Specifying How to Motivate People in Computer Assisted Rehabilitation

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Abstract. The growing interest in computer assisted rehabilitation to alleviate the lack of enough facilities and specialists to cope with current demand for rehabilitation, especially related to the ageing of population, has pushed forward challenges and innovation related to the design and development of such systems. One of the aspects present in rehabilitation is motivation. Motivation is not essential in rehabilitation, but has been proven a useful factor to increase the efficiency of a rehabilitation process. In this paper we discuss the concept of motivation by providing a model that aims at supporting the design of the characteristics of motivation. Influence Awareness model is introduced as a vehicle to provide the patient with the information required to influence her behavior to improve her motivation towards rehabilitation in a computer assisted environment. Moreover, this Influence Awareness is integrated into a modelling language that enables the specification of the tasks to be accomplished during rehabilitation. Lastly, these concepts are exemplified in a case study.

Keywords: Influence · Awareness · Rehabilitation · Task model · CSRML

1 Introduction

It is well-known the growing interest in the development of e-health solutions, because of the on-going ageing of population. This ageing has introduced the need to find solutions that can cope with the increasing number of persons that require assistance from the healthcare system, but also as a solution to support a better healthcare assistance. This healthcare assistance can be oriented to improve the well-being of population as well, for instance by supporting some tele-healthcare assistance so as to prevent the patients with some mobility problems from going to the hospital.

This situation leads to the search of proper solutions that range from the assistive robot technology initiative in Japan [1] to the different initiatives in both Europe and the USA. To put this phenomenon into figures, the European Commission estimates a growth from 7.6 to 17.6 billion Euros already by 2017 in the global e-Health market [2]. Among these initiatives for e-Health we can found many topics included into the rehabilitation spectrum. Rehabilitation is closely related to population ageing as well, since many diseases that require rehabilitation are more usual in older people.

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Health at the times of Internet, or e-Health, is the second most popular topic on the Web and it has an enormous potential in terms of quality, efficiency, and cost of health-care systems, it could bring transformational changes in medical research and practice, given that it is technically mature. And despite that, all the attempts to extend very successful pilot projects to a general framework have not met the promised results or they have failed to a large extent. Additional characteristics must be considered in order to design and develop this kind of high interactive applications properly and guarantee its success.

In this work, we focus our interest on motivation, a key factor in the success or failure of an interactive system. In order to achieve this characteristic our proposal integrates human-centered design and influence techniques. Thus, we are aimed at providing a mean for the designers and developers of rehabilitation activities to be able to incorporate into their developments those aspects related to motivation, relying on a solid foundation.

This paper is structured like this: after this introduction we discussed some issues related to the motivation in the e-Health domain. Next, we describe the design approach proposed to design e-Health systems. The details about how motivation can be modelled and the awareness interpretation created follow. Afterwards, a case study to illustrate the approach is explained. Some hints about how the specification could be implemented are provided next. The paper is rounded up with some conclusions and future work.

2 Motivation in the e-Health Domain

Although making rehabilitation activities easy to do is critical for its success, there is more to it than just that. How do you ensure that people experience exactly what you want them to experience? The answer is by increasing motivation.

Motivation is considered a key factor, which influences people's ability to use, learn or to make decisions, among other things. There has been much research related to this subject, with important implications for rehabilitation and, therefore, it would be impossible to ignore such an area for e-Health domain.

Specialists in rehabilitation and e-Health systems need to motivate, persuade, and in general, influence patients constantly. A definition of these terms can be found in [3]. Motivation is "the general desire or willingness to do something", while persuasion is "a process designed to change the attitude or behavior of a person or group from their current view to a view that the persuader wants them to hold". Lastly, influencing is "the power to affect a person or course of events without undertaking any direct action and to be a compelling force on the behavior of others".

There are different theories that elaborate on motivation and these related terms, and that have proposed different frameworks or models to describe them. In this sense two of the most widely used are the theory of Influence [3, 4] and the Self-Determination Theory [5].

