Enhancing Memory Skills of Autism Spectrum Disorder Children using Gamification

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final
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ABSTRACT

Sharp memory of growing children is important for education and learning of any new skills. Learning new languages is an important aspect for all children. Kids with Autism Spectrum Disorder (ASD) need extra attention to enhance the memory skills. ASD is a developmental issue that influences communication and social conduct. It leads to the slow development of certain skills in children. The reasons for ASD are yet to obscure; however, it is normal in children having parents of higher age groups. Individuals with ASD generally avoid social communications, lack confidence in the eye to eye contact, fiddle a great deal, and regularly experience the ill effects of other issues like ADHD, OCD, etc.They tend to get distracted very easily. They are often obsessive about particular things and ignorant or indifferent about everything else. ASD does not include mental retardation (MR). Even though individuals experiencing ASD are improper at conveying, they sometimes have a better than average IQ. In this paper, a memory-enhancing mobile game has been designed that would help ASD children to improve the memory and help increase the stock of words that would eventually help in communication skills. The proposed mobile game would help Children diagnose with ASD to increase their memory retention power and help parents' track their progress using gamification concepts.

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1. INTRODUCTION

ASD is a developmental issue that influences communication and social conduct [1]. It prompts moderate advancement of specific abilities in kids. The causes of ASD are yet unknown but are common in older parents. People who have ASD tend to avoid social interactions, eye contact, fiddle a lot, and often suffer from other mental conditions like ADHD, OCD, etc. It is known as a spectrum disorder because there is a wide range in its symptoms and its severity. ASD does not necessarily involve mental retardation (MR). However, people who have ASD are not good at communicating in most cases. People suffering from this disorder have often been shunned in society due to their different behavior and fail to get the attention required to be a normal functioning part of society. However, if given enough care and therapy, they can overcome their symptoms. Several noteworthy people like Albert Einstein (Scientist), Bobby Fischer (Chess Grandmaster) have had ASD and successes in their lives. Game based mediations with youngsters with Autistic Spectrum Disorder (ASD) have been demonstrated to quicken learning measures [2].

2. LITERATURE REVIEW

ASD-affected people often have high sensitivity towards touch, sound, and other senses. They are generally strong visual learners. However, have a problem putting things together in a sequence. Studies regarding autism have been inconsistent and problematic due to the varying degree of symptoms that the affected person exhibits, which is the consequence of formative contrasts and distinction in psychological levels in subject gatherings. However, various examinations have demonstrated that individuals experiencing chemical imbalance do not utilize authoritative techniques or setting to help memory [3]. Many studies have revealed that youngsters with mental imbalance show an absence of acknowledgment of visual groupings [4]. Deficiency in spatial working memory is common in children who have autism while engaged in different social activities [5].Sequential memory is important in the basic daily motions of life. For a person to be in an inclusive environment, it is important to have a certain communication level and recall memory.

Regardless of the varying symptoms in autism, the major similarity seen amongst patients is the brain's affected cerebellum region. The greater part of the brain postmortems led on Autistic people paying little heed to their age, sex, and psychological capacity show an all together low number of Purkinje Cells (PC), fundamentally in the neocerebellar cortex and contiguous archibellar cortex of the cerebella hemispheres. The reduced number of PCs is not proportional to the severity of autism or in Cerebella Pathology in Autism [6].

A study conducted by Jones et al. in 2010 shows that people affected by ASD lack prospective memory and therefore forget to perform actions such as putting the cap back on a pen after using it, returning borrowed items, etc. When it comes to semantic memory (recalling facts) and episodic memory (remembering past experiences and events), autistic people may or may not remember facts about certain things they are obsessive about but are generally impaired when it comes to episodic memory. Even high-functioning autistic people often face cued recall problems, meaning retrieval of information or facts about the past. When a focus group of ASD and non-ASD people were compared, the non-ASD group made fewer intrusion errors on recall trials [7].

