

A HELPFUL MOBILE APPLICATION TO ASSIST THE BEHAVIORS OF AUTISTIC PEOPLE THROUGH MINI GAMES CREATED USING UNITY

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ABSTRACT

With proliferating rates of people being diagnosed with autism, it has rung the bell for immediate change [7]. In an effort to ring the bell louder — though minimalistically — this app was developed to make life easier for autistic kids through the refining of their comprehension skills, decision-making skills, and restrictive behaviors [8]. This was done through the making of minigames and an adventure story. Some minigames were designed to cater to the restrictive behaviors of autistic kids by making the games more engaging. Other games focused on improving comprehension skills, such as memory or vocabulary. The adventure game tested both comprehension and decision-making skills. Despite the app's positive impact, there were blind spots due to the complex nature of autism. The best solution was to continuously tinker with the app to ensure maximum compatibility with the autistic audience. Although autism is a difficult diagnosis to cure, such an app can assist in making the lives of autistic kids easier. With increasing rates of autism diagnosis, this app serves as a reminder of the need for more resources to cater to the growing population of autistic individuals [9].

KEYWORDS

Autism, Behavior, Minigames, Development

1. INTRODUCTION

Autism spectrum disorder (ASD) is a condition that affects development, which is caused by variations in the brain [1]. The condition poses challenges not only for the kid, but for people who care for them. People with ASD have troubles with poor social interaction, sensory issues, and repetitive behaviors [3]. As a result, building strong relationships, learning efficiently in school settings, or even engaging fully in daily life are struggles that people with ASD face [3]. Besides, this condition is not one that can merely be cured, so the thought that knowing someone you care for has ASD can be extremely tough [3]. Even worse, in recent years, the rate at which autism is being contracted has skyrocketed to the point where worrisome and anxiousness has transpired amongst the public. In 2000, only one in 150 kids were diagnosed with autism; however, by 2018, nearly one in 44 kids were diagnosed with autism [1]. In addition to the challenges people with ASD face, families also have to go through the difficulties of finding the right support for them. Each person with ASD is distinct, meaning that all of them will need different kinds of treatment. The process that families may need to take in order to find the right treatment for their kids can be mentally laboring and tedious [2]. Not to mention, the financial

cost of finding and providing the right support for them will also play a role of burden for the families. This conveys the sense of urgency of curing—or at the least finding an effective way to assist them—autism before monotony more readily solidifies into the great minds of the people of Earth.

The first one utilizes a story-telling method to allow people with autism to understand money. The shortcoming of this would be that it is not effective in treating someone with autism as its primary goal is to teach them about money, not treat their autism. Our project, instead, focused on bettering the decision makings of autistic people, while also breaking their restrictive behaviors through fun, easy-to-understand games [10]. The second method was quite similar to our project as it used a reward system in the forty “serious” games they created to improve social behaviors and their emotion recognition. The project also has an adaptability feature for autistic kids, which is something present in our project as well as it incorporates minigames to allow the autistic kid to have a better and more “fluid” experience. The final project used humanoid robots that were programmed to imitate their impression of the autistic kid and the autistic kid’s impression of them in order to improve joint attention and imitation of the autistic kids. However, the shortcoming with this project lies within the fact that it does not deal with more internal skills such as emotions or comprehension skills. On the other hand, our project was made directly to improve many of the internal skills that were limited in an autistic person’s mind such as comprehension, decision making, or restrictive skills.

As mentioned before, autism cannot be cured, but it can be assisted through various methods tailored to each individual's unique challenges and strengths. One effective approach is to introduce them to a variety of mini-games to break their barriers of restrictive behaviors. At first, these games would generally be more on the “interesting” side—sort of like an interest sparker, such as hot potato, hopscotch, tag, simon says, or any other kinds of game that kids nowadays deem as amusing. By doing this, their brain would naturally become more receptive to different things, breaking their barrier of restrictive interests and allowing games such as educational or decision making games to become a reality in the lives of these kids. Games like these are extremely important because it can aid their learning and daily life navigation. However, if kids are not presented with activities of such, they will eventually be stuck in a loophole that would restrict their interests and lead to repetitive actions. As they get older and their brain becomes less receptive to newer things, this loophole that they have unintentionally designed will only become stronger to the point where treatment will be much longer and harder. The project itself will have mazes, a sorting game, a dino run, an interactive band, and a matching game, all of which are super fun nonsensory games. At last, there is an adventure game that tests their decision making skills and uses positive reinforcement to correct them if they do make a mistake in their decisions.

