# Physical Activity Motivating Games: You Can *PLAY, MATE!*

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**ABSTRACT**

Contemporary lifestyle is becoming increasingly more sedentary: a little physical activity and much sedentary activity. The nature of sedentary activity is self-reinforcing, such that increasing physical and decreasing sedentary activity is difficult. Rather than trying to motivate users to reduce the time spent on sedentary activity, we focus on integrating physical activity into the sedentary activity of computer games playing through a novel game design. Our design leverages engagement with games in order to motivate users to perform physical activity, as part of the sedentary playing, by offering game rewards in return for physical activity performed. In this work we report on an initial user study of our game design applied to the open source Neverball game. We motivated users (in this case children) to perform physical activity by reducing the time allocated to perform tasks and captured their activity through accelerometers configured to recognise jumping movements. Findings showed that users performed more physical activity and decreased the amount of sedentary time when playing the active version of Neverball, while not reporting a decrease in perceived enjoyment of playing.

**Author Keywords**

Serious games, game design, physical activity, motivation, behavioural change, user study.

**ACM Classification Keywords**

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces, Interaction Styles, I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems, Games.

## INTRODUCTION

Contemporary lifestyle is becoming increasingly inactive: a little physical activity and much sedentary activity. Since the nature of the sedentary activity is often addictive and self-reinforcing, improving the lifestyle by explicitly increasing the amount of physical and decreasing the amount of sedentary activity cannot be achieved easily. We present a novel approach aimed at combating this problem in context of computer games. Rather than changing the amount of physical and sedentary activity, we propose a new game design that leverages the engagement of users with computer games in order to motivate them to perform physical activity as part of the sedentary playing. This game design is referred to as *PLAY, MATE!* (PhysicaL ActivitY MotivATing gamEs) (Berkovsky et. al., 2009).

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This paper presents and evaluates an application of the *PLAY, MATE!* design to a publicly available computer game, Neverball. In Neverball, user navigates a ball through a maze-shaped surface avoiding obstacles and collecting coins, while accomplishing these tasks in a limited time. We adapted Neverball according to the *PLAY, MATE!* design by reducing the time allocated to accomplish the game tasks, and motivated users to perform physical activity by offering time based game rewards. Each user was equipped with a 3D accelerometer, such that every for every jump recognised by the accelerometer the user gained one extra second to accomplish the game tasks. Here we report on an empirical evaluation involving *180* users. The evaluation ascertained that the *PLAY, MATE!* design can increase the amount of physical activity performed while playing computer games and change the distribution between sedentary and active playing time.

The contributions of this work are two-fold. Firstly, we propose a novel *PLAY, MATE!* design for physical activity motivating games and practically exemplify its application. Secondly, we empirically evaluate the acceptance of the design and its influence on users. These results demonstrate the potential of physical activity motivating games and call for a future research on adaptive application of the *PLAY, MATE!* design to a wider variety of computer games.

## RELATED WORK

Design of information technology solutions to the obesity problem have been studied in (Campbell et. al., 2008) and (Consolvo et. al., 2006) and several practical applications have been developed afterwards. For example, (Lin et. al., 2006) presented a social application recording users' physical activity and linking it to the growth of a virtual fish. Similarly, (Toscos et. al., 2006) presented a mobile application recording users' physical activity and sending messages encouraging exercising. In both cases, the physical activity recorded was walking/running and the recording device was a standalone pedometer, such that the users had to periodically manually feed the counter reading into the system.

These applications had several weaknesses including the unreliability and inaccuracy of self-reporting and the possibility of cheating the application. From a behavioural perspective, these applications were aimed at changing the lifestyle by indirectly encouraging the users to perform physical activity. This form of motivation was seen to be accepted primarily by already motivated users, with non-motivated users resisting it. A similar conclusion is true also for Web based physical activity motivating applications surveyed in (Zhu, 2007). Very few applications led to a short-term influence in promoting physical activity. Unlike the above, our proposed game design does not rely on existing motivational factors, but rather leverages engagement of users with games to motivate them to perform physical activity.

