim (2004) believe its results might be found valuable in e-commerce and in development of cyberspace communities. We tend to think that the basic underlying ideas expressed by the authors are even more universal (Voiskounsky, 2008).

Flow experienced by online gamers or hackers is just an example of a good match between the users' needs and the inner structures of interfaces or programming languages which is likely to match these needs. This sort of matching users' needs and GUI structure should become one of main goals for developers and usability engineers, whenever they work on any new software application. Likeability of flow experience should be a starting point for developing models of human-computer interaction, user scenario, and tasks for usability testing. In the abovementioned studies there are some valuable methodological hints which can be explored and expanded to contribute to the benefit of any usability study.

5.2 A Method of Controlling the Users' Flow Experience

5.2.1 The Need for a Longitudinal Research

Flow is an important factor, which might stimulate any person to use a software product for a long time. Some of the participants described in the previous sections were adolescents, who would reportedly keep switching from one application to another, looking for bugs and exploring features they find interesting. The others would reportedly keep installing and testing operating systems over and over again. They would do so just because this type of behavior enables them to go on experiencing flow.

Any user research team which intends to keep their customers using the same software product for a long enough time (switching from the simplest to the most advanced versions), might think of building the interfaces the way to support the likeability of the would-be users' flow experience. For example, let them undertake a step-by-step tactics, since this tactics is promising for the continuing match of developing skills and increasing challenges. Thinking over the beginners' motivation is supposedly not enough: no less important is to work out effective means that would enable checking whether the users still keep experiencing flow while using the same software product in a one month period, in half a year, and much later.

Thus, the usability practice will inevitably face the problem of trying to check whether users are going to keep experiencing flow in a long perspective. Usability engineers need to have practical means to learn certain details of their customers' work in the future. While no time machine is available, the methodology worked out by Csikszentmihalyi and his collaborators helps researchers to understand some elements of the users' feelings, apart from longitudinal research.

One of the most efficient methods of understanding users' behavior is diary method. When working with diaries, users get short questionnaires to reply every time they use a product, or just write down their own experiences. Sometimes diaries should be filled for several days, sometimes for several weeks or a month. In this case users have a chance to try using software products or new features for a long enough period of time, while researchers have a chance to see how the product usage changes over time. This methodology can give researchers a summary of what users felt during the last 2 or 4 weeks. Thus a usability practitioner collects the much-needed information from the interviews and from the subjects' retrospective self-reports. This information seems to be no less helpful than the logs analysis (Meyer, 2005) which was mentioned in section 2.1.1 as a highly useful but rarely applied in the usability practice methodology, and may be combined (Weinschenk, 2007) with the well-developed and easy-to-use blogging analysis methodology. Along with diaries and/or blogs, video clips may be used in the ESM analytic procedures (Isomursu, Kuutti, & Väinämö, 2004).

5.2.2 Beepers in Usability Research

Csikszentmihalyi suggested a similar methodology to explore flow: among the advantages of this new method is a chance to get constant reports from subjects – these reports being still retrospective, but synchronous and thus more or less "up-to-date". The Experience Sampling Method, or ESM (Larson & Csikszentmihalyi, 1983; Conner, Feldman, Bliss-Moreau, Lebo, & Kaschub, 2003; Hektner, Schmidt, & Csikszentmihalyi, 2007) proved its usefulness for investigating flow in various types of activities; it can possibly contribute greatly to the field of usability research, as well as Chen's (2006) report of a web version substituting the random-time beeper and the activation of pop-ups and the questionnaire items at the monitor screen – more details are presented by Voiskounsky (2008).

While investigating typical life activities, Csikszentmihalyi and his collaborators supplied research participants with pagers, which would beep from time to time, each time signaling that participants are asked to complete an experience sampling form. ESM has an advantage over the traditional self-report methods: it can be used in a field study or in beta-testing, it measures people's self-reported experiences exactly when these experiences occur, or shortly after that.

Experience Sampling Method has been already applied to an increasing number of research projects in diverse fields, including, but not restricted to medicine, social sciences, and communication studies. Beeper studies (another name for ESM) has proved its validity in usability research of handheld devices and other gadgets (Palen & Salzman, 2002; Consolvo & Walker, 2003; Hektner et al., 2007). The abovementioned pioneer work seems promising, and we believe that the new methodology will be included into standard sets and manuals of usability tools. In the IT field, beepers and pagers can be easily substituted with special software which will loudly or visually "beep" randomly, marking the need to report characteristics of flow, or else the absence of these characteristics.

6. Conclusions

On the premise that usability studies of software products are far from 100 per cent satisfying, several promising directions to improve usability research and testing procedures might be named. Most important, usability engineers should pay attention to users' daily routines: the users are sure to prefer the software products which they need and besides, those which are not changing regularly: otherwise the users are likely to switch to a different and probably more stable product. That means, current usability methodology should rely on longitudinal research and on field studies. When a longitudinal fieldwork usability project is being carried out, it is a safe ground to investigate the users' intrinsic motivation which has, undoubtedly, the highest prognostic value. On the contrary, a traditional lab setting is optimal to investigate extrinsic motivation; since intrinsic motivation is unlikely to be revealed while carrying out a traditional type of usability-related work, the importance of motivational research has been largely underestimated.

A promising theoretical and practical approach toward better understanding of specifics of intrinsic motivation is a flow paradigm, introduced by M. Csikszentmihalyi. This paradigm is already being intensely applied, linked to various computer-related activities, including the hackers' and gamers' behavior, investigated by the authors previously. Several practical findings from these studies, which seem to be typical for the conservation and safety of intrinsic motivation, have been extracted. For example, a step-by-step task choice allows an individual to experience flow on every stage of a project fulfillment, by means of the choice of task challenges which match precisely the available skills. The Experience Sampling Method (aka "beeper studies") suggested by Csikszentmihalyi and his collaborators to foster the investigation and control of flow, is already being used in several usability research projects. This method seems to be very promising for carrying out longitudinal fieldwork, including software users' motivational research.

Major factors, contributing to the flow experience, are as follows:

- Good balance between the users' needs and skills, on the one hand, and the inner structure of programming tools, on the other hand; that means, the choice of the "next step" while fulfilling the task needs to match the (possibly) increased skills.
- Availability of a "live help" from others, assumedly more competent colleagues through BBS, Instant Messaging, chat, e-mail, corporate (social) network, blogging, hotline link, etc. Video tutorials, available through corporate and public social networks and uploaded by competent experts, are a popular tool to learn new software products, methods, or crafts.
- Manuals and text-books need to match the interests and needs of every user. The new generation of tutorials should lose any emphasis on descriptiveness and instead contain projects to be done using the actual pieces of program code and include operations which would present more and more complex questions and tasks.

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