aQRdate: assessing how ubiquitous computing can help people with acquired brain injury in their rehabilitation process

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***Abstract*—in this paper we present our ideas about how Ubiquitous Computing (UbiComp) could help people with acquired brain injury. Since these people have problems to engage in daily life activities (e.g. how to do the laundry or prepare breakfast), we propose a system based on mobile devices and QR codes to help them to remember these tasks. The environment will be tagged with QR Codes that will provide mobile devices with personal and interactive manuals for routine tasks. This work has been tested with one user with acquired brain injury as a proof-of-concept.**

Keywords-Acquired Brain Injury, mobile devices, assistive technologies

I. INTRODUCTION

Ubiquitous Computing provides new opportunities for researchers. The work developed in this area can be focused in many aspects: information technologies, communications, house living or healthcare assistance. We think house living and healthcare assistance are very related in some cases. Therefore, some of the work developed in the Ambient Intelligence Laboratory at the Universidad Autónoma de Madrid is focused on promoting the independent life of people with cognitive disabilities (down syndrome and Alzheimer disease) [1]-[3]. Meanwhile, the "Centro de Referencia Estatal de Atención al Daño Cerebral (CEADAC)" is a public reference centre devoted to rehabilitating people with acquired brain injury. Therefore, they offer services for patients and relatives to promote the autonomy of them.

This research area, where the technology is focused on helping people with special needs is also known as "assistive technology". As it is defined in [4] "assistive technology is any device, equipment, instrument, technology and software produced to prevent, compensate, monitor, relieve or neutralize impairments of body structures and body functions, restrictions in activities and problems in social participation". Assistive technology has been developed previously to help people with many diseases, but rarely for people with cognitive impairments [5].

In this paper we will focus on the rehabilitation process of one patient with acquired brain injury. Many experts of different areas participate in this rehabilitation process: occupational therapists, physiotherapist, neuropsychologists, etc. Part of the job of these experts consists of helping patients to acquire a greater level of autonomy in their everyday activities and adapting and modifying the home environment. Since the aim of Ambient Intelligence, as a part of Ubiquitous Computing, is helping the inhabitants of an environment, it seems that these techniques may be useful in the rehabilitation process.

The system proposed in this article tries to help people with acquired brain injury in their daily life activities. Since these patients usually present problems in performing their everyday tasks [6], we propose a solution to guide them during the activity by giving step by step instructions. These instructions are shown in mobile devices, so they can access to the information ubiquitously, and are adapted to their needs.

II. ACQUIRED BRAIN INJURY

This disease is the result of damage in the structure of the brain that can provoke a wide variety of problems. This damage can be caused by a stroke traumatic brain injury, tumors, etc. Middleton defined in [7] a set of after-effects: three groups that affect directly to the patient, and another one for the possible problems that affect to their relatives. The ones that affect to the patient are:

- Physical effects: gross motor difficulties, epilepsy, tremor, sensory loss, etc.
- Cognitive effects: speed of processing, attention and concentration, language and communication, visual, perceptual and spatial skills, memory and learning and executive skills.
- Emotional and behavioural effects: lack of inhibitions, impulsiveness, irritability, fatigue and inertia, anxiety, fear, grief, post-traumatic stress disorder, etc.

The rehabilitation process is critical. It should start as soon as possible (this is, after being medically stable) and, as the IMSERSO (Instituto de Mayores y Servicios Sociales - Elder People and Social Services Institute-, under the authority of the Ministry of Health, Social Politics and

Equality. Spain) poses in [8] the rehabilitation process should focus on seven areas:

- Alert level
- Motor control
- Information processing
- Communication
- Cognitive level
- Emotions and personality
- Everyday life activities

Everyday life activities are highly related to motor conditions and cognitive disabilities, and they are considered an important area to work during the rehabilitation process because they increase the independence of the patient [6]. We think this is the area where Ambient Intelligence can provide an added-value in the rehabilitation process.

