University of Cagliari

Department of Mathematics and Computer Science
PhD course in Computer Science

Ph.D. Thesis

Persuasive Mobile Systems Design to Help People be Physically Active

S.S.D. INF/01 - CICLO XXVI

Paolo Pilloni

Supervisors:

Prof. Salvatore M. Carta
Ing. Fabrizio Mulas

Academic Year 2012/2013

Contents

Acknowledgements

Paolo Pilloni gratefully acknowledges Sardinia Regional Government for the financial support of his PhD scholarship (P.O.R. Sardegna F.S.E. Operational Programme of the Autonomous Region of Sardinia, European Social Fund 2007-2013 - Axis IV Human Resources, Objective l.3, Line of Activity l.3.1.)

Unione europea
Fondo sociale europeo

REGIONE AUTONOMA DELLA SARDEGNA

FSE 2007-2013
POR
SARDEGNA
obiettivo competitività regionale e occupazione

Abstract

This PhD thesis puts forward the results of research activities I have carried out at the Department of Mathematics and Computer Science of the University of Cagliari since March 2011. My work can be placed in the general field of Human-Computer Interaction and, more precisely, in the relative new and trending area of Persuasive Computing. Broadly speaking, a persuasive system is a system designed to change some habits or behaviors of the users by means of persuasion.

My research activity sets out to address fundamental questions related to the application of mobile persuasive technologies to real-life problems, including: Are mobile technologies able to persuade people to a more physically active lifestyle? Are currently available systems actually effective? How can user experience design be improved in this class of softwares? How can human to device interaction be improved to favor users during their physical activities? Are these systems really effective over long time periods?

The research activity this thesis presents, aimed at answering at previous questions through the study of the effects of mobile persuasive systems designed to foster people to a more active lifestyle.
In literature, we can find many examples of prototypal persuasive mobile system. The results they reported are encouraging but, almost always, they are deducted from qualitative studies over short periods of time.
This work endeavors to overcome these limitations through the development of a real world complex software platform designed to encourage people to a more active lifestyle. Users interact with the platform mainly through two Android-based applications freely available on the market. Thanks to our platform, our experimentations can rely on a conspicuous base of real users and a huge amount of automatically recorded statistics for potentially unlimited periods of time.

Chapter 1

Introduction

I spent most of my time seated in front of a computer. I felt uncomfortable, I was not happy with my fitness level. At the end of the day I felt tired although, more and more often, I thought that it would have been nice to go out for some physical activity. Some years ago, I was given the opportunity to start working on a project related to mobile systems to foster sport and fitness. Some time later, after work, I started go out to test the features I was working on. I moved for real. I enjoyed It and I still enjoy it.

Computer Science, by its nature, can be simplistically defined as the science of using computers to solve real-life problems. As a computer scientist, I investigated and studied new methods applied to new technologies and their effectiveness to promote physical activity among people.

Several studies demonstrate that physical inactivity is a major risk factor for many health-related problems. Having a sedentary lifestyle, together with other unhealthy habits, can be the cause of a wide array of illnesses. Just to name a few: weight gain, high blood pressure, diabetes, high levels of cholesterol, depression, and many other chronic diseases. Keeping a healthy and active lifestyle, on the contrary, can help people to reduce the risk of the former diseases in addition to, for example, enhance the quality of their lives, to keep their weights under control, to increase their lives and many other benefits. How can be characterized a healthy lifestyle behavior? As stated in [1], a healthy lifestyle can be characterized as the combination of four protective behaviors: being physically active, a non-smoker, a moderate alcohol consumer, and having adequate fruit and vegetable intake.

Despite being physically active is essential for a healthy lifestyle, the adherence to long-term exercise routines is extremely rare among people. As reported by Fletcher et al. [2], only the 50% of individuals that start some kind of workout plan will continue to keep the habit for more than six months. This is a significant concern given that the human body can benefit from exercising only after a prolonged period of time. These problems have begun to capture the attention of medical scientists several years ago. In the last years this field has started to attract scientists from other disciplines such as psychologists, cognitive sciences and artificial intelligence experts and, thanks also to recent advances in technology, more and more computer scientists. Scientists are working together to find effective strategies to raising awareness about the dangers of a sedentary lifestyle and to encourage people to a steady and prolonged adherence to exercise routines.

As a HCI researcher, in the field of Persuasive Computing for health behavior change, I studied how to model and improve available systems to help people overcome previously cited problems especially through mobile technologies.

In literature, we can find many examples of research studies that aim at helping people in some positive behavioral change. Scientists working in different areas such as health, education, and criminology, are more and more often relying on new technologies to induce a positive change in human behavior. There exist many academic and commercial technological systems designed to help people be motivated to change their exercise habits. Some systems make use of new generation mobile technologies to motivate and to guide users to properly perform their routines. Indoor systems exploit traditional computers to augment users' workouts with digital content in order to make physical activity less monotonous.

In the last years, the most popular games consoles such as Microsoft XBox, Nintendo Wii, and Sony PlayStation have evolved to support ad hoc controllers to allow a new kind of active gaming experience where users are required to move for real to complete the game.

In most of the cases, the solutions based on mobile devices tend to persuade people to change their habits by means of exertion games (i.e., games in which users must move for real to accomplish a certain goal). In general, these systems exploit a fun oriented design together with the power of social relationships to foster positive behavioral changes. The basic idea behind the adoption of mobile devices as persuasive systems is simple: their spread is growing rapidly and it is somehow affecting people's habits. More important, they are relatively inexpensive, versatile, and ubiquitous that is, potentially available at any time and anywhere.

The research activities in which I am involved make deep use of mobile devices. This choice is dictated by the growing number of industrial products and academic studies and, most importantly, by the desire to further explore some aspects not addressed by academic research studies. To this end, an innovative software platform has been developed and it is still under development. Real users interact with this platform mainly through two Android-based mobile applications called *Everywhere Run!* and *Everywhere Race!*. *Everywhere Run!* (EWRun) main feature is the virtual personal trainer. The application is designed to act like a real personal trainer to guide users in real time during their running workouts in order for them to stick to a predefined pace. The application allows a bidirectional interaction between users and, differently from other solutions, it promotes also the interaction between users and real personal trainers. In this way, beginner runners can demand for a custom-tailored workout directly through the application to avoid common first-time mistakes. *Ev-*

erywhere Race! (EWRace) aims at persuading people by exploiting the social and ludic aspects of sport. The application allows users from all over the world to compete against each other in different sport activities based on speed. The application, in a completely innovative way, implements real time virtual competitions among users. A virtual competition is a race similar to a real one in the sense that it has a priori known start time and distance equal for all participants, no matter where they are. The application is designed to favor a strong social interaction among users through a wide array of social features available by means of the famous social network Facebook.[1] Currently, all the applications are freely available on the Play Store[2] and they count an average of more than five thousand users per month.

Thanks to the platform, this thesis presents qualitative and quantitative tests results conducted, for the first time ever for an academic project, over a great amount of real users, and, more important, it allowed us to derive design recommendations for the design of this class of persuasive softwares and to perform long-term studies on the effectiveness of mobile persuasive technologies on people's motivation.

In the following sections I will introduce the research context in which I operate: I will start with an quick overview of the broad field of Human

[1]www.facebook.com

[2]*Everywhere Run!*: http://goo.gl/mY7uLZ - *Everywhere Race!*: http://goo.gl/8xQWSZ

Computer Interaction to then treat more specifically two of its sub-areas to which this research belongs to: ubiquitous and persuasive computing.

1.1 Human Computer Interaction

Everyday people work or, more in general, deal with computers to accomplish some kind of activity. Quite often, the design of these systems and the interaction flow between humans and computers is not specifically designed in terms of usability and in terms of the tasks the users want to perform.

Broadly speaking, when people refer to the term Human-Computer Interaction (HCI) they usually think about the study and the methodologies applied to the design of the interaction between users and computers.

As often happens in many scientific fields, there is no universally accepted definition for the term human-computer interaction. Here I report some of the most popular definitions: Baeker and Buxton in their article [6] define HCI as a “set of processes, dialogues, and actions through which a human user employs and interacts with a computer”. For Long and Dowell in [7], HCI is “the design of humans and computers interacting to perform work effectively”, whereas for Hewett et al. [8], HCI is the “discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”. For Dix [5], HCI is defined as “the study of people, computer technology, and the ways these influence each other".

The term HCI became widely used thanks to the book *The Psychology of Human-Computer Interaction* written by Card, Moran and Newell in 1983 [4], although they first used it in an article published in 1980 [3].

Actually, as Dix in [5] reports, the origins of the term are older and stem from various and well-established disciplines. The performances of humans to complete a certain task was initially studied in the early 1900s with the growth of the industrial production. The Second World War accelerated the studies of the interaction between humans and machines to develop more sophisticated systems of attack. These circumstances led to the formation of the Ergonomics Research Society in 1949. Ergonomics (or Human Factors) deals with the study of physical characteristics of any system and their influence on users performances. In late 40s the computer era was not even at the beginning, but later when the computer became widely used, researchers of previous cited fields started studying more specifically the role of the interaction between humans and computers.

In the last years, HCI has been greatly influenced also by the introduction of new technologies such as portable devices. As we will see later in detail, these new technologies have greatly influenced this research area in the sense that they have favored new and unexplored contexts of interaction. HCI, although greatly influenced by Computer Science and Design, can be defined as a multidisciplinary research area. As its name suggests, it involves disciplines concerning on both the human and the machine side.

An HCI expert should ideally have knowledge on different fields:

- Computer Science: computer graphic for the design of the graphic design, programming languages, and operating systems for the design and the development of the software
- Ergonomics to define the design of the artifacts. From an HCI perspective, the objective is to design systems that favor the completion of a certain task with comfort and satisfaction for the user
- Psychology and cognitive science to understand the human mental processes that cause a certain behavior
- Linguistic, defined in [9] as "the scientific study of human language", to study the problems related to syntax and semantic of languages. This is relevant for the development of graphic interfaces rather than any other information flow provided to the user by means of a technological system
- Social Sciences to model the relationships between individuals and computers

Given the high number of disciplines involved in HCI, Dix in [5], stresses the importance of the teamwork stating that: "it is not possible to design effective interactive systems from one discipline in isolation.

Input is needed from all sides".

In the following I will provide an overview of the two research subareas of HCI to which this thesis belongs to, that is: *Ubiquitous* and *Persuasive Computing*.

1.2 Ubiquitous and Persuasive Computing

The term ubiquitous computing (nowadays also referred to as pervasive computing) was first introduced by Mark Weiser while he was working at Xerox Palo Alto Research Center (PARC) in 1988.

Weiser in [12] stated that "Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives". He envisaged "a new way of thinking about computers in the world, one that takes into account the natural human environment". In his vision, the computers should "vanish into the background" - "weave themselves into the fabric of everyday life until they are indistinguishable from it".

Weiser, always in [12], advanced also some technological proposals for ubiquitous computing ranging from wearable small devices called *Tabs* to meter sized screens called *Boards*. More than 15 years later, Poslad in [13], proposed new forms of devices for ubiquitous computation in pace with technologies available in those years:

- *Dust*: very small devices (nanometer-sized) without graphical interface built from micro electromechanical systems (MEMS)
- *Skin*: MEMS built-in in fabrics for the development of flexible surfaces
- *Clay*: a set of MEMSs disposed into 3D shapes

These are only some of the proposals that have favored the growing of ubiquitous computing (ubicomp) as a new paradigm of human-computer interaction in which the computation can happen at any time and everywhere. It is in contrast to the HCI desktop paradigm in which users start the interaction by sitting behind a desk aware of the task they intend to perform.

There is not an universally accepted definition or characterization of ubicomp. Indeed, since 1988, many scientists have attributed several names to this research area related to different contexts: calm computing [16], invisible computing [17], and pervasive computing [18] just to name a few.

According to Weiser's idea, ubiquitous computing means that the user can interact continuously with the computer, sometimes unconsciously, and by means of many different devices such as tablets, smartphones, new generation TVs and many others, by means of a number of underlying support technologies and protocols such as: internet, advanced operating systems, input/output peripherals, mobile protocols, positioning systems and so on. All models of ubiquitous computing are thought to be small, inexpensive, strictly interconnected, and available in all the scenarios of everyday life.

In [14] Satyanarayanan presents an example scenario of ubiquitous computation related to the project *Aura* developed at the Carnegie Mellon University. The project aims at providing each user with a number of ubiquitous information services [15]. Satyanarayanan depicts a realistic usage scenario in which Aura can operate: a woman called Jane is waiting at a certain airport's gate for her flight. While waiting, Jane is editing many large documents and she would like to email them through the Internet. Unfortunately, at her gate there is not much bandwidth available due to the high number of passengers connected to the Internet. At this point Aura comes into action: at first the service detects that Jane will not be able to send her documents in time for the flight departure and then it starts consulting the airport's weather service and flight schedule service discovering that in another gate not too far from the woman there is an excellent bandwidth available. At this point Aura informs Jane through a pop-up dialog that in a gate near to her there is enough bandwidth available. She accepts Aura's advice and walks to that gate while watching TV. A few minutes later, Aura informs the woman that her messages are almost all sent and she can start walking back just in time for her boarding call. This example put in evidence the unobtrusive and embedded nature of the interaction made available by pervasive technologies. These characteristics have favored its application in many areas such as health care, sport, and education.

In [19], authors propose to exploit low-power integrated circuits, wireless communications, physiological sensor nodes, and wearable health systems to improve health services. They propose a low-cost wearable wireless body area network architecture and a prototype to allow unobtrusive and continuous health monitoring in order to provide real time feedback to patients about their current health status and, at the same time, to allow a continuous monitoring by doctors since the system can transmit patient's medical data remotely through the Internet.

Ubiquitous computing technologies such as GPSs, accelerometers, gyroscopes, and cameras have favored many studies on how to use these technologies also in sport. Researchers are studying what are the most appropriate sensors and how to exploit them to improve athletic performance to prevent injuries and to improve rehabilitation. As an example, Akins in far 1994 [20], imagined and explained how computers could be exploited twenty years later to virtually play golf for preparing a real competition and also how they could help athletes to develop an optimal golf swing. There exist many other applications of pervasive computing technologies in sports. As an example: heart rate monitoring systems to help runners keeping track of their performance, eyetrackers to monitor athletes' gaze during the physical activity, systems that monitor athlete's heart rate in real time to adapt played music to his or her expected performance.

Almost together with the raise of pervasive computing and its application in previous cited fields, there has been the development of theories and techniques to exploit pervasive technologies to stimulate a positive behavioral change in people. These technologies are referred to as persuasive technologies.

The major theoretician in this area is B.J. Fogg that in [21] defines persuasion as "the attempt to change attitudes or behaviors or both (without using coercion or deception)" and persuasive technologies as "any interactive computing system designed to change people's attitudes or behaviors".

One of the first examples of persuasive technology around 1980, as reported by Fogg in [21], is a computer system, named Body Awareness Resource Network designed, to provide adolescents with options and directions for a healthier lifestyle. This kind of systems have had a huge development with the emergence of the Internet. Let us think, for example, to the famous e-commerce site Amazon: when an object is sold, the system records the buyer's preferences and, through advanced recommendation algorithms, it tries to persuade the customer by proposing similar items according to past purchases, feedback, and other similar items purchased by people considered similar to the buyer. This is just one example of use of such technologies. They found application in many other areas, such as: education, learning, safety, sales, politics, religion, fitness, health care, and environmental preservation among others.

To describe this emerging research area Fogg coined the term “captology” an acronym derived from the phrase “computers as persuasive technologies”. Captology results from the overlap of technology and persuasion and focuses on the “design, research, and analysis of interactive computing products created for the purpose of changing people’s attitudes or behaviors” by means of human-computer interaction rather than computer-mediated communication.

Fogg in [21], in order to clarify the concepts related to captology and persuasive technologies introduces what he calls the *functional triad* that is a conceptual framework that “illustrates the three roles computing technology can play: tool, media, and social actor” from the perspective of the user:

- Computers as tools: computers are seen as tools to help people be more productive as well as tools to allow certain tasks that would be impossible without a technological aid
- Computers as media: Fogg identifies symbolic and sensory computers as media according to the way in which they convey information to the users. Computers are symbolic media when they provide in-

formation through symbols (e.g., text, graphics), whereas they are sensory media when they provide sensory information (e.g., audio, video). He states that captology focus mostly on the second category since "computers have unique capabilities to provide interactive experiences that motivate and persuade".

- Computers as social actors: computers are seen as social actors or living entities by people in the sense that humans often interact with them as they were living creatures. Fogg reports the results of an experimentation conducted in 1990 were students used computers to accomplish a certain task. During the work, computers interact with users providing them with some advice and praises and, even though students were familiar with computers, they responded to them as if they were interacting with a real person. This demonstrates that people tend to treat computers as if they were other people, not machines

According to Fogg, the knowledge of this framework is essential to exploit the persuasive power of computers in the sense that the choice of a persuasion strategy will change according to the role played by the computing technology in the functional triad. When computers act like a tool they can influence people, for example, by facilitating a certain task that motivate, when they act as a medium they can persuade by means of compelling interactive simulations and, when computers act like social actors, they can exploit the same techniques used by people to foster a behavioral change such as through positive feedback and encouragements.

