Transforming Solitary Exercises into Social Exergames

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ABSTRACT
This paper discusses an approach for transforming solitary exercises into social exergames. We frame our discussion by highlighting the relation between the original exercises and game interactions, and by analyzing an example exergame which is successfully transformed from its original solitary exercise. We present a user study of the exergame that evaluates the need for holistic transformation strategies from solitary exercises into social exergames.

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Human Factors; Design.

INTRODUCTION

Sports are an entertaining and engaging means to improve people's athletic abilities and physical condition. Team sports also play an important role in strengthening sociability and solidarity between players. As players act and react to each other, their resulting interactions mesh together. The moment of a clean, perfectly timed pass from a teammate followed by an exquisite shot to a goal, creates an unparalleled feeling of excitement and achievement that is shared among all one's teammates. This kind of extraordinary sensation resulting from synchronized team interaction is an important part of what immerses people in team sports, making it a favored form of physical exercise.

However, it is difficult for many people with their busy and erratic urban lifestyles to engage in such social sports frequently as such activities take place at a strict designated time and place. As a result, many people perform physical training in the form of a solitary exercise that can be done at a more convenient time and place, such as treadmill running at home. It may be difficult for many people to be motivated to perform these monotonous, repetitive, and isolated exercises. Moreover, the results of intrinsic rewards of exercise such as better general health [5] and appearance are not immediately observable. Finally, solitary exercise does not satisfy the need for social interaction, which is important for individual health and sense of well-being [4].

In this paper, we discuss an approach for transforming solitary exercises into social exergames. We frame our discussion by highlighting the relation between the original exercises and game interactions, and by analyzing an example exergame which is successfully transformed from its original solitary exercise. We present a user study of the exergame that evaluates the need for holistic transformation strategies from solitary exercises into social exergames.

We note that a recent work provides a design framework for exergame design [7]. We appreciate that our discussion can be understood as a specialized study framed within the viewpoint of this work. Overall, our work mainly touches on *the moving body* and *the relating body* aspects of *the exertion framework*, through utilizing solitary exercises and providing relationships among players, respectively.

TRANSFORMATION GUIDELINES

While designing exergames based on solitary exercises, designers should keep in mind that the original exercises and game interactions affect each other. Thus, they produce nontrivial problems which are not exposed while being treated independently, thereby requiring the designers to understand the elements from a holistic point of view. That is, exercises expand the design space of games beyond that of traditional games. In detail, designers should integrate a given exercise with a game by utilizing physical actions of the exercise, as well as evaluate whether the game is a suitable fit for the exercise. In this section, we introduce guidelines for the conversion, obtained by analyzing prior studies on traditional games and exergames by Salen and Zimmerman [13], Campbell et al. [3], and Mueller et al. [7]

Exercise-Aware Game Interaction Design

Obtaining Design Primitives from Exercises

As discussed in [13], designing game interaction largely consists of building a meaningful relationship between players and with a game system by defining a set of rules describing the relationship. Specifically, interaction between players is induced by sharing a part of the game system. In the case of social exergames, the shared part of the game system can be derived from a state or outcomes of the original exercise. In this context, it helps designers to create a glossary of a given exercise by thoroughly observing and identifying the states and the outcomes of a target exercise. For example, in the case of running, design primitives from the exercise include the action of taking steps and swinging hands, current speed, elapsed time or duration, distance, and the state of running itself, etc.

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Choosing Key Primitives for Interaction

Designers should carefully choose key primitives, depending on the type of experience that they want to focus on delivering: exercising, playing the game, or most likely a mixture of both. The selection should consider the levels of abstraction of the primitives as they can influence aspects of game play and players' experiences. For example, distance is a primitive at a higher level of abstraction than the action of swinging hands while running. These primitives are used as the main inputs in Nike+ iPod [10] and the 100 meters sprint of Wii Olympics [12], respectively. The former preserves the original exercise well; however, it hardly gives players a sense of playing a game while running as indicated by Campbell et al. [3] Conversely, the latter adjusts the original running activity to an easier form, and thus players may feel that they are not running but playing a physical game. We do not aim to discuss what the best form for exergames is, but rather we simply wish to indicate that the key primitives of a game should be chosen depending on the purpose of the game. In Jogging over a Distance [9] and Kukini [3], both also originating from running, these works utilize the players' jogging state and distance, respectively. These games give hints as to ways to create a variety of exergames by choosing different key primitives from the same exercise.