III. Related Work

In this article we are going to focus on "cognitive prosthetics". This term was coined by Kirsch et al. [9], and defined as "a compensatory strategy which alters the patient's environment for performing specific functional activities". A few years later, Cole [10] expanded this term and added a set of attributes:

- Uses computer technology.
- Is designed specifically for rehabilitation purposes.
- Directly assists the individual in performing some of her everyday activities.
- Is highly customizable to the needs of the individual.

LoPresti et al. [11], put "cognitive prosthetics" and "cognitive orthoses" together and referred to them as "assistive technology for cognition" (ATC). They also made a review of the state-of-art of assistive technologies for cognitive rehabilitation and proposed a classification based on the cognitive area they wanted to make improvements:

- Technology for memory and executive function impairments, that included technologies for memory, planning, problem solving and "context orthoses".
- Technology for information processing impairments: sensory processing and social and behavioural issues.

In Tsui and Yanco [12], there is an up to date revision of the field closer to the subject of this article, devices for memory aids for task sequencing. Besides, it offers end-user evaluations for some of the projects studied. They talk about four kind of aids: "no-tech ATC", such as pictureSET [13]; ATC that support linear sequences, such as iPACS [14], iPrompt [15] (both for Apple's iPhone/iPod/iPad) and The Jogger [16]; ATC devices that support branches, PEAT (Planning and Execution Assistant and Trainer) [17] and Visual Assistant [18]; and finally "ATC devices with artificial Intelligence" are introduced (GUIDE [19] and COACH [20]).

The work we present in this article can be embraced under LoPresti, and Tsui and Yanco classifications under the topic "Personal Electronics as ATC Devices". As we will see in later sections, our proposal looks similar to pictureSET, but the images are shown in a mobile device. Besides, ourproposal facilitate the rehabilitation process by progressively adapting the amount of guidance needed to perform an identified everyday life task, as well as providing a detailed execution log to the caregiver.

IV. Our proposal: aQRdate

As we said before, patients who suffer acquired brain injury may present memory and executive functions deficits. In concrete, some patients could have problems to engage in how to perform daily life activities, such as doing the laundry or ironing a shirt. This difficulty has motivated us to think about a possible system that may help them in their daily routines.

In this article we propose "aQRdate" (read like acuérdate -remember- in Spanish). This time, we plan to generate a personalized set of instructions to perform an activity. That is, the user points at the tag with her device (a mobile phone, in example). Once the system detects a QR Code, it automatically captures it and decodes it. The information stored in these QR Codes is the name of the activity. From this name, and based on the characteristics of the device and the necessities of the user, the system displays a set of instructions that can help the user to accomplish some task. These instructions can be presented in different modalities, graphical, text and oral.

A. *Requirements and previous considerations*

Our goal is to help people with acquired brain injury in their rehabilitation process, so we have to consider a couple of ideas:

- These patients may present a wide variety of injuries: motor control, diminished memory, communication restrictions (reading, writing, and even, speaking), etc. We must consider all of them while designing tools for helping them.
- We will focus in daily life activities as they are considered an important part of the rehabilitation process. These activities are usually linear (there are no choices) but different users may require different instructions.
- Occupational Therapists may relay important information about interaction restrictions and needs.

If we read carefully those considerations, we can extract some system requisites:

- Users have to be able to access the information anywhere and at any time. We consider that, if a user is performing an activity at the kitchen, she should not have to move to another room (where the computer is) to know the next step.
- Different users may require different sets of instructions to perform the same task, so the system must be flexible enough to admit it.
- The interface should be adapted to the user, with her needs, and the device. This adaptation should also include modality (text, images, voice, etc.)

- Caregivers or therapists should be able to get data back from the execution.

B. *Architecture of the system*

Previous work developed at the laboratory, described in [21], provides a middle layer for Ambient Intelligence supported by ontologies. It was called “The Blackboard”, since it was based on the blackboard metaphor [22]. This data model is a representation of the information relative to the world, which is independent from the source that generates it and the abstraction level. It is divided into two clearly different but narrowly related parts: The schema model and the repository. The schema model contains the description of the world, in terms of classes, their properties, capabilities and the relations that can appear between them, that is, an ontological model. On the other hand, the repository stores entities that are the realizations of the classes of the schema. Entities can represent physical objects, such as computers, people, etc. or virtual objects, such as pictures, personal information, songs, etc. Regardless of the nature of the entities, all their information is accessible through the global information structure.