The rise of new generation mobile technologies has opened new frontiers for persuasion because, differently from a traditional desktop computer, they move with people and can persuade at the right time and context and, very important, allow users to interconnect in real time between them. According to Fogg [21], mobile technologies are able to exploit the *principle of Kairos* in the sense that they can offer suggestions to users at opportune moments given that they can know at any moment the user's current location, routines, and daily goals in order to intervene effectively only in those moments in which is possible to maximize their persuasive effect. Mobile technologies are almost always available and the interaction can be quick and instant so that they can exploit what Fogg calls the *principle of Convenience*: "interactive experiences that are easy to access have greater opportunity to persuade". Mobile applications must be easy to use (*principle of Mobile Simplicity*) and they have to be perceived by users as if they work to satisfy their needs rather than those of a third party (*principle of Mobile Loyalty*).

Another notable advantage of mobile technologies is their "connected nature". Nowadays, mobile devices are designed to interconnect people mostly through the Internet and, according to Fogg, this can be very effective in terms of persuasion since they can provide current (relevant at a certain point in time), contingent (relevant to users' needs), and coordinated (from different sources) information with respect to non-interconnected devices ("principle of Information Quality").

Interconnected devices, thanks also to social networks, can effectively exploit the so called social influence that is how an individual's behavior can be influenced by other people. Even though social influence is a broad field of sociology composed of many different theories, Fogg in [21] identifies four major principles that are relevant in the field of mobile connected persuasive devices:

- *Principle of Social Facilitation*: "People are more likely to perform a well-learned target behavior if they know they are being observed via computing technology, or if they can discern via technology that others are performing the behavior along with them"
- *Principle of Social Comparison*: "People will have greater motivation to perform a target behavior if they are given information, via computing technology, about how their performance compares with the performance of others, especially others who are similar to themselves"
- *Principle of Normative Influence*: "Computing technology can leverage normative influence (peer pressure) to increase the likelihood that a person will adopt [will avoid] performing a target behavior"
- *Principle of Social Learning*: "A person will be more motivated to per-

form a target behavior if he or she can use computing technology to observe others performing the behavior and being rewarded for it"

Connected mobile technologies in addition to exploit previously cited principles, can also take advantage from users' intrinsic motivation which, according to Ryan et al. [23], refers "to doing something because it is inherently interesting or enjoyable" that means that people do not need some external stimulus to perform some action or maintain a certain behavior. Related to intrinsic motivations, Fogg identifies three principles:

- *Principle of Competition*: "Computing technology can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to compete"
- *Principle of Cooperation*: "Computing technology can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to cooperate"
- *Principle of Recognition*: "By offering public recognition (individual or group), computing technology can increase the likelihood that a person or group will adopt a target attitude or behavior"

As previously stated, this thesis presents the results of the research studies conducted on a persuasive software platform that helps people be more active. Users interact with the platform mainly with two mobile applications that are able to guide and to motivate users during their workouts. Since from early design stages, we follow main principles proposed by Fogg to augment the persuasive power of the platform. As an example, both *Everywhere Run!* and *Everywhere Race!* follow the four principles related to connected products: the applications allow a strict interconnection between users and real personal trainers both by means of ad hoc web communities and social networks. Users can be followed in real time during their trainings both by a real trainer and other users (principle of Social Facilitation). The software is designed to provide real time statistics about the current performances of the user and those of other users and, in the case of a race, the most updated ranking is reported to augment the motivations (principles of Social Comparison and Normative Influence). The statistics and rankings of the whole community are collected and made available both through the web community and social networks and, in case of a competition, users are even able to follow an ongoing race in real time on multiple supports (principle of Social Learning).

Our persuasive infrastructure follows also the three principles related to intrinsic motivation previously presented. Especially in the case of the virtual races (note that in the future *Everywhere Run!* and *Everywhere Race!* will converge into a single mobile platform so that users can also compete while following a tailored training plan), the virtual real time race stimulates the competition through fun and social pressure (Principle of Competition). Thanks both to social networks and the web community people can create a competition among friends, or groups of friends can compete with other people and the resulting results with also top users statistics will be made available on all supported channels (mobile application, web community, and social networks) - (Principle of Cooperation and Recognition).

1.3 Thesis Goals and Contribution

All work presented in this thesis aimed at demonstrating how innovative persuasive techniques, built on top of new generation technologies, can be exploited in real life to help and guide people either to adopt or maintain a more active lifestyle. To this end, we designed and developed a complex software platform that is freely available and usable by anyone. Users interact with this platform mainly by means of two mobile applications. The first application called *Everywhere Run!* is designed to act like a real personal trainer in order to guide users during their running routines. The second, called *Everywhere Race!*, is an exergame that allows users to compete in real time distributed races. Both the applications give great importance to social relationships; in particular, EWRun favors the interactions between users and real trainers in order for the users to obtain custom tailored workout routines to train in total safety. EWRace too supports a wide array of social features by means of the social network Facebook but, differently from EWRun, the emphasis is on the interaction among users to favor fun and social pressure.

We have two main distinctive traits from prior academic work on this subject: since from the beginning we started investigating the effectiveness of this kind of supports on real world applications instead of prototypes and, more important, on real users that freely chose to use it. Nowadays, our experimentations can rely on a large number of real users and also to automatically collected anonymous statistics for potentially unlimited periods of time[3].

Summarizing the main results obtained so far, we demonstrated that EWRun, in addition to allow the interaction between users and real trainers and to proper guide users during their workouts, has favored an enhancement of users' motivation.

Both social and innovative exergaming features of EWRace have been proven to help people to start or maintain an active lifestyle.

We also put in evidence how a good/poor user experience is able to alter users' perception of the offered features and how it is directly related to motivation.

Thanks to the training experiences of our users we designed, developed, and tested with good results a new set of interaction features. This work gave us the opportunity to provide some guidelines that we believe

[3]Note that at the moment the system counts more than 5,000 active users and nearly 100,000 downloads. For the first studies the number of real users was significatively lower (little less than three hundred users).

will be helpful for designers of mobile persuasive systems.

The work I will present in next chapters have been peer reviewed and published. In particular, the work which presents *Everywhere Run!* and a preliminary study which investigates the impact of the virtual trainer on users' motivation has been published in [50] and its extension in [51].

The research in which we studied and evaluated the effects of the user experience in persuasive softwares has been published in [86], whereas an extended version in which we studied the impact of the user experience on people's motivation has been published in [87].

The experiences of real users allowed us to propose, to implement, and to evaluate an innovative set of interaction features that helped us to derive some design guidelines that aim at improving the interaction experience in mobile persuasive technologies (Note: this research is still a work in progress).

Finally, the work in which we presented and evaluated the impact of the innovative exergaming and social features offered by *Everywhere Race!* on users' motivation has been published in [57].

1.4 Outline

In the following chapter, I will provide an overview of the main health problems related to a sedentary lifestyle with also an overview of the studies and technological solutions proposed by academia and by industries to combat them. Finally, I will highlight the strengths of our proposals both in terms of innovative features introduced and in terms of the new evaluation scenarios our platform makes available.

In Chapter 3, I will provide a detailed description of *Everywhere Run!* and *Everywhere Race!* and the corresponding virtual communities.

In Chapter 4, I will present the results of a pilot study conducted on real users of EWRun to investigate the impact of its new features on motivation.

In Chapter 5, I will present a study which investigated on the influence of the user experience on users' perception of the offered features. Instead, another study investigated on the impact of the user experience on people's motivation.

In Chapter 6, I will present the interaction features we developed for EWRun inspired by the training experiences of real users and by the results of our previous studies. I will also present some interaction design guidelines we believe will be helpful to the designers of mobile applications designed for contexts in which users have limited possibilities of interaction.

In Chapter 7, I will present the results of an EMI-2 evaluation conducted on real users of EWRace. The study aimed at evaluating the influence of gamification through real time competitions and social interactions on users' behavior.

Finally, the Conclusion Chapter provides a brief summary of the work presented in this thesis. Moreover, it reports the current and future work for improving the platform and the new research scenarios these improvements will make possible.

Chapter 2

Related Work

2.1 Background on Persuasive Technologies for Sport and Health

A lot of medical studies report that in the last years there has been an alarming increase of many health problems such as obesity, type two diabetes, heart diseases, high blood pressure, and high blood cholesterol just to name a few. These studies put in evidence that people suffering these pathologies can benefit from regular physical activity. Researchers agree that a healthy lifestyle is a key factor for people well-being. They state that an active lifestyle, in addition to reduce the risk of the previous cited diseases, can help people to increase their chances of living longer, to stay at a healthy weight, to reduce the risk of depression, to reinforce muscles and bones, and many other minor mental and physical benefits (see, for example, [24][25][2][26]).

Despite these scientific results are quite known, millions of people worldwide conduct a sedentary lifestyle. The data collected by the World Health Organization (WHO) for the years 2008-2010 highlight that we are living in a mainly sedentary society. These statistics are clear on this [27]:

- In 2008 1.4 billion adults were overweight
- About 40 million children are overweight
- 65% of world population lives in countries where overweight and obesity kills more people than underweight
- 35% of adults aged 20 and over were overweight in 2008, and 11% were obese
- Obesity is preventable

The just cited report, along with other studies on the subject (see, for example, [28][29]), suggests some guidelines to be followed in order to overcome or prevent health problems. Here we report some suggested advice:

- Engage in regular physical activity

- Limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats towards the elimination of trans-fatty acids
- Increase consumption of fruits, vegetables, and legumes, whole grains and nuts
- Achieve energy balance and healthy weight
- Limit the intake of free sugars
- Limit salt (sodium) consumption

A regular physical activity is a leading factor for a healthy lifestyle. Fletcher et al. [2] report that only the 50% of people that start an exercise routine will continue to keep the habit for more than six months. This data is very meaningful given that the benefits of a regular physical activity occur only after long periods of time. This is the reason why scientists from various disciplines are working to develop new strategies and technological systems to help people both to initiate and to encourage long-term adherence to controlled exercise routines. Many of the proposed solutions share a common approach: the exploit of new generation technologies to persuade people to change their exercise habits.

Many systems make use of mobile devices, such as modern smartphones, equipped with applications designed to guide users during their training routines. There exist also several indoor systems that exploit common computers to enrich the exercise experience with digital content. The most famous traditional game consoles such as Microsoft XBox, Nintendo Wii and Sony PlayStation have been equipped with special controllers that exploit the movements of the users to play fitness games. They aim at transforming the gaming experience from passive to active letting the users move for real during the game.

In the next section, with no claim to being exhaustive, I will report some examples of studies and technological systems proposed both by academia and by industries belonging to the categories mentioned above designed to help and to motivate people during daily physical activity.

Finally, I will highlight the main strengths of our proposals both in terms of the novelty of the proposed features and the new evaluation possibilities that our platform makes available.

2.2 Related Work

In [30], Consolvo et al. present a mobile system called UbiFit Garden aimed at motivating mainly sedentary users to stay active. The system is composed of three main components: a *fitness device* that automatically detects and transmits the data of the physical activity performed both to the *glanceable display* and to the *interactive application*. The application stores all the information of the users' activities and provides a journal where users can add, edit, and delete the data of their activities. The display resides on the background of the device's screen and it shows an aesthetic representation of user's physical activities and attained goals in order to stimulate motivation. To display unobtrusively the current level of physical activity, the display uses the metaphor of a garden that becomes gradually luxuriant as the user performs physical activities throughout the week.

Preliminary results, derived from a three-week field trial with 12 testers, revealed that users were positively surprised by the novelties the application introduced and their responses helped authors to derive some guidelines for the design and the evaluation of this kind of systems.

In [31], IJsselsteijn et al. investigate on intrinsic motivation enhancement and technology factors for users of home exercise equipments. For their experimentation they realized a virtual coach system to help users while cycling on a stationary home bike. The users were asked to sit on the bike that was placed in front of a wall screen where a virtual coach and a landscape were projected. Authors measured both users' heart rate in order to control virtual coach's cues and average speed as one of the indicators of the level of motivation.

Authors show that users who exercise at home can benefit in terms of motivation while exercising on a highly immersive environment. They report also a good users reaction to the stimuli provided by the coach and derived some important results about the way the users perceived the information provided by the virtual coach during the trainings.

In [32], is presented a commercial console game called Your Shape Fitness Evolved designed to help and motivate users during indoor workouts. The game, among other features, allows users to exercise by means of training plans designed by experts, to design a custom workout, to keep track of training statistics, and to socialize and to challenge other users by means of a virtual community.

Chittaro et al. [33] propose a mobile location-based exergame based on the classic Snake mobile game in which the snake is guided by users' movements. The work aims at encouraging users to walk more frequently, at introducing new metrics for the evaluation of this kind of mobile games and finally, at demonstrating the effectiveness of the proposed solution through the adoption of standard questionnaires mainly used in the medical field.

From the results obtained through well known and used evaluation tools (e.g., GPAQ, PACES, and PES) they outline how users' behavior and lifestyle can be positively influenced by the enjoyment resulting from this kind of games.

Toscos et al. [34] present Chick Clique, a preventative health mobile application that aims at helping and motivating teenage girls to stay active by exploiting social dynamics typical of adolescence. By means of a pedometer, users count the steps taken to measure their physical activity level and then input this data on the application together with the amount of food consumed. The application fosters a positive competition among small groups of friends and provides feedback to them by sending standard text messages at opportune times in addition to provide tailored nutritional tips based on the amount of steps taken at a certain moment.

The results obtained from a preliminary pilot study show that thanks to the application users have acquired more awareness about the importance of food and physical activity for a healthy lifestyle.

Oliveira et al. [35] propose a mobile phone application called Triple-Beat. The application is designed to help runners to reach predefined exercise goals by stimulating their motivation through musical feedback, a glanceable interface to augment users' personal awareness, and virtual competition. The application exploits an ECG and an accelerometer to let users create their exercise routine in terms both of a desired heart rate and the number of desired steps per minute. The application then monitors in real time the data coming from these devices in order to select the most appropriate music to proper guide users during the training.

Their experimentation revealed two important facts: a well-designed graphical user interface is a key factor to enforce users' motivations, whereas virtual competition and social influence favor a more enjoyable training experience.

In [36], authors present a persuasive mobile application called Houston. The prototype makes use of a pedometer to count, to record, and to share within a small group of friend the results achieved by a user in order to motivate the others to a more active lifestyle.

From their qualitative experimentation the authors derived four key design guidelines to be followed by this class of persuasive systems:

- Users expect to have thorough measures and long term statistical reports of their activities
- Provide personal awareness of activity level
- Support for social features to improve users' motivation through a friendly competition
- Take into account the comfort of proposed solutions

Hoysniemi et al. [37] illustrate the results of an online questionnaire conducted on a dance exergame called Dance Dance Revolution. The aim of the game is simple: the user must step on a dance pad according to the directions provided by the game and then he or she is rewarded according to the precision and the timing of his or her steps. More that 500 people responded to the questionnaire that investigated primarily on: players' gaming background, skills, motivational and user experience factors, and physical effects of dance gaming.

Obtained results stress the positive influence of gaming especially on sedentary people with respect to motivational, physical, and social factors.

In [38], authors study the effects of mobile guides in fitness activities. To this end, they developed a PocketPC application called Mobile Personal

Trainer (MOPET) that exploits GPS device and vocal cues to monitor current user's position in order to guide and to motivate him or her during the execution of the exercises.

Authors evaluated the effects of the system on a sample of 12 users. The data collected during the evaluation put in evidence the effectiveness and the potentialities of the new approach at helping users to correctly perform their routines with respect to traditional systems.

Jayant et al. [39] study the effects of using human movements as game controller. To achieve this, they developed a mobile application called MarioFit in order to allow users to play the Nintendo game Mario Bros on a PDA. The system is able to count the steps taken by the user and to compare his or her game scores with those of his or her friends.

From their experimentation they derived that it is possible to play the game using user's movements as game inputs and that such a kind of active gaming experience can be of help to motivate people be physically active.

In [40], authors present a fitness game for mobile phones called Monster & Gold. The application is designed to guide and to motivate users to jog outdoors at a controlled intensity. The software, through a Bluetooth pulse oximeter, is able to determine the user's heart rate, whereas the user's position is acquired through the GPS device. By exploiting these information together with the help of a sport physiologist and a professional trainer the application can guide users to maximize cardiovascular benefits. The game shows users a virtual trail that moves proportionally to the distance covered for real by the user. From time to time virtual monsters, gold, potions, and others elements appear along the path and then disappear. The elements appear at predefined moments to push users to run at a correct intensity in order for them to collect beneficial elements and avoid the others.

From the two experimentations performed authors derive that the application is a valid support for users to favor cardiovascular exercise.

In [41], authors present an exergame called Jogging over a Distance to conduct a series of experiments investigating how social and exertion interactions can affect users while training at a distance. The application exploits a wireless heart rate monitor that allows users to measure their heart rate in real time and also to input a desired heart rate intensity in order for them to specify a physical effort (in terms of that intensity) best suited for their physical skills. By means of a remote server the system elaborates the heart rate data in order to modify the 2D position of the audio sent to the jogging partner according to their current performance. If the two runners maintain the heart rate at the level they had previously specified, they can hear the audio of the partner as if they were jogging side-by-side.

