PinchFun: A Cooperative Fine Motor Training Game for Preschool Children with Developmental Delay

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Abstract
Children with developmental delayed can make progress through early intervention and training. However, from the interviews with occupational therapists and parents, we found that current training techniques lack variety and bore children in a short while. To improve the training effect, we proposed PinchFun, a cooperative game aiming to provide fine motor training for preschool children (under 6 years old) with developmental delay, in which the parent can cooperate with the child to achieve the game goals and adjust the game difficulty to meet different developmental milestones. The game employs the Leap motion controller and force-sensitive resistor (FSR) to detect the hand gesture and level of pressure of fingers. PinchFun integrates the physical assistive devices, i.e. clips and rubber band, and the virtual interactive game to optimize learning impact and gaming experience.

Author Keywords
Developmental delay; cooperative game; early intervention; fine motor training; parent involvement.

ACM Classification Keywords
K.3.1 Computers and education: Computer Uses in Education; K.8.0 [Personal Computing]: General Games

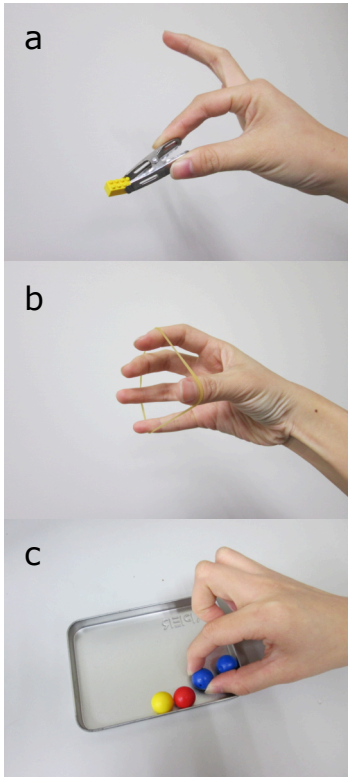

Figure 1: Fine motor training activities. (a) Using a clip to move a bean. (b) Stretching rubber bands between the fingers to cause resistance against fingers. (c) Putting beads on right place.

Introduction

Children develop at different rates and they learn variable skills in the process of growing. These skills are known as developmental milestones. A child who is not achieving milestones within the age range of that normal variability called developmental delay. In this paper, we focus on fine motor skills which involve the exercise of small muscles of the hand that enable functions such as writing, dressing, eating, grasping objects and doing many other things.

In early intervention or kindergarten, children are given some tasks as mini work-outs for fingers and muscles, for example, using a clip to move a bean, putting beads on right place, stretching rubber bands between the fingers to cause resistance against fingers (Figure 1). It is proved that children will improve after training for a period of time depends on their performance.

However, we found some problem of the current training techniques from preliminary interviews. Firstly, children get bored with the repetitive and monotone tasks easily. Secondly, the training could not continue at home. These problems reduce the effect of training. Therefore, we design a game which is entertaining and attractive to children. It's easier for parents to take part in the training process due to the interactive game design. Children could then get the training spontaneously and continuously.

To make our game more immersive and enhance parents' involvement, our game mission is designed to be completed cooperatively. Researches have shown the importance of family involvement and encourage parents to accompany children when training [4]. Cooperation game design enables them to communicate with each other and try their best to accomplish the game mission.

Related work

Research [1, 2] has examined the association between fine motor skills and achievement in academic performance and cognition development. In preschool and kindergarten, children participate in a variety of activities [7] to coordinate their motor skills and make greater processing capacity to learn more complex concepts [3]. Besides, researchers have reported a positive relation between parent involvement and child achievement in early intervention [4]. Based on these facts, we develop a cooperative game that child and parent can achieve the game goals together.

Several existing designs show the integration of the physical devices and virtual interactive contents to improve the user experience and training effect. MusicGlove [5] is a device used in occupational hand therapy; user can wear a glove to play an interactive music game. Nesra Yannier [6] demonstrated the potential to bring together the advantages of physical and virtual worlds to enhance learning and enjoyment. Based on these concepts, we present PinchFun, a cooperative game for children with developmental delay.

Design and Development

The background story of the game is the marine. Dolphin Amo is going to visit its best friend who lives far, far away. Amo determines to prepare a lot of gifts for the friend; therefore, it has to blow bubble all the way, in order to collect as many gifts as possible.

