

A preliminary study on design of rehabilitation game for children with autism spectrum disorder

Sara Reisi Dehkordi, Marina Ismail, Norizan Mat Diah

Faculty of Computer and Mathematical Science, University Technology Mara, Malaysia

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ABSTRACT

This research presented a preliminary study on designing a rehabilitation game for children with Autism Spectrum Disorder. It has been proved that children with Autism are not interested in attending traditional rehabilitation treatments. Existing researches have shown that games and their usage in the rehabilitation area are growing fast. However, there is less research used to design a rehabilitation game ensuring that the proposed design criteria are based on the preference and requirements of users in order to maximize the engagement rate of the game. In this research, one-month observation sessions were conducted with five autistic participants with no design expertise in order to collect essential design considerations for a rehabilitation game. This paper proposed design considerations, which can be helpful to design a rehabilitation game to promote user engagement by addressing game mechanics and behavioral techniques according to the result of our observations.

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Corresponding Author:

Sara Reisi Dehkordi,
Faculty of Computer and Mathematical Science,
University Technology Mara,
40450 Shah Alam, Selangor, Malaysia.
Email: sarahraissy@yahoo.com

1. INTRODUCTION

ation and socialization accompanied by engagement in stereotyped and repetitive behaviors [1]. It is well known that children with Autism demonstrate a significant delay in language development that impacts their ability to engage in robust conversations [2]. It would be easier to engage a child to play games on the computer or other devices rather than attending a therapy session [3]. Individuals with ASD have strong interests in video games, as a result, autism researchers have been increasingly interested in examining the effects of games [4].

Most of the serious games on market have been designed to provide supporting learning or treatment in the main area of difficulty such as communication, social or motor skills with a clear visual and/or auditory components. There is a number of researches were developed to address one specific purpose related to the learning approach about users. For example, Go-Go-Game [5] is to teach a skill known as multiple cues responding using Pivotal Response Treatment (PRT). A virtual Dolphinarium by [6] proposed in autism therapy to promote learning and positive behavior.

The topics related to motion interaction games in the field of rehabilitation vary. For instance, [7] created a motion-based touch-less software that considered rehabilitation for children with Autism. [8] proposed an instrument to monitor and analyze stereotypes movement about children with Autism. Studies in this paragraph include topics on rehabilitation and physical activity, such as [9] proposed a system for physical rehabilitation, called the Kinerehab and tested on two young adults (16 and 17) for rehabilitation goals. Kinerehab shows gesture recognition abilities are a variable rehabilitation instrument that reduced impediments on two young individuals with Motor impairments in one public school.

Real-life testing of Kinect-o-Therapy by [10] in the field of rehabilitation shows that six patients and physiotherapists both find it quite engaging, easy-to-use and a motivational alternative of rehabilitation. The results from [11] suggest that Dual-Task Tai Chi (DTTC) using motion-capture device training is effective for improving executive cognitive functions as well.

Rehabilitation can take many types but generally, there are four categories that it can be delivered, this will be limited to the basic rehab disciplines of physical therapy (PT), which Asteroids kRehab and 3DPong kRehab by [12] are examples of PT, occupational therapy (OT), respiratory therapy and speech therapy. For instance, Carauti, designed by [13] is a speech-based game, which can be highly personalized based on each individual, which is important in therapeutic applications. Effective rehabilitation depends upon motivation; the effectiveness of rehabilitation and the motivation of the person are often non-linearly related [10].

A serious game needs to fulfill certain requirements in order to be used in the rehabilitation process such as learning by imitating a movement, using vibration feedback, a repeated strong workout, mental training and so on [14]. However, designing a game with all the features that could benefit the rehabilitation process is a complex task. The identification, classification and assessment of game features that are relevant for the health rehabilitation domain are very important [15]. Only in a few kinds of researches that focus on motor skills or psychological methods the learning systems are customized or designed to meet the needs and the objectives of the participants [16].

When designing technology-based interventions for children with ASD, it is essential to understand the expectations of technology from the view of therapists and special education teachers as they work closely with children with ASD [17]. On the other hand, the value and importance of user-centered design have been recognized [18]. In terms of designing a game, participatory design (PD) methods are usually used by researchers to ensure that they provide acceptable intervention and design requirements for their users.

