Exploring Audio Storytelling in Mobile Exergames to Affect the Perception of Physical Exercise

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***Abstract*—Exergames (video games that combine exercise and play) can make the experience of physical activities more enjoyable. Mobile exergames are particularly interesting as they can be used for outdoors, open-air physical activities. Unfortunately, current mobile exergames tend to require the player to frequently or continuously look at the screen. This can be hard to do while exercising, and it also requires the player to considerably distract visual attention from the surrounding physical environment, introducing safety issues in activities such as outdoor running. In this paper, we focus on two main goals. First, we explore how to use audio storytelling techniques to make physical exercise more engaging and enjoyable by exploiting a soundscape that provides prompt feedback in response to players' activity and does not require the player to look at the screen during running. Second, we study if the exergame is fun for users and if it positively affects the perception of the running experience. We measure important variables such as level of physical activity in player's lifestyle and player's physical activity enjoyment through validated methods employed in the medical literature. The results of the study show that the use of audio storytelling techniques in mobile exergames is appreciated by users, and the exergame has positive effects on the perception of physical exercise.**

***Keywords*—mobile, exergames, physical exercise, enjoyment, health, safety, audio, storytelling, pervasive technology**

I. Introduction

A sedentary lifestyle can play a role in causing medical conditions such as diabetes [1], blood circulation problems [2] and certain types of cancer [3]. For this reason, cardiologists and oncologists recommend to perform regular physical activity for disease prevention purposes. However, motivating people to follow these recommendations can be difficult, and the fitness industry is looking for new, engaging tools that can be appealing also to people who do not exercise on a regular basis and need additional motivation to exercise. Exergames aim to accomplish this goal by combining play and exercise [4]. The latest generation of home consoles has been successful in bringing exergaming to homes, with titles such as *Wii Sports* [5], *Wii Fit Plus* [6], and *EA Active Sports 2* [7]. Unlike home consoles, mobile devices can be used in a large variety of different environments. Since only some physical activities lend themselves to be practiced indoors, and practicing outdoors brings the additional benefits of open-air environments, exergames that run on mobile devices (*mobile exergames*) can be more interesting than traditional domestic exergames. However, during open-air activities such as running and biking, users' visual attention needs to be focused on the surrounding environment for safety reasons. Moreover, having to look at the small screen of the mobile device while performing a physical activity is hard. For these reasons, the design of effective mobile exergames requires alternative solutions to the use of graphics as a primary element to engage the player in the game. Therefore, our research pursued two main goals. First, we wanted to explore how to use audio storytelling techniques to make physical exercise more engaging and enjoyable by exploiting a soundscape that provides prompt feedback in response to players' activity, and does not require the player to look at the screen during running. Second, we wanted to study if the exergame was fun for users and if it could positively affect the perception of physical exercise.

II. Related work

A. Mobile Exergames

Modern portable game consoles include exergames in their software libraries. For example, *Pokémon HeartGold* and *Pokémon SoulSilver* [8] can be played by using a pedometer nicknamed *Pokéwalker*, which aims to encourage walking by using a simple reward mechanism based on the number of steps performed: the player can power up the stats of currently owned Pokémons and also obtain rare Pokémon specimen that can be earned only by using the accessory. Other exergames are designed to run on smartphones, exploiting their built-in GPS and accelerometer sensors to detect user's activity. For example, *Health Defender* [9] is a shoot 'em up exergame in which the player has to face alien waves to defend planet Earth. Ship movement is handled through the phone keypad, while jumping on the spot is necessary to fire. The game provides bonus stages in which the player has to raise her heart rate by performing any kind of physical activity to obtain more powerful weapons and shields. *Health Defender* makes intensive use of graphical elements to represent the game world, so that looking at the screen of the smartphone is necessary to enjoy the game experience. The exergame was informally evaluated by collecting user opinions and remarks about the game. *Monster & Gold* [10] is a mobile exergame in which the player has to jog while keeping her heart rate in a certain range. Heart rate is sampled using a pulse-oximeter clipped to the user's earlobe that communicates with the smartphone via Bluetooth. Players watch the screen that displays a stylized course track on which treasures to be collected and monsters to be avoided are used to encourage them to respectively increase or decrease speed. *Monster & Gold* was informally evaluated to assess if players understood game mechanics and the effectiveness of its visual and audio feedback.