Building Intuitive Interaction

Intuitiveness of interactions should be considered essential in exergame design. In general, the more intuitive an interaction is, the faster players engage in game play. Exergames, in particular, explicitly require interactions which are intuitive enough to perform during exercise. To design an intuitive game interaction based on a certain exercise, *modalities* and *affordances* [6] of the exercise must be identified in advance, i.e., which actions, body parts, and senses are involved in the exercise and to what degree. We refer to actions fundamental to the exercise as primary actions and to other actions as non-primary actions.

Preserving Primary Actions in the Core Mechanics

To make interactions more intuitive, it is often effective to use primary actions that are usually performed throughout the duration of exercise, as the main input for the core mechanics of a game. For example, Table Tennis for Three [8] converted a solitary wall-hitting practice into a social exergame. It preserved and actively employed the primary action of the original exercise into the converted game, namely hitting specific positions using a paddle and a ball.

Utilizing Non-primary Actions

Also, it is possible to utilize additional actions involving non-primary body parts and senses which can be performed concurrently along with the main actions of the exercise. These actions can be useful as additional game inputs to enrich the interactions between players and make the game more dynamic and fun. However, designing non-primary interaction requires careful consideration. The additional interaction should not interfere nor incur any direct physical conflict with the main interaction. Also, the new interaction should be designed not to distract too much attention away from the primary interaction, to guarantee the players' safety and performance of the primary interaction. We present an example later in the Revisiting Design Section.

Motivating Players

In the context of exergames, motivating players becomes more important than in non-exergames, largely because players should exercise as well as play the games. One of the essential components of a game to promote players' motivation is the goal, and the players struggle towards achieving goals [13]. Also, interactions between players, usually conceptualized as competition and cooperation[1], elaborate the struggles, i.e., players actively strive against or assist each other to win the game. In this subsection, we discuss important points on arranging goals and shaping interactions between players in exergames.

Creating and Arranging Micro Goals in Exergames

In general games, it is important to provide micro goals [3], sometimes referred to as short-term goals [13]. Micro goals are used as milestones towards bigger goals and for keeping players engaged in game play. Summarizing discussions in [3, 11, 13], micro goals encourage engagement in three ways; they provide (1) a sense of achievement frequently, (2) an easier way to gauge overall progress, and (3) a path for reaching long-term macro goals. Therefore, in the case of exergame design, it is more important to carefully arrange such micro goals throughout the game play, to keep players involved in strenuous exercise motivated. For example, in Table Tennis for Three players weaken blocks on a screen by hitting them with a ball. The last person to break a weakened block gets the point for the ball, accomplishing this micro goal.

While designing each micro goal, designers should also consider whether the players can achieve the goal given their physical availability. In video games, players learn game objects' characteristics by experience, e.g., the acceleration power of a vehicle or the maximum jumping height of a game character. The players then build strategies to achieve a given goal, taking these characteristics into account. In exergames, some of these characteristics are embodied by the players' physical capabilities, e.g., speeds of vehicles depend on players' running speeds. In that case, the players should adjust their strategies depending on their physical capabilities, as should designers of micro goals. Here we refer to yet another characteristic of exergames which does not exist in non-exergames: 'the outcome of the game is predominantly determined by physical effort.' [7]

Interaction between Players: Competition and Cooperation

Inter-player interactions in exergames resemble those in sports, as indicated in [7, 16]. In general, exciting sports feature highly synchronized interactions between players. Interaction among players can thus be tightly coupled to the point where player's actions are coordinated over very short

[1] In this paper, competition and cooperation refer to explicitly guided ones by game rules.