Cialdini in [4] describes how someone can be influenced relying on six different psychological principles, namely: reciprocity, scarcity, authority, consistency, liking and consensus. Moreover, these principles have been empirically validated [3].

Section 4.1 includes a discussion of these principles.

On the other hand, Self-Determination Theory (SDT) relies on three principles: competence, relatedness and autonomy. Competence principle says that the motivation of a person is increased whenever that person feels competent for the action being performed. Relatedness says that the feeling of belongingness and connectedness with others also has an influence in improving motivation. Lastly, autonomy principle says that a person is more motivated when he feels has some autonomy and therefore has the locus of causality. These principles have been also empirically validated.

It's also important to highlight that in SDT there is distinction between intrinsic motivation and extrinsic motivation. Intrinsic motivation is the "prototypic manifestation of the human tendency toward learning and creativity", while extrinsic motivation "refers to the performance of an activity in order to attain some separable outcome and, thus, contrasts with intrinsic motivation, which refers to doing an activity for the inherent satisfaction of the activity itself" [5].

In this paper, we focus on the six principles by Cialdini, since currently it is the theory we have been using in out developments, but SDT adds some extra dimension to influence motivation that can complement those offered by Cialdini's principles.

These principles will be reviewed and integrated with the concept of Awareness [6] to provide a tool for designers to guide the inclusion of motivation aspects in their designs.

3 Designing e-Health System

In e-Health systems older people or patients interact with a platform and they must understand some new information that is essential to their rehabilitation. Sometimes, it can be challenging to motivate these people during their rehabilitation process. You may feel as if the patients are only participating because they have to, not because they want to. Patients may approach the rehabilitation as routine and compulsory. Because human behavior is complex and people are naturally curious it is important to design assisted rehabilitation that motivates the patients.

Knowing what motivates people, what satisfies humans in terms of design and how it influences the rehabilitation process, enables the design of an effective e-Health design. Motivation itself is a broad subject. There are different motivation theories that have been developed by scientists and psychologists that try to explain ways to motivate patients and older people. They seek to explain motivation and how it affects the rehabilitation process [7].

Even though different development approaches can be used to develop rehabilitation systems, we support the use of the Model-Based User Development approach. Model-Based User Interface Development (Mb-UID) is one approach that aims at coping with the challenges of the interactive systems and at decreasing the effort needed to develop UIs while ensuring UI quality. The purpose of Model-Based Design [8] is to identify high-level models that allow designers to specify and analyze interactive applications from a semantic oriented level, rather than just starting immediately to address the implementation level. This enables focusing on the more important aspects without

being immediately confused by myriad of implementation details, and then to use tools that generate an implementation consistent with the high-level choices made during modelling.

Among the typical models involved in Mb-UID are: the task model, the domain model and the context of use mode. It promotes a user-centered development lifecycle. The task model is especially relevant in this paper, since our approach starts with a design of the motivation that is embedded in this model. Task models are useful when designing and developing interactive systems. They describe the steps to be carried out to perform a users' goals, together with their temporal relationships (e.g., T2 cannot be executed until T1 is finished). In our context, these activities and tasks are related to the rehabilitation process.

There are different specification languages for task modeling. In our proposal, CSRML (Collaborative Systems Requirements Modeling Language) [9] will be used as the task modelling language. This language is a Goal-Oriented and i*-inspired Requirements Engineering Language that enables the specification of CSCW (Computer Supported Cooperative Work) systems. By using CSRML, a whole CSCW can be modeled: tasks (individual, collaboration, coordination and communication tasks), goals, participants, resources and awareness needs.