B. Digital Audio Storytelling and Audio Games

Digital Storytelling is a concept that revolves around the idea of combining the art of telling stories with a variety of digital multimedia, such as images, audio, and video [11]. Spector [12] distinguishes two main kinds of storytelling. along with a list of attributes which make the game immersive and compelling to the player. In *Linear Storytelling*, the narrated story is pre-determined by game designers and the player cannot directly influence or change the sequence of pre-determined events. On the other hand, *Interactive Storytelling* gives the player in-game instruments that let her change the course of narrated events, which is only sketched by the game designers. To implement an effective storytelling, Spector highlights four main attributes that have to be taken into account. *Change* is the modification of the main character, of the virtual world and of the secondary characters' states in response to the user's actions. The story *pacing* must be adjusted during the game to catch and hold the player's interest during the gaming experience. Spector suggests a quick build up at the beginning of the game, when the player has to learn how the world works. Pace may be slowed down during the middle stages when the player has to understand which tasks are to be performed to win the game, and once this happens the designer may decide to speed up the pace again to reach the climax of the story. The virtual world should also be populated by *compelling characters* featuring their own peculiar behavior and personality. Finally, there must exist a *subtext*, an underlying plot supporting and justifying the succession of the narrated events.

Digital audio storytelling is a type of storytelling which makes exclusive use of digital auditory cues to narrate events and immerse the player in a virtual world. This narrative technique is often followed in *audio games*, i.e. computer games featuring auditory interfaces that allow users to play without the need of graphics [13]. These games were initially targeted at visually impaired players, and progressively evolved to offer an unique gaming experience to a broader audience of gamers. A comprehensive list of resources on audio gaming can be found at *Audiogames.net* [14], with hundreds of software titles covering different genres such as platform, racing and puzzle games, as well as domestic exergames. From a narrative point of view, audio games exploit unique solutions to partially or completely replace visual elements with sounds when describing the game world and its features, providing interesting examples regarding how to effectively implement digital audio storytelling.

Liljedahl et al. [15] present the development of *Beowulf*, an audio game using sounds aimed to stimulate players in creating their own personal mental representation of the virtual world, and respond to it from an emotional point of view. Mobile devices were used as an ideal testbed due to their limited screen size (not suited to represent the game world in an immersive way through graphics) and large potential for stereo sound reproduction. To design a game with only a few graphical elements which can be engaging and immersive for the player, the authors focused on two main concepts: *User Investment* and *Scary Shadow Syndrome*. *User Investment* describes a process in which the game designer and the player subscribe to a mutual contract: the player accepts to suspend her judgement concerning the implausibility of the narrative (reaching a mental state defined by Coleridge as *willing suspension of disbelief* [16]) and to invest time and imagination in the game experience, thus sharing the creative process with the game designers. The concept of *Scary Shadow Syndrome* originates from the narrative techniques used in old horror movies with restricted budgets, in which scary scenes were shot without showing the actual events on the screen, forcing spectators to use their imagination and thus creating an intense emotional response. The only graphical part of the *Beowulf* game consists of a stylized map representing the dark lair of Beowulf, which the player enters to fight and overcome the epic monster without being able to see what lies around her. Movement is controlled using the navigation keys on the phone. The sounds that represent the virtual world and narrate the story have been categorized in five main groups: *footsteps* and *environmental/ambient* sounds are used to describe the current location by representing the nature of the terrain the player is interacting with and the peculiar features on each part of the lair, in addition to *dynamic landscape elements* sounds (such as waterfalls and bubbling lava) and *living elements* sounds (e.g. bats, snakes etc.). *Combat* sounds (for example sword hits and misses) are used to represent the outcome of user actions during battles. The evaluation of the game showed that the players were able to reach all the selected locations, building an inner picture of the game world and feeling emotionally involved in the story.

Based on the experience acquired with Beowulf, its authors exploited sound-based narrative techniques in *iSpooks* [17], which is available in the iTunes App Store [18]. The goal was to create a marketable mostly-audio casual game, suitable for brief game sessions whose short duration would not negatively impact the overall gaming experience. iSpooks puts the player in a haunted mansion, where she has to uncover a mystery, discovering clues and putting together pieces of evidence by picking up objects and speaking with ghosts. The visual part of the game is a 2D map, representing pre-defined paths in which the player can move. Vibration is used to indicate that an object can be picked up at the current location, while an elaborated soundscape is used to represent different locations. The events are narrated through a *fragmented narrative*, in which the user is given only a partial explanation of what is happening in the game, in the attempt to create an engaging atmosphere by stimulating players to build their own interpretation of the story, using their imagination to think over and interpret the ambiguities in the narrated plot.