The results obtained from a qualitative study put emphasis on the importance of social interactions for exertion activities in addition to provide some guidance for designers that aim at facilitating social experiences in exergames.

Berkovsky et al. [42] propose an innovative game design to help motivating people to change their sedentary playing habits. They try to motivate users to be more active by means of virtual rewards they can gain only if they perform some physical activity during the game. The design they proposed is achieved by modifying some components of the game and the interaction between players and the game environment. As an example, they proposed to: modify the game to allow virtual rewards to motivate physical activity, provide an external activity monitor to users in order to calculate the proper virtual reward, and play the game by means of a modified game controller designed to favor the active gaming experience. They implemented their design recommendations in an exergame called Neverball and evaluated it through an empirical test on 180 participants.

The main results obtained revealed that the game helped users to be more active by augmenting the total amount of active gaming.

Along with academic studies and proposals, there exist several commercial products designed to support and motivate users during their training routines.

Nike+ [43] is one of the most popular mobile applications designed to support people during sport activities. Some of its main strengths are: the advanced vocal cues and music management system, the availability of several features to allow the interaction with social networks, the support of a web community where users can create their training plans and socialize with other people, in addition to the possibility to enrich the training experience through ad hoc devices specifically designed for the application.

Along with Nike+, there exist several other commercial examples of such a kind of applications. Just to name the most popular ones: Adidas miCoach, Endomondo, MapMyFitness, RunKeeper, and Runtastic (see Section “Bibliography” for the references). All these systems provide more or less the same core functionalities:

- Route and workout data tracking
- Detailed physical activity reports
- Social interaction and results sharing through social networks and ad hoc communities

With respect to the state-of-the-art proposals, our platform, by means of *Everywhere Run!*, offers for the first time the possibility to encourage physical activity by promoting interactions between users and real personal trainers also through an ad hoc community. The community is designed to favor a positive social interaction in addition to allow users to perform their training routines monitored by skilled persons. Other existing solutions are designed to focus mainly on the interaction between the user and the application relying almost exclusively on “artificial intelligences”. They can be engaging but can not provide the same support that a real qualified trainer can offer.

Everywhere Race! too offers several innovative features. The active gaming experience is favored through distributed real time races. Indeed, the software offers users the opportunity to compete and to interact through Facebook during real time virtual races that follow the same rules of the real ones. Other existing solutions motive users mostly by comparing their current performance to their past ones or those of their friends. The application most similar to EWRace instead, offers the possibility to race but not following the classical rules of a real race (see [49]).

In addition to the innovative persuasive techniques proposed, our platform differs substantially from other similar academic proposals. Since from the beginning, we focused to design systems that would be effectively used by real people rather than prototypes with a limited set of features and not actually used by real users. After nearly three years of hard work, the most part of the platform's components are available for free through popular distribution channels.

Nowadays, we count more than 5,000 real users that train by means of the platform. This set us apart from traditional academic research studies since a non-prototype product give us the opportunity to automatically collect a great amount of usage statistics from real users and also to rely on a fair number of beta tester users that constantly helped and are helping us for our experimentations.

Chapter 3

The Persuasive Platform

As repeatedly mentioned in the previous chapters, the objective of my research activity is to study, to develop, to propose, and to investigate by means of experimentations on a high number of real users the effectiveness of our new methods to foster healthier behaviors in people through sport.

To this end, me and my colleagues, starting from the study of available academic researchers and prototypes, have developed and are currently developing a complex persuasive software platform that makes deep use of nowadays most widespread technological media: mobile devices, Web 2.0 technologies and social networks.

From users' point of view, the interaction with the platform during the physical activity takes place by means of two mobile applications called *Everywhere Run!* (EWRun) and *Everywhere Race!* (EWRace).

EWRun is designed to impersonate a real personal trainer. The virtual personal trainer aims at guiding users step by step in real time during their trainings in order for them to adhere to a priori defined training plan.

By means of a web community, the application allows the interactions between users, and most important, between users and real personal trainers. In this way, the application favors social interactions and makes it easy for beginner runners to obtain a tailored workout plan directly from a real personal trainer seamlessly inside the application to start their activity in a safe and controlled way.

Recently, the backend part of the platform has been extended with a new set of functionalities (in testing phase at the moment) that allow to profile the current running abilities of the user in order to automatically build a customized entry-level training plan available in few seconds to the mobile application. This feature will allow us both to investigate how users react in terms of engagement and motivation, and at the same time, to offer an additional (and costless) option to further reduce the barriers that usually are hard to overcome especially for sedentary people.

EWRace, differently from EWRun, is designed to persuade people to a more active lifestyle by exploiting fun and social pressure typical of group sports. Differently from other applications, it allows people to create virtual races and to compete against each other in real time wherever they are in the world. The application implements a realistic concept of race: a distributed virtual race is identical to a real one with the sole exception of the geographical position of users. Like a real race it has a priori known start time and the race distance must be covered by all participants only from that start time.

In addition to the mobile application, users can interact with the platform also through a web community that allows them, for example, to keep track of their trainings, to follow a race in real time, to create and to subscribe or unsubscribe from a race, to consult both the statistics of the whole community and those of their friends and many more. Both the mobile application and the web community strictly depend on a web service that implements all the features available to users. The web service, in turn, depends on the social network Facebook to provide users with all the social features they can use by means of the mobile application and the web community.

This has been just a quick overview to introduce the main components of the platform available so far. One thing important to note is that the two mobile applications and respective communities have been designed to be a single entity, and only due to the huge amount of work needed to create a real product different from a prototype (typical of the academic works on persuasive technologies) we decided to split the functionalities to reduce the time to market in order to quickly start the experimentations. We are currently working on merging the two applications in order to augment users' motivation to either start training or train more regularly by exploiting the fun and social effects of the virtual competitions.

In the following I will give a detailed description of all the components directly available to users: the mobile applications and the respective web communities.

3.1 Everywhere Run!

Everywhere Run![1] is designed to act like a virtual personal trainer to guide users step by step during their running routines. The application offers a wide array of features in order to provide a flexible and comprehensive tool suitable for both beginners and advanced users.

In the following I will provide a description of the application through a possible navigation flow a user can take while interacting with the application.

Once the application is started, the user is shown the main dashboard (see Figure 5.1). The screen is divided in two sections: the upper section reports the total distance covered, the total amount of training time, and the total number of trainings performed so far, whereas the lower one reports the speed respectively for the fastest, the average, and the slowest workout. Finally, a message at the bottom of the screen reminds the user the date of the last training session performed.

The "Free Workout" is a mode designed to let both occasional users to run without the need to obtain a customized training plan and let begin-

[1] www.everywhererun.com

Figure 3.1: Main dashboard screen

Figure 3.2: Free workout screen

ner ones become familiar with the software. The upper part of the screen (see Figure 3.2) reports the total time elapsed, the total distance covered, the average, and the instantaneous speed for the last kilometer (or mile), whereas the lower part reports the same statistics for the whole workout.

The "Guided Workout" mode allows users to create quite complex training plans and gives them the possibility to organize their trainings for several days/weeks or, for example, to load a preexisting plan. Through the workout creation screen (see Figure 3.3) users can plan relatively complex regimes like the one, called monday "Monday", shown by the figure. Each training is composed of several "sessions", called "traits", and for each of them it is possible to define the distance and the pace (or speed)

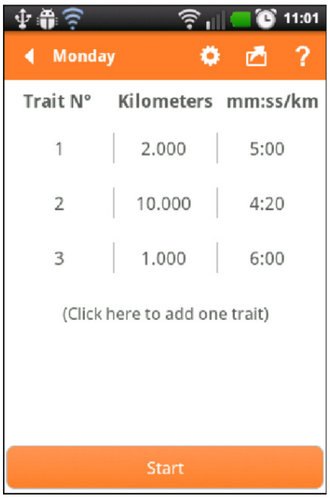

Figure 3.3: Workout creation menu

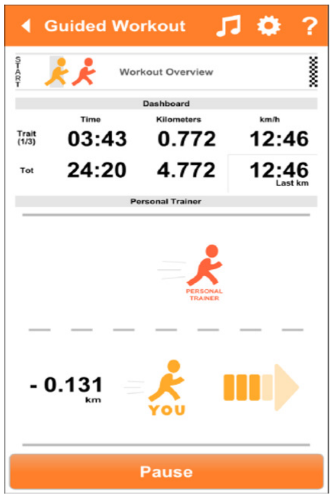

Figure 3.4: The virtual personal trainer

the user wants to keep. A training session can have as many as desired traits or just one. For example, in the workout depicted in Figure 3.3, the "trait 1" means that the user wants to run 2km at a pace of 5 minutes per kilometer (note that runners generally express the speed as the time to run one kilometer or mile). After the first trait follows the "trait 2" where the user intends to run 10km at a higher pace with respect to the previous trait. Hence, the application offers a great flexibility allowing users to define quite complex regimes in order to satisfy even the most demanding ones.

As mentioned above, the most important feature of EWRun is its ability to act as a virtual personal trainer. Indeed, it is able to guide and to motivate the runner through the whole workout in such a manner for him or her to meet his or her goals (i.e., the objectives defined in terms of distance and pace (or speed) to keep as set in the workout creation menu - see Figure 3.3). This is achieved using an intuitive application interface (in addition to vocal cues) where the user can eventually get at a glance all needed information while running. In Figure 3.4, it is possible to observe the ongoing workout screen and how the virtual personal trainer feature works. In Figure 3.4 is depicted the virtual personal trainer represented by the orange stickman in the bottom part of the screen. The virtual trainer behaves as a pacemaker (note: in reality, a pacemaker has the task to keep the pace for other runners). The user, virtually represented by the yellow stickman just below the trainer, has just to follow the trainer's directions focusing only on the run.

In the topmost part of the screen a horizontal band depicts an overview of the whole workout and the actual position of the runner with respect to the virtual personal trainer (note that this is possible because the workout length is known a priori since it has been defined in the workout creation screen - see Figure 3.3). Just below the band, a dashboard reports the current speeds, the distances, and the times regarding both the current trait and the whole workout. The big arrow on the right (see Figure 3.4) signals to the user if he or she is keeping the right pace. It changes its orientation according to the current position of the user with respect to the virtual personal trainer and it will be proportionally filled according to the current performance of the user. In the scenario depicted in Figure 3.4, the

Figure 3.5: Workout history menu

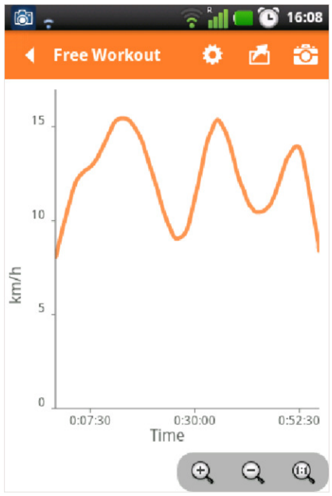

Figure 3.6: Cartesian graph of a workout

user is not keeping the desired pace (he or she is more than one hundred meters behind the trainer) so the arrow is filled to signal that he or she has to speed up in order to reach the coach and consequently to keep the desired pace.

The application allows users also to keep track of all the statistics of their past trainings. From the dashboard screen (see Figure 5.1) it is possible to enter the "Workout History" screen (see Figure 3.5) in which the user is presented a list of the previous completed workouts. For each of them the date, the time, the total distance covered, the speed, and the total duration of the training are reported. Each workout (element of the list) is further clickable to open another screen in which for each trait of the workout both the expected and the actual distance and speed are shown. In addition, the user is also offered the possibility to open both the map corresponding to the training in which he or she can view the followed path and a Cartesian graph (see Figure 3.6) that reports on the horizontal axis the time and in the vertical one the speed maintained during the training.

3.2 Runners and Personal Trainers Community

Social interaction is fundamental to motivate people either to start or exercise more regularly. As mentioned in the previous section, our platform encourages the interaction among runners and between runners and personal trainers. In this way, we aim at favoring social pressure and also giving users the opportunity to share their training plans. Through the community beginner runners can easily get a plan from other most experienced runners or they can buy a tailored one directly from a qualified real trainer at a lower cost (users are not forced to meet the trainer frequently). All this is possible thanks to the web community I will describe hereinafter.

The very first version of the community[2] is based on an extended and customized version of the famous content management system Word-

[2] www.ewr.altervista.org/0vE0lNUr/wordpress/

Press.[3]

By leveraging the native functionalities of WordPress, users in the community are given a role by the site administrator in order to establish what actions are allowed for each of them. Except for the administrative roles, a user can be an "editor" that is, a user that can publish and manage his or her own posts including those of other users. An "author" is a user that can publish and manage only his or her own posts, whereas a "contributor" is someone who can write and manage his or her own posts without publishing rights. Finally, a user with "subscriber" role can only manage his or her own profile. Each user, regardless the role, owns a profile in which can enter personal information such as, for example, first and last name, his or her contact information, and can express also some customization preferences.

Users are allowed to write articles containing text, images, and other multimedia contents, to add, edit, or delete a comment from an article or reply to comments from other users. All the articles will be publicly available only after an authorized user has approved them; they are published by date and categorized so that users can search for them according to a category and/or publication date.

The default features have been extended with publicly available plugins both to model the community according to the domain needs and to

[3] http://wordpress.com/

provide users with more flexibility. In particular:

- Private messages: each account now has an associated mailbox useful to favor deeper personal relationships
- Validation of new accounts: each new created account must be validated by an administrator. This feature is useful to verify users' identities (especially for users that claim to be personal trainers) in order to avoid the proliferation of fake accounts typical of "open" communities

I come now to describe the most important domain-specific features that have been developed from scratch that is, neither natively supported by the framework nor available through some available plugin:

- User profile information: users are given the opportunity both to request to the administrator to be accredited as a personal trainer and to make public their email address. Users have also more control over their personal information: for each personal information category, they are now able both to specify different privacy rules and to choose, for example, whether or not to make publicly available their personal profile
- Trainings support features: the framework has been extended to allow trainers to create and to send a tailored training plan to a user. Training plans can be of two types: basic or advanced. Basic

trainings, as already said in the previous section, are composed of a series of traits expressed in terms of a pace/speed and a distance, whereas an advanced one is composed of several basic trainings distributed over one or more days or weeks. Training plans can be sent either to a registered or an unregistered user: the former can receive a tailored training plan (codified in an XML file) both through email and through his or her personal area, whereas the latter can only receive a plan through email

- Reputation management: once a user receives a training plan he or she can leave a comment and vote (also for several times) the personal trainer on a scale of 1 to 5. In this way, personal trainers can build their reputation (as is the case of several famous e-commerce sites) and users can look for a trainer basing their searches also on trainers' reputation
- Availability on multiple devices: a web service has been developed in order to expose all the features of the community for future availability on multiple platforms and devices

3.3 Everywhere Race!

Everywhere Race! (EWRace)[4], as stated in the previous sections, is a persuasive mobile application that tries to motivate users by promoting active

[4]www.everywhererace.com

gaming and social interactions. It allows users from all over the world to compete in real time against other users in different sports based on speed such as running and bicycle. Its most important and innovative feature is the real time virtual race. Such a race is similar to a real one in the sense that it has a priori known start time and total distance equal for all the participants wherever they are in the world.

The software offers users several social features in order to encourage and to favor social interactions by exploiting the social experience offered by Facebook. Users, by means of the application, can easily look for races where their friends are enrolled in and join them, cheer friends up while racing, create a new race and invite a friend to that race, and look for the results of friends' past races and many more.

Once a user creates or chooses the race that best meets his or her preferences, he or she has only to wait till the start time of the race. Some minutes before the race start the application begins a countdown that is the same for all the participants.

During the competition EWRace both records and reports to the user his or her statistics - such as the total distance covered, the elapsed time so far, the average speed/pace, and the current position in the competition - and those of the other participants in terms of position and distance gap from him or her as in a real race.

When the race finishes that is, all the participants either have covered the race distance or have abandoned the race, the application, by means of the web service, establishes and publishes the final race ranking with finishing positions, times, and speeds as in a real race offering users also the possibility to post their result on their respective Facebook profiles. EWRace offers another innovative feature: users can create a virtual race and associate it to a real event such as, for example, a marathon. In this way, people that can not take part to the real event can virtually join it and compete against all other participants. For example, imagine to take part at the New York Marathon without being physically there, perhaps running in your city park or even on your treadmill.

In the following I will provide a more detailed description of the application currently available on the Google Play Store through a possible navigation flow a user can take while interacting with the application.

