Engineering Awareness™: An e-Service Design Approach for Behavioral Change in Healthcare and Well-Being

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Abstract. Personalized interventions that empower users through pertinent and reliable information alongside ubiquitous and user-friendly services can provide them with the opportunity of adopting healthy lifestyle choices which improve quality of life and help prevent a vast number of chronic diseases. The eServices for Life and Health research unit alongside the City of the Future Living Lab strives to apply an e-Service Design approach to deploy innovative ICT and multi-device based services, aimed at truly responding to user needs and aspirations – both inside and outside hospital walls.

Keywords: Design philosophy of HCI and UX, heuristics, healthcare and well-being.

1 Addressing Lifestyles: Transforming a Prescription into an Experience

An OECD-WHO's analysis [1] of a wide spectrum of strategies addressing issues such as unhealthy diets, sedentary lifestyles and obesity for the prevention of chronic diseases, unveils that the more interventions are personalized and directly involve highly skilled medical experts, the higher their success compared to the impersonal interventions of mass media communication campaigns.

This means that Healthcare systems must adopt a more proactive approach by providing Individuals with comprehensible information and education to raise awareness on health and well-being, as well as build a vast network of services that can sustain them in their choices towards healthier lifestyle choices and behaviors.

The underlying concept behind this new proactive approach that Healthcare is indeed already widely tested and used in the old "reactive" approach: once a disease/condition is identified, a (set of) drug(s) is prescribed and administered, and this prescription's compliance is monitored together with the development of the patient's clinical picture. There is wide evidence in literature that regular physical activity and a correct diet can have the same effect of a drug, and in many cases can be used to reduce/substitute the drug prescribed. Adopting proper "behaviors" (not only limited

A. Marcus (Ed.): DUXU/HCII 2013, Part III, LNCS 8014, pp. 558–567, 2013.

to physical activity and nutrition, but for example also sleep, etc.) and, more in general, proper lifestyles is a matter of what we can call "culture of health", which implies the strong need to educate the patient. The “extended prescription” concept thus uses the following three assumption:

- Physical activity is medicine
- Nutrition is medicine
- Education is medicine

With these assumptions in mind, it becomes evident the importance of both a correct prescription (which should be personalized and tailored to the specific patient’s needs), and a correct administration (and compliance monitoring) of these three “medicines”. As a further generalization of this concept, we should consider physical activity, nutrition and education as three of many behaviors (e.g., sleeping, working, etc.) which impacts strongly on the health of people, and which needs to be constantly prescribed, administered and monitored. Administration and monitoring of behaviors is possible only through ICT, as will be explained in the following subsection.

2 ICT as Healthier Ecosystem Enabler

Such a proactive approach described above will lead to a dramatic expansion of evidence-based medical knowledge domains due to the intrinsic need of an interdisciplinary approach to care. At the same time, the etiology of the single clinical case implies that doctors and their teams will have to deal with an exponentially higher quantity and types of Patient's data (e.g., physiological data and information collected by wearable sensors, data and information on patient's behavior in nutrition, physical activity, medication regimens, education, awareness, etc. collected by mobile apps). These will in turn drastically change the present concept of Electronic Healthcare Record (EHR), which will evolve towards the much broader paradigm of Personal Health Record (PHR): both aspects imply levels of ‘Big Data’ storage and analytics that only ICT can provide.

On the patient side, doctors' prescriptions will need to turn into comprehensible, practical and actionable advices that help guide them towards making informed choices in everyday life (while shopping, cooking, dining out, exercising, etc.). In this way, a lifestyle prescription becomes actionable and adaptive to Individual and context, raising the Healthcare System-Citizen relationship to a higher level of mutual collaboration.