It is undoubtedly true that due to the characteristic of children with Autism (including social and communication skills) involving them in a PD process can be quite challenging and impact the result of the process. Apart from these difficulties, some researches have used PD method with children with developmental disability successfully in their design process. For instance, [19] present strategies to integrate the expertise of clinicians, contributions of children by PD method and experience of designers through a set of elicitation and merging techniques. In terms of learning purpose for children with ASD, [20] is another example to use a participatory design method for designing and developing mobile games.

In addition, some researchers such as [21] proposed the design of the eye-hand coordination game on Kinect for children with ASD based on the user-centered design model. Similarly, [22] proposed a therapeutic game for autistic children focus on communication skills, which engagement requirements were gathered from users. Findings from the preliminary study suggest that motion interaction games on gesture recognition device might be useful rehabilitation aides for users with developmental disability.

Along these lines, motion interaction game devices have been employed to teaching a range of motor skills to children with developmental disability. Numbers of researchers have spent many weeks investigating various aspects of motion interaction games with the aim of showing that technology can benefit children with developmental disability. The outcomes are promising but there is not enough research to present a framework and design components for children with developmental disability to address specific goal based on the rehabilitation.

Based on [23] about 80% of gamified solutions will fail in reaching their objectives due to a lack of understanding of game design and inefficient player engagement strategies. Researches were reviewed in the literature review are still lagging behind the advancement made in the design to fulfill rehabilitation objectives or better screening procedure for users, professionals and parents [24].

In this paper, we are going to present a set of classifications and design requirements that we consider as relevant for the rehabilitation game design and that will help us to design and develop a rehabilitation game for children with Autism.

1.1. Current research

The purpose of current research is to design and develop a rehabilitation game by considering preferences and requirements for gameplay among children with ASD. In order to collect related data about rehabilitation game on motion interaction device, the needs of the users and their limitations should be considered so as to maximize the effectiveness of the treatment. Information from literature review alone cannot be sufficient to understand the users. To find out this issue structured questionnaire, interview with experts and observation sessions were conducted due to their advantages in providing insight about what children with ASD are expecting from a rehabilitation game. This approach is based on the gathering information from observation of children with ASD and to provide a rich understanding of the positive and negative reactions to the traditional treatments in their school.

2. RESEARCH METHOD

2.1. Participants

We worked with Tehran School in Iran, which provides education and treatment facilities for young and children with Autism and other special needs. At first, two brainstorming sessions with one teacher and principal of school were conducted. The teacher provided Information about participants, classes and their treatment plans and recommended five participants in three different classes with five teachers. The participants had a wide range of physical and cognitive disabilities. Participants were aged 5-12 years old (5 female). All of them were diagnosed with Autism spectrum disorder, one basic information table about participants and classes were prepared, and then the school informed parents and collected permission letter from them.

2.2. Observation Procedure

There were three study and playing rooms and one main hall in the school, where group activities were performed there. There were two tables in each study room; one of the study rooms was arranged for our observation sessions to conduct activities there. After each treatment activity, the children who have successfully performed their tasks were allowed to use the playing room.

The structure of each observation session was based on the rules of the school. Each session involved one participant who was introduced by the principal of the school, and one researcher writing the reactions and procedure of each therapy method and one teacher acting as a tutor and answering any questions and explain about each game.

The playing room was covered with a safe rubber floor and there were some toys such as balls and dolls in the room, the children could play there with no supervision. The main hall was the largest room, which was used as a waiting room and some times group physical activities were performed there. The hall had a ceramic floor so children couldn't play there independently, but some times teachers provide 3 or 4 rubber mat for them for their safety.

At first, the teacher explained the procedures of each class, therapy methods and a treatment plan before each session. Then, the necessary instruments (toys, pen and paper, cards, photos and a personal form) were prepared. The treatment activities were introduced to each child by questioning and using cards, each session was approximately between 5 to 20 minutes (It was depended on the child) three to four times a week, or 10 to 20 minutes twice a week or 20 to 25 minutes a week with, more or less, so they were in each class approximately 15 minutes each day, Table 1 described the summery of games in observation sessions.

Finally, the observation itself was performed for one month. After each session, the teacher answered some questions regarding the child's reactions in order to collect more details.

2.3. Observation Material

- Questions and Answers form for researcher for taking note and write the answers. We created a table based on [20] to review and validate and define the changes planned in the previous session according to teachers/therapists idea.
- Camera for some of the participants (only some of the parents/teachers were agreed for video recording or taking photo).
- Cards and other material such as playing blocks and tokens, loops, toys, pictures and books for teachers.