A similar narrative approach using structured soundscapes is used in *Mudsplat* and *Tim's Journey*, two audio games developed for the *Tactile Interactive Multimedia* (*TiM*) project [13] which aims to assess if certain game genres and concepts can be translated to use exclusively auditory interfaces. The design of these games incorporate Chion's subdivision of human listening into three main categories [19]: *casual listening* refers to listening for understanding what is the source of sound, *semantic listening* is used when understanding auditory codes (e.g. Morse code) and *reduced listening* consists of listening to the sound qualities (e.g. pitch, rhythm etc.) without focusing on the source. One or more of these modes are simultaneously used to build a full featured auditory interface. *Mudsplat* is an audio arcade game in which the protagonist, armed with an hydrant, is fighting monsters throwing mud at him. Spatial audio is used to represent the position of

the monsters with respect to the player, and certain features of the sound samples (such as volume, pitch and panning) are used to convey different monster features to the player. Tim's Journey is an adventure game in which the player has to explore a virtual island to solve a mystery. The island is divided into different *scenes*, each represented by a specific musical theme characterizing its peculiar identity in the virtual world. By moving through the scenes, the player generates an unique soundtrack based on his/her current position. The soundscape is composed of five different sound categories, including *avatar sounds* (describing players' actions), *objects sounds* (to indicate players' presence in the game world), *character sounds* (generated by non-playing characters), *ornamental sounds* (ambient music etc.) and *instructions* (speech recordings providing information on how to play the game). The most challenging task in creating these games was regarded by the authors as appropriately balancing the aesthetic and functional features of the soundscape: while the former are important to build an immersive atmosphere, the latter are necessary when designing an auditory interface capable of effectively replacing graphics.

Valente et al. [20] employ a categorized soundscape in *The Audio Flashlight*, a virtual treasure hunt game for visually impaired persons running on mobile devices. The game world is a dark room, and players have to find a hidden treasure with a special "flashlight" device (implemented with a smartphone) which is able to guide them through the use of sounds. Sound design is based on audio signs used to indicate the beginning of the game (the sound of an opening door), end of the game (the slam of a door closing), successful retrieval of the treasure (a sound of applause), and player movement (sound of footsteps). Distance from target is mapped into the volume and speed of the background music track: the closer the player gets to the target, the louder and faster the music is played. A preliminary evaluation showed how the sound of footsteps was considered by users as the primary system feedback, helping them to differentiate between activity and inactivity. Background music was reported to be helpful in creating tension and excitement, thus making the game immersive and engaging.

To the best of our knowledge, *Zombies, Run!* [21] is the only available attempt at introducing audio storytelling elements into mobile exergaming. The player takes the role of a zombie apocalypse survivor searching for weapons and supplies to help the people of one of the last standing cities. The goal of the game is to complete a series of missions with different goals (such as finding a certain object or gathering supplies for the survivors) by performing a running session. Gameplay is organized in two parts (during the run, after the run) that are strictly related to each other. During the run, the player can pick up supplies and items required to complete the current mission; items are picked up automatically, with a robotic voice notifying the player about what kind of object has been obtained. The game tracks speed and movement using GPS and accelerometer, but unfortunately it does not use such data to influence the player's running pace. The player can thus run at paces that are inappropriate for her fitness conditions. While running, random zombie encounters are triggered: the player has to increase her speed about 20% from base pace for about a minute to escape, otherwise she will lose some of the collected items. After the run, gathered items can be used to power up and expand the city, unlocking new missions. The story is narrated through pre-recorded audio cutscenes, and the post-apocalyptic setting is recreated using various sound effects (such as gun shots and zombie growls) which can be mixed with any audio file chosen by the player. No user evaluations of *Zombies, Run!* have been reported in the literature.

III. The proposed audio Exergame

The main goal of our proposed mobile exergame (called *Time:Runner*) is to make outdoor physical exercise more enjoyable and engaging. In particular, Time:Runner aims to enhance running, by providing the runner with an interactive audio-based story and virtual world that reacts to her actions. People in mobility conditions can devote only a very limited visual attention to a mobile application, having to attend to a constant flow of events and stimuli that come from the surrounding environment. This need is even more stringent when running because the greater speed at which the user moves requires faster reactions, e.g. time to collision with unexpected objects or persons is shorter. By observing people who run outdoors, one can easily notice that they use mobile devices as long as they do not require continuous visual attention, e.g. they often use them to listen to music, but not to watch videos. On the contrary, while running on indoor treadmills at home or at the gym, people are willing to watch movies, because the protected setting does not require the level of visual monitoring of the environment needed in outdoor running. In Time:Runner, we thus employ audio storytelling techniques to engage the runner in the game and to deliver feedback about her physical performance without requiring her to look at the screen. Following the classification of videogame narrative structures outlined by Spector [12], we have chosen the *Rollercoaster* structure, in which the events happen in a pre-defined order from which the player cannot diverge. The details of the story are unveiled progressively, exploiting the *Scary Shadow Syndrome* effects outlined in [15].

