

The Design of Kinect Posture Game in Treating Sensory Integration Dysfunction

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Abstract:

Therapists have search for a better solution to integrate with sensory integrative therapy for the purpose of multisensory stimulation for children with sensory integration dysfunction (SID). This research designs a digital posture game using in treating SID. Challenges in this game mainly designed to stimulate the vestibular and proprioceptive of SID children. Patients have to transform their postures to accomplish the game task, achieving therapeutic purposes. Researchers hope through this game, we can provide the therapist more treatment information of patients to improve the overall effectiveness of the treatment.

Keywords: Sensory integration dysfunction, Kinect, digital game, game design

1. Introduction

Recently, there is a new type of treatment appear for SID, using digital somatosensory interactive games (Lee, Chuang, & Lin, 2011). Traditional treatment for SID is often refused by the young patients since repeated actions were uninteresting. Digital game is offers a very different option. Because somatosensory interactive game device does not require large space and equipment like traditional treatment (Chuang, Hsu, Huang, Lee, 2012) and the children could proceed with the treatment at home as the caregivers could save time from traveling. Moreover, users can get instant feedbacks from the digital game right after they complete the tasks in the game which increases the sense of interaction, confidence, and accomplishment (Chuang, Lee, & Chen, 2010). It prolongs the training for better effectiveness.

Most studies in the past used Nintendo Wii and Wii balance board as the therapeutic tools (Chuang, et al., 2010; Lee, et al., 2011; Lin, 2009). When Wii is used, players need to control the Wii remote which may cause distractions from the training (Erhel&Jamet, 2013; Tsai, Yu, & Hsiao, 2012). It is also possible that the Wii remote would be thrown out accidentally can hurt other players or cause damages to the environment (Taylor, McCormick, Impson, Shawis, & Griffin, 2011). Wii balance board is mostly used to train patients' balance control ability by sensing the gravity moving, but the range of motion is limited to the board. It reduces the diversity of the training actions. In 2010, Microsoft published Kinect for Xbox 360. Players can interact with the game with body movements. This study would develop a game for SID treatment using Kinect for Xbox360.

Commercial off-the-shelf games today had bad influences to children such as creating too much excitements or having demanding tasks which are overloading to children especially those with SID. Thus, this study intends to design a game that can stimulate vestibular, proprioception and improve the balance control ability rather than using commercial off-the-shelf as the base model (Lin, 2009). Functions like treatment instructions, skeleton positions are added so that patients' motions and balance control abilities can be improved. At the same time, patients' motivation to receive the treatments, confidence and sense of accomplishments can be increased.

When patients are playing, we hope caregivers can give some help and feedback to patients through the instructions in the game, and give the records to therapists so they can make further adjustments for the follow-up treatment.

2. Literature Review

2.1 Sensory integration

"Sensory integration theory" was first proposed by Anna Jean Ayres. She evolved this theory to explain the relationship between "the defect of abilities to understand the information from body and

environment” and “difficulties of academic and action learning” (Bundy, Lane, & Murray. 2002).

Categories of sensory include proprioception, vestibular, hearing, sight, and tactile. SID means when body was stimulated, the message could not be combined effectively, and further affect the performance of the functional coordination. SID is presented in two ways: "Modulation dysfunction" and "Dyspraxia". A patient may have individual or combined dysfunctions.

Dyspraxia means the ability of making plans is damaged. Dyspraxia includes four dysfunctions: postural deficits, deficits in tactile discrimination, bilateral integration and sequencing deficits, and somatodyspraxia. On the other hand, modulation dysfunction includes four types, sensory defensiveness, gravitational insecurity, aversive responses to movement, under responsiveness to sensation (Bundy et al., 2002).

2.2 Rehabilitation treat and digital game

Digital game was generated for people's entertainment, and further developed for other applications such as educational training. When people playing digital games, they have to use equipment as medium to interactive with games. In past few years, more innovative game consoles such as Nintendo Wii, Sony Eye Toy, Xbox Kinect, and so forth were released. The way of game controller is changing. Players can use body postures with limbs or body gravity shifts to control the game. These activities combined with sound and light effects could make rehabilitation process more fun and effective (Taylor et al., 2011).

