Liberi and the Racer Bike: Exergaming Technology for Children with Cerebral Palsy

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ABSTRACT

Children with cerebral palsy (CP) often have limited opportunities to engage in physical exercise and to interact with other children. We report on the design of a multiplayer exercise video game and a novel cycling-based exergaming station that allow children with CP to perform vigorous exercise while playing with other children. The game and the station were designed through an iterative and incremental participatory design process involving medical professionals, game designers, computer scientists, kinesiologists, physiotherapists, and eight children with CP. The station combines a physical platform allowing children with CP to provide pedaling input into a game, and a standard PC gamepad. With this station seven of eight children could play a cycling-based game effectively. The game is a virtual world featuring several minigames, group play, and an in-game money-based reward system. Abilities and limitations associated with CP were considered when designing the game. The data collected during the design sessions shows that the games are fun, engaging and allow the children to reach exertion levels recommended by the American College of Sports Medicine.

Categories and Subject Descriptors

H.5.2 [Information Interfaces And Presentation]: User Interfaces – Input devices and strategies;

General Terms

Human Factors, Design.

Keywords

Cerebral palsy, children, exergames, exergaming station

1. INTRODUCTION

Cerebral palsy (CP) is a group of disorders that affect development of motor function [3]. Children with CP find it difficult to participate in traditional exercise and thus it is difficult for them to get the benefits associated with physical activity. As they become adults, multiple factors including a lack of exercise can result in muscular deconditioning, causing a reduction in mobility. This loss of mobility in turn limits the opportunities for social participation.

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Exergames, video games whose play requires physical activity, represent a promising way of enabling children with CP to get the physical activity they need while also allowing them to interact with other children in fun ways. Nintendo Wii Sports and Kinect Adventures are examples of exergames for the general population. Some of these games have been used for rehabilitation of motor function. These are almost uniformly focused on extending range of motion and improving balance [1,4], but little has been done in terms of physical fitness [7]. Designing hardware that allows children with CP to play exergames vigorously is challenging due to the muscle weakness, limited mobility and spasticity that are typical of CP. Additionally, the design of the exergames themselves should avoid involving quick, accurate and fine motor movements, because they are difficult for children with CP and therefore prevent continuous vigorous exercise.

We designed a physical station and an exergame that allow children with CP to engage in vigorous exercise while playing and socializing with other children. We conducted seven participatory design sessions involving medical professionals, game designers, computer scientists, kinesiologists, physical therapists, and eight children with CP. In each session we tested and refined the physical station, focusing on safety, comfort and ease of use. We tested the game in terms of playability, exertion, engagement and fun. Results show that the game is fun, engaging and allows the children to reach exertion levels recommended by the American College of Sports Medicine.

2. THE PHYSICAL STATION

We considered three main challenges when designing the station: the physical challenge, the control challenge and the vigour challenge.

To address the physical challenge it is necessary that the station allows the children to move easily from their mobility aid into the station, to be stable and safe while performing the physical activity, and to provide vigorous input to the games in a safe and comfortable way. For the control challenge, it is necessary that the physical activity input be mapped naturally to different game styles, and that the actions in the games be triggered using a simple control scheme that considers limitations such as spasticity and poor fine motor control. For the vigour challenge, it is necessary that the station allow the children to reach levels of energy expenditure leading to improved health, as recommended by the American College of Sports Medicine [6].

Motivated by the proven effectiveness of bicycles for allowing vigorous exercise [5], the stability and comfort provided by recumbent bikes, and the natural mapping of cycling input to the movement of in-game avatars, we designed a recumbent cycling-

Figure 1. The Racer Bike

station that we called the Racer Bike (Figure 1). This station includes safety features such as adjustable pedal frames to secure the children's feet; a non-slip seat, a seat belt and lateral pads to avoid slipping; handles that make it easy for the children to enter and exit the station, and a solid back that allows the children to put more force on the pedals. Only three of eight children could play a cycling-based game effectively with the seating options tested in early sessions, while seven of eight could play effectively using the Racer Bike.

An additional benefit of this station is that it leaves the children's hands free, allowing them to use a gamepad. We tested different gamepad control schemes. To address limitations in the children's fine motor skills, we settled on a simple scheme using only one-button to trigger in-game actions and one joystick to specify direction, removing the difficulty of pressing two buttons consecutively, pressing two buttons at the same time, and pressing unwanted buttons accidentally.

More details on the design of the Racer Bike have been published earlier [2].

3. THE EXERGAME

To allow children with CP to have a fun, vigorous and engaging experience, we developed Liberi, a cycling-based network game suitable for children with CP. The main challenges for the design of Liberi were to provide high playability, short and long term motivation, opportunities for interactions between players, and activities that motivate continuous and vigorous physical activity.

Aiming for long term motivation, we included several minigames in Liberi for variety. These minigames allow a choice of competitive and cooperative group play. Additionally, an in-game scoring system allows the players to earn money and collect resources in the minigames, and spend them in in-game shops to enhance their character's abilities.

We tested the minigames iteratively in each session, and based on the feedback, we modified them to improve playability, fun, and exertion. We found that the difficulty of the minigames, high cognitive load in the mechanics or strategy, and the need for high accuracy in positioning the avatar affected playability. Also, minigames involving frequent stopping and starting of pedaling increased the difficulty of play, and decreased the levels of exertion. These led to simplification of the minigames' designs. This simplification was challenging, as oversimplification can reduce fun, with negative consequences to long term engagement.

Figure 2 shows one of the most successful minigames in Liberi, the Gekku Race, where each player controls a "gekku" racing to the top of a wall. The players can shoot cashews or fire at their competitors to hold them back from winning. Gekku Race led to vigorous gameplay according to heart rate and perceived exertion data. Standard and custom questionnaires and discussions with the children and their parents indicated that the game is fun.

Figure 2. The Gekku Race minigame in Liberi

4. THE DEMO PRESENTATION

In our demo presentation ASSETS' attendees will play our Liberi exergame; trying competitive and cooperative minigames using one of our exergaming stations, pedaling the bike and using a gamepad. They will play over a network with members of our team at Queen's University in Canada. Additionally, we will play recordings of our design sessions showing the children using the station and playing the game.

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