In fitness training, people often benefit from the presence of a *personal trainer*, who performs two main roles: monitoring the individual who engages in physical activity to make sure she is performing the exercise in the correct way, and encouraging her at appropriate times during the session. In Time:Runner, we introduced a non-playable character (NPC) we called *remote operator* which performs the role of the personal trainer in a way that follows the underlying story. To this purpose, we draw inspiration from popular video games such as *Metal Gear Solid* [22] (Figure 1) which employs NPCs performing three main functions: monitor the actions of the players and motivate them to proceed throughout the game, provide appropriate instructions on how to interact with the game depending on the current context, explaining the game controls in detail, and narrate the story as it progresses during the game. Our remote operator closely follows this model, providing continuous feedback on the running session to have players perform inside a physical difficulty range they have chosen.

To create a convincing representation of the virtual world with audio elements that replace the visual ones, special care must be taken in order to carefully design a soundscape that can stimulate the players to reach *willing suspension of disbelief*, thus making them part of the alternate reality. Our

(a) Story narration. (b) Context-aware instructions.

Fig. 1. An example of NPC in Konami's Metal Gear Solid performing a supporting role similar to our *remote operator*.

soundscape is made of three types of sounds: sounds indicating the *presence of non-playing characters* (such as the remote operator and players' antagonists), *symbolic* sounds (such as the auditory notifications of the damage suffered by the player, as well as alarm sounds when the running speed is too high or too low), and *decorative* sounds (such as background music and ambient sound effects).

Although our soundscape mixes a variety of different sounds, the warnings and encouragements of the remote operator are perceived with greater priority over other auditory elements, consistently with Chion's *vococentrism* principle [23], that points out how in every audio mix, the presence of a human voice instantly sets up a hierarchy of perception. This is extremely important, as the sentences pronounced by the remote operator are the most prominent feedback that we provide to players in response to their actions.

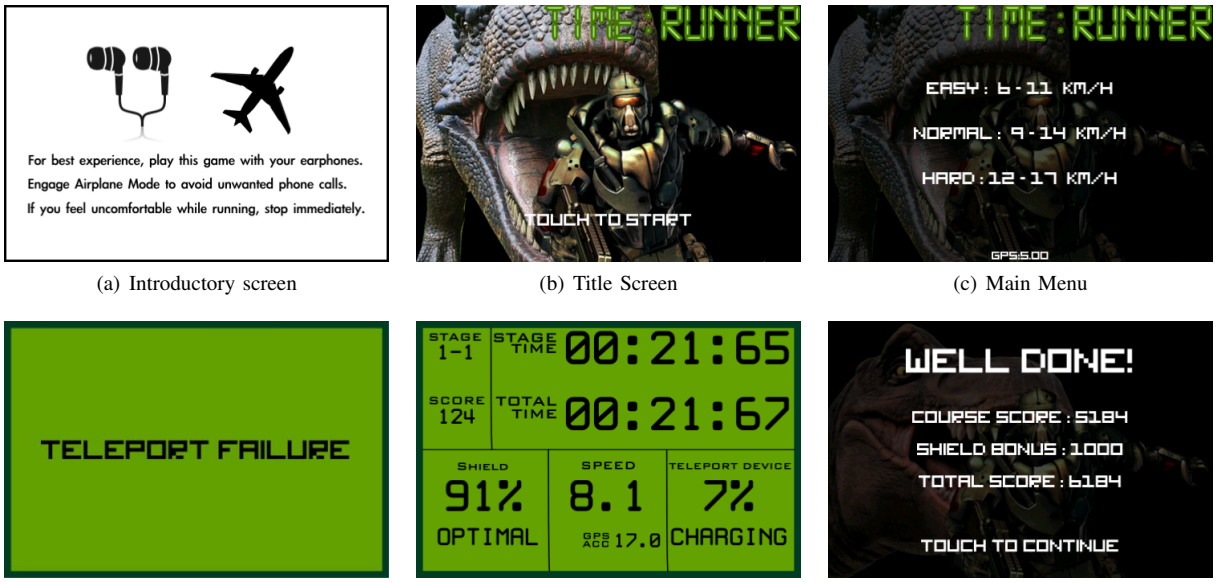
To further engage players in the narrated events, we decided to give the iPhone device a precise role in the narrated story, by making the remote operator refer to it as an advanced communication device included in the main character's futuristic equipment. We considered Waern's research on *pervasive games* [24] which employ a narration built on top of objects and features belonging to the real world, integrating the devices used during the game session in the narrated storyline. For example, in the alternate reality game *Momentum* the player can discover "sources of magic" hidden in the real world by using the "*Thumin glove*", implemented using a modified motorcycle glove enhanced with a *RFID* reader, a vibrator and a Bluetooth card. When the glove gets in contact with a magic source, it indicates its presence with a strong vibration. By blurring the line between fantasy and reality, Waern aims to create a "360° illusion" that can make games more immersive and engaging.