There is no particular clinical test to decide whether an individual has ASD or not, which makes finding somewhat troublesome. The age of 2-3 commonly analyzes it out of two phases: (i) Developmental Screening & (ii) Comprehensive Diagnostic Evaluation [8].Developmental Screening is a test to decide whether a kid has a developmental slack in their fundamental abilities and if they are acting, talking, and moving typically, which a typical strategy is taken by pediatricians. The second step of diagnosis is the Comprehensive Diagnostic Evaluation conducted by a specialist such as a developmental pediatrician, a child neurologist, or a psychiatrist [9]. However, there is often no diagnosis carried out by general pediatricians, and new parents are unaware of such conditions, which leads to a delay in the diagnosis since parents ignore the symptoms. Such practices lead to undiagnosed cases, leading to lives being harder for such patients [10].

Traditionally, children with ASD go through extensive therapy sessions with trained professionals to overcome their symptoms and adjust to normal life [11]. However, according to the CDC, the number of ASD-affected children has risen from 1 in 150 in 2000 to about 1 in 54 in 2016, and there is not enough help available to each of them. Therefore HCI can play a major role in reaching out to more and more ASD-affected children [12].The use of games can help improve social skills and be used for creating safe environments to teach ASD children things like how to crossroads, interview training, and exercising using VR [13]. Modified role-playing games like Sky rim have been used to make children comfortable interacting with people, reacting to dialogue, exploring, and helping their communication skills, as shown in a study [14]. Several experts also recommend technology as a means of communication and teaching assistant for verbal and non-verbal children [15].

3. METHODOLOGY

A literature review was conducted using keywords related to Gamification, Autism Spectrum Disorder, Inclusive Design, memory game, etc., through several web research search tools (e.g., Scopus document search, Research Gate, Google Scholar, etc.). After that, a combination of interviews and surveys was conducted with special educators teaching students with ASD and parents of the ASD-diagnosed kids to determine the different teaching-learning methods used to teach these children and what methods have yielded the most promising results. These methods were later observed using the 'fly on the wall' observation technique while the educators working with the children.

3.1 Interviewing Special Educators

Special educators at Universal High School in Thane and Symbiosis International School in Pune were interviewed to understand their teaching methods. They used visual cues with a combination of voice-assisted apps to teach children with special needs in both places. Over the years, they would found that children with ASD tend to recall things faster when repeatedly prompted. At Symbiosis, they used an app called Avaz to add visual-based questions which the kid had to answer; they said that such a practice over time made them remember things better. At Universal High School, they used similar techniques with a more traditional but tedious

method. They used cue cards with words and visuals to associate them.

3.2 Parents Survey

A sample size of 25 parents was surveyed using Google Forms with children having ASD whose ages ranged from 4-15 years. The survey's insight showed that 52% of their kids were not undergoing any medical treatment, and 80% of them were undergoing special education or therapy. Only 32% of them were using apps to teach their kids (namely MITA, POOZA, Star fall, Let me talk, story building apps, etc.), whereas the rest solely on play-based activities. However, parents who were using apps and visual games had more success in increasing vocabulary, and kids remember more in such cases. Also, it found in the survey that 80% of the children had short-term memory recall problems.

3.3 System Ideation

A thorough analysis of the collected data has been carried out. Few considerable insights that reflect from the analysis were taken into consideration while ideating memory-related issues. These are discussed here. (i) Most parents were unaware of their child's condition and blame the child for not trying hard enough to acquire the knowledge. (ii) Only parents whose children were non-verbal realized that their child had a condition, whereas parents whose children were verbal thought that the lack of social interaction and learning lag was just a phase. (iii) People found apps to be the most effective way to keep their children engaged and teach them. (iv)Parents who used apps and did activities at home to help their children observed great results.

After much iterative phase of brainstorming, ideation, and conceptualization, a prototype of an engaging mobile game has been designed for ASD children. Details of the concept had described in the following section of the paper.

4. RESULTS AND DISCUSSION

4.1 Game Concept

The concept of the proposed memory-enhancing game compares a child's progress to standard progress that one should have based on the child's age. In case the child does not meet the standard, the parents are notified that there may be a possibility of a developmental lag. The

game then adjusts the game's difficulty using machine learning to help the child increase their recall memory capacity. The complete task flow had shown in Fig. 1.