Nowadays, interactive computer games have entered the field of rehabilitation (Joo et al., 2010). Physical therapy is based on a conception—"repeat" to achieve actions in a range or stimulate a specific muscle group. However, long-term and continuous single movements would make people feel tedious which ultimately lead to ineffective rehabilitation. But by playing games, the rehabilitation is presented in the form of entertainment. It could increase patients' learning motivation which is important to rehabilitation (Taylor et al., 2011).

Today, digital games were used as rehabilitation in many ways. But many studies used commercial games as the tool. Although these games could help patients to have physical progress in balance and strength, there are still restrictions because the games are not designed for rehabilitations (Taylor et al., 2011). Tasks in the commercial games may be too hard to achieve or control to patients. Feedbacks from the game consoles are perhaps not complete enough. Game interface may be too exciting to cause seizures (Joo et al., 2010). And most of the clinical experiments used natural observations that have little strict controls in the experiments (Primack et al., 2012). Therefore, the effectiveness of commercial off-the-shelf games in rehabilitation is still open to question.

3. Research method

3.1 Experiment design and subjects

The game of this research would be designed and played by Kinect for Xbox 360. Patients would be trained by playing this game hoping the effectiveness can be as well as receiving the conventional treatments. The goal of the experiment is to observe whether the game could improve participants' limb control, and how they would feel and think about the game.

This research cooperates with occupational therapists from a national hospital. Before the treatment, occupational therapists would evaluate the participants' level and symptoms of SID. They will help to diagnose and screen out 10 patients that are suitable for the experiment. Patients are first and second grade elementary school children, age between 7 and 8 years old who have one or more sensory disorders, either proprioceptive, vestibular, or balance.

The participants of this research will be divided into experimental group and control group. Therapists and caregivers of both groups need to write sensory integration functions assessment scale for children, sensory profile, and checklist for the sensory integration development in the pre-test and post-test. The experiment will take three months. Control group receives conventional treatment provided by professional therapists for 30 minutes each time, twice a week. Experimental group receive the same treatment with the additional digital game treatment designed in this study for extra 1 hour each time. 10 minutes break are taken for every 25 minutes game. During the experiment, researchers observe, record, and capture image by the side. Researchers could give subjects verbal or physical guidance as the patients requires assistance. For the rest of time, researchers would remain un-intervened. If patients have physical or mental problems at the site, trainings will be rescheduled.

Caregivers of the experimental group are interviewed about the patients' medical history, daily life conditions, and school lives.

3.2 Experimental venue and tools

The experiment would be conducted in an university laboratory. The experimental site will be equipped with TV, Kinect for Xbox 360, and the game designed for the treatment. Past studies showed that Kinect is an useful tool for assessing postural control in the clinical setting (Clark et al., 2012; Zhang, Song, Shao, Shibasaki, & Zhao, 2013) since it has certain accuracy to the identification of users' skeleton. Also, the cost is low; caregivers can save a huge amount of medical expenses. We put soft texture pad on the ground to prevent accidents. Sensory integration therapy, "Sensory Integration Functions Assessment Scale for Children", "Sensory Profile", and "Checklist for the Sensory Integration Development of Children" will be used.

3.3 Data collection and analysis

This study uses on-site observations and interviews to collect data. Players' gaming processes are recorded and compared with the measurement forms of the body postures. Movement evaluation results are shown with movement errors. Post-tests of the experimental and control groups are compared to investigate the differences of the players' movement control abilities.

4. Game Design

4.1 Game character and features

There are two characters in this game, protagonist and Non-player character (NPC). There are many different kinds of NPC in this game. Each level had its own NPC, and most of them are enemies or their leaders who attack the protagonist. This game uses the previous versions (Chuang et al., 2012; Lin, 2009) and other commercial games to investigate the pros and cons of the game. Features of SID treatments were extracted for the design of the game. Problems of commercial games like have complicated interface, fast rhythm, and little feedback (Joo et al., 2010) were avoided in the game designed in this research, and more tasks were provided to strengthen players' vestibular, proprioception, sight, and balance coordination training. Players would adjust their body movements, postures, and angles to control the avatars in the game.