To monitor the physical effort of players, Time:Runner measures their running speed using the built-in GPS in the iPhone. Based on the detected speed, the events that happen in the game are meant to help the player maintain her running speed inside the physical difficulty range she has chosen. Since the ideal running speed varies considerably from person to person depending on different factors (such as sex, age, weight and fitness condition), we created three different difficulty levels, each one using a different speed interval. The *Easy* difficulty level, suitable for people who exercise very rarely, requires the player to keep her speed anywhere between 6 and 11 Km/h (3.7 - 6.8 Mi/h). In the *Medium* difficulty level, tailored for people who perform a regular moderate physical activity, the player keeps her speed between 9 and 14 Km/h (5.6 - 8.7 Mi/h). The *Hard* difficulty level requires the player to run at a speed between 12 and 17 Km/h (7.4 - 10.5 Mi/h). This level is suitable for regular runners in excellent fitness conditions.

Before the player starts running, when it is still possible for her to comfortably and safely watch the mobile device, a series of introductory screens is shown. First, the player is asked to wear her earbuds and is warned to stop playing the game if she feels uncomfortable while running (Figure 2(a)). Then, the title screen is shown (Figure 2(b)), depicting the main character of the game dressed in a futuristic suit, escaping from a giant dinosaur. The main character's face is covered with a helmet, to hide gender and promote player's identification with the character. By tapping on the main screen, the player can choose among the different levels of difficulty we previously described (Figure 2(c)). Then, the game plays an audio intro sequence describing the underlying story using the *fragmented narrative* technique. The player starts hearing a soundscape composed of jungle sounds including cries of exotic birds, monkeys and other animals. Suddenly, static noise starts crackling, suggesting an incoming radio communication. Meanwhile, the screen of the device displays only a blinking message that says "*Teleport Failure*" (Figure 2(d)).

Static noise eventually fades away as the remote operator is able to start a communication with the player, explaining that the last time transport procedure meant to bring him/her home resulted in an unexpected change of destination: the player is now located in an unknown part of prehistoric South America. Making up for an emergency solution, the remote operator reveals the existence of an emergency time travel system in the mobile device worn by the player, that needs to be remotely activated with a procedure that requires some time. Then, the remote operator briefly describes the shield system included in the player's equipment, which can sustain a certain amount of damage, offering limited protection for possible attacks. Suddenly, loud foot stomps and animal howls interrupt the conversation: the remote operator urges to start running as a dinosaur begins to chase the player, who has to escape until the operator manages to activate the emergency teleport system.

During running, score is increased by 2 points every 1/10th of second during which the player is able to keep his/her speed inside the speed interval of the current difficulty level. During this period, the remote operator encourages the player to keep going at the current speed every 10 seconds. If the player's speed is below the lower bound of the speed interval, the



(a) Introductory screen (b) Title Screen (c) Main Menu

(d) Introductory audio sequence (e) In-game screen (f) Debriefing screen

Fig. 2. Screenshots from Time:Runner. The title screen includes the *"Futuristic Soldier"* artwork by Dominik Zielinski (used with permission) and the dinosaur picture by Dave Catchpole (Creative Commons Attribution 2.0 Generic License).

narrator recommends to accelerate. In this case, the player's score is initially kept unchanged. If the player fails to speed up, then 5 seconds after the operator's warning the dinosaur will perform an audible physical attack, decreasing the shield efficiency by 9% and the player's score by 100 points (if the score becomes negative, it will be set to zero). The dinosaur will keep attacking every 5 seconds, until the player is able to bring her speed inside her chosen speed interval. If the player's speed is above the higher bound of the speed interval, the remote operator recommends to slow down, warning players that their high speed is causing localization problems for the remote team in their attempt to activate the emergency time travel system. During this phase, the player's score is kept unchanged.