Table 1. The summery of games in observation sessions

Games	Rehabilitation criteria	Players	Playing time	Treatment time	Materials
What is the subject?	Social skills	5	5 to 20 min	3 times in a week	Flash cards
PIX Therapy	Social skills	5	5 to 20 min	3 times in a week	Flash cards
Making Timetable	Social skills	5	10 to 20 min	4 times in a week	Big table Flash cards Stickers
Hand Gestures	Motor skills social skills	5	10 to 25 min	3 times in a week	Flash Cards Stickers Basket, Toys
Foam Painting	Motor skills	5	15 to 25 min	1 time in a week	Foam, Music Player
Ball Games	Motor skills	5	10 to 20 min	2 times in a week	Ball, basket, Loop
Find The Route	Motor skills	5	5 to 10 min	2 times in a week	Lego, Blocks, Rubber Mat

3. RESULT

In the observation phase seven different treatment activities were tested with five participants, each activity title was categorized into motor skills and social skills to determine: 1) what is the reward strategy in each activity? 2) Are the game components interesting for children? 3) What are the positive and negative reactions of the user? 4) What is the behavioral technique in each game?

The main therapy method was used for social skills game was PIX therapy, by using interesting and familiar pictures for children to make a sentence, answer a question or creates a timetable. In this method, pictures can help players to express themselves more easily. In each session, with social skills purpose the teacher showed one picture to the child, and point to and name the object/action. Then the child has to place the picture in a communication book in order to learn the subject of the sentence, make a timetable and be familiar with objects and cause and effect actions. This helps the child learn to use pictures for effective communication in the classroom and at home.

Based on our observation, two participants age ranging 11 and 12 years old had positive reactions to cartoon faces in comparison with real pictures, while three participants age ranging from 5 to 7 years old were interested in real photos. In this case, the therapist changed the photos for each player, for each child there was a collection of familiar photos including the player's face, his parents and his teacher. Objects for each activity should be familiar/favorite objects for the player; their favorite objects were foods (snacks / ice-cream/popsicle) Fruits (strawberry/ apple/ banana) Personal items and toys (shirt / glasses/ cars).

Results observed from each session and note analysis showed each game shouldn't take too long. Taking a break and using playing room after each successful task was a reward for four participants. After four sessions the levels of the game became gradually difficult (start from 3 or 5 levels and increase to maximum 15 or 20 levels). Before starting the activity, the teacher showed how many levels should player pass by showing him some tokens (there were 5 tokens in the table, if the child finishes each level then one token will be taken when all the tokens have gone the child will have a break).

Several reactions associated with rehabilitation games were observed during our preliminary study: wrong reaction, international reaction (when the child knows this answer is wrong but enjoys trying it times and times), The child indicates disliking the activity or being bored, The child takes his teacher's hand to show cannot continue and not knowing the procedure without help and the teacher has to help, the child stops the activity before reaching the purpose, The child has physical or other limitations during interaction with the activity.

4. ANALYSIS OF RESULT

We have adapted the Rehabilitation Game Model (RGM) [25], this model is a combination of techniques for adapting user behavior to engage in rehabilitation games through capability, opportunity and motivation. Proposed game design considerations will provide the fundamental game design techniques for each of the individual based on user characteristic and their favorite rewards.

The analyses about observation focus on the treatment plan; behavioral techniques and mechanics are provided in Table 2. Treatment plan was obtained from the reactions of participants and the main goal of each treatment activity and was cross-referenced with descriptions from teachers after each task. Although each Design requirement was categorized into two parts for physical and social activities in order to provide comprehensive requirements.

During observation, each treatment activity focused on one goal only for example the activities for the first day were working on changing the routines or the subject for treatment activity on the second day was teaching body language and hand gestures and etc. This strategy leads to a combination of engagement elements in order to achieve each goal in a fun way. Resulting treatment plan categories included: (1) Routines, (2) Challenge, (3) Secrets, (4) Skills, (5) Creativity, (6) Choices and (7) Cooperation.

In terms of mechanics of the game, the result addressed by the researcher, and was integrated with the analysis of observation and teachers recommendations. Data relevant to this research was analyzed based on the RGM in Table 2. Game mechanics proposed in this research show that game themes should design based on behavioral techniques. There are recommendations for each treatment activity in both aspects of game mechanics and behavioral techniques to translate each activity into a design phase.