Two controllers are used in the game. One is Leap Motion that detects hand position and control the

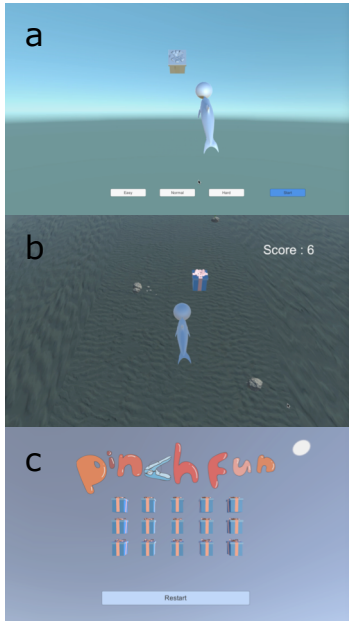

Figure 2: (a) A warm-up scene to get ready for game. (b) Two players need to cooperate with each other. One moves toward the gift and the other pinch the clip at the right time to collect the gift. (c) The game will end after twenty gifts all appears and report the number of collected gifts.

swimming speed of the dolphin, while the other is a force-sensitive resistor (FSR) attached on clip, which determine the analog input to Arduino UNO and control the size of bubble made by the dolphin.

One player is in charge of the control of dolphin's swimming movement (Player S, Figure 3b). It is more challenging because Player S determines the right position by both hands posed closely with a rubber band to keep balance. The idea of using rubber band is learnt from current training activities. By moving hands up and down more quickly, dolphin will swing its caudal fin and move forward faster.

Another player is in charge of pinching the clip, which controls the timing of dolphin blowing bubbles (Player B, Figure 3a) to catch a gift.

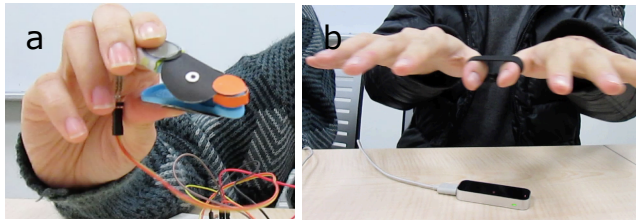

Figure 3: The game employs the (a) force-sensitive resistor (FSR) and (b) Leap motion controller to detect the hand gesture and level of pressure of fingers.

At the beginning of the game, a warm-up scene (Figure 2a) will show up and each player can test their controllers by moving hands and pressing the sensor, the effect would be shown directly on the screen. Both players can see the change of different hands' position and the level of pressure. Before staring the game, players can choose the level of difficulty, which can be changed by altering the threshold value of pressure level.

In the game, Player S controls the movement and speed of dolphin while Player B controls the blowing of bubble and collecting the gift. Two Players need to cooperate; Player S moves toward the gift and Player B pinch the clip at the right time to collect the gift (Figure 2b). There are a total of twenty gifts to collect. The game will end after twenty gifts all appears. Players then see the score on the upper-right side of screen as the gift being collected. After the game, the scoreboard scene will count the collected gifts and show the number. Players can choose to start a new game by pressing restart button.

Discussion

We have conducted several preliminary playtests to explore how children interact with different type of feedback. Our first prototype (Figure 4) use FSR attached to the clip as control input, by which we observed how preschool kids would react to only auditory and light feedback. The appearance of the clip is also designed to look like animals such as fish, frog, or penguin. The harder the clip is pinched, the more LED light bulb would glow. A sound effect will be played as the player reaches the highest level of strength. The evaluation was done to three preschool kids to explore how they interacted with the clip. The result showed that the feedback brings a lot of fun and activates learning motivation.

As mention above, we aim to provide a better feedback to the training scenario, also building a stronger connection to the interaction between physical control and the feedback. Therefore we further applied the

Figure 4: The first prototype. When pinching the clip harder, more LED light bulb will glow.

Leap motion controller to our game, and kept the special "animal" presence of the clip to make it more related to the game.

In the evaluation of dolphin version prototype, we found that children showed interests after being introduced to the game, which showed that the game has potential to enhance training effect. At first, they were not familiar to the game control. After one to two times of practice, however, their performances are gradually improved in a few try. Before every game starts, a parent or teacher can help adjust the difficulties of the game to best suit the children's ability. In the game, children and parents need to cooperate to complete the game. Parents can help children complete their task. We observed that each player shows excitement during gameplay, and they also show reaction according to each other's performances. After one round of gameplay, parents and children can switch control and play in different role. Some children object to switch role while some show high interest in switching. It's also envisioned that the game contents can be further expanded by applying other game theme to current design including the concept of cooperation and fine motor training.

Conclusion and Future work

By using physical assistive devices and virtual interactive game, we explore the potential of enhancing training effect. In our work, we emphasize the importance of collaboration between parent and child in fine motor training game.

We believe that game should always provide and maintain a level of motivation and focus on its main goal. In future work, we will include more fine motor skills and our preliminary findings to polish the game design, before we evaluate the game by experiment it with more children and their parents.

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