The game level set in prehistoric times ends successfully if the player manages to keep her protective shield functional and escapes from the dinosaur (which requires 5 minutes of running). In this case, the remote operator will successfully trigger the emergency time travel system that will teleport home the player, and will then congratulate her for being able to complete the mission. A debriefing screen (Figure 2(f)) on the display will show the final score with an added bonus calculated by multiplying by 10 the remaining shield efficiency, then the player will be able to choose if she wants to play the next game level. If the dinosaur manages to entirely destroy the player's shield (bringing its efficiency to zero) by repeatedly hitting the player, the game ends with a *Game Over* sequence, displaying the final score obtained during the game session. During this sequence, the remote operator keeps calling the player with a dramatic voice tone as the radio communication is abruptly terminated. A Game Over also occurs if the player keeps running at a speed above the higher bound of the allowed interval for more than 20 seconds. In this case, the remote operator cannot locate the player anymore, and is unable to bring her back.

During running, the player is not required to look at the screen. In case she occasionally wants to glance at the screen, what she sees are in-game stats (such as the current score, shield efficiency and teleport activation status) as well as running data like the partial level run time, total run time and current speed (Figure 2(e)).

IV. User Study

We carried out a user study that focused on two main aspects. First, we wanted to assess if Time:Runner is an enjoyable and engaging mobile game for users with different activity lifestyles. Second, we wanted to study the effectiveness of the exergame in positively affecting the perception of physical activity, in our case running. Since a recent paper [25] suggested a negative correlation between activity lifestyle and efficacy of an exergame (the more active the player lifestyle, the lower the improvement in enjoyment of physical activity when playing the game), we decided to accurately measure the level of activity in participants' lifestyle to control for this factor in the analysis.

A. Participants

The evaluation involved a sample of 32 users (19 M, 13 F) recruited among university students and professionals from different kinds of industries. Age ranged from 22 to 57 (M= 30.40, SD = 9.29). The majority of participants were not familiar with video games or rarely played them: 15 participants never play video games, 4 play video games no more than once a month, 7 play them no more than few times a month, 3 plays them multiple times in a week, 2 play them every day for less than an hour and 1 plays them everyday for 1 to 3 hours. Most participants were also unfamiliar with domestic exergames: 27 do not usually play them, 1 plays them about once a month, 2 play them at least a few times in a month, and 2 play them multiple times per week. The majority of participants were not familiar with mobile exergames as

well: 26 do not play mobile exergames, 5 play them about once a month and 1 plays them few times a month.

B. Materials

The game was tested using an iPhone 4S with a 3.5", 960 x 640 pixels display. A Belkin armband (Figure 3) was strapped on the user's arm of choice to hold the iPhone, and the user was provided with a pair of earbuds (that was sanitized after each use).

Fig. 3. Wearing the iPhone using the provided armband.

C. Measures

1) Level of physical activity in user's lifestyle: To assess level of physical activity in users' lifestyle, we employed the *Global Physical Activity Questionnaire* (GPAQ) [26], standardized by the World Health Organization. The GPAQ contains 16 questions that collect information on physical activity participation in three settings (activity at work, travel to and from places and recreational activities), as well as sedentary behavior. After defining the MET (metabolic equivalent) as the energy cost of sitting quietly, the GPAQ analysis guide [27] specifies how to calculate the weekly amount of physical activity of a person in terms of METminutes per week (METM) (i.e., the weighted time spent on moderate and vigorous intensity activities), and categorize the level of physical activity in the person's lifestyle as *high*, *moderate* or *low*. Based on the analysis of GPAQ data, 8 participants (3 M, 5 F) in our sample had a lifestyle with a low level of physical activity, 10 participants (4 M, 6 F) had a lifestyle with a moderate level of physical activity, and 14 participants (13 M, 1 F) had a lifestyle with a high level of physical activity. The METM value in the sample ranged from 240 to 6960 (M = 2379, SD = 1930).