Game technologies involving users' physical activity have been developed and disseminated in commercial products, such as Dance-Dance Revolution (www.konami.com), Nintendo Wii (www.nintendo.com), and PCGamerBike (www.pcgamerbike.com). The first is a dancing pad with directional arrows, on which users step to control the game. The second uses an accelerometer equipped input device, allowing the users to control the game by their body movements. The third is a programmable controller using bicycle pedalling motion to control the game. Despite being similar to the proposed approach (all of them aim at motivating users to perform physical activity while playing games), these examples should be treated as commercial products providing bodily interfaces or controllers allowing an intuitive interaction mode with computer games rather than motivators of physical activity.

To the best of our knowledge, the only user study of practical integration of physical activity into computer games was presented in (Fujiki et. al., 2008). User's activity data captured by a 3D accelerometer were visualised by a simple race-like game interface. The captured data affected the visualisation of the game: speed of the game character, its standing in comparison to other users, and facial expression of the user's avatar. However, the race-like interface was designed exclusively to visualise the user's physical activity, lacking the attractiveness of commercial games. Rather than designing new games and interfaces, our work aims at developing a new game design that, if integrated with a variety of existing and future games, will motivate users to perform physical activity as part of playing the games (Berkovsky et. al., 2009).

## DESIGN PRINCIPLES AND PRACTICAL APPLICATION OF *PLAY, MATE!*

The goal of the *PLAY, MATE!* game design is to change the sedentary nature of game playing to include certain aspects of physical activity. Physical activity is introduced as an integral part of the playing and the engagement of users with the game is leveraged to motivate them to perform physical activity. The motivation to perform physical activity is achieved by modifying the following game components and aspects of user interaction with the game:

- Game motivator. Users are made aware of the possibility to gain virtual rewards in return for performing real physical activity. Also, the game is modified to motivate users to perform physical activity, such that certain game functionalities can be enabled or reinforced by the rewards.
- Activity interface. Users are provided with an external interface capturing their physical activity, processing it, and eventually converting it into virtual game rewards.
- Game control. Since performing physical activity and controlling the game simultaneously could be over-complicated, users are given supplementary control over the flow of the game.

Using the above modifications, users are motivated to perform physical activity in the following way. On one hand, the game is modified such that certain functionalities are disabled and/or certain features are diminished. On the other hand, users are made aware of the possibility to perform physical activity and gain game related rewards, i.e., enable the disabled functionalities and/or reinforce the diminished features. A composition of these two factors, combined with the existing engagement with the game and the enjoyment of playing, motivates users to perform physical activity. Hence, they can use the supplementary game control, interrupt the sedentary playing, and perform physical activity. When performed, the activity is captured by the physical activity interface, processed, and converted into the game rewards, such that the disabled game functionalities are enabled and/or the diminished game features are reinforced. These rewards are visualised by the game interface. Hence, the user remains in control of the amount and timing of the physical activity performed and can continue the sedentary playing at any point of time.

To experimentally evaluate the *PLAY, MATE!* design, we applied it to an open source GPL Neverball game (www.neverball.org). In Neverball, users navigate a ball to a target point through a maze shaped surface and collect the required number of coins, while accomplishing these two tasks in a limited time (see Figure 1 left). The availability of the source codes of the game simplified the application of the *PLAY, MATE!* design.

We applied a time based game motivator. The time allocated to accomplish levels was shortened and users were made aware of the possibility to gain extra time in return for performing physical activity. We used a 3D accelerometer to capture user's physical activity (Helmer et. al., 2008). The accelerometer was attached to user's waist using an elastic band (see Figure 1 right) and transmitted the acceleration signal to Neverball. The signal was processed such that for every activity burst (referred to as jump) captured and recognised, users gained one extra second to accomplish the levels.

Note that the effort required to apply the *PLAY, MATE!* design to an existing game (game related motivator implantation and physical activity interface calibration) is negligible in comparison with the effort required to design and develop a new game. This is due to the fact that when the design is applied to an existing game, many available components, such as game logic, input/output, visualisation, and others, can be reused rather than developed from scratch.