As virtual objects can be modeled in the schema and the realizations can be stored in the repository, we decided to describe the activities following that model. This way, all the information would be accessible for clients easily.

We decided to reduce the bandwidth consumption by adding an intermediate server that resolves all the links and makes the communication easier. This way, the client only has to make one query to get the step information. An schematic representation of the architecture is presented in Figure 1.

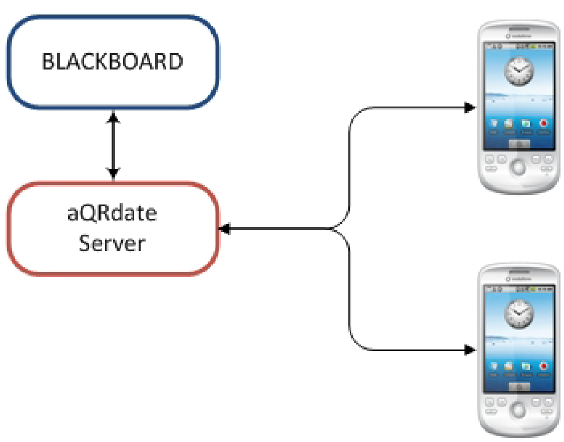

Figure 1. Architecture of the system

Once all the descriptions of routines and tasks are stored in the Blackboard, the “aQRdate Server” asks the Blackboard for all the routines it has. With this information, the “aQRdate Server” generates trees that represents the sequences, resolves links (relations) and makes it accessible for client applications.

In summary, we can divide the system in three parts: the Blackboard that stores descriptions of routines; aQRdate Server that resolves relations and generate trees; and clients, that present the steps to the user.

C. *Description of routines*

The first task a therapist must do before including the aQRdate program in the rehabilitation process of a patient is to identify and describe all the steps that compose the routine she wants the patient to do. At the moment, and as we said before, we describe them with the language proposed in [21]. This way, we finally obtain a set of entities and relations. There are three types of entities that correspond to classes in the schema:

- Routines: represent a sequence of steps that the user must perform to do an activity, so they can be printed in QR Codes to be scanned. They are composed of other Routines or Tasks. This is pointed by the relation “hasAction”. Routines don't have to have a parent--relation with other Routine, but they can be related with other Routines or Tasks by relations “previousAction” or “nextAction”.
- Tasks: are each step that the user must perform. They can be preceded or followed by other Tasks or Routines (relations “previousAction” and “nextAction”) and also must have a parent--relation with a Routine (“composesRoutine”). They are composed of Fragments, one at least. This is indicated by the relation “hasFragment”.
- Fragments: contains a piece of information related to a Task. They have two properties narrowly related: the type and the content. The type can be “title”, “description” or “image” and is determined by the nature of the information stored in the content property. They are related to other Fragments (“nextFragment” and “previousFragment” relations) and with the Task they belong to (“composesTask” relation).

Since different users may require different set of instructions for the same activity, an adaptation mechanism has been provided. We can define the sequence for a generic user but we can also establish different next/previous relations for different users. In example, we can define the routine to water a plant that can be composed of a huge set of instructions (Tasks). There could be a user that only needs a reduced set, because she is making progress in her rehabilitation process, so the therapist can make new next/previous relations (for that user) to avoid some of the steps.

D. *Client Application*

Mobile phones are becoming very popular and their technological capabilities grow every day. Current devices can perform numerous tasks, thanks to its memory and processor improvements, new hardware components (High definition cameras, GPS receivers, digital compass, etc.) and, also, some of these new capabilities are provided thanks to the new operating systems (iOS, Android, Windows Phone 7, etc.) The connectivity has also been improved since they are able to connect to 3G, HSDPA or WiFi networks. So, these devices seem to fit in the requirements and also provide the advantage that, in many cases, they are familiar to users.