Once the user logs in using his or her Facebook credentials, the first screen users come across is the "Main Menu" (see Figure 3.7). At the top of the screen an alert message is shown to the user to inform him or her that the application is querying the web service for retrieving his or her most imminent races. If there is a race starting in less than 30 minutes the application automatically begins the countdown (see below), whereas the remaining time to the most imminent race is shown on the bottom part of the screen if there is not a race within half an hour. In the example of Figure 3.7, the next user's race will be in a little more than a day. From this screen the user can create a new race and share it through Facebook, perform a search for existing ones based on common attributes (such as

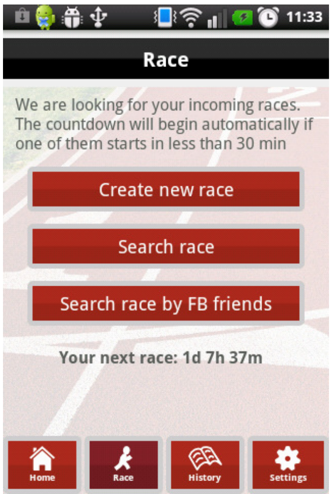

Figure 3.7: Main menu

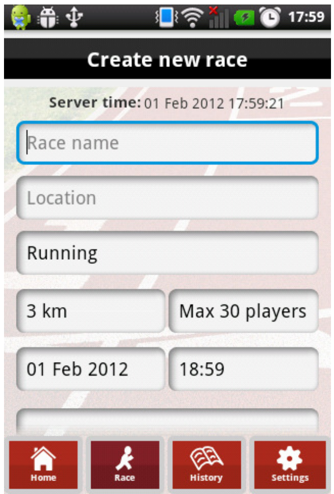

Figure 3.8: Create new race menu

the sport, the distance, and the starting time), or search for races in which his or her friends are involved in.

Through the first button of the "Main Menu" screen the user accesses the "Create new race" menu depicted in Figure 3.8. From this screen it is possible to create a new race by choosing the desired parameters such as, for example: the name, the length, the start date and time, the maximum number of allowed opponents, and the sport. The user can also decide to post the information of the race on his or her Facebook wall in order to inform his or her friends that a race has been created. As stated above, the application allows two kinds of searches: in the first type the user can perform a search according to a set of parameters (see above) and, in

Figure 3.9: Search results

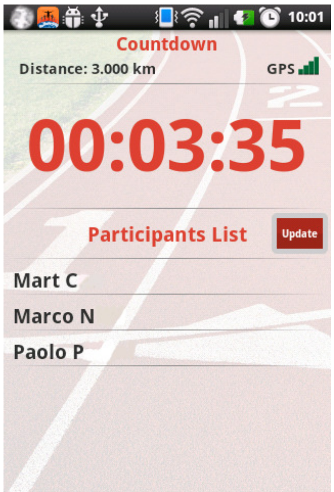

Figure 3.10: Countdown menu

the second type, the user can search for races in which one of his or her Facebook friends is enrolled in. An example of search result is shown in Figure 3.9. For every returned race (item of the list) that matches the query parameters is shown respectively: the remaining time to the start of the race, the sport, the start time and date, the length, the number of opponents enrolled in so far, and the state of the race that, in the example in Figure 3.9, is "past race" for every returned race (this state means that all the races are already started). In addition to these information, the user can also obtain additional details about a race by tapping on the corresponding item. These are all the steps needed to create/find an existing race in order to enroll on it; let us speak now about the most important feature provided by EWRace, the real time race.

As stated above, a countdown will automatically start if the next user's race begins in less than thirty minutes (see Figure 3.7). Figure 3.10 shows that case: the next user's race will start in little more than three minutes. From this menu the user is able to: download the list of the other users that will participate to the race and post the race on Facebook to inform his or her friends in order to listen to eventual comments to that post during the race.

Note: to avoid possible misunderstandings, till the end of this section, the word "user" will be used to refer to the user of the current mobile device and the word "opponents" will denote the remote users that are challenging the "user".

Figure 3.11 shows what the user sees during a race. The most important visual information needed while racing is reported in this screen (note that audio feedback are also available). Starting from the topmost part of the screen, the user can see the race nominal distance and some other data like the GPS signal strength and a legend in which are reported the meaning of the colors that may appear while racing to signal the state of the opponents (for example, if an opponent abandons a race his or her corresponding entry in the list of all the opponents will become yellow-colored). The rest of the screen shows a snapshot of a running race at a certain point in time. In this particular case (see Figure 3.11) it is reported the state of the race among three opponents at about two minutes from the start. The first

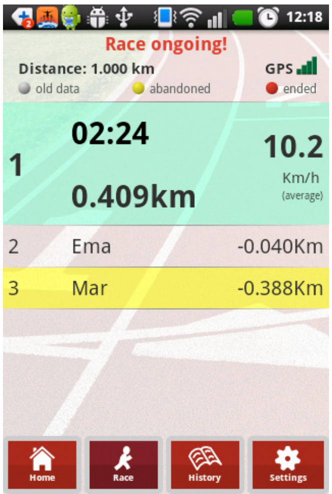

Figure 3.11: Ongoing race

Figure 3.12: Race results

row reports the data of the current first player. In this case the first player corresponds to the current user and this is why his or her row is bigger than the others. The cell reports the user's position, the race time, the covered distance so far, and the average speed. The other two rows show respectively the race statistics for the current second and third opponent with their gap (expressed as a distance) from the user.

As soon as the current user covers the whole race distance, the race for him or her is finished, just as it happens in a real race. At this point, the user can decide whether or not to publish his or her result on Facebook. Finally, as depicted in Figure 3.12, EWRace shows the actual classification that can be temporary if there are some opponents still racing or definitive

Figure 3.13: Races history

if all the opponents ended the race.

As in the case of EWRun, the user can maintain detailed reports of all his or her past races. Through the “Races History” menu (see Figure 3.13) the user can download the list of the races he or she have participated in starting from the most recent one. For every returned race are shown respectively: the sport of the race, the start date and time, the distance, the number of opponents and, through a colored spot on the right, the state of the race (the meaning of each color is clearly indicated by the legend shown at the top of the screen). Each cell is in turn clickable to access the ranking screen of that race. This feature gives users also the opportunity, in case the race is still ongoing, to follow in real time the evolution of the challenge and to interact with the participants by means of Facebook.

3.4 Racers Community

The race management system comprises a web community that allows users to interact with the whole system also by means of devices equipped with a web browser. The web application, by means of some of the functionalities exposed by the web service, has been designed to support and port to web browsers some of the features related to a race that in the past where available only through *Everywhere Race!* mobile application (e.g., the creation of a race, the subscription/unsubscription, or the possibility to follow a race in real time without taking part in it).

The web application aims at offering users an improved social experience by making available to them several innovative social features by means of the Facebook social network. In this way, users can share their experiences with their friends, engage new friends or socialize with other people and, most important, they can keep their motivation high for longer time periods.

In the following I will describe the web application architecture and how it can interact with the mobile counterpart (see Figure 3.14). The user side includes both the Android and the web version of the application. By means of the mobile application users can access all the features implemented by the web service related to the races, like the creation, the subscription/unsubscription, and the active participation to a race among the others. The mobile Android application continuously sends and re-

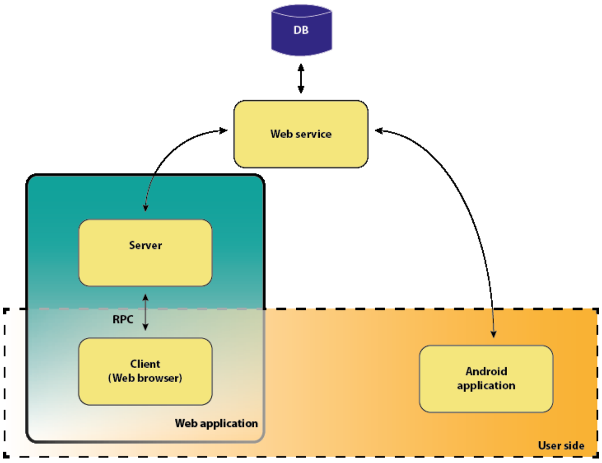

Figure 3.14: Overall architecture

ceives the data of all the users who joined a certain race from the web service. Among these data there are: the distance covered so far, the elapsed time, their position and the geographic coordinates and so on.

The web application can access all the features previously mentioned except to those related to the active participation to a race. Like the mobile app, it requests to the web service the data generated by the users currently racing in order to allow, for example, other users to follow in real time a certain race directly from a desktop computer. As shown in Figure 3.14, the web application is internally divided into two main parts: the client that is executed by the web browsers and the Server. The data generated by the user through the web browser are sent to the server by means of a remote procedure call (RPC) and in turn, they are forwarded from the server to the

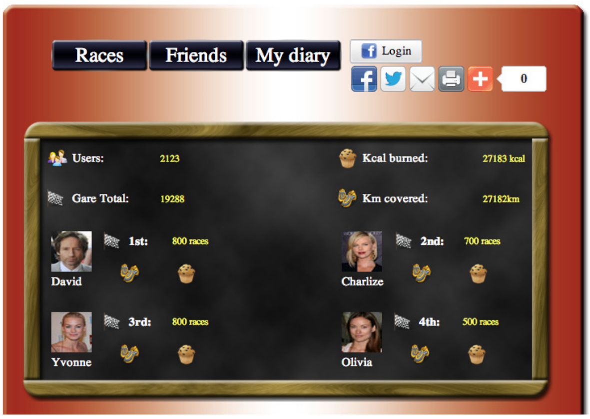

Figure 3.15: Main dashboard

web service which elaborates and stores them in a database. In a similar way is handled the data flow from the web service to the web client: the client, by means of the server, makes a request to the web service (e.g., the list of current available races), and the web service in turn responds to that request sending the corresponding data to the server that forwards them to the requesting web client.

In Figure 3.15 is possible to see the main menu of the web application. In the top left part of the screen a menu composed of three buttons offers to the user three choices, respectively: "Races", "Friends", and "My Diary". The content of these three sections, according to the user's choice, is shown below the "dashboard" area that is, the black area just below this menu. The dashboard (starting from the top) shows the total number of users in the community, the total number of races performed so far by all the users, the calories burned, and the total distance covered by the current logged in user. The content of the dashboard will change according to the button pressed by the user (see above):

- “Races” button: shows the races related to all the users
- “Friends” button: shows the races of the Facebook friends of the current logged in user
- “My Diary” button: shows all the data of the races for the current logged in user

The top right part of the Figure 3.15 shows the menu that allows users to login and to logout using Facebook, whereas by means of the other buttons it is possible to interact with several other social networks.

The top part of Figure 3.16 shows the search feature that allows users to search for already created races through a set of constraints such as: the sport, the start date and time, the distance and so on. Just below the search area, a menu shows the available races subdivided by state (i.e., ongoing, finished, and future). This list will also change according to the button pressed on top of the screen (i.e., “Races”, “Friends”, and “My Diary”).

The button “Create race”, just above the list of available races, allows to create a race by inserting all the required attributes of a race such as for example: the race name, the place, the distance, the maximum number of participants and so on. For every returned race the user can also decide to

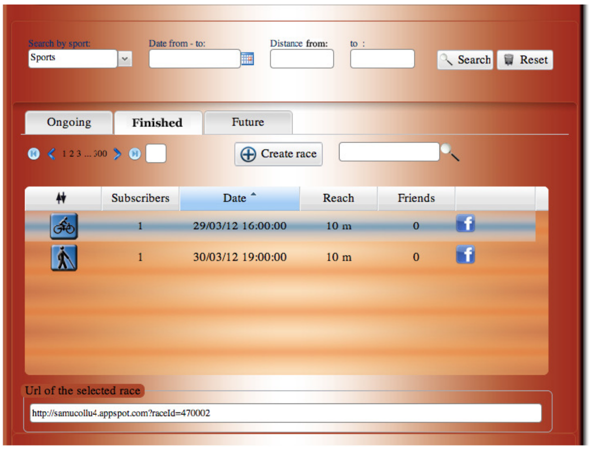

Figure 3.16: List of races

post the race on his or her Facebook profile by means of the button with the Facebook logo on the left of each entry. The selection of a race from the list makes available to the user the URL of the race (bottom part of Figure 3.16) in order to quickly share the details of the race by copying its URL. Moreover, the other information associated to the race are shown under the URL area (see Figure 3.17). This section is divided in three parts:

- "Details": contains the details of a race (i.e., the name, the description, the date, the place, and the distance) in addition to the list of user's Facebook friends involved in that race
- "Rank": shows the list of the participants to the race and, for each of them, it is reported the current or arrival position in the race, the state of the race, the elapsed time so far, and the total distance covered. By

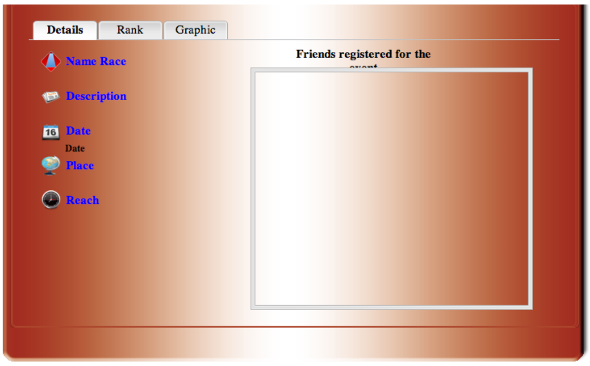

Figure 3.17: Details of a race

means of this subsection users can also watch a temporary or a final ranking according to the state of the race (i.e., ongoing or finished)

- “Graphic”: shows the evolution of a race through a graphic

In order to favor social influence among users, the web application allows to create different Facebook posts according both to the state of the race and the participation of the user in that race. Through these posts the web application motivates users in several ways such as: by motivating the current logged in user thanks to the comments and likes he or she might receive from his or her posts, by pushing sedentary users (friends of the current logged in user) to start exercise or, for active users, by augmenting their motivation to improve the performance.

For more details on the platform see [88] and [89].

Chapter 4

Everywhere Run! Preliminary Evaluation

4.1 Introduction

Everywhere Run! is a mobile Android application that aims at motivating and supporting people during their running activities (see Section 3.1 for more details).

The most common reasons that lead people to be sedentary generally are: motivational lack, time constraints, difficulties to start training, high membership fees, equipment costs, and so on. Running can in part address some of the above obstacles to start exercising. It does not require special equipment, there are not any fees to pay especially for amateurs runners, and it can help to overcome time constraints given that it can be done at anytime, anywhere.

One of the biggest barriers beginner runners face is about the way they should train. Questions like "how much distance should I run?", "how many times a week?", "how do I warm up?", "what pace should I keep?" are quite common to come across in specialized websites, blogs, and running magazines. Often people do end up designing their workouts on their own, perhaps exposing themselves to serious consequences. Indeed, it is quite easy for beginner runners to overtrain. In most of the cases they then feel tired and stop working out labeling running as "too tiring". Instead, if they persist training in an incorrect way they can incur in pains and injuries (as various types of tendinitis). In any case they may stop training, a situation that it is mandatory to prevent for a healthy lifestyle.

Our mobile application, as stated in the previous chapter (see Section 3.1), addresses this scenario fostering a social interaction between runners and real personal trainers so that the former can get a workout plan specifically tailored for their needs. Thus, it makes it easy to start running and avoiding common errors cited above. By means of the application a personal trainer is able to build a tailored and detailed running regime and send it to a user by email. The latter will receive his or her tailored running regime inside the application, seamlessly. Then the application, by means of the virtual personal trainer (see Section 3.1 for more details), will assist the user as if a real personal trainer were there with him or her, assuring he or she will run the proper distance at the right speed. Hence, a beginner runner does not have to worry about anything else but just focusing on the run.

As in many other sports, also in running, the social aspects are very important. Indeed, several research studies demonstrate that social interactions motivate people to exercise (see, for example, [34][36][38]). Running (or more in general performing any other physical activities) under the constant support of a qualified personal trainer is much more motivating and safe too. Nevertheless, many people avoid this possibility for economic reasons or just because they do not want time constraints (users must meet the personal trainers). The ideal solution would be to have a personal trainer available everywhere every time he or she is needed, for free. This is obviously an unreal scenario. EWRun is designed to address these circumstances: it allows users to get in touch with a real trainer and to obtain a custom tailored workout regime in order to instruct the virtual personal trainer that is available anytime, anywhere. The real personal trainer still needs to be paid, but given that it is not strictly necessary to meet with him or her, some of the costs are cut down and it should lead to cheaper fees.

In this chapter I present the results of the first pilot study we conducted to investigate the very first version of the application just after its launch on the Google Play Store. Thanks to a group of beta tester users, we were able to evaluate the usability of the application and to conduct a survey to evaluate how users perceived the application. Obtained results demonstrate that users consider the application a valid support tool and gave us also the opportunity to correct several usability issues.

This work has been published in [50] and an extended version in [51].

4.2 Experimental Results

In this study we performed some experiments both to evaluate some characteristics of the application (like motivational aspects and innovative features) and to test its overall usability.

Subsection 4.2.1 describes the usability tests and their results. Subsection 4.2.2 reports the results about a custom survey that has been conducted to evaluate some characteristics of the application.

4.2.1 Usability Tests

We performed some usability tests in order to discover potential misbehaviors and features to improve. They basically consisted on observing users while interacting with the software.