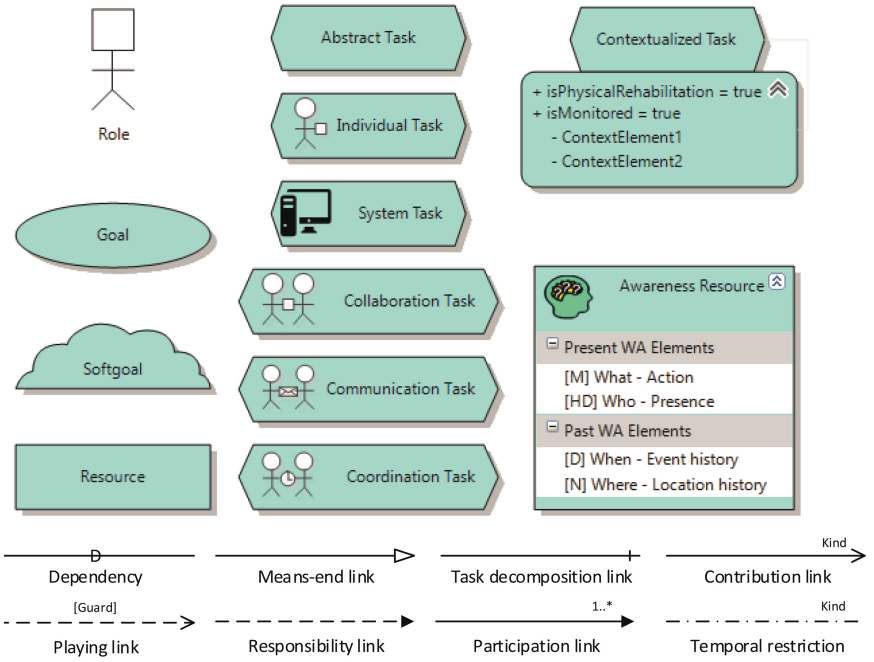

Fig. 1. Elements of the CSRML.

Figure 1 shows the elements and relationships defined on CSRML. Different kinds of tasks can be specified with these elements and several types of relationships can be defined between those elements. Another important element in the CSRML language

are the resources and the awareness resources, these elements are useful to specify and design for motivation. For a whole specification of the language please refer to [9].

4 Designing Motivation in e-Health Systems

As stated in [10], motivation is not essential to patient rehabilitation, but in most cases results in better outcomes. Therefore, if we plan to create a good rehabilitation system, neglecting the design of how motivation will be delivered to the patient can result in a worse design, of even discourage the patient from using it. Thus, we find that the design of those aspects related to motivation in rehabilitation cannot be left to the imagination of the application designer without explicit guidance.

Motivating a person can be achieved by using different approaches. One of them is by using influence [3] to motivate the user to do something, and therefore improving the willingness the user has with regard behave in a specific way. In our case, in the domain of e-Health what we are pursuing is influence the patients to foster their willingness to perform their rehabilitation duties.

Influence emerges from social interaction, for instance, a person is more willing to something if he learns other people has already done that. This social dimension of interaction is closely related to awareness. Dourish and Belloti defined awareness as the "understanding of the activities of others, which provides a context for your own activity" [6]. In this sense, different types of awareness can provide the information required to influence a person by supplying the right information at the right time. Among the different types of awareness, Workspace Awareness [11] was chosen as the foundation of this approach, since it is probably the approach that covers more features of interaction and it is widely validated. Not any information can be used to use influence to motivate people, but on the contrary, just specific information has been proved to be useful for this purpose. Therefore, we must select what information can be used to provide the different types of influence.

In this paper we are relying of the six influence principles enumerated by Cialdini [3], but other theories can be merged to provide a richer view. Cialdini principles are widely used, and they are also concrete enough to be specified and shared between the stakeholders (developers, specialists, etc.).

4.1 Designing Influence Awareness

In this section we describe those awareness elements that have been derived from the influence principles of Cialdini. Moreover, how each element of this type of awareness is used will be described in depth. The explanation will be split according to the six principles (Table 1).