All the prototypes implemented were presented and discussed with the clinical team. Finally, we designed the interface that is shown in Figure 2. The text at the top corresponds to the title of the task and is read aloud when the interface is loaded (if it is set in the configuration) or if the user touches the screen. Then, we have an image that represents the action. This is useful in some cases because it could help the user to identify the object she need. After the image, we have a small text that represents the current task number and the total number of tasks (or steps) required to complete the routine. Finally, there are two buttons to go to the next or to the previous task.

Figure 2. An example of the interface

The interface can be adapted to user preferences or needs. To do that, a configuration tool has been created. This way, the therapist or caregiver can select the best characteristics for the patient:

- Name: that is the name of the patient. This way, the log can be classified and studied individually.
- Time Out: the therapist can establish a time out. When it is reached, the device repeats the task aloud or plays a sound to alert the patient. This is useful since some users have to be remembered what they have to do, so this mechanism does it automatically.
- Time Out Alarm: therapists or caregivers can choose between an acoustic alert (a beep) or a voice repeating the task. A haptic alert (vibration) is also provided.
- Read after loading: the system can be configured to read the task aloud after loading the information. This way, no human intervention is required to hear the message.

Since we didn't want the user to select an activity from a list or introduce the name of the routine, we decided to employ QR Codes. These codes store all the information needed to identify a routine. Besides, they can be printed making the cost lower than other approaches such as RFID tags. Once the user starts the client application, a screen is presented where the content is the image captured from the camera in real time. When the system detects a QR Code, it automatically captures and decodes it. All this process is provided by the “ZXing Library” (Online at http://code.google.com/p/zxing/) and “Barcode Scanner” application (Available at the Android Market for free).

V. EVALUATION

Since it was the first evaluation, and it was done as a proof-of-concept, we wanted to check our approach by measuring the progress of the patients to evaluate the suitability of new technologies in rehabilitation processes. To do that, we designed a routine to be performed by a patient with acquired brain injury. This routine consisted of preparing a breakfast: coffee with milk, orange juice and toasts with butter and marmalade. The rehabilitation team considered it is already trained as an objective of rehabilitation at their houses. Besides, it integrates several cognitive and manipulative abilities such as memory, planning, sequencing and bi-manual coordination (marmalade blisters, in example).

That routine was designed by the rehabilitation team, specifying the different tasks that composed it. Finally, we got a total set 44 steps that formed 5 routines: prepare coffee, prepare orange juice, prepare toasts, heat milk and add coffee, and prepare the table.

To measure the progress of the patient, we prepared an evaluation process that consisted of four steps:

- Select a patient: the patient must satisfy some epidemiological and socio-cultural requisites.
- Perform a first evaluation without aQRdate: we asked the patient to prepare a breakfast without any technological aid and measured the number of tasks he did, the number of times the therapist guided and supervised, and the total time it took him. All this information provided a starting point to evaluate the progress of the patient.
- Include aQRdate in her rehabilitation process: a mobile phone equipped with aQRdate application and the corresponding QR Codes were given to the patient. He tried the application for a week in her therapy at CEADAC. This way, the patient got accustomed to the phone, the interface and the instructions. Then he used it at home in her everyday live.
- Final test without aQRdate: a couple of weeks after we decided to ask the patient to prepare a breakfast, to proof if he could do it autonomously.

Finally, we asked the relatives about how they feel the patient and the application, and the suitability of the system in the rehabilitation process.

A. *Select a patient*

Selecting the best patient for the evaluation was a critical task. To do that in a standard way, the rehabilitation team proposed a set of epidemiological and socio-cultural criteria that the patient should satisfy:

- He had to be able to understand simple orders.
- Learning and handling capability.
- Lack of initiative.
- Alteration of executive functions (planning, sequence, etc.)
- It was highly recommended that he had an Internet connection at home.

According to those criteria, the rehabilitation team selected a patient that suffered a cranioencephalic trauma. Among his lesions, we found:

- Severe deficit of executive operation with implication in behavioral regulation (planning and executing).
- Moderate anterograde amnesia.
- Bradypsychia (Slowness of mental information processing)

The deficit of executive operation involves that the patient presents problems in initiative and sequencing tasks. We considered that aQRdate might provide a valuable help in the completion of the proposed everyday life task. The anterograde amnesia means that the patient can't create and remember new long-term memories. This involves that the knowledge he acquired might not been remembered after a period of time, so it would be recommended to check it. The slowness of mental reactions had to be kept in mind since he might present troubles to process complex orders.