As stated in [52], in most of the cases large scale usability tests are not necessary especially if the product under evaluation is not mature enough. In these studies are reported the experiences of several real projects where authors notice that the best results (also in terms of costs and resources) came from iterate as many as possible usability tests on no more than five

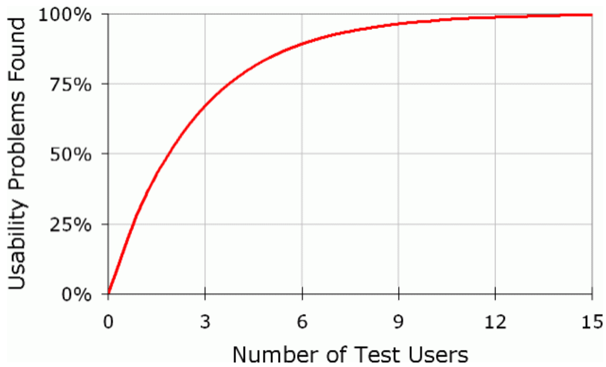

Figure 4.1: Number of usability problems in function of the number of testers [52]

users. Nielsen and Landauer in [53] state that the number of usability issues found during a test with *n* users typically follows the trend showed in the Figure 4.1. The graph in Figure 4.1 shows that a single user is able to identify almost a third of the design problems. The second user will find some of the same problems identified by the first user in addition to new issues and so on with the remaining users. In general, new information tend to drastically decrease starting from the fifth user onwards. When little information is added, the best thing to do in order to avoid a waste of resources is to redesign according to users insights and reiterate the usability test.

In [54], the author reports the results of three experiments that show how the identification of usability problems in an evaluation test is related to the number of testers. The results helped the author to derive that four or five users are enough to identify about the 80% of usability issues. More than five users will add very few information given that the most important problems are likely to have been already discovered by the group of four or five users.

Our tests mainly focused at evaluating:

- Performance: it evaluates the time needed to complete a single task
- Accuracy: it measures the number of mistakes made by a user
- Emotional response: it estimates the user satisfaction

For our experiments we chose five people with an age ranging from 20 to 35 and with some experience using smartphones. Only two people were expert runners while others were just occasionally joggers.

We instructed the group with a quick overview about the application but without giving them any explanation about its usage. Then, in order to assess the application usability, users were asked to perform some operations, such as creating a workout, editing it, and so on.

Observing their interaction with the application we were able to detect and to correct some troubles. In general, our testers reported a positive evaluation about the software usability (using a rate scale from 0 to 5, we scored an average rating of 3.8).

The application resulted very intuitive for experienced runners. On the other hand, at the first submission, two inexperienced users came across some difficulties while creating a workout. The cause of the fault was the unit of measurement. Indeed, runners are used to indicating the speed as time to run one kilometer (or mile), for example 5:30/km (5 minutes and 30 seconds per kilometer). This misled the two above users that interpreted it as the time to run the whole workout distance. As a consequence they created an incorrect workout. We then corrected this source of troubles putting the more usual speed unit of measure (i.e., km/h or mi/h) as the default one and adding a better explanation of the other unit. As a consequence, at the following resubmissions, users do not encounter the same difficulties.

4.2.2 Software Evaluation

To evaluate the software's capabilities we submitted a survey to a group of ten runners that tested EWRun for three weeks. The group consisted of five males and five females with an average age of 28.3. Only four users were used to exercising regularly. We asked them to rate the application with regard to several characteristics. The score ranged from a minimum of 0, meaning "strongly disagree", to a maximum of 5, meaning "strongly agree". Figure 4.2 shows the characteristics under valuation and the corresponding results. As it is possible to see in Figure 4.2, the average rating for the whole application was 3.8. Users said that EWRun had been very useful to support their workouts. In particular, they preferred audio cues over visual advice pointing out that the former are handier while exer-

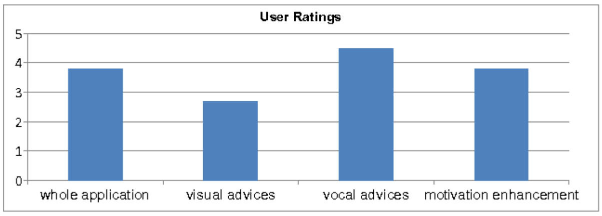

Figure 4.2: Users' ratings

cising. Indeed, vocal advice were found absolutely necessary scoring 4.5. With regard to motivational aspects, the rate was 3.8. Runners noticed that working out with our application is more engaging. The just discussed results suggest us that the software is perceived as a valid support tool that greatly helps runners to follow their predefined training programs.

4.3 Conclusions

In this chapter I presented the very first evaluation of *Everywhere Run!* conducted a few months later its release on the Google Play Store.

We performed a pilot study with a group of ten people in order to assess the impact of the software on the user's motivation to exercise. The results of this evaluation revealed an average enhancement of the motivation among participants. Thanks to the support of the application they reported to train more often on average with respect to the past.

By means of usability tests we were able to detect and then correct some design mistakes such as the unit of measure used by default during the creation of a training plan.

The results presented here have been very important to favor the development of the application. Users' insights gave us the opportunity to understand what would have been the next features to be designed. As an example: the support of heart rate monitors (currently supported in a development version of the software) and the support of social interaction also by means of the most famous social networks in addition to the custom community of runners and trainers.

This work has been published in [50] and an extended version in [51].

Chapter 5

User Experience Design Implications on Users Motivation

5.1 Introduction

Everywhere Run! is a mobile application that aims at helping people to stay active behaving like a virtual personal trainer (see Section 3.1). With respect to other persuasive proposals our approach promotes interactions between users and real personal trainers through a community of runners.

Preliminary results confirm that real users appreciate the application and that it is perceived as a valid mean to foster motivation (see Chapter 4). Nevertheless, application usage statistics suggest that a great set of features, although innovative, are not enough if the whole design has not been realized with a special attention to user experience. This assertion follows from radical changes we made to the early design of the application. We moved from a relatively simple and not user centered design to a better one following common standard usability guidelines and some Android design recommendations [70]. As a result, we observed a considerable increment of the user base and, as a consequence, of the total number of daily trainings even if there were no notable functional improvements. For these reasons, we decided to evaluate the new design and its possible implications on users' motivation.

In this chapter I present the results resulting from the comparison of the two designs in terms of usability obtained by means of an A/B test conducted on 40 real users through two standard System Usability Scale (SUS) questionnaires [63] (one questionnaire for each design under evaluation [64]). Moreover, since user experience seems to be able to influence users motivational sphere, we started investigating its impact on users' motivation thanks to a sample of 30 beta tester users that responded to a custom questionnaire and to a well known motivation assessment tool.

Obtained results demonstrate the usability goodness of the new design with respect to the old one both statistically and in terms of users' perception. Preliminary investigation on motivation seems to confirm our intuition concerning the influence of user experience on individuals' motivations. The good results obtained so far suggest that the offered functionalities without the right design are not enough to attract and to motivate people especially for a long time period. To the best of our knowledge we are the first, in the field of mobile persuasive technologies, to show similar results for a real world application constantly used by hundreds of users everyday.

This work has been published in [86] and a version with extended tests in [87].

5.2 Application Redesign

The redesign of the application has followed some of the design guidelines proposed in [36]. To this end, we introduced a new home screen (see Figure 5.1) that reports the aggregate statistics of user's trainings such as: the total distance covered, the total number of workouts, the average speeds and so on.

Figure 5.2 and Figure 5.3 show the workout creation screen respectively for the old and the new design. Through this menu it is possible to plan relatively complex regimes like the one, called "Monday", shown in the two figures: the training is composed of several "sessions", called "traits", defined in terms of distance and pace (or speed) to keep. For example, trait 1 (see Figure 5.2 or Figure 5.3) means the user wants to run 2km at a pace of 5 minutes per kilometer (note: runners generally express

Figure 5.1: Application dashboard

speed as the time to run one kilometer or mile). Trait 1 is followed by trait 2 where the runner expects to run 10km at a higher pace than before (4 minutes and 20 seconds per kilometer). Hence, EWRun permits to define quite complex regimes in order to satisfy even the most demanding runners. Both designs offer the same features in terms of training design complexity, although the new one is very different in terms of usability (note that the following consideration holds for all of the screens of the new design): global application settings have been made available in this screen, whereas many other options local to the screen have been moved from the bottom of the screen to the topmost bar as suggested also by the new Android design guidelines. This allows us to give more homogeneity to the navigation between screens and to keep many locally available func-

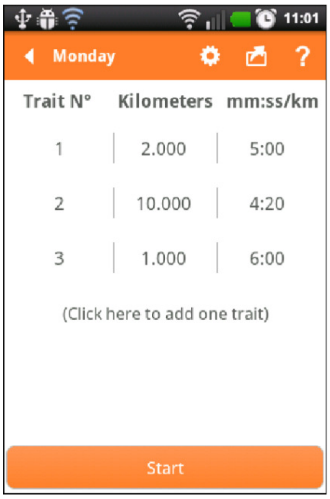

Figure 5.2: Old workout creation menu Figure 5.3: New workout creation menu

tionalities grouped in the top bar rather than scattered all over the screen.

As already emphasized, the most important feature of EWRun is the virtual personal trainer. Thanks to this functionality, the application is able both to guide and to encourage the runner during the whole workout in order for him or her to reach predefined goals (i.e., the goals set by means of the workout creation screen, see Figure 5.2 or Figure 5.3). This is achieved both through real time audio cues and by means of an intuitive interface where the user can get all needed information at a glance, while running. In Figure 5.4 and in Figure 5.5 it is possible to observe, again for the old and the new design, the ongoing workout screen and how the virtual personal trainer feature works. The Figure 5.4 (note, again, the features are the same

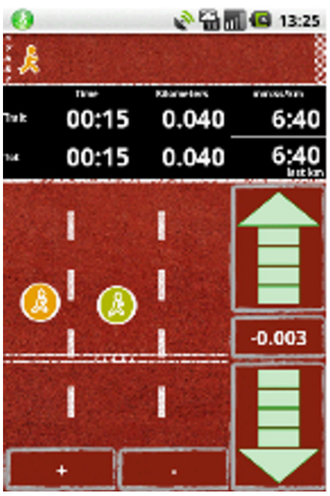

Figure 5.4: Old personal trainer screen

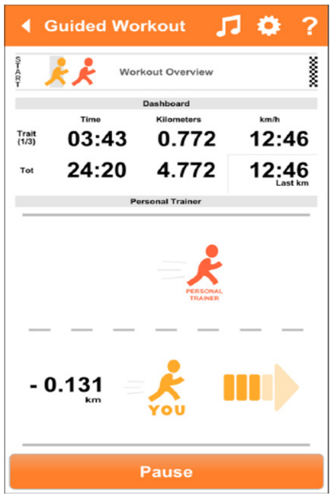

Figure 5.5: New personal trainer screen

in both cases) shows the virtual trainer represented by the orange icon in the left center of the screen. The virtual trainer has the role of a pacemaker (note: a pacemaker is a runner that leads the race to keep the pace for other runners) so that the user (virtually represented by the green icon in the center of the screen) has just to follow him or her focusing only on the run. In both designs, the topmost part of the screen contains a horizontal bar to give user an overview of the whole workout (note that the workout length is known a priori since it has been defined in the workout creation screen) with the actual position of the runner with respect to the virtual trainer. Just below the bar there is a dashboard that reports current speeds, distances, and times regarding both the current trait and the whole training session. The two buttons in the bottommost of the screen (only for the old releases) allow to zoom in/out the part of the whole workout depicted in the central part of the screen. This was supposed to make it easier for the user to estimate the current distance to the trainer (see below).

In the old design the two big arrows in the right side of the screen suggested to the user if he or she has respectively to slow down or to speed up. In between the arrows, the current distance of the runner to the trainer is clearly indicated. Furthermore, the two arrows will be alternatively filled proportionally to the need of slowing down or speeding up. Hence, the user knows at any moment his or her current performance level with just a quick glance at the screen.

All that can be observed in Figure 5.4. The figure depicts a runner just 3 meters behind the virtual coach, thus none of the arrows is filled to signal that the user is keeping the proper pace.

Now, we are going to further explore the differences between the two designs: in addition to the aforementioned bar at the topmost of the screen (see Figure 5.5), used both to improve the navigability and to more evenly group both global and local options, we focused our efforts to redesign the portion of the screen that depicts the user and the virtual coach during a training session (i.e., the "personal trainer" area in the lower half of Figure 5.5). We decided, thanks also to some advice from beta testers, to simplify the various components originally present. At first, in addition to a general graphic improvement, we switched the "personal trainer" area from a vertical to a horizontal orientation to be consistent with the whole workout perspective at the topmost of the screen. Secondly, the zoom in/out buttons have been removed since they seem to cause some troubles when used during a training and finally, we removed one of the two arrows. Indeed, now there is only one arrow that changes its orientation accordingly to the current position whit respect to the virtual personal trainer. The distance gap between the user and the trainer is now near the icon representing the user, in its left. In this way, we keep user data as compact as possible, also decreasing the total number of shown elements, for an improved readability.

5.3 Experimental Results

The new design of *Everywhere Run!* caused a statistically significant user base growth. As a result, we decided to compare the two designs by means of a standard testing methodology known as A/B testing [65].

Let us start by describing the application usage statistics that inspired us to conduct this study and, afterwards, we will describe in more detail the above technique and the mathematical tools we used for the experimentation.

Figure 5.6 shows the number of weekly workouts (by all users) performed with the old and the new application design. The data have been collected over a three months period, from November 2012 to January

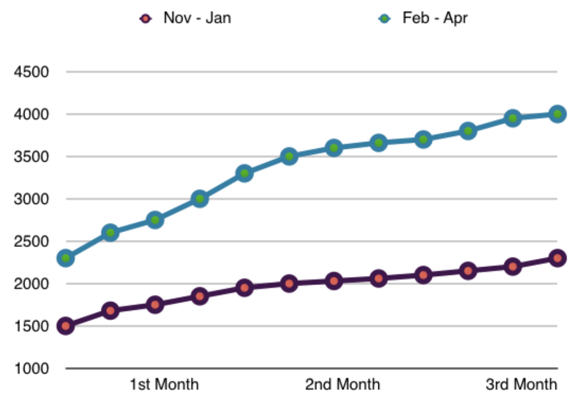

Figure 5.6: Number of trainings with old (Nov 2012. to Jan 2013) and new design (Feb. to Apr. 2013)

2013 for the old design and from February to April 2013 for the new design. The graphic (see Figure 5.6) shows the number of trainings passing from about 1500 of the 1st of November 2012 to about 2300 (+53%) at the end of January 2013. In general, there is a positive growth rate but much lower when compared to usage statistics for the next three months. With the introduction of the new graphic design in February 2013 (again there were no new features offered) the number of trainings passed from about 2300 to about 4000 (+74%).

Now we are going to explain the A/B test we conducted. A/B testing, also known as split testing, is a widely adopted technique typically used to compare two design variants (A and B) of the same system. Amazon was probably the first industrial entity to adopt this procedure to evaluate the user experience of its marketplace. Differences between version A and version B can range from completely different layouts to, for example, the font type, the different disposition of a button and so on. The goal of the evaluation is to identify some changes that can increase a certain metric of interest.

The test has been conducted using the System Usability Scale (SUS) questionnaire [63]. SUS is a well known tool (it counts more than 600 citations [66]) used both by industries and by academics. It is technology independent and it has been used to test web sites, hardware, consumer software and much more. The questionnaire is composed of 10 questions with 5 response options. Each question is rated using a Likert scale ranging from 0 ("strongly disagree") to 5 ("strongly agree"). We conducted our experiment with a sample of 40 users that used both application versions. The sample was composed of 34 males and 6 females with an average age of 35.8 years (standard deviation was 10.4 years). All the users regularly practiced sport at an amateur level and they all have had at least a previous experience with applications to support physical activity. Table 6.1 reports the results obtained by the SUS questionnaire.

For our experimentation we adopted the method proposed by Sauro et al. [65] to prove what the statistics suggest (see Figure 5.6). Often, in many research fields (HCI is no exception), the population mean and standard deviation are not known so it is not possible to use the Empirical Rule and z-scores (see [67] and [65]). Under those circumstances it is used a paired

Table 5.1: SUS Mean Scores

	New Design	Old Design	Difference
Mean	**86.3**	**59.5**	**26.8**

t-test (see [68]) to compare how a limited number of testers perform in two different test conditions. In particular, a paired *t*-test will allow us to determine if the difference between SUS score means for the two designs is significant or not. To calculate the test statistic t the formula 5.1 is used:

$$t = \frac{D}{\frac{S_d}{\sqrt{n}}} \tag{5.1}$$

where: D is the mean of the difference scores, S_d is the standard deviation of the difference scores and n is the sample size. In our case (see Table 6.1), D is equal to 26.8, S_d is equal to 15.621, and the sample size (n) is 40. From the Formula 5.1 we obtain a value for t equal to 18.85. Is this value statistically significant? To answer this question we have to look up the *p*-value [69] using the *Student's* distribution table with n-1 (39) degrees of freedom. The table give us 2.415×10^{-13}. This very small value tell us that the SUS scores for the two designs is different with a probability very close to 100%. This result confirms us that the difference is statistically significant but, is it significant enough for users so that they will notice it? The confidence interval around the difference will answer to this question.