As this new paradigm involves several aspects of the patient’s daily life as a whole, it is clear that this new paradigm will require new players, which implies more market opportunities also in companies/sectors that traditionally do not belong to healthcare. These new players have been thoroughly described in the PREVE project [2], called with the name of Co-producers of Health (CPH). A CPH is an actor who, pursuing its own business opportunities, is in parallel improving the health of the citizens, or it is contributing to create the conditions for the persons to have an healthier lifestyle.

The fact that the Co-production of Health model is citizen-centric doesn't mean that it is restricted to the person only. Of course to realize this vision, different levels in the society should be involved, from the individual level (single citizens), to the interpersonal level (friends, family, co-workers, etc.), to the organizational level (policies and practices of civic, religious, social, political, and related organizations), to community level (attributes, resources and norms of the person's communities, such as neighborhoods, markets, restaurants, etc.), to public policy level (laws and regulations that affect the person).

All these actors, institutions, public bodies, companies, etc. can participate to improve the personal health of the Individual, if properly engaged through ICTs.

From a medical perspective, a Personal Health Record and a new Lifestyle Personal Guidance Systems model of care is suitable both for primary and secondary prevention and leverages on Patient/Consumer empowerment at every life stage. From a market perspective, the introduction of a health-trusted third party acting as a demand-driven broker in the Consumer market, enables disruptive business models to take place in the form of healthier lifestyle-related added value networks that aggregate and offer personalized bundles of education, media, entertainment, food & beverage, consumer electronics, sport & fitness, leisure & tourism products and services according to Individual's needs and preferences.

3 Engineering Awareness: An e-Service Design Model

In order to respond to this r-evolution in healthcare, the e-Services for Life and Health research unit has developed a unique Service Design model that synchronizes Emotions (a trigger to an Individual's psychological reaction in context with his/her preferences) and Relations (a trigger for a social interaction with other Individuals physically present or not, and/or with a proximity or remote environment in context with his/her preferences) to Functions (an Individual's practical need addressed by the service) delivered. This Service Design model is called Engineering AwarenessTM.

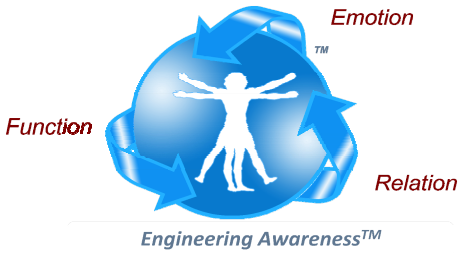

Fig. 1. Engineering AwarenessTM process

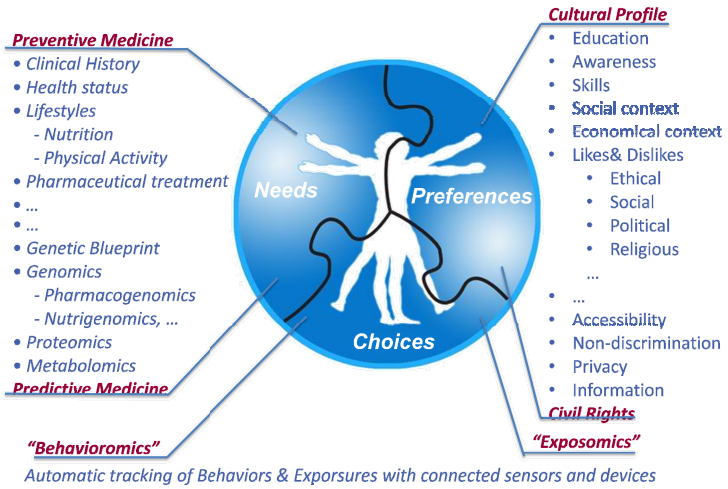

Fig. 2. Engineering AwarenessTM description

Designing for Individual's awareness and behavioral change is the primary ethical objective of any personalized service developed within the eServices for Life and Health. The mission of this research unit is not to manipulate Individuals (i.e., making them doing a supposed "right thing/healthy thing" as decided on behalf of them by a knowledgeable third party) but provide them with an unbiased understanding of the impact that a given decision/action implies. Each Individual is characterized by his/her own digital profile which is a complex, dynamic and progressive repository of personal data, information and events which is split into three parts as illustrated on the right of the Figure:

- needs, i.e. the medical part of the profile: the genetic blueprint and the meaningful biochemical/physiological parameters of an Individual that are considered relevant for a statistical health risk assessment at the state of the art knowledge in primary/secondary preventive medicine and predictive medicine;
- preferences, i.e. the personal preferences part of the profile: the unique cultural resources of an Individual, that include his/her likes and dislikes and ethical beliefs;
- actions, i.e. the health-related actions part of the Individual's profile: the unique (and constantly evolving) series of meaningful health-related actions performed by an Individual ("Behavioromics") and exposures to environmental factors ("Exposomics") in his/her daily life.

4 eServices for Life and Health Research Pilots in the San Raffaele City of the Future Living Lab

There is an array of definitions used to define what is meant by Smart Cities[3] or Intelligent Cities[4] in contemporary literature, but all of them stress the important

role technology plays in improving communication, creativity, business, urban growth, social and relational capital, as well as social and environmental sustainability [5,6]. e-Services for Life and Health[7] in this context is a research unit at the Scientific Institute San Raffaele in Milano (Italy), whose mission is to design, develop and demonstrate the ethical, scientific, economic and technological feasibility of innovative personalized services aimed at promoting well-being and informed choices and behaviors in daily life. e-Services for Life and Health has three main research and innovation streamlines - Smarter Hospital, Smarter Life and Smarter City - that are managed within the unique context of the San Raffaele City of the Future Living Lab (ENOLL member, European Network of Living labs[8]): i.e., an ecosystem within an area of 300,000m2 that can be described as a tertiary urban area or a compact urban district where all daily and typical operations are concentrated in a reduced space and its structures allows to access, understand, study and measure the interactions among an estimated 27,000+ community of City of the Future daily Users (20,000+ a day turn-over of inpatients, outpatients and visitors of all ages and needs; 5000+ on site employees, researches, etc.; 1700+ students).

4.1 City of the Future Living Lab Methodology

The Living Lab follows along the conceptual framework presented by ESoCE-Net, in which user-driven innovation is fully integrated within the co-creation process of new services, products and societal infrastructures. [9] The Living Lab process is focused on four concurrent phases: co-creation, exploration, experimentation, and evaluation. There isn't a real starting point because the approach is iterative and reflective, so the LL process can take live in any stage of each activity.

In the City of the Future Living Labe the target is to gain the access to the users' needs, knowledge, ideas, desires, and anything else could be a support to improve services, products or applications. The involvement of the stakeholders and users from the early stages of the products is to take advantage of their support in each activities of the production, in order to implement and define realistic, useful, desirable and effective artifacts.[10]

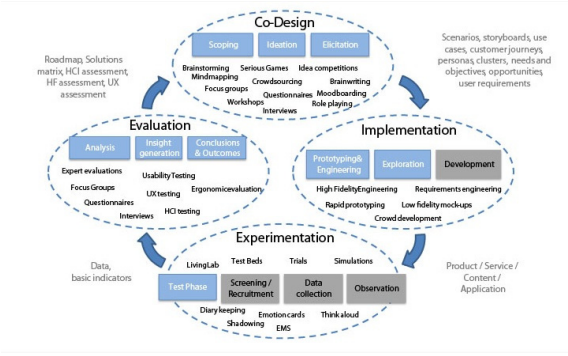

Fig. 3. Living Lab methodology

4.2 European and Italian Projects

Such a unique environment has been field of international ICT research projects in 5th, 6th and 7th European Commission Framework R&D Programs and Italian/Lombardy Region R&D Programs since year 2000, nurturing intense cross-disciplinary collaborations between medical and healthcare professionals, designers, engineers, scientists, policy makers, and entrepreneurs across a number of well-being, life and health-related fields. The following 5 cases better represent the efforts of this research unit and its users:

M3 (Mobile Medical Monitoring). M3 is a project funded by the Italian Region of Lombardy. It consists of a wearable patch, a Smartphone and tablet app and web portal. It is a service where users (both professional athletes as well as the average individual) can monitor different biological parameters (e.g., heart rate, breathing, METS) and share this data as well as other data with their trainers, doctors, nutritionists and so on, in order to receive from them personalized help via both the app and the web portal. The service is integrated with individuals' PHR. The current state of this work, at the time of the writing of this paper, is that the relevant technologies have been selected, the PHR was deployed on a Cloud and is now ready to be used. The evaluation saw two fases: the first was the Co-Design phase consisted in the participation of a group of expert users (including nutritionists, cardiologists, biomedical engineers and professional athletes) alongside a team of City of the Future researchers (including engineers and designers) to a focus group. Throughout this activity, the different actors were guided through a phase of analysis (questions were asked such as who could the end user of the service be, what are the user requirements of this user, in what context could the service be used on a day-to-day basis, what other similar products and services already exist, and so on) as well as through a phase of brainstorming. The insights gathered from the phase of co-design (and which include the Engineering Awareness™ Model) were used as base for the phase of Implementation, where ideas and user and service requirements were translated by City of the Future's tech team into a series of rough prototypes for the Smart Patch. In the second phase, some end users (N=10, 5 males and 5 females, ages 25-34) were involved in the usability tests: they were requested to create an account on the web portal, to fill life-style related questionnaires and then to use the M3 system for at least 3 days. The system includes a smart patch (equipped with sensors for heart rate monitoring, temperature monitoring, breath rate monitoring, ECG and caloric consumption) and an Android mobile phone, with an application to visualize the data coming from the sensors. Users were of course also properly instructed and trained in the use of the devices and the web-portal. The tests were run during November 2012. Most of the usability concerns were of course related to the smart patch (e.g., about recharging, wearing it, etc.), and some of them related to the Android application (e.g., graph readability, etc.). All the users' feedbacks were taken into account to improve the devices and services, as foreseen in the Living Lab methodology. The department of Physical Activity and Sport Medicine is now ready to enroll more patients to experiment the system.

Fig. 4. M3 devices

Well-Being on the Go. It's a service that falls into the ELLIOT (Experiential Living Lab for the Internet Of Things) European Commission FP7 project. It is composed by a set of real interactive vending machines [11] deployed within the City of the Future Living Lab. The service offers not only healthy food options in non-places, but also personalized and pertinent information on health, nutrition, well-being, mobility, entertainment and socialization via different identification mechanism. It will soon be integrated with PHR. The vending machines have been deployed and are currently being used by employees and external users. Statistics are under collection and they will be analyzed soon to understand/improve the usability of the system.

Fig. 5. Vending machine details

ALIZ-E - Adaptive Strategies for Sustainable Long-Term Social Interaction. This is a European Commission FP7 R&D project. The ambitious aim of this project is to create a companion for hospitalized children that plays with them, supports their learning of health-related behaviors (such as nutrition, physical activity, and specifically diabetes management), and motivates them to follow healthy behaviors in their daily life. Currently 200+ children have interacted with the robotic companion, in several small scale experiments to understand how children perceive this technology, how they react to it, and thus how it can be used to create an additional channel toward the child to convey useful information [12].

Fig. 6. Pictures from Aliz-e project

Feed for Good. This is also a project funded by the Italian Region of Lombardy. It rides the current trend of TV food shows and web platforms, combining their entertaining and social aspects with information on food culture, nutrition and healthy eating. A set of semantically coded video recipes can be viewed by users alongside personalized information on one's eating habits and health status. The main support system consists of a web portal and an application for mobile devices (especially for tablets and smartphones), which provides an easy and immediate access to services, with the advantage of specific applications developed to support the user in the various daily contexts (e.g., during the purchase as Shopping Assistant, or during the preparation of specific dishes as Cooking Assistant, etc.). This project is still in the prototyping phase, however there is a plan for users' involvement to validate/improve the software interface, usability and functionalities.