Reciprocity. People feels like they are in debt with someone that gave them something. Since reciprocity is directly related to what people has received from other persons, two different elements were identified. On the one hand, the object that was given (*Reciprocity Item*) to the user to foster reciprocity must be specified. On the other hand, the

identity of the person that gave (*Reciprocity Identity*) the object should also be specified. Thus, we will be able to influence a person by reminding him what was given to him, and who did. Please, note that there is also a time component playing a role in this awareness elements. That is, similarly to what Gutwin proposes for Workspace awareness we include a temporal dimension as well. This is interesting to describe when the object we plan to use to produce the reprocity effect was given. Maybe this object was given to the person we want to influence in the past, right now or will be given in the future. Thus, suppose we want to influence a person to share the knowledge she gets in a learning platform. We could provide her with awareness about what knowledge has been share with here by other students in her group, so she feels more attracted to the idea of sharing what she has just learn with them, and thus boost learning in a collaborative learning environment.

Scarcity. We tend to prefer those things which are scarce, because of our fear of losing the potential benefits of the scarce element if it becomes unavailable. Therefore, if we would like to use scarcity to influence a person we should make that person aware of the object which is scarce (*Scarce Item*), the amount of items of that object left (*Availability*), who else owns that object (*Owners*) and the benefits that we lose in we don't get the item (*Benefits*). Depending on the item whose scarcity we want to highlight, it is also interesting introducing the time dimension in the specification. That is, we could say that an item was scarce in the *past*, or that it is scarce currently (*present*) or even that it will be scarce in the *future*. Furthermore, the *Availability* and the *Owners* of the scarce item could be different depending on the time dimension. For instance, to influence the motivation of students you could say that there are only two pass with honors grades available per year. Thus, by using scarcity awareness we could say provide information about the scarce item (pass with honors), the *Availability* in the past was 2, and in the present could be 1 (because one student already got one). In this case the *Availability* in the future is not relevant. Lastly, by using the *Owners* element of scarcity we could provide awareness about who already got one pass with honors (if any). This last *Owners* element can also be used to show relevant persons that got pass with honors grade in the past to increase more the influence. Additionally, we could provide also awareness about the *Benefits* by showing the student that if they get the pass with honors degree they will be included in the Hall of Fame of students.

Authority. People in general usually respects authority. E.g., we are more willing to do what someone in uniform tells us. If we plan to use authority to influence someone's behavior, we should provide awareness that help to reinforce this authority. Authority can be reinforced by providing the *Ranks* of a person. These *ranks* can be a degree in something, a diploma, the position held in an organization, etc. Depending on the situation, and the goal of influence, the designer should decide which *ranks* are more relevant to show the authority of the person trying to influence someone's behavior. Another source of authority is *Recommendations*. We are willing to listen to someone having good recommendations. Lastly, *Experience* provides a mean to express how knowledgeable a person is. Again, the time dimension can be introduced to express that the *rank,* the *recommendations,* or the *Experience* were in the past, the present of the future.

For instance, is not the same saying that a person has a *rank* of degree in physiotherapy for one year than for 20 years (*Experience*). We tend to play attention to people with more experience even though we don't know whether this experience was good or bad. The authority of this physiotherapist could be reinforced by proving awareness about who recommends this professional as found in many on-line buying websites. It is usual in these on-line buying websites that the recommendations can be order according to time dimension.

Consistency. For us is easier to make commitments if we make them voluntarily and if this commitment is public. Therefore, if we want to use consistency principle of influence we can offer awareness about what *Commitments* we made and also about how those *Commitments* were made publicly available (*Publicity*). Again, the time dimension can play an important role to show when these commitments were made. For instance, if a person has to walk for 45 min each day, a reminder can be used to reinforce the commitment and also we can provide awareness about in which social networks this commitment has been shared. Thus, we are showing how public this commitment is and showing that people now about that commitment.