The formula 5.2 is used to determine the confidence interval.

$$D \pm t_{\alpha} \frac{S_d}{\sqrt{n}} \tag{5.2}$$

where: D is the mean of the difference scores, n is the sample size, S_d is the standard deviation of the difference scores, and t_{α} is the critical value for n-1 degrees of freedom. For a 95% confidence interval and 39 degrees of freedom t_{α} is equal to 2.07. Plugging in all the values in Formula 5.2 we get 26.8±5.006. In other words, we can be 95% confident the actual difference of scores is between 21.8 and 31.8. These results confirm our initial intuition and demonstrate that the new design usability is better both statistically and in terms of users perception.

To further investigate if the new design was positively influencing users' motivation, we conducted a preliminary custom survey over a sample of 30 beta tester users. The sample was composed of 24 males and 6 females with an average age of 34.9 years and standard deviation equal to 9.2. All testers used both the versions of the application for at least 6 months and they all exercised regularly at least one time per week. We asked to them to report how many times per week they generally exercised both with the old and new version of the application. The results are shown in the Table 5.2. Table 5.2 reports that the average number of trainings per week is 2.10 for the old design (standard deviation 1.09) and 2.77 for the new design (standard deviation 1.13). Thus users exercised, on average,

Table 5.2: Exercise frequency per week

	Old Design	New Design	Difference
1	1	2	1
2	1	1	0
3	1	3	2
4	2	2	0
5	1	3	2
6	2	4	2
7	3	3	0
8	1	1	0
9	2	3	1
10	3	2	-1
11	2	2	0
12	5	5	0
13	2	4	2
14	1	1	0
15	2	4	2
16	4	4	0
17	3	4	1
18	1	1	0
19	4	4	0
20	3	4	1
21	1	3	2
22	2	1	-1
23	1	2	1
24	3	3	0
25	3	3	0
26	1	3	2
27	2	2	0
28	1	3	2
29	2	2	0
30	3	4	1
Mean	**2.10**	**2.77**	**0.67**

about 32% more often with the new application version. These data seem to support our intuition even if they are referred to a short period of time (indeed, assessing user motivation would need years rather than months). In order to further validate these preliminary encouraging results, we decided to conduct another evaluation on the same group of 30 beta testers presented above. Always with the intent to figure out whether and how user motivation has been affected by the redesign, we used the Exercise Motivations Inventory - 2 (EMI-2) [60]. It is a questionnaire composed of 51 items subdivided into 14 scales. Each item is rated using a Likert scale ranging from 0 (which means “not at all true for me”) to 5 (which means “very true for me”). Users where asked to compile one questionnaire for the new version and another for the old version. The graph depicted in Figure 5.7 reports, for the new design, the mean values obtained for each scale. As it is possible to see, all the scales received good average scores (3.8 out of 5 is the lowest value) with a total average score of 4.2 out of 5 (for the new version) with respect to the old version scored 3.9 out of 5 (see Figure 5.8).

In conclusion, although a stronger and reliable evaluation would require years instead of months and many more testers, we can be rather confident that our case study shed new light on how a good user experience design can be a critical factor for the engagement and the motivation of users.

Figure 5.7: EMI-2 results for the new design

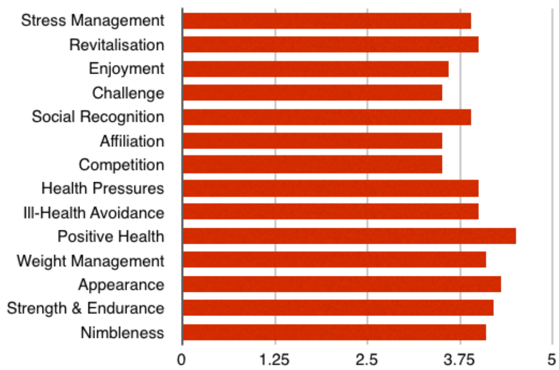

Figure 5.8: EMI-2 results for the old design

5.4 Conclusions

In this chapter I presented the results of two experimentations we conducted on a total of 70 real users of *Everywhere Run!*.

The experimentation was inspired by real users reactions to the user experience redesign of the application. As a consequence of the redesign, we observed a remarkable user base growth even if the application was not offering any new notable features. To analyze this fact, we decided to compare the usability of the early and the new design. We conducted a test on 40 real users that used both versions by means of a standard and well known methodology which uses a SUS questionnaire. Positive results led us also to investigate the relationship between user experience and motivation through a pilot study conducted on 30 real users by means of a custom questionnaire and a well known motivation assessment tool.

We obtained encouraging results that confirmed our hypothesis: innovative features may not be enough to motivate and correct users' behavior especially if the user experience is not taken into great account. Anyway, the impact of the user experience on individuals' motivation still needs further studies to investigate the trend of motivation over a period of time not smaller than two or three years.

This work has been published in [86] and a version with extended tests in [87].

Chapter 6

Interaction Design Guidelines for Sport Mobile Systems

6.1 Introduction

Everywhere Run! is an Android-based mobile application that, by means of a virtual personal trainer, aims at encouraging and guiding people to a more active lifestyle (see Section 3.1).

Past studies and evaluations of the application (see Chapter 4 and 5), real users experiences, and insights along with results from studies on how to help people with visual impairments gave us the opportunity to study and to develop an innovative interaction model to enhance the user experience during a workout. In such situation the interaction between humans and devices is a key factor to favor exertion. This kind of limited interaction can be somehow compared to the interaction that people with visual impairments is forced to have while interacting with some sort of technological device. Indeed, runners during a training must have an immediate and as flexible as possible interaction with their devices. This led us to introduce a set of new features to improve the interaction capabilities of the system and consequently the exertion experience. We give users the possibility to activate the vocal synthesis system to reproduce predefined training statistics on demand with simple touch gestures as well as the possibility to follow virtual trainer's cues by exploiting haptic impulses.

In this chapter I present some interaction design recommendations and the proposal of new interaction features inspired by real users feedback. The main contribution of this work is the proposal of a core set of interaction design guidelines and, for some of them, a practical usage scenario. All the proposals presented here aim at helping sport persuasive technologies designers to augment the usability and the persuasive power of their systems to push users be more active over long-time periods.

This research is still in progress hence I will report the preliminary results obtained so far.

6.2 Related Work

This section reports some studies and technological gesture-based systems designed to improve the accessibility of a mobile device in different contexts.

Guerreiro et al. [74] developed NavTouch a gesture-based text-entry method designed to aid vision-impaired users with mobile devices equipped with touch screens. Using NavTouch, people navigate the alphabet by performing directional gestures on the screen. To complement navigation, special actions (such as "ok" and "erase") are available on screen corners.

Kane et al. [81] developed Slide Rule, a set of accessible multi-touch audio-based interaction techniques for touch screen interfaces that enable blind users to access touch screen applications. Slide Rule provides a completely non-visual interface that repurposes a touch screen as a "talking" touch-sensitive surface. Slide Rule uses a set of four basic gesture interactions: 1) a one-finger scan to browse lists, 2) a second-finger tap to select items, 3) a multi-directional flick gesture to perform additional actions, and 4) an *L*-select gesture to browse hierarchical information. Slide Rule requires a standard multi-touch screen and audio output, but no additional hardware.

Negulescu et al. [75] analyse the relative cognitive cost of motion, tap, and surface gestures as input for smartphone devices under conditions of light distraction. They show that, for both walking and eyes-free input, the cognitive cost of motion gestures (measured as a function of reaction time) is statistically indistinguishable from the cognitive costs of tap and surface gestures. As a result, motion gestures represent a viable input alternative for situations where eyes-free input may be required.

Li in [76] presents Gesture-Search a tool that allows a user to quickly access various data items on a mobile phone by drawing gestures on its touch screen. Indeed, modern mobile phones can store a large amount of data, such as contacts, applications, and music. However, it is difficult to access specific data items via existing mobile user interfaces.

Ruiz et al. in [82] describe the results of a guessability study for motion gestures which elicits natural gestures from end-users as follows: given a task to perform through the device (e.g., answer the phone, navigate in a map and so on), participants were asked to specify a motion gesture that would execute that task.

Ashbrook and Starner in [83] presented MAGIC, an interactive system for exploring and designing motion gestures. MAGIC encourages iteration in design, provides facilities for retrospection of input, and allows the designer to test the created gestures against a corpus of activities to ensure that the gestures will not be unintentionally activated by a user.

Kane et al. [79] conducted two user studies that compared how blind people and sighted people use touch screen gestures. They found that blind people have different gesture preferences than sighted people, including preferences for edge-based gestures and gestures that involve tapping virtual keys on a keyboard. In addition, they also found significant differences in the speed, size, and shape of gestures performed by blind people versus those performed by sighted people.

Ruiz and Li [80] present DoubleFlip, a motion gesture designed as an input delimiter for mobile motion-based interaction. The DoubleFlip gesture is distinct from common motion gestures available on a mobile device. Based on a collection of 2,100 hours of motion data captured from 99 users, they found that DoubleFlip recognizer is extremely resistant to false positive conditions, while still achieving a high recognition rate. Since DoubleFlip can be easily performed and unlikely to be accidentally invoked, it provides an always-active input event for mobile interaction.

The most famous commercial mobile persuasive applications, similarly to the previous versions of EWRun, support users during a workout mainly with timed audio cues and visual cues. To the best of our knowledge, only Nike+ [43] offers on demand audio cues with aggregate statistics of the current activity activated through a 2D gesture. Differently from Nike+, our application is able to provide different statistics by means of different 2D gestures in addition to the capability to exploit haptic impulses to provide virtual trainer's cues to users.

6.3 Interaction Design Guided by Feedback from Real Users

Over the years, we have received much feedback from real users of the application. Some of them complained that the virtual personal trainer screen (see Figure 3.4) provides too much information. It was difficult for them to read the statistics with a quick glance at the screen. As an example: *"I'm not able to look at the screen while running. It's uncomfortable [the user wore an arm belt] and I have to pause the training to look at it"*. Others, complained that they do not have the possibility to request certain statistics at a certain moment through the vocal cues: *"It would be great if I could somehow request some of my favorite statistics when I need them. Waiting every time for 100 meters [in general, a certain distance interval] is annoying..."*. Many others, instead, hate to wear headphones during the training only to hear virtual trainer's directions: *"I find hard to run with headphones! They often fall to the ground and I miss virtual trainer's cues. It's frustrating!"*. These are the reasons why we decided to design and to develop new features to allow a more flexible interaction during a training.

To let the users run without the need to look at the screen or wait a predefined amount of time to listen to the vocal cues, we decided to let the users trigger vocal synthesis for some of their preferred statistics only when they need it. From a technical point of view, we realized it by exploiting common 2D gestures. The virtual trainer screen, just after the start of a

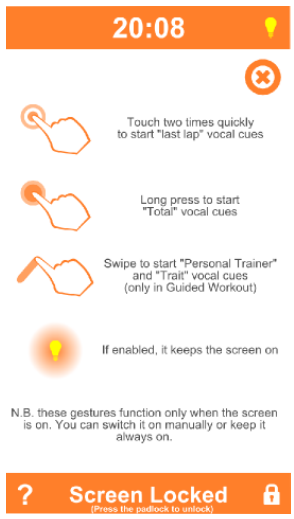

Figure 6.1: On demand vocal cues users' guide

training, enters in a locked state to listen to some common gestures (see Figure 6.1). As soon as the system detects a known gesture, it triggers the vocal reproduction of user's selected statistics. In this way, it is a lot easier for a user to request vocal cues without losing focus on the training and, even better, without the need to pause the workout to look at the screen.

We addressed the third aforementioned problem, on how to reduce the equipment needed during an activity, through the use of vibration impulses. To let the users run without the need to wear headphones to listen to virtual trainer's cues, we map some of these cues to a combination of vibration impulses. As an example: one impulse can be mapped to the speed up command, whereas, the slow down command can be associated to two impulses or vice versa. All that, is fully configurable by the user in terms both of the number and the intensity of impulses for each virtual trainer's command. Now the users, according to their preferences, can even choose to run without any extra equipment.

6.4 Experimental Results

In this section, we will report the results of a usability test we conducted to prove the effectiveness of the new interaction features we presented in the previous section. Encouraging preliminary results will support our proposal of design guidelines for an improved interaction experience (see Section 6.5).

The test we are going to illustrate has been conducted through a standard A/B testing methodology. We will evaluate the perceived usability of the new interaction functionalities with respect to the old ones. In general, an A/B test consists of comparing two variants of the same system. Differences between the two variants can range from the different disposition of the elements of the layout, to a different set of features, different style of color and so on. The evaluation aims at identifying some elements that are responsible of increasing a certain metric of interest.

The evaluation of the usability for the new and the old interaction features has been conducted through a System Usability Scale questionnaire (see Section 5.3 for more details on the method).

Table 6.1: SUS Mean Scores

	New	Old	Difference
Mean	**88.1**	**58.94**	**29.16**

Table 6.1 shows main results of the SUS evaluation required for the following calculation steps.

For this test we adopted the method proposed in [65] to evaluate, from the point of view of usability, the new interaction features and their design. To perform the evaluation, we recruited 25 beta testers (without any reward) who have run with both versions of EWRun. The sample consist of 16 males and 9 females with an age ranging from 15 to 61 (average 32.48 and standard deviation 12.32). Almost all the users run regularly two or three times per week and they all have had a previous knowledge of such a kind of applications.

To statistically prove the effectiveness of these features, we conduct a paired t-test that will allow us to prove if there is a significant difference between SUS score means for the two versions of the application. Using Formula 5.1 we obtained a value for t equal to 11.9.

We remain to prove if this value is statistically significant or not: looking up a the p-value using the Student's distribution with n-1 (24) degrees of freedom, we obtain 1.48×10^{-11}. This value is very small, thus we can conclude that the two scores are different with a probability very close to

100%.

This result give us a statistical evidence of the difference of scores, but we are interested in understanding whether or not this difference is relevant for users. We will calculate the confidence interval around the difference to figure out that. For a 95% confidence interval and 24 degrees of freedom t_α is equal to 2.063. Plugging in all the values in Formula 5.2 we obtain 29.16 ± 5.054. In sum, we can be 95% confident the actual difference of scores is between 24.10 and 34.21.

6.5 Design Guidelines to Improve the Interaction Experience

In this section we will list some design recommendations we propose to enhance multimodal systems interaction experience for sport persuasive mobile applications.

The recommendations are mostly derived from users' insights, from the results obtained by our tests as a result of the introduction of the aforementioned new features (see Section 6.3), and more in general by exploiting previous results about the interaction between multimodal systems and people with visual impairments (see Section 6.2). Why a runner supported by a mobile application can be compared to a person with visual impairments? The answer is very simple: during a run, it is not possible to look at the screen or handle the device frequently. In this scenario, the interaction with the application must be as fast, functional, and unobtrusive as possible to create a better training experience.

At the beginning of this Section, we introduced the term "multimodal system", but what is meant by this term in Human Computer Interaction? Dix [5] defines a multimodal interactive system as a system that relies on the use of multiple human communication channels. Each different channel for the user is referred to as a modality of interaction. Nigay and Coutaz [84] define multimodality as the capacity of the system to communicate with a user through different types of communication channels and to extract and convey meaning automatically. In a nutshell, any human sense can be viewed as a modality. In general, the major modalities through which a computer can exchange information with humans are: vision modality through sight, audition modality through hearing, and tactile modality through touch. There exist other modalities, as for example, the olfaction and gustation modalities, respectively through the sense of taste and smell, but at the moment they are used mainly at experimental level.

Nowadays, new generation mobile devices do not differ very much from computers in terms of interaction modalities. Indeed, we interact with our mobile devices mostly through sight, hearing, and touch. What really changes are not the used modalities, but the context where the interaction takes place and the flexibility and the new usage scenarios they are making possible. Among these usages, there are the so called mobile persuasive technologies that is, technologies used to foster some behavioral change in users. *Everywhere Run!*, as previously mentioned, is one of these mobile systems designed to help people to achieve a more active lifestyle. During a training session, the majority of these applications interact with the user mostly through the audition modality, that is by means of audio cues (see Section 6.2). EWRun is no exception: the user, according to his or her preferences, can set the timing of cues in terms of an elapsed time or distance interval. In other words, the interaction has a sort of deterministic pattern meaning that it happens regularly with little flexibility for the user.

The experiences of our users (see Section 6.3), validated also through the experimentation (see Section 6.4), suggested us to model this kind of interaction in a more flexible way. We decided to introduce new interaction facilities to allow users to request vocal cues in a non-deterministic fashion that is to say on demand, when they really need it. From the user interaction scheme point of view, we have achieved it exploiting the tactile modality.

In mobile devices, touch is a first class citizen in the sense that is natively supported by every modern mobile operating system. The idea is simple: during a workout we capture common gestures, such as the double tap action, to trigger vocal synthesis for the user's preferred training statistics only when he or she needs to listen to them. This is just one possible scenario on how it is possible to improve user to device interaction.