2) Game enjoyment: To evaluate game enjoyment we employed 11 of the 13 items of the *Player Enjoyment Scale* (PES) [28], which derives from the *EGameFlow* scale [29] and is based on the concept of *flow* [30]. PES includes 13 bipolar statements, both positive and negative, with scores from 1 (strongly disagree) to 7 (strongly agree). We removed the 7th and 12th items ("The difficulty of challenges in the game increased as my skills improve" and "I experienced an altered sense of time while playing the game"), because the difficulty did not change during the played level, and the gaming session was short (5 minutes). We had to slightly change the 8th item ("The game provided new challenges with an appropriate pacing") into "The game proceeded with an appropriated pacing", because no new challenges were introduced during the single level played. This modified version of the scale (for brevity, mPES) returns a total enjoyment score in the [11, 77] range, obtained by reversing the negative item scores and summing them to positive item scores.

3) Physical activity enjoyment: To compare the perception of running without Time:Runner and running with Time:Runner, we employed the *Physical Activity Enjoyment Scale* (PACES) [31], an instrument thoroughly validated in the sports and exercise literature (e.g. [32], [33]). This scale includes 18 bipolar statements with scores from 1 (strongly disagree) to 7 (strongly agree). The PACES produces a total enjoyment score in the [18-126] range. In our study, participants filled a PACES at the beginning of the evaluation concerning their perception of the running activity, and a PACES after playing Time:Runner concerning their perception of the running activity while playing the exergame. We hypothesized that, by engaging the user in the audio-based narrative during the physical activity, Time:Runner could have a positive effect on the user's perception of running, making it a more enjoyable activity. We thus expected the score for the second PACES to be higher than the score for the first PACES.

D. Procedure

Each participant was met at a city park with a public running course. Users were told that the goal of the study was to evaluate a game for the iPhone that requires to run while maintaining the speed within a certain range chosen by the player. They filled a demographic questionnaire to record age, gender and current occupation, video game usage, desktop exergames usage and mobile exergames usage. Then, they answered the GPAQ questions and filled the first PACES questionnaire. Before trying the exergame, users were asked to perform a brief warm-up run at low speed to increase the temperature of their muscles (thus improving their flexibility).

Each participant was then assisted in wearing the iPhone on their arm of choice using the armband, and asked to choose the difficulty level they felt more representative of their athletic condition to ensure that the level of exertion was neither too light nor too demanding. Users were told to closely follow the audio instructions (which also tell players when they have to start running). The running session with the game had a duration of about 5 minutes.

After the session, users filled the second PACES and the mPES. We then asked players four open questions about Time:Runner: what they liked and did not like about the exergame, if the game was difficult to use and if (and how) they would like to see it improved. Finally, users were debriefed and thanked for their participation.

V. Results

1) Game Enjoyment and Physical Activity Enjoyment: The mean mPES score obtained by Time:Runner was 64 (SD = 6.46). Differences in physical activity enjoyment were analyzed with a within-subjects ANCOVA, using the PACES score as dependent variable and the METM value as co-variate. The difference between the two PACES was statistically significant ($F(1,30) = 10.62$, $p < .01$, $\eta^2 = .26$), and the mean score for the second PACES (M = 100.8, SD = 15.14) was higher than the score for the first PACES (M = 92.4, SD = 20.53) as shown

in Figure 4. There was no interaction between PACES and METM.

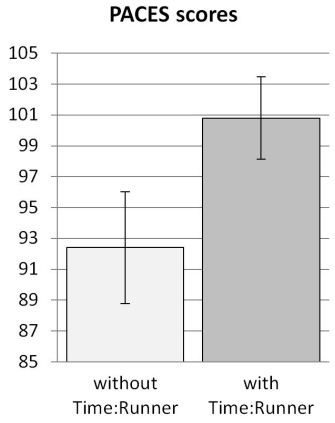


Fig. 4. PACES scores for running without and with Time:Runner. Capped vertical bars denote ± 1 SE.

2) Answers to open questions: In answering the question "What did you like about Time:Runner?" players identified the following elements: (i) the atmosphere created by the soundscape (10 users), (ii) the introduction of the remote operator as a motivational entity (12 users), (iii) the capability of the remote operator to help the user in keeping an appropriate pace during the run (4 users), (iv) the background music supporting digital audio storytelling (2 users), (v) the narrated story as an interesting alternative to music during running (2 users). Answers provided to the question "What did you dislike about Time:Runner?" included: (i) lack of a more detailed plot (5 users), (ii) encouragements made by the remote operator were too repetitive (6 users), (iii) the volume of dinosaur audio samples was too low (3 users), (iv) *Easy* mode was not enough physically demanding (3 users), (v) scarce reactivity in detecting speed changes (1 user), (vi) layout used in presenting information on the display (1 user). In answering the question "Did you experience difficulties in using the game?", only two users reported problems which concerned the need to often adjust the earbuds while running. Users gave the following answers to the question "What would you change to improve Time:Runner?": (i) introduction of more levels with different settings to add variety to the game (8 users), (ii) introduction of more sentences spoken by the remote operator (6 users), (iii) possibility to define customized training sessions by modifying target speed and session duration (4 users), (iv) implementation of a game-based warm-up (3 users).