Liking. It's easier for us to do what people alike us do. To comply with this principle, we aim at providing awareness about who is similar to us (*Similarities*), who makes compliments to us (*Supporters*) and who collaborates with us *(Collaborators*). Time dimension is relevant here as well, since it is interesting knowing when they made the compliments or when they collaborated with the person being influenced. For instance, when if we want to apply liking principle is would be possible to offer awareness about what likings we share (musical styles, sports teams, etc.) (*Similarities*), how many times I have made compliments by forwarding or liking one of his publications in a social network (*Supporters*) and how many times we have made an activity together (for instance attending together an event) (*Collaborators*). By providing these awareness elements we are showing the strength of our links and the person will be more predisposed to be influenced.

Consensus. It is very common to do what other people do. In this principle we want to influence the behavior by providing feedback about what other people does, did in past or will do (*Someone else's Tasks*). Therefore, time dimension is again relevant in this principle. If we would like a person to walk for 45 min every day we can show awareness about who else already did that, is doing it or will do it.

At first, we could think that including every single element of influence awareness would be the best solution to improve motivation. Nevertheless, this is not true, since overloading the user with information will result in the user ignoring most of the information because of the high cognitive load of the user interface. Therefore, for each situation we should choose only those influence awareness elements we find relevant to the situation and the target audience.

Table 1. Overview of the influence awareness elements.

Concern	Element	Description
Reciprocity	*Reciprocity Item*	What items were given to expect reciprocity?
	Reciprocity Identity	Who gave the items for reciprocity?
Scarcity	*Scarce Item*	What items are scarce?
	Availability	What is the availability of the scarce items?
	Owners	Who is already an owner of a scarce item?
	Benefits	What benefits are expected from the scarce item?
Authority	*Ranks*	What degrees, diplomas, position are relevant to reflect authority?
	Recommendations	Who recommends the person trying to influence someone?
	Experience	What experience has the person influencing?
Consistency	*Commitments*	What commitments has the user?
	Publicity	Where have been made public those commitments?
Liking	*Similarities*	What are the similarities between the user and the influencer?
	Supporters	Who makes compliments to the person influenced?
	Collaborators	Who collaborates with the person influenced?
Consensus	*Someone else's Tasks*	What related task have been made o are being made o will be made by someone else?

4.2 A Case Study: Including Influence Awareness in an Upper Limb Rehabilitation Activity

In this section we present a case study where influence awareness is illustrated in a rehabilitation exercise. This rehabilitation exercise is taken from [12], where different rehabilitation activities for elder people are described. In the activity chosen, the patient is asked to move her arms until she reaches a specific position to perform the so called *Upper Limb Rehabilitation* (ULR). This activity is aimed at strengthening the arms of the patient, therefore she is asked to perform the movements a number of repetitions (between 3 and 8 times). In our setup, this activity is performed in an environment where a Microsoft Kinect is used to monitor the motion and positioning of the arms of the patient [13].

Figure 2 depicts a task model specified by using CSRML language [9] that describes this rehabilitation exercise together with the awareness resources provided to improve the user experience. The task model has been pruned for the sake of understandability. The root of the model is *Upper Limb Rehabilitation (ULR)*. This task is decomposed into *Start ULR*, *Execute ULR* and *Stop ULR*. *Start ULR* represents the initial positioning of the patient to start the rehabilitation exercise. *Execute ULR* is used to represent the execution of the exercise and *Stop ULR* represents when the user stops the exercise. Please, note how they are connected by using temporal operators. *Execute ULR* can't be performed by the user until *Start ULR* is finished. *Stop ULR* is related to *Execute ULR* by using the *disabling* operator. It means that whenever *Stop ULR* task is executed the other two tasks are disabled, and therefore the execution of the exercise is finished. On

the other hand, *Start ULR* is further decomposed into *Good Seated Posture* and *Hold Arms Straight*. It describes that the user should start the exercise both seated and with arms straight. *Execute ULR* is further decomposed into *Move UL* and *Cancel ULR*. Lastly, *Move UL* is decomposed into *Move Left Arm* and *Move Right Arm*. These last two task represent the actual move of both arms to do the exercise. Since the exercise should be made between 3 and 8 times, the user is allowed to cancel the exercise when it has already been performed 3 times by using the optional (denoted by *[])* task *Cancel ULR*.