Recommendations by game mechanics such as "Exploration", "Game Mastery" and "Constructive play" facilitated a series of new skills and knowledge, which can lead to behavioral improvements. A game structure definition indicates that there are games ideas for the purpose of encouraging and guiding physical and social activity, in support of rehabilitation. To be engaging, the game should include short rewards, photos and positive sound effects and music that are enjoyable for children.

Table 2. From treatment plan to game structure (Actions and Events)

Treatment Plan	Design Requirements (Social skills)	Design Requirements (physical skills)	Game Mechanics	Behavioral Technique
Routines	Show Waiting time/playing time and turn-taking (Time table) Cause and effect tasks	Follow shape line by finger repeatedly Self-help skills	Constructive play Planned tasks	Information about other approval
Challenge	Find the problem and solve it	Painting by both hands separately	Exploration Imperfect information Area control	Material reward Restricting the physical environment
Secrets	Recognize objects/alphabets in different shapes, find a treasure			
Skills	Self-help skills, communication skills, imitation skills in communication	Body language, body gestures skills, focus and Balance and coordination	Communication Channels Competitions Multiplayer games	Social comparison Social support
Creativity	Tell a story, find the rule of the game without help, imagine an action/object before talking about it	Make art craft items		
Choices	Show the sequence of a story or routine	Use both hand together or left/right hands	Game Mastery Higher-level closure as game play	Problem solving Goal setting
Cooperation	Be leader in the game, help and interact with characters of the game			

5. CONCLUSION AND FUTURE WORKS

Analysis of the results and observations in this research has adapted RGM from treatment activity to mechanics of rehabilitation designed for children with Autism. This preliminary study proposes a valuable combination of activities, derived from treatment methods and game design considerations, which aim to categorized design elements based on the children's limitations and therapy methods.

The main goal of this research is to design a rehabilitation game to motivate children with Autism but designing the rehabilitation game on a suitable technical device as the control method, developing the main interface and adding design considerations, such as pictures, number of levels, themes and rewards strategy are in process of idea generation.

The provided findings will help future researched exploring design approach in rehabilitation games for children with ASD. After the completion of the current research, it will be time for a big step to design and develop a rehabilitation game based on our findings to validates out analysis. In other words, a rehabilitation game will be designed by children`s contributions and expert`s knowledge.

REFERENCES

- [1] R. C. Pennington, "Computer-Assisted Instruction for Teaching Academic Skills to Students With Autism Spectrum Disorders: A Review of Literature," *Focus Autism Other Dev. Disabl.*, vol. 25, no. 4, pp. 239–248, Aug. 2010.
- [2] N. Stockall and L. R. Dennis, "Using Pivotal Response Training and Technology to Engage Preschoolers With Autism in Conversations," *Interv. Sch. Clin.*, vol. 49, no. 4, pp. 195–202, Nov. 2013.
- [3] A. Dehkordi, R. Noor, and A. Sardan, "Computer Game Approach Focusing on Social Communication Skills for Children with Autism Spectrum Disorder: An Initial Study," no. VisioGame 2013, 2014.
- [4] M. O. Mazurek, C. R. Engelhardt, and K. E. Clark, "Video games from the perspective of adults with autism spectrum disorder," *Comput. Human Behav.*, vol. 51, no. PA, pp. 122–130, 2015.
- [5] A. Hiniker, "Go Go Games : Therapeutic Video Games for Children with Autism Spectrum Disorders," *Interact. Des. Child.* 2013, pp. 463–466, 2013.
- [6] Y. Cai, N. K. H. Chia, D. Thalmann, N. K. N. Kee, J. Zheng, and N. M. Thalmann, "Design and development of a Virtual Dolphinarium for children with autism.," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 21, no. 2, pp. 208–17, Mar. 2013.
- [7] L. Bartoli and S. Lassi, "Experimental Study of Results Obtained from the Interaction with Softwares Motion-based Touchless Created for Habilitation-rehabilitation in users with Diagnosis of Autism Spectrum Disorders," *Procedia Manuf.*, vol. 3, no. Ahfe, pp. 5176–5183, 2015.
- [8] N. Gonçalves, S. Costa, J. Rodrigues, and F. Soares, "Detection of stereotyped hand flapping movements in Autistic children using the Kinect sensor: A case study," in *2014 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2014*, 2014, pp. 212–216.
- [9] Y. Chang, S. Chen, and J. Huang, "Research in Developmental Disabilities A Kinect-based system for physical rehabilitation: A pilot study for young adults with motor disabilities," *Res. Dev. Disabil.*, vol. 32, no. 6, pp. 2566–2570, 2011.
- [10] A. K. Roy, Y. Soni, and S. Dubey, "Enhancing effectiveness of motor rehabilitation using kinect motion sensing