VI. Discussion

The results on physical activity enjoyment indicate that the exergame was effective in positively affecting the perception of physical activity: playing the game makes running a more enjoyable activity for users. The lack of interaction between METM and PACES indicates that the correlation described in [25] was not present in this study. This may be simply due to the fact that *LocoSnake*, the exergame evaluated in [25], is completely different from Time:Runner. For example, while Time:Runner does not require players to look at the screen during physical activity, *LocoSnake* is based on a casual game that requires players to continuously look at the screen and its evaluation reports that the most physically active users complained about that. Another difference between the two studies could have played a role: the physical activity we considered was running, which is much more demanding than the light walking activity performed in [25], making it more likely that the help provided by the exergame is noticed and appreciated by people with different levels of physical activity in their lifestyles. This would be consistent with the fact that, in the informal interviews, participants with a low, moderate and high active lifestyle praised the ability of Time:Runner to distract them from the fatigue perceived while running. Since the intensity of running encouraged by Time:Runner was chosen by users according to their physical conditions, the physical activity they performed should have been similarly demanding.

As indicated by the mean mPES score, the exergame was well received and enjoyed by participants. This is also confirmed by the high rating received by the first item in the mPES scale ("I enjoyed playing this game", M = 6.31, SD = 0.89). The remote operator entity performed reasonably well in fulfilling its functions according to the mean rating of the 4th ("Overall, game goals were presented clearly") and the 5th ("I received feedback on how well I was doing in the game") item of the mPES scale, which were respectively 6.46 (SD = 0.76) and 6.25 (SD = 0.71). The soundscape designed to represent the virtual world without the need of visual elements turned out to be engaging and emotionally absorbing, as highlighted by the mean ratings of the last two mPES statements ("I temporarily forget worries about everyday life while playing the game" and "I felt emotionally involved in the game") which were respectively 5.93 (SD = 1.18) and 5.78 (SD = 1.12). One interesting comment about the atmosphere created by the soundscape was collected during an informal discussion in the debriefing session: two participants pointed out that while they appreciated the exergame, they were so engaged in the action sequence that they felt a sense of anxiety and tension while being chased by the dinosaur. While this unexpected result is consistent with the engrossing properties of the audio storytelling techniques we employed, it also highlights a further direction to explore concerning the level of anxiety induced by the story plot and when it could be possibly detrimental to the effectiveness of the experience and unsuitable for some users.

VII. Conclusions

This paper has shown that digital audio storytelling can allow designers to create mobile exergames that are effective at positively affecting the perception of physical activity, making it more enjoyable, while at the same time addressing the need to minimize the visual attention required by mobile devices to users who are moving in outdoor environments. We now plan to extend the game plot by exploiting the ambiguities of the narration and the plot holes introduced by the fragmented narrative technique, creating additional levels staged in different ages. For example, after the prehistoric level, the player will be transported in a Mayan temple full of traps, and then in the XV century during a witch hunt (in which people will notice the futuristic equipment and will start chasing him/her). In a subsequent level, the remote operator will be finally able to locate the extraterrestrial entity responsible for jamming the time travel system, and the player will have to face this

final enemy before being able to get back home. We are also exploring how to integrate a physical warm-up level that fits in the narrated plot.

We are interested in monitoring additional parameters during the running session, e.g. by using heart rate sensors. We believe that combining such data with GPS speed readings will enable us to extend the effectiveness of the remote narrator (which could have a more detailed picture of the runner's physical status and provide more specific advice and/or encouragement) and increasing the adaptivity of the gaming experience.

The audio storytelling techniques used in Time:Runner could also be exploited for treadmills, cyclettes and other kinds of equipment commonly used in gyms and fitness centers. *Exertainer* [34] is an example of fitness tool (a treadmill) integrated with computer hardware: a similar project could use the audio-based approach employed in Time:Runner to create a more engaging indoor fitness tool.

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