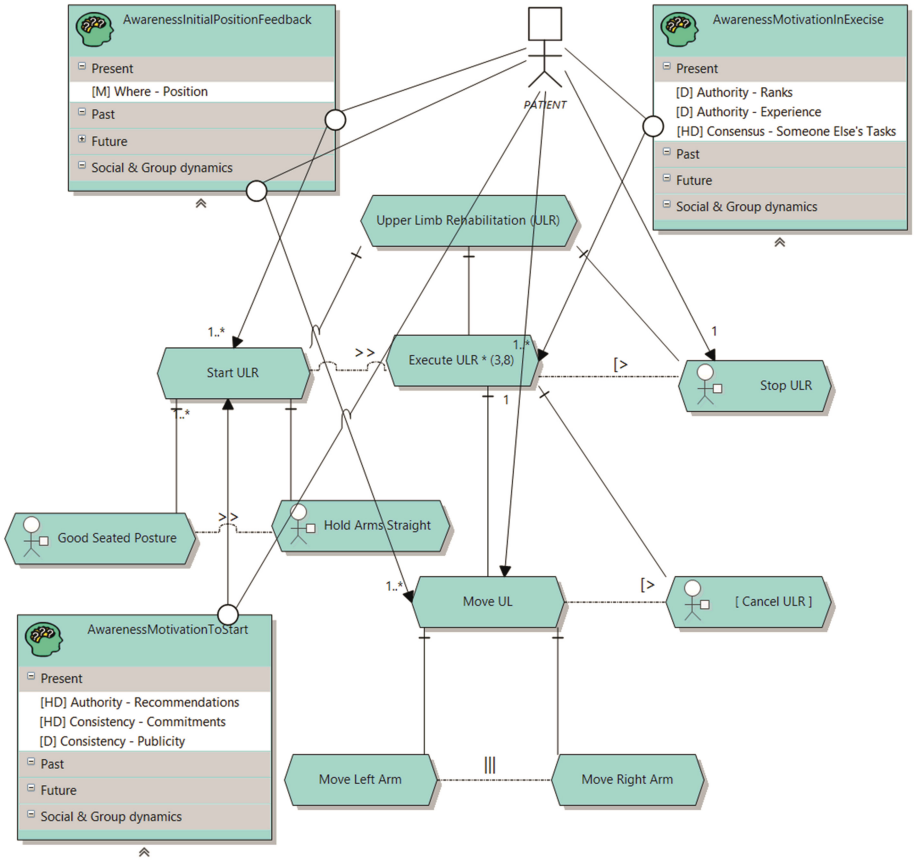

Fig. 2. A task model specification including influence awareness.

In the task model there is a single role, namely *PATIENT*. This role represents the patient who will perform the exercise. Therefore, the patient is the role responsible for making the rehabilitation tasks properly. In this case, two different awareness resources are included. These awareness resources are aimed at improving the user experience by providing valuable information that will help the user be aware of surrounding information that the designer found relevant. At the top left corner *AwarenessInitial*