- technology,” in *Global Humanitarian Technology Conference: South Asia Satellite (GHTC-SAS), 2013 IEEE*, 2013, pp. 298–304.
- [11] H. Kayama, K. Okamoto, S. Nishiguchi, M. Yamada, T. Kuroda, and T. Aoyama, “Effect of a Kinect-based exercise game on improving executive cognitive performance in community-dwelling elderly: Case control study,” *J. Med. Internet Res.*, vol. 16, no. 2, pp. 362–365, 2014.
- [12] R. C. M. Jr, U. P. K. A. Batista, U. A. Q. Ramos, and A. F. C. Medeiros, “Development of a Complete Game Based System for Physical Therapy with Kinect,” pp. 1–6, 2014.
- [13] S. Golestan, A. Mahmoudi-Nejad, and H. Moradi, “A framework for easier designs: Augmented intelligence in serious games for cognitive development,” *IEEE Consum. Electron. Mag.*, vol. 8, no. 1, pp. 19–24, 2019.
- [14] A. Shapi’i, H. Arshad, M. S. Baharuddin, and H. Mohd Sarim, “Serious Games for Post-Stroke Rehabilitation Using Microsoft Kinect,” *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, no. 4–2, p. 1654, 2018.
- [15] P. A. Rego, P. M. Moreira, and L. P. Reis, “A Serious Games Framework for Health Rehabilitation,” *Int. J. Healthc. Inf. Syst. Informatics*, vol. 9, no. 3, pp. 1–21, 2014.
- [16] F. R. Sheu and N. S. Chen, “Taking a signal: A review of gesture-based computing research in education,” *Comput. Educ.*, vol. 78, pp. 268–277, 2014.
- [17] A. I. Soysa and A. Al Mahmud, “Assessing Tablet Applications Focused on Social Interactions: What Functionalities Do Sri Lankan Practitioners Want for Children with ASD ?,” no. Cdi, pp. 32–41, 2018.
- [18] S. Parsons, “Learning to work together: Designing a multi-user virtual reality game for social collaboration and perspective-taking for children with autism,” *Int. J. Child-Computer Interact.*, vol. 6, pp. 28–38, 2015.
- [19] L. Malinverni, J. Mora-guiard, V. Padillo, L. Valero, and N. Pares, “An inclusive design approach for developing video games for children with Autism Spectrum Disorder,” 2016.
- [20] T. Porcino, D. Trevisan, E. Clua, M. Rodrigues, and D. Barbosa, “A Participatory Approach for Game Design to Support the Learning and Communication of Autistic Children,” vol. 8770, pp. 17–31, 2014.
- [21] A. Shapi’i, N. A. Abd Rahman, M. S. Baharuddin, and M. R. Yaakub, “Interactive Games Using Hand-Eye Coordination Method for Autistic Children Therapy,” *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, no. 4–2, p. 1381, 2018.
- [22] S. R. Dehkordi and R. M. Rias, “tap on me : atherapeutic game for childre with autism spectrum disorder focusi g o social commu icatio skills,” *Knowl. Manag. Int. Conf. 2014 (KMICE 2014)*, no. August, pp. 773–777, 2014.
- [23] L. Malinverni, “A Critical analysis of full-body interaction learning environments : towards novel design and evaluation methods,” Universitat Pompeu Fabra Barcelona, 2016.
- [24] N. K. H. Chia and J. Li, “Design of a generic questionnaire for reflective evaluation of a virtual reality-based intervention using virtual dolphins for children with autism,” *Int. J. Spec. Educ.*, vol. 27, no. 3, pp. 44–53, 2012.
- [25] D. Holmes, D. Charles, P. Morrow, S. McClean, and S. McDonough, “Rehabilitation Game Model for Personalised Exercise,” *Proc. - 2015 Int. Conf. Interact. Technol. Games, ITAG 2015*, no. October, pp. 41–48, 2016.