Figure 1. A team playing Swan Boat

time frames resulting in near-simultaneous actions. Actions are time-critical and failure to perform timely actions can result in penalties to the point of losing a game (in competitive cases) or degradation of the quality of the activity to the point where the current iteration cannot continue (in cooperative cases). For example, in Table Tennis for Three, a block must be hit three times before it breaks. Competing players must quickly coordinate their strategy to break the brick, instantaneously adjusting their actions to opponents'.

REVISITING DESIGN: SWAN BOAT

Swan Boat [1] is a social exergame designed for treadmill running (see Figure 1). It enhances the bland experience of running on a treadmill with rich interaction among players, encouraging intensive synchronized movement with their teammates. In the case of treadmill running, we easily observe that the legs are the main body parts used in the exercise and that leg movements are performed repeatedly as the *primary action*. Thus, walking or running actions can be used as the main game input. Also, as the arm and hand movements involve *non-primary body parts* while running, they can be utilized to design additional interactions.

In the game design, the designers adopt a paddle boat-type swan boat and a swan boat race as the game entity and metaphor. The metaphor is used to sketch the outline of the core mechanics: runners compete against each other in teams by cooperatively controlling a team boat. In a two-person team's case, one takes the role of the left paddler and the other, the right. As a result, the difference in speed between team members determines the direction of their boat. For example, if a team wants to steer their boat to port, the member in charge of that direction should run faster than her teammate. Players continuously change their running speed, the *key primitive* of interaction, to fine-tune the speed of their individual steps to adjust to the running pace of their teammates. (The speed of the treadmill is automatically adjusted to the pace of the runners.) This closely harmonized interaction immerses the players in the intense and fun game experience of playing together.

There are a number of *micro goals* designed to enhance the fun of playing Swan Boat by taking advantage of synchronized interaction. Runners promptly change their speed in synchronization with their teammates to steer their boats around *obstacles* and *traps* and rush to acquire *boosters* that temporarily accelerate the speed of their boat.

Simple arm- or hand-gestures are designed for additional fun interactions since they do not incur any conflicts with the main activity of running. Designers added "*punching together*" and "*flapping together*" gestures as additional synchronized interactions. Players in a team flap their arms together to rise back to the surface of the water when their boat is weighed down by a *trap* special item. Team members can also attack nearby opponents by punching together in sync to shove an opponent away with their swan boat's "wing", slowing down the opponent's boat.

Swan Boat supports synchronized interaction with other runners in distant locations over the Internet; players meet other runners of various skill levels and styles in Internet virtual communities to play with. Players can meet up with game partners with whom they meshed well in the past. These partners may forge friendships similar to those found in offline team sports such as soccer.

USER STUDY AND DISCUSSION

We conducted a user study to evaluate the effectiveness of Swan Boat. We compared two conditions: typical treadmill running and team racing in Swan Boat. 4 female and 8 male participants between 20 and 25 years old were recruited via Internet BBS and e-mail. All participants were paired randomly, except two pairs who were previously acquainted. The pairs participated together in each session. Each participant participated in four 20-minute sessions over two weeks. In the first week, participants ran on an interactive treadmill without playing Swan Boat. In the second week, participants ran on the treadmill playing Swan Boat.

Afterwards, participants were interviewed using open-ended questions. To compare energy expenditure in different conditions, we consulted a physical education specialist and decided to use average MET (metabolic equivalent) as a shorthand method for estimating the energy expenditure of the physical activity [2].

Intuitiveness of Game Interaction

The user study confirmed the tightly coupled nature of the design considerations, game play and the original exercise, and highlighted their relationship. Although the game mechanics required synchronization of exercise and close collaboration, most participants played the game well and enjoyed their exercise. All of them (strongly) agreed to the statement 'the game is intuitive to play' and 'the game is compatible with the running activity'. In addition, we carefully observed and interviewed whether *non-primary actions* such as punching together disturbs the primary game play, i.e., the cooperative boat control. Though punching together requires additional attention and gestural inputs, no participants complained about any distraction from the main running activity and when asked about it explicitly, participants simply stated that they did not experience any such difficulty.