4.2 Tasks design

The game starts with a story as follows.

Amusement park is children's paradise. One day an invader comes to take over the amusement park. All places are guarded by his minions. Players play the role of the amusement park guardians who are responsible to defeat the enemies and challenge the invader trying to get back the park. Five different levels were design for this game:

Level 1- Sealed gate: The task in this level, players need to use both hands to designate the magic ball of the right color into one of the four positions. As the players complete the task, the sealed gate would open so the protagonist can enter the amusement park. In this game, hand waving is to train players' proprioception, and the color matching is to train sight and color distinguish ability

Level 2- Magmatic hell: The task in this level is to go through the single-plank bridge. Players have to dodge the attack of the enemies and collect magic balls at the same time. As the scenery of the game is to simulate balance beams, players are trained to overcome their fear of height and lower the sense of gravitational insecurity. The whole challenge can train players' sense of balance, proprioception, and sight coordination.

Level 3- Sky drifting: The task in this level is to flights to chase enemies, dodge their attack, and collect magic balls. Players need to use their upper body angel to control the flights. The game requires players' fists to be higher than their elbows, and elbows higher than their waists. Therefore, the game trains players' balance and proprioception ability, and stimulate their vestibular ability.

Level 4- Valley of landmine: The task in this level is to pass through the landmine area to reach the location of the invader. In the game, players have to move their body to keep themselves balance, and place their feet on the guided area to avoid explosion. The game trains players' balance and proprioception ability.

Level 5- Final duel: The last task of the game is to defeat the invader. Players need to combine

the magic ball to create weapons to fight the invader. Players need to dodge the attacks of the boss and adjust their throwing directions to aim at the moving boss. In the end of the game, players have to pass through the swinging single-plank bridge and fire the last attack. These movements would train players' hand-eye coordination, balance, and sight.

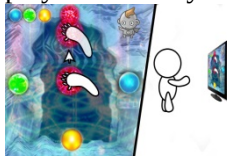


Fig.1 Level 1

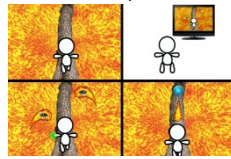


Fig.2 Level 2

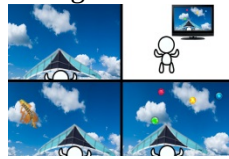


Fig.3 Level 3

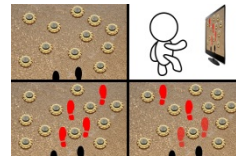


Fig.4 Level 4

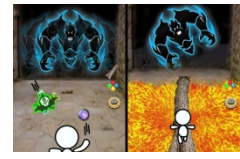


Fig.5 Level 5

4.3 Game rule and system setting

There are two tasks in each level, easy and advanced. All beginners start from the easy task, and advancement to the advanced task after the easy task has been completed. In the game, players need to follow the guideline shown on the screen. If there are actions that cannot be detected by Kinect, game would stop until players adjust their actions to fulfill the skeleton coordination range requirements. At the end of each level, the game would display the number of actions taken successfully in the task, and the time spends for the task. The completion of each level would gain the players a log file, in which are numbers of success and failure numbers in each task, times of pause, and time for competing the tasks.

5. Discussion and Conclusion

The game designed in this study still has some technical limitations. For example, crossing legs would cause skeleton extract error so that some balance training actions cannot be properly shown in the game. Although finger extension action and gestures can be detected in the game, body strength is still undetectable.

Today's technique can successfully extract skeleton of hand-held items, and can distinguish the minor differences effectively. In the future research, this movement can be added into the game design so that players can touch tools in different materials to lower down users' sensory defensiveness. Other than that, simple voice control can be added in the game to train users' control abilities to tongue and mouth shape. Such as stimulate vestibular and proprioception actions are also options to future studies.

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