The game has been designing based on a story to engage a child in-game organically. The game features a mad scientist named Dr. Memory, who plans to take over the world. The player is the only one who can stop him and assist by a friendly scientist who explains the rules and gives tips when needed.The player enters the doctor's mansion and has to solve various memory and logic-based puzzles to reach the doctor.Once the

player reaches the doctor, he/she must fight him on a memory game that can only be won with a perfect score, which ensures continuity and a drive for the player to complete the game without mistakes. Few scenes of the game have been shown in Figs. 2 to 6. Fig. 2 shows ASD memory enchantment mobile game screen 1, and Fig. 3 shows ASD memory enchantment mobile game screen 2. Fig. 4 shows ASD memory enchantment mobile game screen 3, and Fig. 5 shows the ASD memory enchantment mobile game message screen. Fig. 6 shows the ASD memory enchantment mobile game screen input notification.
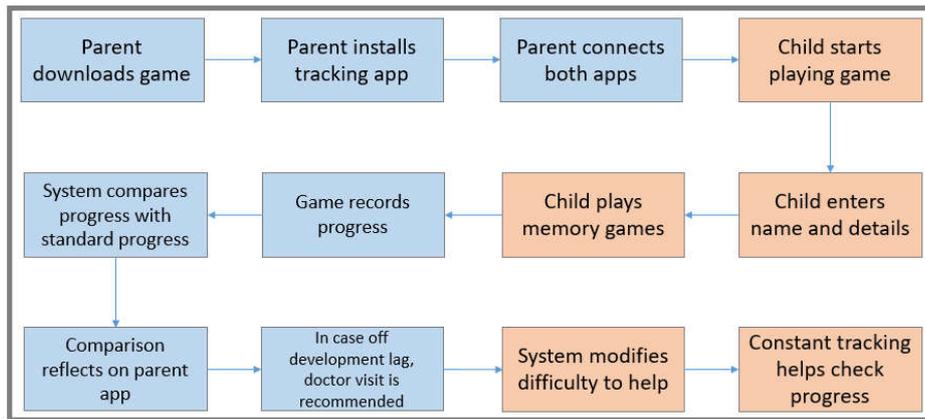

Fig. 1. Task Flow of the ASD memory enchantment mobile game

4.2 Game Screens

Fig. 2. ASD memory enchantment mobile game screen 1

Fig. 3. ASD memory enchantment mobile game screen 2

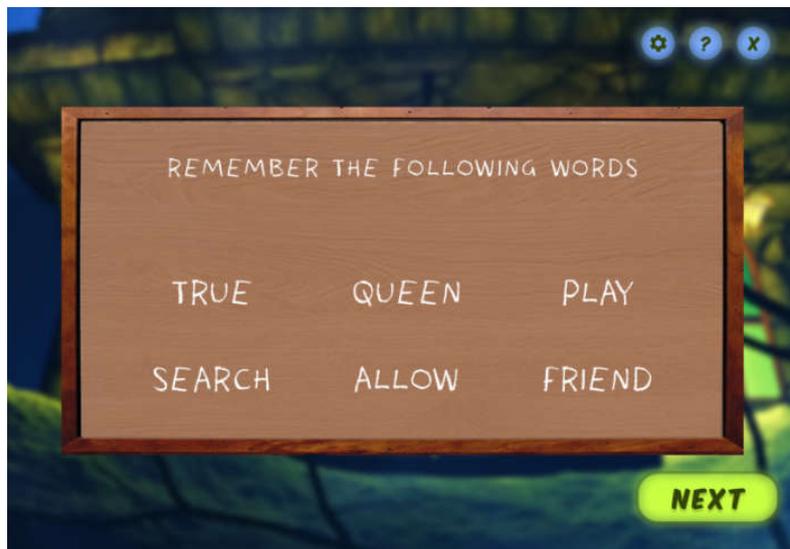**Fig. 4. ASD memory enchantment mobile game screen 3**