Cooperation and Competition Effects

In the interviews, our participants commented on the cooperative effects, particularly on those due to the cooperative boat control game mechanic. Participants noted that they engaged in frequent verbal interaction to coordinate their cooperative play, suggesting that cooperative play increases social interaction: *"During the game play, we continuously discussed each other's running speed"* [P5]. However, some participants reported that they felt inconvenienced during team play: *"I prefer to run at my*

own pace" [P20]. Considering the study on the relationship between individual differences in competiveness and the competition experience [14], we can tentatively conjecture that there is a relationship between individual willingness, derived intrinsically or from the relation between co-players, and cooperation and the cooperation experience.

Participants' comments on the competitive nature of the game mainly focused on observations that closely competing with opponents provided strong motivations to keep running hard: "*When the opponents' boat was gaining on us, we ran hard to stay in the lead*" [P4]. This result is consistent with prior works which evaluate competition effects [14]. Competition was reported to make treadmill running much more exciting: *"Passing another boat just before reaching the goal was really thrilling."* [P12].

Interestingly, some participants wondered how the experience would change if a team consisted of more than two players. From on-site discussions with the participants, we could imagine the changes through two example sports, i.e., dragon boat racing and tug of war. That is, as the number of players in a team increases, the sense of belonging to and unity in a group will become still more important, as partially shown in Nike+ iPod [10].

Effects on the Exercise: Balance and Overexertion

Energy expenditure

The estimated energy expenditure while playing Swan Boat was about 54% higher than running on a treadmill; participants' average energy expenditure of Swan Boat playing was 9.47 (MET) and that value for the same time during typical treadmill running was 6.15 (MET). Therefore, we expect that players playing Swan Boat exercise more intensely than conventional treadmill running. The interviews confirmed this assumption as the participants noted that playing Swan Boat encouraged them to run much harder than treadmill running alone. Reasons for running harder while playing Swan Boat include the psychology of competition and not wanting to let down one's teammate.

Inter-player Balance and Overexertion

In incorporating social interaction into an exercise, one must consider how it may affect the original exercise activity itself. Issues not inherent to solitary exercise like differences in physical abilities may threaten fair play between players. Actually, some participants quickly realized their differences in physical ability within a few trials. Also, we observed that excessive motivation can cause overexertion: *"I could not maintain my own pace while trying to catch up with the others' boat. After the race, I realized that I exerted myself too much."* [P4].

Revisiting Game Play Design: Mitigating Imbalance

A potential solution for fine-tuning gameplay balance is to provide a physical ability balancing mechanism between players through the game mechanics. [9, 15] helps mitigate the differences between players' physical abilities by utilizing physical indicators, e.g., individual target heart rates, as criteria for exergame balance. Using such an approach, a player with lower physical ability could compete or collaborate fairly with one with higher ability using handicaps for boat speeds. We can also add game features preventing users from overexerting. For example, a boat can have an attribute called an *overheating gauge*. The gauge fills up gradually when a player runs faster than 7 mph, which is possibly dangerous. The boat slows down automatically when the gauge exceeds its maximum. Now overheating avoidance becomes a part of the game strategy, whereby players control their speed to avoid the penalty.

Field Experiences

We had opportunities to present Swan Boat at a local science festival. During the festival over 100 people tried our game. We observed parents who were unaccustomed to gaming easily interact with our system. The game provided an opportunity for gaming-novice parents to easily play along with their gaming-veteran children.

CONCLUSION

We discussed guidelines for transforming solitary exercises into social exergames, that is, exercise-aware game design, building intuitive interaction, and motivating players. We also analyzed the detailed design of the Swan Boat game to justify our guidelines. We presented a user study of the exergame that evaluates the need for holistic transformation strategies from solitary exercises into social exergames.

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