Our testers suggested us to exploit the flexibility of this interaction method also to enhance the integration between sport-oriented persuasive technologies and social networks. Social interactions have been demonstrated to be a very powerful instrument to foster motivations especially for non-expert sportsmen [61].

Several systems allow social interactions. The most part of these offer limited interaction capabilities letting the user share his or her results only after the end of a workout. Only two systems [57][43], for the best of our knowledge, support real time social interaction while exercising. Nevertheless, the interaction is really limited: the user can only listen to friends' cheers during a workout.

We want to allow a real time bidirectional communication with social networks. All that, as one of our prior works shows [85], can be ideally achieved through vocal recognition, though the currently available vocal recognition systems are not freely available and, when available, they are not very accurate in this particular context of use. We are planning to map usage entered text or emoticons to gestures or a combination of them. In this way, although very limited, it is possible to realize a bidirectional communication with social networks enhancing the virtual social experience of users.

The experiences of our users gave us the opportunity also to reconsider at first and, at a later stage, to exploit the haptic modality in EWRun.

Some of them complained that they were forced to listen to vocal cues to follow virtual trainer recommendations; they found uncomfortable to exercise with headphones. For this reason, we introduced the possibility to codify virtual trainer's cues to different vibration impulses. In this way, users can even exercise using only their device without any extra unwieldy equipment.

In summary, when designing the interaction model of such a kind of systems, we suggest designers to take care of:

- *Design for flexible interactions*
  Avoid, when possible, to provide real time information only in a deterministic way that is, with predefined patterns. Provided information should also be available on demand and with the least possible effort for the users.

- *Limit domain information to essential*
  Avoid to overload the information flow. By providing only basic information (in our case study the virtual trainer's cues) has allowed us, at a later time, to exploit haptic feedback to provide the same information that in the past was available only through vocal synthesis.

- *Interaction facilities should not rely on any extra equipment*
  By allowing users to map some audio cues to haptic feedback (see the previous point), gave us the opportunity to let the user choose the

preferred equipment for his or her workouts. The unobtrusiveness is a key factor to promote this kind of mobile applications. Many users can stop training, or for example, the most advanced ones may continue to prefer other devices such as running watches that are unobtrusive by design.

Obtained results, and most important the different experiences of our users, allowed us to improve our system, and at the same time, to derive design recommendations that can help to overcome some common limitations of general purpose mobile devices when used in this particular context.

We believe our work on how to design the interaction model to improve the user experience for sport-oriented mobile persuasive technologies will aid designers in developing solutions more oriented to user needs. Our goal is to help users to maintain a high motivational level in order for them to profit from the benefits of an active lifestyle.

6.6 Conclusions

In this chapter I presented the new interaction facilities we introduced in *Everywhere Run!*. By analyzing users' feedback, the results of our preliminary evaluation, and some studies concerning the interaction design for people with visual impairments, we have been able at first to introduce a set of new features to facilitate the interaction and then, after a usability evaluation conducted on 25 real users, to derive three key design guidelines recommendations to develop a more flexible and user-oriented interaction paradigm for this class of mobile persuasive technologies.

We suggested to design the interaction paradigm in the most flexible way as possible. The idea is to allow users to interact with the software on demand when they really need it. We recommend also to keep domain-specific information (in our case the training statistics) reduced to the minimum. This will favor, for example, the availability of new and simpler interaction modalities and in some cases, as previously stated, it may facilitate unobtrusiveness by reducing the required training equipment.

With our work, we believe to be helpful to all designers of sport oriented mobile persuasive technologies in order for them to exploit our experience and design recommendations to favor, through a more flexible interaction model, the training experience and thus the long-term motivations of users.

Chapter 7

Everywhere Race!: Exergaming Influence on Users Motivation

7.1 Introduction

The term *exergaming* derives from the combination of the terms “exercise” and “gaming” and it is used to refer to a particular type of video games that expect users to move for real during the game (see, for example, [55][56]). Nowadays, this kind of games rely on technologies able to track user’s position, body movements, and other environmental information. They are increasingly used in several domains such as sport and health (see Chapter 2) and, in this case, they are usually designed to promote an active lifestyle by means of an active gaming experience in which users must move for real. Ubiquitous mobile devices and their intrinsic relationship with social networks are becoming one of the most popular persuasive technologies on which many exergames are based on.

Everywhere Race! is an example of exergame designed to promote physical activity through fun. It aims at helping people get motivated by exploiting social and ludic aspects of sport. The application allows users from all over the world to compete against each other in real time in different speed-based sports. The application implements a virtual race that is similar to a real one in the sense that it has a priori known start time and distance and both are same for all the users, no matter where they are. One of the main strengths of the application is the support of several social features to promote social interactions by means of the social network Facebook (for more details see Section 3.3).

This chapter will present the results of an evaluation conducted on 35 real users where we wanted to investigate both the effects of our application on users' motivation and also to evaluate its innovative social-oriented design. Obtained results have shown that users appreciate provided social features and, most important, that the application is able to motivate non-habitual sportsmen to start working out and habitual ones to keep on exercising.

This work has been published in [57].

7.2 Experimental Results

To evaluate the effectiveness of the proposed application we submitted a subjective evaluation test to a sample of 35 volunteers that used *Everywhere Race!* for 30 days. The sample was composed of 25 male users and 10 female users aged between 19 and 40. Ten users regularly practiced sport at amateur level (6 males and 4 females), whereas the remaining testers were mostly sedentary. Among active users 4 exercised about four times a week, while the others from two to one times a week for an average training session duration of 30 minutes. Twenty-seven users (5 females and 22 males) were non-technical and they had never used before any application as a support to physical activity, whereas the remaining part of testers already had some experience with such kind of applications.

With these evaluation tests, we wanted to investigate the influence of our application on users' motivation in order to validate both current application features and understand how to proceed for future developments.

There are several definitions of motivation:

> the psychological process that gives behavior purpose and direction (Kreitner)

> a predisposition to behave in a purposive manner to achieve specific, unmet needs (Butford, Bedeian and Lindner)

> an internal drive to satisfy an unsatisfied need (Higgins)

the will to achieve (Bedeian)

Ryan et al. [23] propose the following subclassification of motivation:

- Intrinsic motivation: refers to doing something because it is inherently interesting or enjoyable
- Extrinsic motivation: refers to doing something because it leads to a separable outcome

Vallerand et al. [58] studied the differences between intrinsic and extrinsic motivational factors in sports. They claim that intrinsic motives are generally considered to be more relevant than extrinsic ones especially for non-habitual sportsmen. These results are generally considered valid, although other studies (see, for example, [59]) show that the user's gender may affect the predominant motive. Females appear to have more intrinsic motives than males which, vice-versa, have more extrinsic motives than females.

The description of how *Everywhere Race!* impacts on motivational aspects has been evaluated follows. For this purpose, we chose to adopt the Exercise Motivations Inventory - 2 (EMI-2) developed by Markland et al. [60]. EMI-2 is composed of 51 items belonging to 14 scales. Testers are asked to rate each item on a five-point scale ranging from 0 ("not at all true for me") to 5 ("very true for me").

Scale scores are obtained by calculating means for each item belonging

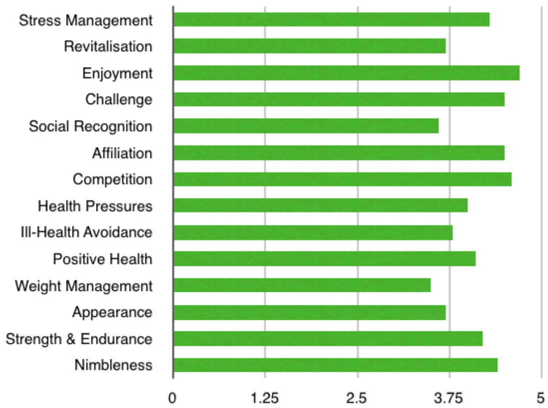

Figure 7.1: EMI-2 results

to the appropriate scale.

The graphic in Figure 7.1 shows the obtained results. All the scales received good scores (average score is 4.1 out of 5) meaning that the application is perceived as a valid motivational mean to help people to start working out. Some of the most important scales that we wanted to test were those related to enjoyment, challenge, affiliation, and competition. This is because we aimed at evaluating the innovative features provided by *Everywhere Race!* in order to understand if our application is evolving in the right direction. All these scales received very promising scores with an average score of 4.6 out of 5.

We submitted an additional questionnaire to deeper investigate the effects of the application on users sport habits. Testers were asked to rate

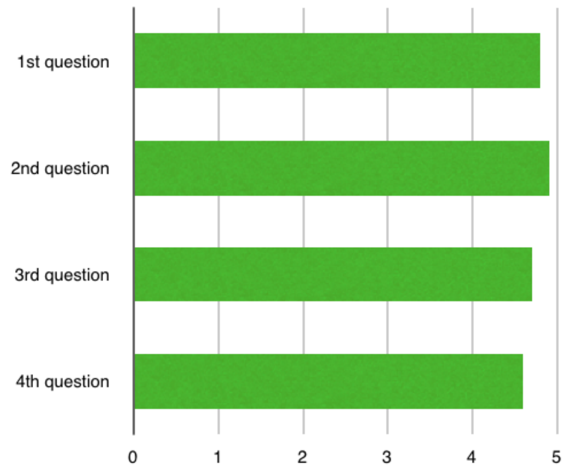

Figure 7.2: Questionnaire results

each question with the same scale (ranging from 0 to 5) used to rate the EMI-2 items. Here are the questions:

1. "Did EWRace help you to improve performances?"

2. "Were social features important to improve your performances?"

3. "Did EWRace change your sport habits?"

4. "Will you continue to use EWRace in the future?"

The average results shown in Figure 7.2 put in evidence that the majority of users perceive the application as a valid tool that helps to achieve sport goals in a more enjoyable and regular manner. As it is possible to see, despite the limited sample of test users, we have obtained encouraging results. The positive trend emerging from our tests shows that the application may help to increase motivational factors on longer time periods through this new engaging and social way of active gaming.

7.3 Conclusions

In this chapter I presented an evaluation study conducted to investigate how the innovative features offered by *Everywhere Race!* can affect users' motivation. The application aims at encouraging people to a more active lifestyle by means of fun and social interactions (see Section 3.3). The importance of these two factors has been demonstrated to be crucial especially in sports (see, for example, [61][62]). To evaluate these aspects we conducted a test with a group of 35 volunteers that used EWRace for 30 days. We asked them to respond to two questionnaires: a standard and well known questionnaire called EMI-2 and a custom one we decided to administer to further investigate the results obtained from the first evaluation. Our goal was to assess how the application was perceived by users in terms of motivation.

Obtained results showed that the majority of people that in the past conducted a mostly sedentary lifestyle got motivated to working out more often. All these benefits, as the results of the two questionnaires put in evidence, have a close relationship with the innovative features provided by the application.

This work has been published in [57].

Chapter 8

Conclusion

8.1 Future Directions

In the last three years we have had a continuous interaction with real users of our persuasive platform. Users' experiences and suggestions, together with the results of the experimentations presented in this thesis, have provided us with many ideas for further enhancing the persuasive capabilities of our platform. These improvements will allow us to conduct new experimentations and to investigate some aspects that are partially emerged from our studies.

For example, we are extending *Everywhere Run!* and its backend side with several new features. In particular, we have already studied and developed (only for beta tester users) a set of algorithms that allow the application to estimate automatically the physical profile of a user. To this end, we are using two methods: the first, makes use of the methodology proposed by the famous coach Jack Daniels in the 1970s [71]. Basically, it determines a value called VDOT that is an approximation of the VO2max (maximum oxygen consumption[1]) that can be determined only by laboratory measurements. This method requires the user to input his or her best time achieved for a certain distance in order to find the corresponding VDOT value and, consequently, to predict his or her pace for different distances (see [71] for more details). The second method allows to profile users by exploiting common bluetooth heart rate monitors. The application is able to guide users step by step to perform several well known athletic field tests (as, for example, the 2km Walking and the Conconi tests [72][73]). During a test the application monitors and analyzes users' heart rate in order to automatically determine their current fitness level. Thanks to a sport medicine expert, we are currently designing a new set of algorithms (to be introduced in the backend side of the application) that will receive as an input argument the results from the two methods above in order to build automatically a custom tailored training plan according both to the user's fitness level and to his or her training preferences (i.e., the user will be able to choose a tailored race-specific training). Once the system determines the fitness level of the user it will send a custom tailored

[1]VO2max is the maximum volume of oxygen the human body can use during exercise. It is a biological parameter that indicates the fitness level of an individual.

running workout plan directly to the mobile application in order for the user to start his or her training guided by the virtual personal trainer.

In addition to the introduction of the previous cited algorithms, EWRun together with its backend side, will provide users also the possibility to make a backup copy of all the information related to their past trainings. This feature, in addition to provide more flexibility to users, will allow us to exploit a large amount of anonymized data for our experimentations: the fitness profile of users and all their training statistics including also the GPS tracks of the paths they have followed during their trainings. All these information will be very important for our experiments in several ways: first, they will allow us to reduce the need of custom questionnaires that usually we adopt to investigate some aspects not covered by standard assessment tools. Second, they will allow us to obtain very accurate athletic profiles of users and, most important, their complete training history in order for us to study their adherence to the training plans and to better evaluate on a large scale how their performance and motivation were affected by the features we have introduced over time. Last, we will use recommendation algorithms to recommend training routes to users according to their location and fitness profile to improve their training experience and, more important, to favor socialization also in real world.

Another area of research we are pursuing is the study and the development of artificial intelligence algorithms to investigate if it is possible to exploit fictitious users to favor social pressure and thus stimulate a positive competition among real users. At the moment, by exploiting Facebook test users[2], we are already able to simulate a real user during a race. According to the type of race in which the fictitious user is involved, it is able to simulate the performance of a real user according to a certain athletic profile that is calculated only the first time it is created. We are currently evaluating the possibility to attribute to the fictitious users a sort of "limited social behaviour" in the sense that these users, in addition to compete with other people, will be also able to update automatically a very limited subset of their Facebook profile. Basically, we aim at influencing real users through the content that fictitious users will publish on Facebook. A fictitious user will be able to choose contents related to, for example, our platform and, more in general, related to fitness and wellness topics and post them on certain pages or groups (note that the sources and the destination of the information will be established in advance). Common social media metrics will allow us to study and to evaluate if the social behaviour of fictitious users, albeit limited, will be able to influence and to make aware real users about the importance and the benefits of a healthy lifestyle.

In parallel with the just cited improvements, we are working on merging *Everywhere Run!* and *Everywhere Race!* mobile applications to give users the possibility to train by taking advantage from the strengths of both of them. In essence, the user will be able to start a training routine

[2] http://developers.facebook.com/docs/test_users/

guided by the virtual trainer and, at the same time, he or she will be able to take part to a virtual race in which are involved participants with his or her own physical abilities. The resulting application will allow us to further investigate the effects of fun and social interactions provided by EWRace on users. In particular, we aim at investigating how advanced users (who usually are rather self-motivated) will react to the new features in terms of performances and adherence to their training programs. Moreover, it will be also interesting to investigate how the exergaming will affect beginner users who are just starting a training program to understand for how long the effects of exergaming can be deemed crucial to push them to exercise regularly.

8.2 Conclusion

The work presented in this thesis has put in evidence how a real world persuasive platform can be designed and exploited to successfully motivate real users to be more active. The design phases of the various components of the platform have been greatly supported by our continuous interaction with real users that allowed us to gradually create a product more and more appreciated by the people. The mobile applications, freely available on the Google Play Store, provide users with a rich set of innovative features giving them the possibility to train in a controlled and amusing way.

In our experimentations we have assessed the effectiveness of the proposed solutions by means of tests conducted on real users and, gradually, using automatically collected statistics from thousands of trainings over quite long periods of time.

In the following, I report a summary of the works presented in this thesis and the most significant contributions they provided to the persuasive computing research field:

1. The work in Chapter 4 presents *Everywhere Run!*, a mobile application that, with respect to other mobile persuasive applications, is able to guide users step by step during their workouts by means of a virtual personal trainer. Users, thanks to the application and to the virtual community, can obtain a custom tailored workout plan from a real and qualified personal trainer in order to exercise in total safety guided by the virtual coach. The results of a pilot study revealed that users appreciate the virtual trainer feature and that the application has favored an average enhancement of the motivations among participants (see [50][51])

2. The study presented in Chapter 5, has been inspired by the reaction of people as a result of EWRun graphical/usability redesign. We proved that the user experience is a key factor also for persuasive technologies since it can alter users' perception of the offered features. Moreover, we started investigating how the user experience can impact on people's motivation: by means of an EMI-2 evaluation

questionnaire we proved that the new design has favored an increment of motivation in people who trained with both versions for at least six months (see [86] [87])

3. The work of Chapter 6 presents some interaction design guidelines inspired by the experiences of real users. These experiences pushed us to extend the interaction capabilities offered by EWRun during a training. In particular, we provide users with a more flexible and less obtrusive interaction capability by exploiting common surface gestures and haptic feedback. The test we conducted to evaluate the effectiveness of the new features revealed that users appreciate them. We believe that the new guidelines we proposed will be helpful to the designers of sport oriented persuasive mobile technologies and, more in general, to those that need to design a flexible interaction model for contexts of use where users have limited possibilities of interaction (Note: This research is still in progress)

4. Chapter 7 presents *Everywhere Race!*, an innovative concept of mobile exergame. The application allows users to compete in distributed real time races of different speed-based sports. Moreover, the game experience is enriched with several social features provided by means of the social network Facebook. As revealed by the EMI-2 questionnaire results, the realistic real time competition together with social features have proven to be very important to push people to start or

maintain an active lifestyle (see [57])

Bibliography

[1] J. Harrington, I. J. Perry, J. Lutomski, A. P. Fitzgerald, F. Shiely, H. McGee, M. M. Barry, E. Van Lente, K. Morgan, and E. Shelley, "Living longer and feeling better: healthy lifestyle, self-rated health, obesity and depression in ireland," *The European Journal of Public Health*, vol. 20, no. 1, pp. 91–95, 2010.