B. *First evaluation, without aQRdate*

This first evaluation was carried out at CEADAC. There, some training rooms had been furnished as kitchens with electrical appliances (stove, oven, microwave, etc.). This way, patients can perform or practice daily life activities as part as their rehabilitation process, under the supervision of an occupational therapist. This time, the patient was asked to prepare the breakfast. To do that, all the materials needed were provided: coffee, milk, oranges, bread, etc.

The therapist who supervised the task gave the following set of instructions: first, prepare coffee, then the orange juice, after that, the toast and finally, heat milk and put everything on the table. He understood perfectly all the steps and started with the coffee. He looked a bit nervous but presented a confident attitude while preparing each of the tasks. Besides, he was aware of time, since part of his therapy consisted on following the timetable proposed by the rehabilitation team (that included the rest of therapies: physical therapy, neuropsychology, etc.). He presented some troubles to initiate the following activity once he has finished the first one. In example, once he prepared the coffee, he asked what was the next tasks and so. He also presented troubles in divided attention, that is, doing a task while other. E.g. take a plate while the bread is toasting.

It took him 24 minutes and 49 seconds to prepare the breakfast. In this period, he was warned four times: in two of them, the therapist suggested him what was the next step. Therefore, if the therapist didn't have advised him, he wouldn't have been able to continue, since he wasn't proactive enough to take the initiative and he presented problems to remember all the sequence. The other two advises were to notify that both the coffee maker and the juicer must be unplugged after being used. Although keeping appliances plugged is not very dangerous we consider that is a good habit to unplug them in order to avoid electrical problems.

C. *aQRdate as a part of the rehabilitation process*

Once the patient was evaluated without aQRdate aid, he was trained with the system we propose on this article. Before starting the routines, he was shown the application during a 30 minutes session to train on it: buttons, icons, texts, etc. It was also useful to confirm that the user understood the instructions, since his clinical profile denoted that he might have problems to process orders due to his bradypsychia.

The therapy was divided in two parts: the first one was to prepare the breakfast at the CEADAC Building (for three times) using the mobile and under the supervision of a therapist. This way we were able to observe the realization of the routine, notify patient feelings and check that he was doing it correctly. After these training sessions, he did the routine at home for eleven times. This period was not established previously, rather that the process lasted the time the user needed to perform the activity autonomously. The whole process lasted 4 weeks in total.

During this evaluation we collected the log provided by aQRdate application and studied it. We noticed that the patient seemed to need only a few steps to do all the tasks. This was observed physically at CEADAC and also in the logs, since some tasks took a while and others only just a few seconds. These steps corresponded to the ones that involved a change of activity or routine. In example, when he was asked to take the coffee maker, he did all the steps to prepare the coffee and then he looked up the phone, so he advanced all the steps involved in preparing the coffee.

This fact motivated us to adapt the sequence that was shown to the patient by reducing the set of instructions. Although he skipped some of the steps, we decided to keep them in the sequence, since we considered them dangerous. These dangerous steps were the ones that can make something burn (in example, keep turned on the toaster) or the ones warnings of a possible danger (in example, when he had to cut the oranges to make juice). We reduced the activity from 44 steps to 21 that is less than a half.

In summary, the patient needed 14 executions (4 a week) to become independent in preparing the breakfast. Besides, he showed a good progress during the therapy, so the rehabilitation team decided to reduce his sequence from 44 to 21 steps. Finally, the rehabilitation team evaluated the patient and decided that he was doing his best so no more rehabilitation was needed for these kind of activities.