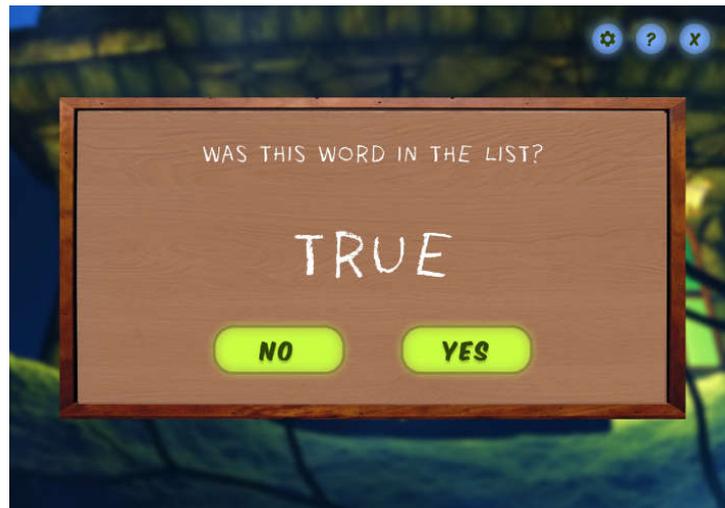**Fig. 5. ASD memory enchantment mobile game message screen**

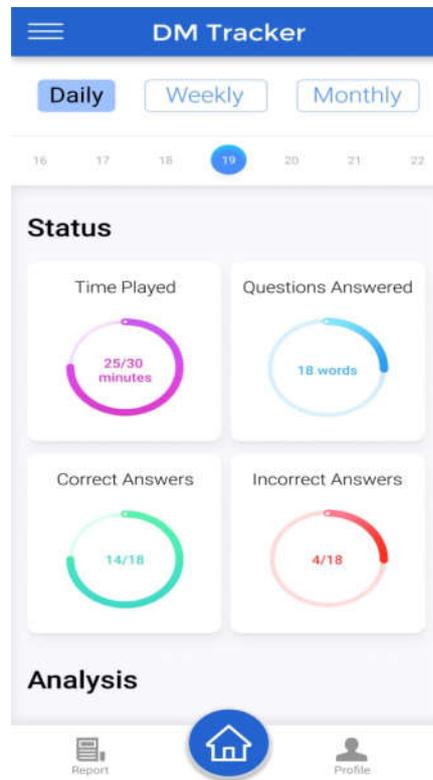**Fig. 6. ASD memory enchantment mobile game screen input notification**

Fig. 7. Screen layout of parent monitoring app

The proposed mobile game for ASD children has been linked with a separate parent monitoring app. This linked app would help keep a record of the child's daily progress and analyze the child's improvement. According to their choices, a parent can view the report on a daily, weekly, or monthly basis. The layout of the parent app has been shown in Fig. 7. A parent can keep track of how much time the child had played the game. How many times has a child been given a right or wrong answer? And so on.

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The parent monitoring app would help the parent take necessary measures and treatment based on the regular reports.

5. EVALUATION AND REVIEW

Complete usability heuristic evaluation on the clickable prototype of the mobile game and parent monitoring app is given to parents and made as user friendly. Survey conducted by several user experience designers and the special educators of schools. Reviewers also gave good response for this gaming app to child and it includes psychology teachers. It had evaluated by the experts that the basic user experience design heuristic was followed in the application. Heuristic-like system status and visibility have been thoroughly observed in the prototype. The freedom in user's control of the application is systematically given to the parents that would help parents control the child's overall learning. Other parameters like the aesthetic of the game had been designed as per the children's preference. The prototype had been designed with a minimalistic design approach. Reviewers also suggested that the standard of questions should be based on the kid's age, and different stages of the proposed game could be designed based on progressive learning of a particular language. The expert review could conclude that the concept of the proposed memory-enhancing game was very good and would work well to help ASD children to enhance memory skills.

6. CONCLUSION

A clickable prototype of memory enhancing the mobile game and a parent's monitoring app for the ASD children had designed in this paper. Learning new languages is a significant phase for all youngsters. Children with ASD need extra attention to enhance the memory skills; the proposed memory-enhancing game would help children learn quickly. The game's visual design was attractive and engaging for children, though the special educators had suggested few aspects could be the future scope of the application. One of the experts, a special educator and a psychology teacher while evaluating the mobile game, suggested that auditory cues and visual cues might be added to the easier understanding of children in the game. Also, a longitudinal study could be done to test the learning improvement in different languages on the same concept for children with ASD.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Ethical Clearance Taken from Symbiosis Institute of Design, Symbiosis International (Deemed University), Pune, Maharashtra, India

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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