[2] G. F. Fletcher, G. Balady, S. N. Blair, J. Blumenthal, C. Caspersen, B. Chaitman, S. Epstein, E. S. S. Froelicher, V. F. Froelicher, I. L. Pina *et al.*, "Statement on exercise: Benefits and recommendations for physical activity programs for all americans a statement for health professionals by the committee on exercise and cardiac rehabilitation of the council on clinical cardiology, american heart association," *Circulation*, vol. 94, no. 4, pp. 857–862, 1996.

[3] S. K. Card, T. P. Moran, and A. Newell, "The keystroke-level model for user performance time with interactive systems," *Communications*

of the ACM, vol. 23, no. 7, pp. 396–410, 1980.

[4] ——, *The psychology of human computer interaction*. Routledge, 1983.

[5] A. Dix, *Human computer interaction*. Pearson Education, 2004.

[6] R. Baecker and W. Buxton, "Readings in human-computer interaction: A multidisciplinary approach," 1987.

[7] J. Long and J. Dowell, "Conceptions of the discipline ofhci: Craft, applied science, and engineering," in *People and Computers V: Proceedings of the Fifth Conference of the British Computer Society Human-Computer Interaction Specialist Group, University of Nottingham, 5-8 September 1989*, vol. 5. Cambridge University Press, 1989, p. 9.

[8] T. T. Chairman-Hewett, *ACM SIGCHI curricula for human-computer interaction*. ACM, 1992.

[9] D. Isac and C. Reiss, *I-language: An introduction to linguistics as cognitive science*. Oxford University Press, 2013.

[10] J. Preece, *Human-computer interaction*, ser. Ics Series. Addison-Wesley Pub. Co., 1994.

[11] D. A. Norman, *The psychology of everyday things*. Basic books, 1988.

[12] M. Weiser, "The computer for the 21st century," *Scientific american*, vol. 265, no. 3, pp. 94–104, 1991.

[13] S. Poslad, *Ubiquitous Computing: Smart Devices, Environments and Interactions*. Wiley, 2011.

[14] M. Satyanarayanan, "Pervasive computing: Vision and challenges," *Personal Communications, IEEE*, vol. 8, no. 4, pp. 10–17, 2001.

[15] "Project aura," http://www.cs.cmu.edu/ aura/, accessed: 2013-09-26.

[16] M. Weiser and J. S. Brown, "Designing calm technology," *POWERGRID JOURNAL*, vol. 1, 1996.

[17] M. Esler, J. Hightower, T. Anderson, and G. Borriello, "Next century challenges: data-centric networking for invisible computing: the portolano project at the university of washington," in *Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking*, ser. MobiCom '99. New York, NY, USA: ACM, 1999, pp. 256–262. [Online]. Available: http://doi.acm.org/10.1145/313451.313553

[18] W. S. Ark and T. Selker, "A look at human interaction with pervasive computers," *IBM systems journal*, vol. 38, no. 4, pp. 504–507, 1999.

[19] A. Milenković, C. Otto, and E. Jovanov, "Wireless sensor networks for personal health monitoring: Issues and an implementation," *Computer communications*, vol. 29, no. 13, pp. 2521–2533, 2006.

[20] A. Akins, "Golfers tee off into the future," *The Futurist*, vol. 28, 1994.

[21] B. Fogg, *Persuasive Technology: Using Computers to Change what We Think and Do*, ser. Interactive Technologies Series. Morgan Kaufmann Publishers, 2003.

[22] K. Bosworth, B. Chewning, T. Day, R. Hawkins, and D. Gustafson, "Barny a computer based health information system for adolescents," *The Journal of Early Adolescence*, vol. 1, no. 3, pp. 315–321, 1981.

[23] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivations: Classic definitions and new directions," *Contemporary educational psychology*, vol. 25, no. 1, pp. 54–67, 2000.

[24] D. E. Warburton, C. W. Nicol, and S. S. Bredin, "Health benefits of physical activity: the evidence," *Canadian medical association journal*, vol. 174, no. 6, pp. 801–809, 2006.

[25] R. R. Pate, M. Pratt, S. N. Blair, W. L. Haskell, C. A. Macera, C. Bouchard, D. Buchner, W. Ettinger, G. W. Heath, A. C. King *et al.*, "Physical activity and public health," *JAMA: the journal of the American Medical Association*, vol. 273, no. 5, pp. 402–407, 1995.

[26] cdc.gov, "Physical activity and health," http://www.cdc.gov/physicalactivity/everyone/health/, accessed: 2013-10-09.

[27] WorldHealthOrganization, “Obesity and overweight,” www.who.int/mediacentre/factsheets/fs311/en, accessed: 2013-10-09.

[28] ——, “Who-diet,” www.who.int/dietphysicalactivity/diet/en, accessed: 2013-10-09.

[29] U. D. of Agricolture, “Why is physical activity important?” http://www.choosemyplate.gov/physical-activity/why.html, accessed: 2013-09-21.

[30] S. Consolvo, D. W. McDonald, T. Toscos, M. Y. Chen, J. Froehlich, B. Harrison, P. Klasnja, A. LaMarca, L. LeGrand, R. Libby, I. Smith, and J. A. Landay, “Activity sensing in the wild: a field trial of ubifit garden,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI ’08. New York, NY, USA: ACM, 2008, pp. 1797–1806. [Online]. Available: http://doi.acm.org/10.1145/1357054.1357335

[31] W. IJsselsteijn, Y. de Kort, J. Westerink, M. de Jager, and R. Bonants, “Fun and sports: Enhancing the home fitness experience,” in *Entertainment Computing–ICEC 2004*. Springer, 2004, pp. 46–56.

[32] “Your shape fitness evolved,” your-shape-fitness-evolved.ubi.com/2012, accessed: 2013-10-09.

[33] L. Chittaro and R. Sioni, "Turning the classic snake mobile game into a location–based exergame that encourages walking," in *Persuasive Technology. Design for Health and Safety*. Springer, 2012, pp. 43–54.

[34] T. Toscos, A. Faber, S. An, and M. P. Gandhi, "Chick clique: persuasive technology to motivate teenage girls to exercise," in *CHI'06 extended abstracts on Human factors in computing systems*. ACM, 2006, pp. 1873–1878.

[35] R. de Oliveira and N. Oliver, "Triplebeat: enhancing exercise performance with persuasion," in *Proceedings of the 10th international conference on Human computer interaction with mobile devices and services*. ACM, 2008, pp. 255–264.

[36] S. Consolvo, K. Everitt, I. Smith, and J. A. Landay, "Design requirements for technologies that encourage physical activity," in *Proceedings of the SIGCHI conference on Human Factors in computing systems*. ACM, 2006, pp. 457–466.

[37] J. Hoysniemi, "International survey on the dance dance revolution game," *Computers in Entertainment (CIE)*, vol. 4, no. 2, p. 8, 2006.

[38] F. Buttussi, L. Chittaro, and D. Nadalutti, "Bringing mobile guides and fitness activities together: a solution based on an embodied virtual trainer," in *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services*. ACM, 2006, pp. 29–36.

[39] C. Jayant and T. S. Saponas, “Mariofit: Exercise through mobile entertainment,” 2005.

[40] F. Buttussi and L. Chittaro, “Smarter phones for healthier lifestyles: An adaptive fitness game,” *Pervasive Computing, IEEE*, vol. 9, no. 4, pp. 51–57, 2010.

[41] F. F. Mueller, F. Vetere, M. R. Gibbs, S. Agamanolis, and J. Sheridan, “Jogging over a distance: the influence of design in parallel exertion games,” in *Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games*, ser. Sandbox ’10. New York, NY, USA: ACM, 2010, pp. 63–68. [Online]. Available: http://doi.acm.org/10.1145/1836135.1836145

[42] S. Berkovsky, M. Coombe, J. Freyne, D. Bhandari, and N. Baghaei, “Physical activity motivating games: virtual rewards for real activity,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2010, pp. 243–252.

[43] Nike, “Nike+ gps,” nikerunning.nike.com, accessed: 2013-10-05.

[44] “Runtastic,” www.runtastic.com, accessed: 2013-10-05.

[45] “Endomondo,” www.endomondo.com, accessed: 2013-10-05.

[46] “Runkeeper,” runkeeper.com, accessed: 2013-10-05.

[47] “Mapmyfitness,” www.mapmyfitness.com, accessed: 2013-10-05.

[48] "micoach," www.adidas.com/fi/micoach, accessed: 2013-10-05.

[49] "Softrace," www.softrace.net, accessed: 2013-10-05.

[50] F. Mulas, S. Carta, P. Pilloni, and M. Manca, "Everywhere run: a virtual personal trainer for supporting people in their running activity," in *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*, ser. ACE '11. New York, NY, USA: ACM, 2011, pp. 70:1–70:2. [Online]. Available: http://doi.acm.org/10.1145/2071423.2071510

[51] M. Fabrizio, C. Salvatore, P. Paolo, and B. Ludovico, "Everywhere run: a virtual personal trainer for supporting people in their running activity," in *International Journal of Advanced Computer Science*. IJACSci, 2013, vol. 3.

[52] "Why you only need to test with 5 users," www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/, accessed: 2013-10-15.

[53] J. Nielsen and T. K. Landauer, "A mathematical model of the finding of usability problems," in *Proceedings of the INTERACT'93 and CHI'93 conference on Human factors in computing systems*. ACM, 1993, pp. 206–213.

[54] R. A. Virzi, "Refining the test phase of usability evaluation: how many subjects is enough?" *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 34, no. 4, pp. 457–468, 1992.

[55] S. Göbel, S. Hardy, V. Wendel, F. Mehm, and R. Steinmetz, "Serious games for health: personalized exergames," in *Proceedings of the international conference on Multimedia*. ACM, 2010, pp. 1663–1666.

[56] J. Sinclair, P. Hingston, and M. Masek, "Considerations for the design of exergames," in *Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia*. ACM, 2007, pp. 289–295.

[57] F. Mulas, P. Pilloni, and S. Carta, "Everywhere race!: A social mobile platform for sport engagement and motivation," in *SOTICS 2012, The Second International Conference on Social Eco-Informatics*, 2012, pp. 63–69.

[58] R. Vallerand, E. Deci, and R. Ryan, "Intrinsic motivation in sport," *Exercise & Sport Sciences Reviews*, vol. 15, pp. 389–426, Jan 1987.

[59] M. S. Fortier, R. J. Vallerand, N. M. Briere, P. J. Provencher *et al.*, "Competitive and recreational sport structures and gender: A test of their relationship with sport motivation," *International journal of sport psychology*, vol. 26, pp. 24–24, 1995.

[60] D. Markland and D. K. Ingledew, "The measurement of exercise motives: Factorial validity and invariance across gender of a revised exercise motivations inventory," *British Journal of Health Psychology*, vol. 2, no. 4, pp. 361–376, 1997.

[61] B. Schellenberger, "The significance of social relations in sport activity," *International Review for the Sociology of Sport*, vol. 16, no. 2, pp. 69–77, 1981.

[62] S. Ashida, A. V. Wilkinson, and L. M. Koehly, "Social influence and motivation to change health behaviors among mexican-origin adults: Implications for diet and physical activity," *American Journal of Health Promotion*, vol. 26, no. 3, pp. 176–179, 2012.

[63] J. Brooke, "Sus-a quick and dirty usability scale," *Usability evaluation in industry*, vol. 189, p. 194, 1996.

[64] "Evwrywhere run!'s sus questionnaire," bit.ly/ewrunsus, accessed: 2013-05-29.

[65] J. Sauro and J. R. Lewis, *Quantifying the user experience: Practical statistics for user research*. Morgan Kaufmann, 2012.

[66] J. Sauro, "Measuring usability with the system usability scale (sus)," www.measuringusability.com/sus.php, accessed: 2013-10-21.

[67] Wikipedia, "Normal distribution," https://en.wikipedia.org/wiki/Normal_-distribution, accessed: 2013-10-19.

[68] ——, "Student's t-test," https://en.wikipedia.org/wiki/Student's_t-test, accessed: 2013-10-21.

[69] ——, "P-value," http://en.wikipedia.org/wiki/P-value, accessed: 2013-10-21.

[70] "Android design guidelines," developer.android.com/design/index.html, accessed: 2013-10-12.

[71] J. Daniels, *Daniels' running formula*. Human Kinetics, 2005.

[72] P. Oja, R. Laukkanen, M. Pasanen, T. Tyry, and I. Vuori, "A 2-km walking test for assessing the cardiorespiratory fitness of healthy adults," *International journal of sports medicine*, vol. 12, no. 04, pp. 356–362, 1991.

[73] F. Conconi, M. Ferrari, P. G. Ziglio, P. Droghetti, and L. Codeca, "Determination of the anaerobic threshold by a noninvasive field test in runners," *Journal of Applied Physiology*, vol. 52, no. 4, pp. 869–873, 1982.

[74] T. Guerreiro, P. Lagoa, H. Nicolau, D. Goncalves, and J. A. Jorge, "From tapping to touching: Making touch screens accessible to blind users," *IEEE Multimedia*, vol. 15, no. 4, pp. 48–50, 2008.

[75] M. Negulescu, J. Ruiz, Y. Li, and E. Lank, "Tap, swipe, or move: attentional demands for distracted smartphone input," in *Proceedings*

of the International Working Conference on Advanced Visual Interfaces. ACM, 2012, pp. 173–180.

[76] Y. Li, "Gesture search: a tool for fast mobile data access," in *Proceedings of the 23nd annual ACM symposium on User interface software and technology*. ACM, 2010, pp. 87–96.

[77] S. Zhai and P. O. Kristensson, "The word-gesture keyboard: Reimagining keyboard interaction," *Communications of the ACM*, vol. 55, no. 9, pp. 91–101, 2012.

[78] S. Heo and G. Lee, "Forcetap: extending the input vocabulary of mobile touch screens by adding tap gestures," in *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services*. ACM, 2011, pp. 113–122.

[79] S. K. Kane, J. O. Wobbrock, and R. E. Ladner, "Usable gestures for blind people: understanding preference and performance," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2011, pp. 413–422.

[80] J. Ruiz and Y. Li, "Doubleflip: a motion gesture delimiter for mobile interaction," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2011, pp. 2717–2720.

[81] S. K. Kane, J. P. Bigham, and J. O. Wobbrock, "Slide rule: making mobile touch screens accessible to blind people using multi-touch interaction techniques," in *Proceedings of the 10th international ACM SIGACCESS conference on Computers and accessibility*. ACM, 2008, pp. 73–80.

[82] J. Ruiz, Y. Li, and E. Lank, "User-defined motion gestures for mobile interaction," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2011, pp. 197–206.

[83] D. Ashbrook and T. Starner, "Magic: a motion gesture design tool," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2010, pp. 2159–2168.

[84] L. Nigay and J. Coutaz, "A design space for multimodal systems: concurrent processing and data fusion," in *Proceedings of the INTER-ACT'93 and CHI'93 conference on Human factors in computing systems*. ACM, 1993, pp. 172–178.

[85] P. Pilloni, "Real time social engagement for sport motivation," 2010, master's Degree Thesis, Dept. of Computer Science, University of Cagliari.

[86] P. Pilloni, F. Mulas, L. Piredda, and S. Carta, "How user experience design can affect motivation: A study on a real world sport appli-

cation," in *SOTICS 2013, The Third International Conference on Social Eco-Informatics*, 2013, pp. 67–72.

[87] ——, "Assessing the user experience design as a persuasive methodology in a real world sport application," in *Proceedings of International Conference on Advances in Mobile Computing & Multimedia*, ser. MoMM '13. New York, NY, USA: ACM, 2013, pp. 387:387–387:394. [Online]. Available: http://doi.acm.org/10.1145/2536853.2536874

[88] F. Mulas, P. Pilloni, M. Manca, L. Boratto, and S. Carta, "Linking human-computer interaction with the social web: A web application to improve motivation in the exercising activity of users," in *Cognitive Infocommunications (CogInfoCom), 2013 IEEE 4th International Conference on*. IEEE, 2013, pp. 351–356.

[89] ——, "Using new communication technologies and social media interaction to improve the motivation of users to exercise," in *Future Generation Communication Technology (FGCT), 2013 Second International Conference on*. IEEE, 2013, pp. 87–92.