PositionFeedback is found. This resource is provided to the user for two different tasks: *Start URL* and *Move UL*. Both tasks require the user to be aware of her position. Thus, for the user to be able to know whether the initial position has been achieved or how well is doing an exercise, we provide the user with awareness information about the position of her body at any time. Moreover, two awareness resources are used to improve the motivation of the patient. On the one hand, in the left bottom corner *AwarenessMotivationToStart* is an awareness resources aimed at improving the motivation of the patient to start the exercise. Three awareness elements have been included: *Ranks*, *Experience* and *Someone else's tasks*. Thus, we would like to influence the patient behavior towards the rehabilitation by showing the *Rank* and the *Experience* of the physiotherapist that designed the rehabilitation activity (*Authority* principle) and also by showing who else is performing this exercise (*Consensus* principle). Additionally, at the top right corner of the task model we can find *AwarenessMotivationInExercise*. This awareness resource is aimed at improving the motivation during the execution of the exercise. In this sense, we have chosen three influence awareness elements for this purpose: *Recommendations*, *Commitments* and *Publicity*. By providing awareness about who has recommended this exercise (*Authority* principle) we are telling the patient that this exercise is appropriate, with the backup of the recommendations of other patients. On the contrary, with *Commitments* and *Publicity* (*Consistency* principle) we want to reinforce the commitment to finish the exercise of the patient, by reminding her the commitment she made and that other people know about her commitment as well.

4.3 Implementing Influence Awareness

After the designer has modelled the influence awareness to be used to increase the motivation in the exercise, it is time to implement it. There is no one-to-one mapping between an awareness element and the way it is presented to the user. On the contrary, there is a myriad of possibilities to represent the same awareness element. For instance, focusing on reprocity in an e-commerce website, if we want to help to persuade the user to subscribe to a service in our website we can show on the profile information on the top right corner the cost of all the free services he has already enjoyed. To further influence the user to subscribe to our service scarcity principle could be used by showing the limited number of subscriptions available (*Scarce Item* is the subscription and the number of subscriptions available is *Availability*).

In the previous example the presentation chosen has been mostly textual, but graphical hints can convey meaningful information faster and more efficiently in many situations. For instance, in our rehabilitation example for the presentation of the rank, we can provide awareness about the authority of the person that designed the activity by showing an avatar with the typical medical white coat. In this way we are showing the authority of the avatar that is telling the patient to do an exercise in a graphical an implicit manner.

As aforementioned there are plenty of possibilities to represent the awareness influence elements chosen. Choosing one or another can depend on the target platform, but mostly on the target user we want to influence.

5 Conclusions and Future Work

Motivation can play an important role for patients during rehabilitation activities. One of the tools therapist have to improve this motivation is by influencing the behavior of the patient towards the rehabilitation. To achieve this influence different theories can be used. Similarly, in the context of computer assisted rehabilitation this influence can also be used to foster motivation during the rehabilitation. This influence during rehabilitation can be realized by providing awareness about those elements from the surrounding environment that promote and influence in patients' motivation.

In this work an awareness definition is introduced, namely Influence Awareness, aimed at providing an underlying foundation to provide this kind of awareness when the designer needs to model how he can influence someone. This awareness interpretation emerges for the empirically tested influence principles enunciated by Cialdini [3]. Moreover, this awareness interpretation is integrated into CSRML, a modelling language that has been proved useful in the design of rehabilitation systems [14]. By using this influence awareness interpretation, the designer of the application can more easily choose which elements related to each influence principles contribute to improve the motivation of the user and can also inspire the designer in those changes available to achieve the motivation. When talking about influence, the reader should not forget the ethical issues that can raise, for example, by using these influence awareness elements to provide false information.

Even though this awareness interpretation already helps the designer in knowing and understanding some plausible means to influence someone's behavior, some additional tools can be devised to further guide influence to motivate. For instance, it would be nice to have a set of predefined widgets that provided an implementation for each awareness element, as it already exists for workspace awareness [15].

The use of different profiles would be also advisable when providing this influence awareness, because probably neither the same awareness elements nor the same presentation will be equally effective, for example, for children and elder persons.

Future work will integrate and clarify the value of further dynamic adaptation by integrating Influence Awareness into the ISATINE adaptation framework [16] as well. Also some other motivation theories will be integrated into the approach, e.g. SDT.

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