Fig. 7. Feed for Good interface

5 a Day. The program started some years ago as a nutritional and technological training to motivate children to eat more fruits and vegetables. In a first step we carried out the 5 a day program in four primary school classes for a total of 76 children. Fruits

and vegetables consumption was measured before and after a classroom intervention, with the purpose to educate children about the importance of healthy eating habits. The experiment underlined an increase of the 12.7% in the consumption, with the most significant increase in vegetables intake.

In a second step the program was moved into the hospital, with the aim to create an environment able to satisfy patients' needs and dedicated to well-being promotion. In this case an Interactive Totem was placed in the pediatric ward, with educational services created to entertain and empower the hospitalized children. This platform is part of an Internet of Things system that is used to understand the impact of the services offered, achieve fine-tuning from the collaboration of children, and explore the role of an Internet of Things System in the Living Lab process [13]. In particular, the Totem is able to communicate information, educational and motivational contents, related to the importance of fruit and vegetable daily consumption, that are provided to children at the meals booking time (reservation for lunch and dinner). This second step is still going on in the pediatric ward, with periodic co-creation activities.

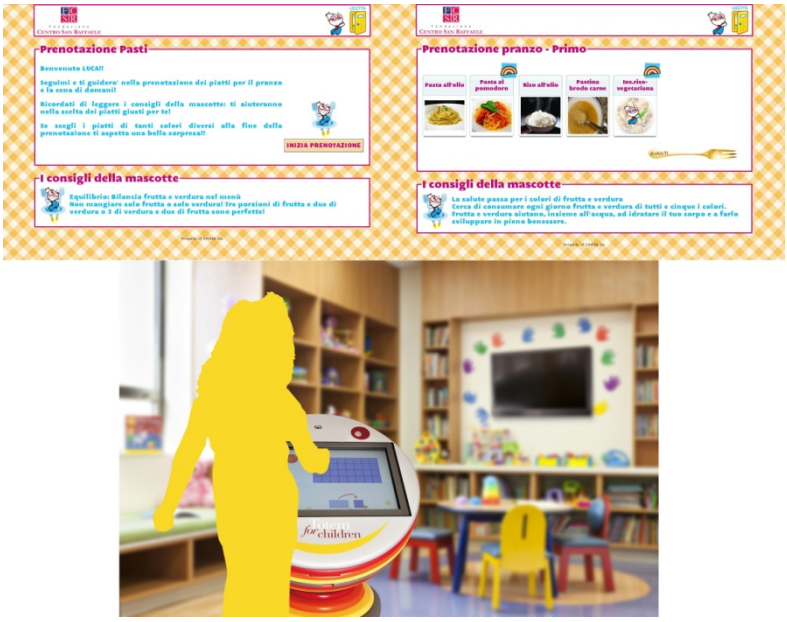

Fig. 8. 5 a Day interface and Interactive Totem

5 Conclusions and Future Developments

The main strategic prerogative for the growth of City of the Future Living Lab is without a doubt to strengthen relationships with partners that the eService for Life and Health unit has been able to create over time, as well as to create new partnerships and business models that reflect the changes in action.

From a technical and scientific point of view, there is the strive to refine even further the methodology adopted and the implementation of new tools, methods and competences able to sustain the Living Lab's evolution and ability to foster innovation.

The experiences made so far were related to heterogeneous activities (education, physical activity, nutrition, etc.), for sure a future evolution of the City of the Future Living Lab will be related to the integration of different kind of services, pervasively surrounding the patients in the different aspects of their daily life. At that point the full potential of the City of the Future Living Lab will be exploited, and it will be really able to design integrated, useful, and usable applications, interoperating data and services to seamlessly improve the health of the patients.

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