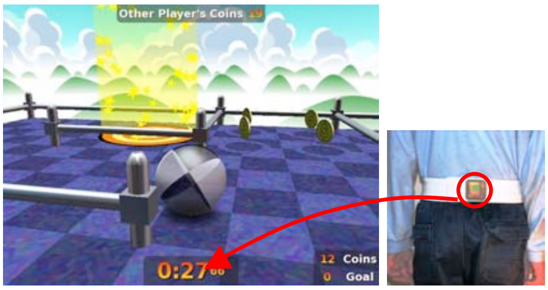


**Figure 1 Neverball interface (left) and accelerometer (right)**

## EMPIRICAL EVALUATION

We conducted an experimental evaluation involving *180* children aged *9* to *12* (estimated target age for Neverball). They were divided into two groups: half of them played the sedentary version of Neverball, while the other half played the *PLAY, MATE!* version of Neverball. Both versions were altered such that time rewards for jumping were available, but only the active version had the allocated completion times shortened. The duration of the playing session in both cases was *20* minutes. The main indicators of acceptance of the *PLAY, MATE!* design are the amount of physical activity performed while playing, and the enjoyment of playing.

Figure 2 compares the number of jumps recognised in these two groups. During the playing session users of the sedentary group jumped on average *41.9* times, whereas users of the active group jumped *257.5* times. To support this, Figure 3 compares the relative time distribution between the sedentary playing and performing physical activity. Users of the sedentary group spent on average *95.4%* of time on sedentary playing and *4.6%* on physical activity, whereas users of the active group spent only *76%* of time on sedentary playing and *24%* on physical activity.

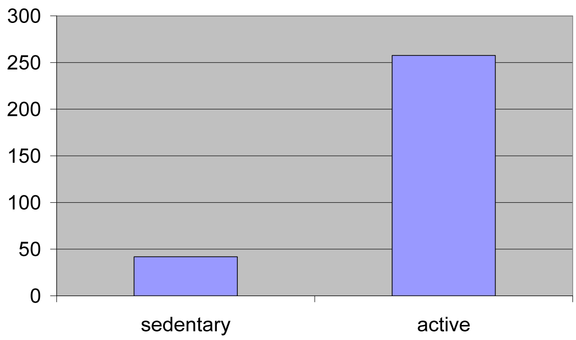


**Figure 2. Average number of jumps captured**

In addition to the amount of physical activity performed, the enjoyment of playing is an important indicator of the acceptance of the *PLAY, MATE!* design. We analysed the enjoyment and the users' perception of playing. In the post-study questionnaire the users reflected on their perception of the playing session on a [*-1,+1*] continuum, where *+1* means that it is perceived as pure sedentary activity and *-1* means that it is perceived as physical activity. Figure 4 depicts the average perception across the two groups.