D. Final evaluation

Two weeks after the last execution we decided to ask the patient to prepare a breakfast again (without aQRdate aid) to check that he kept the capabilities obtained with the therapy after a period of time. The therapist told him to prepare the same breakfast he was trained before. According to what he said, he considered himself prepared enough to do that without help. This time he only needed 16 minutes, that is a 33% less than the first time, and the therapist only took part to suggest him that he should unplug the electrical appliances. As we said before, these advices are considered as “best practices” in managing electrical appliances but, at any moment, these advices were given because the patient didn't know how to continue or supposed a risk. That is, he could have done the routine without any advice.

By repeating the therapy after a few weeks, we could check that the user maintained performance on the trained activity and that it lasted in time and that it lasted in time. As the rehabilitation team and the family of the patient guaranteed, he keeps preparing his breakfast autonomously, with no aid.

E. Discussion

Since aQRdate provides timing information about the executions, we were able to study them to value the progress of the patient objectively. To do that, we created the graph that is shown in Figure 3. There, we have represented the total time that the patient took to perform the full routine. Thus, in the X axe we present each execution while the Y axe represent the total time (in minutes).

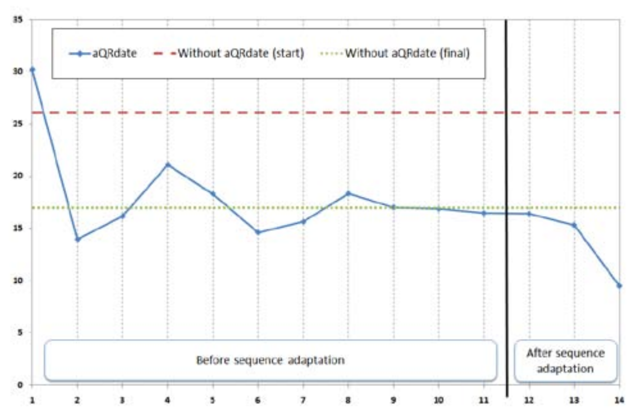

Figure 3. Total time needed to perform the routine for each execution.

We are going to focus on the line that represents aQRdate (the solid one). As we can see, the patient seemed to learn quickly. There was a great improvement in his times in the firsts executions. Then, after some oscillations, he looked to stabilize his times around the average (that is 17 minutes, approximately). That occurred around the ninth execution and made us to think about the possibility that he was doing his best in reference to the time he spent to do the activity. At this point (ninth execution) he had already improved his times around 35%, so we decided to go a step further and try to make advancements in his memory and sequence planning. This way, the rehabilitation team customized the routine for the patient and showed him only a reduced set of steps. They reduced the activity from 44 steps to 21 that is less than a half.

In this graph we can identify three lines: the solid one corresponds to the total time employed on each execution; the broken one indicates the total time needed in the first execution without aQRdate (at the top); the dashed at the bottom one corresponds to the total time in the last execution without aQRdate. In addition, we have divided it into two parts: the first one that takes from the first execution to eleventh cover the executions before the rehabilitation team adapted the sequence to the patient progress. The second one, from the twelfth to the fourteenth, corresponds to the ones after adaptation. As Figure 3 shows:

- If we compare the time needed in the first execution to the time spent using aQRdate, we see that there is an improvement in time. After only nine executions the patient stabilized his time performance.
- After we adapted the routine we observed a decrease in time performance.
- The evaluation carried out a few weeks after the last execution and with no aQRdate aid shown that the patient did actually acquire the knowledge to do the routine autonomously and performed in his most reduced time attained during training.
- According to the graph, the improvement between the first and the last execution without aQRdate was around 35%.

This improvement is also related to independence. He was guided less times and he was not told what to do next. In contrast, he was only guided about unplugging electrical appliances. Therefore, we consider that he could do the activity by his own, without any external aid, making him more independent.

In addition to the graph, we can include the information provided by his relatives. They considered aQRdate a useful tool in the early steps of the rehabilitation, since it promotes the independence of the patient. On the other hand, they notified that, as the patient progressed, the application lost its usefulness; since he was able perform tasks with no aid. We consider it is a good conclusion, since our objective is accomplished: make the patient independent enough to perform daily life activities autonomously.