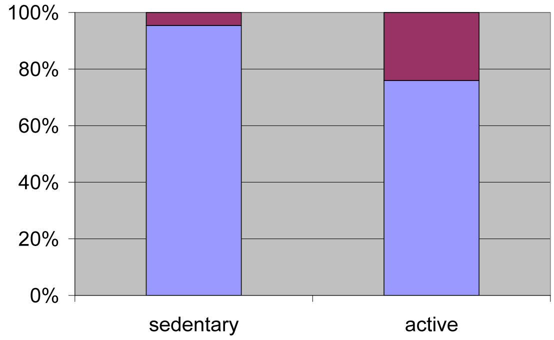


**Figure 3. Distribution between sedentary and active time**

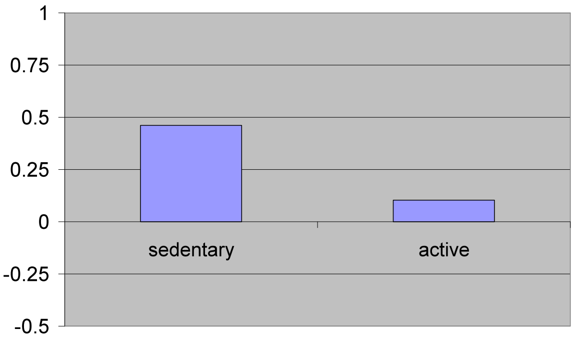


**Figure 4. Sedentary playing vs physical activity perception**

As can be seen, average perception of playing in the sedentary group is *+0.46*, i.e., the users perceive it as mostly sedentary playing activity. However, in the active group the perception is *+0.11*, i.e., the users perceive it as almost equally sedentary and physical activity. This perception corresponds to the amount of physical activity shown in Figure 2. To support this, Figure 5 shows the playing perception as a function of the number of jumps recognised. A linear regression of the reported perceptions has a negative slope. Also, Pearson's correlation value between the number of jumps and the perception of playing is *-0.47*. This ascertains that the perception of the users is realistic: the perception of playing as a sedentary activity decreases when the number of jumps performed increases.

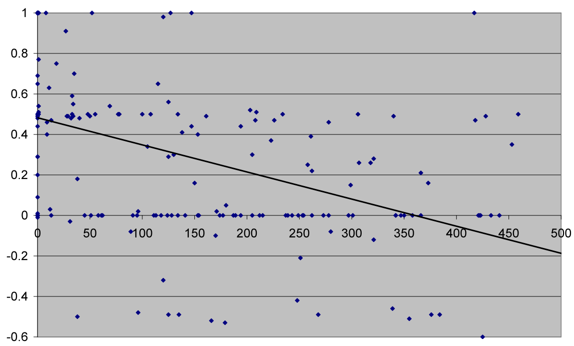


**Figure 5. Perception of playing vs. number of jumps**

Although the users realistically perceived the amount of physical activity performed while playing, they did not report a decrease in perceived enjoyment of playing (measured on a 6-Likert scale). Users of the sedentary group reported average enjoyment of *5.52*, while users of the active group were very close and reported average enjoyment of *5.48*.

We conjecture that applying the *PLAY, MATE!* design to Neverball had a mixed influence on the enjoyment factors of playing. By introducing physical activity as part of the game we disrupted the designed flow of playing (Sweetser and Wyeth, 2005) as sedentary playing activity became interlaced with physical activity. This could have a negative effect on enjoyment. However, users were provided with a new interaction mode with the game through the activity interface. This new interaction, not available in the state of the art computer games, allowed more control over the game and this, coupled with its novelty, could have a positive effect on enjoyment. The observation that the perceived enjoyment of playing did not change considerably across the two groups allows us to conjecture that these two effects balanced each other.

The post-study questionnaire supports this conjecture. In the questionnaire, the users were asked to reflect on the factors that made their playing enjoyable. They were presented with a list of factors and asked to tick all the factors with which they agree. Table 1 shows the number of users that agreed with two factors of a particular relevance to the enjoyment.

| *I liked to ...* | *Sedentary* | *Active* |
|---|---|---|
| *... control the ball in the maze* | *65* | *55* |
| *... get time by doing physical activity* | *35* | *60* |

**Table 1. Playing enjoyment factors.**

The first question refers to the sedentary playing component. The agreement level decreases in the active group, in which the users performed the greatest amount of physical activity. The second question refers to gaining extra time in return for performing physical activity. As can be clearly seen, the agreement level increases considerably in the active group, indicating that the users liked the new interaction mode through the activity interface.

## CONCLUSIONS AND FUTURE WORK

This work presented a novel *PLAY, MATE!* design of active games. According to this design, physical activity is introduced as an integral part of sedentary playing, such that performing the activity gain the users virtual game rewards. The design was applied to an open source Neverball game by offering time based rewards and we conducted an initial study involving *180* users.

The results allow us to draw two important conclusions. Firstly, we were able to ascertain that physical activity motivating games can indeed motivate users to perform physical activity. This was clearly shown by the increased amount of physical activity and modified sedentary/active time distribution. Secondly, although users were required to perform physical activity as part of playing and realistically perceived the activity performed, they did not report a decrease in the enjoyment of playing.

These results demonstrate the potential of physical activity motivating games and call for future research on user dependent application of the *PLAY, MATE!* design to various types of computer games, and for a thorough longitudinal study, which will assess the attitudinal and/or behavioural change caused by physical activity motivating games.

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