This way, we are in position to say that aQRdate helped in the independent performance of the proposed everyday life activity. According to his clinical profile, he presented troubles in planning and executing tasks, which we consider is covered by our system, since all the sequence is presented in a multimodal way. The multimodality provides a good way to present the steps, since some patient may present communication problems or, as in the case of this study, slowness in information processing. This time, images and oral instructions were critical. Without them, the patient may have needed a long time to read each step and perform it.

Besides, aQRdate provides mechanisms to help the patient in the case he gets blocked and doesn't know how to continue. He can consult the device anywhere and check the next step instead of asking a caregiver or therapist. Or even, he can get advised automatically, since aQRdate provides a mechanism to program alerts. These mechanisms make him more independent, promoting his autonomy.

Another conclusion we can extract from the logs is that this mechanism, programmed alerts, wasn't as necessary as we thought, since he wasn't warned too much times by the mobile. We consider that the fact that the sequence was displayed was enough to make him finish the activity.

This evaluation provides a good benchmark to prove our ideas. First, we could check how Ambient Intelligence can be added in daily life activities to help people. Then, we proved our approach with a real user and helped him in his rehabilitation process. Besides, meanwhile he was using aQRdate, we were able to try other ideas, such as adapting the set of instructions to his progress. The adaptation seemed to be useful, since his times improved. Finally, we were able to check that the patient kept the knowledge acquired in time, since he was capable to repeat the sequence without any technological aid or advices from therapists.

VI. Conclusions

In this article we have presented our system, aQRdate, and the results of the evaluation after adding it in the rehabilitation process of a patient with acquired brain injury.

aQRdate (read “acuerdate” -remember- in Spanish) is a system based on mobile devices and QR codes that helps people with acquired brain injury in their everyday life activities. These people present damages in their brains (after a stroke, in example) so any capability may be affected. In this sense, these people usually present troubles in performing daily life activities, such as ironing or cooking.

We consider that mobile devices (such as mobile phones) are appropriate for this kind of tasks because they are familiar devices almost and are permanently carried by the user. Their functionality has improved dramatically in the last years and now they are able to perform advanced computational tasks. They also allow multiple ways of interaction, by means of a keyboard, gestures or voice. And the information displayed on these devices can adapt to each task or the necessities of each individual user.

The elements of the environment will be tagged with QR Codes, which are low cost and easy to integrate sources of information. Relatives or caregivers can create new QR Codes and print them for their immediate use in the environment.

With the combination of both elements (mobile devices and QR Codes) the system will provide interactive and personal manuals that will help users with acquired brain injury to remember how to perform simple routines. These manuals can be based on simple tasks related to a specific element (e.g. how to use an appliance) or more complex tasks related to a routine (e.g. how to iron or make the breakfast). They also are adapted to the necessities of each user and can change dynamically depending on the progress of the patient.

The interaction with these manuals can be monitored and evaluated, so relatives and caregivers can receive a full log of each execution of the patient. As we saw in the evaluation, the fact that the therapists were able to study each execution involved that they could adapt the sequence to the patient progress and it meant a significant improvement in his times.

Regarding to the evaluation carried out, we conclude that our approach seemed to help the patient. His times improved each execution with aQRdate. The evaluation performed before including aQRdate in his rehabilitation process and the later one demonstrates an improvement in time around the 30%. He also showed a self confident attitude and autonomy doing the activity. Thus, the rehabilitation team considered he was doing his best in this therapy (daily life activities) and decided to stop the therapy.

VII. Future Work

Experts in rehabilitation, doctors and therapists will describe these manuals, so an authoring tool is required. In this tool they should be able to configure the instructions, input methods and other features, such as language, color palettes, font sizes or flow of interaction.

The set of instructions could include, in example, a text or multimedia content, and some kind of close questions: yes/no, numbers, etc. Therefore, the system could also adapt the user manual to the context or the situation of the environment.

Another improvement could be the addition of an adaptation engine that studies automatically the log and proposes the adaptation of a routine to a concrete user. We think this engine should propose adaptation in contrast adapting it automatically, since the therapist must evaluate these changes before applying them.

The evaluation presented in this article included only one patient, so a lager one should be done. This new evaluation should include a greater number of patients with different clinical profiles and the progress in this therapy should be compared to the progression in others.

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