The experiments targeted blind spots regarding the navigability of the app and how well an autistic person can play the adventure game. The solution to tackling these blind spots would be to use a survey and ask people, who are experienced with autistic kids, to try the app themselves and rate the navigability of the app and the ease of finishing the adventure game, then asking what they believe an autistic kid would rate it. Although it would be better if an autistic kid could rate it, getting a rating from them is another difficulty that may want to be avoided due to possibilities of false ratings. Nevertheless, the results that were received were reasonable and made complete sense. For both surveys, there was a fluctuation in the results — both having a 3 number range in a 1 to 5 scale — but that could be explained by the fact that every autistic person is distinct with their own challenges and strengths. Also, considering how most of the app was built for autistic kids, simplicity was often considered and implemented throughout. For navigability, much was done to keep the app’s content short, sweet, and understandable. For the adventure game, much was done to meet the “expected” comprehension skill of autistic kids.

However, obviously, this being a game that isn't perfect, there are many spots that can only be improved to a limit, which explains the slightly reduced rating of each survey.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Identify the most suitable games

As previously noted, games are essential components of an autistic child's life because it is a way of addressing their restrictive behaviors and, if sophisticated and well-built enough, can improve other aspects such as communication. This being said, it is challenging to identify the most suitable games for these kids, as they have diverse ways of understanding and can be highly selective in their choices. A possible solution to this would be gathering many different kinds of games and picking the most interesting ones out, as it would possibly diminish the effect of their restrictive behavior and slowly allow them to enjoy many different games, and not just a couple that they have found deep interest in. Or, if there is an intent to improve social communication, then delve deeper into each game and find out which one is more communication based.

2.2. The game's effectiveness

As one knows one's self best, it isn't easy to understand what is happening inside the mind of an autistic person. As a result, another layer of complexity was added when creating the storyline for autistic kids because the level of comprehension and clarity of instructions is questioned throughout. Pretty much, the question of how easy the storyline is to understand is brought up. While the solution may involve adding more instructions, this may impact the game's effectiveness in developing decision-making skills, as the child may end up merely following instructions rather than learning, which is not the goal of the game. The right solution would be to find just the right amount of clarity so that they would still be able to improve their decision-making skills simultaneously.

2.3. Make the content easy to understand

Taking both challenges into consideration, the content of the app must be easy to understand and also appealing. As autistic kids have weaker comprehension abilities, making the app easy to navigate is essential for consistent activity of the games in the app because kids are more likely to do certain activities that are straightforward and fun. This leads to the next challenge, which is fostering "fun" into the app by making the app more visually appealing. One way to go about this is by adding brighter and more "joyful" colors into the app, whether it would be in the main menu or the games itself.

3. SOLUTION

The app uses the Unity game engine and is programmed in C# [11]. When opening the app, one will experience the beauty of our simplistic, yet intricate menu, which embodies colors that convey senses of positivity that may prompt kids to play the game. Immediately, players are given a wide range of choices: an adventure game, a matching game, a runner game, a maze game, an interactive band, and a sorting game (and if their curiosity allows, they can read the About) [12]. In the adventure game, players are tasked to return a carriage of goods to the village. Throughout the course, they will find obstacles in which they will have to evade in order to bring back as many goods as they can. If failed, a lost screen would appear along with a retry button; if

won, a win screen would appear, in which you can click off and explore the map, or you can return to the main menu. Next, there is a matching game that consists of 12 cards (6 pairs) in which the player must match all 6 pairs to win. There is also a runner game, which is a replica of the dino game but with a different setting and different character, both of which were designed to incorporate colors that may help with the interests of autistic kids. Further, there is a maze game with levels easy, medium, and hard for players to choose from. In addition, there is an interactive band that has four different instruments, producing a sound every time it is pressed, for the player to interact with. Lastly, there is a sorting game in which an object appears and players are tasked with dragging the object to its corresponding topic.

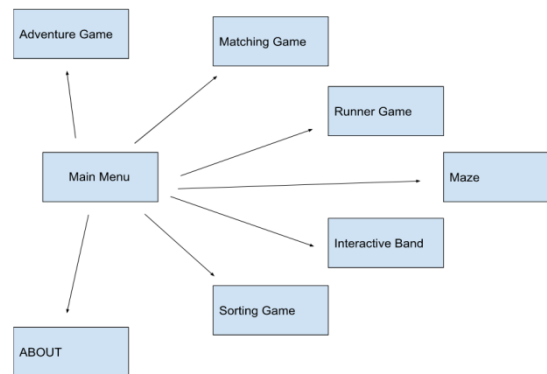


Figure 1. Overview of the solution

The addition of a sorting game was crucial to the app because it directly targets the comprehension skills of autistic kids. By requesting the player to quickly click the correct topic corresponding to the image shown, it helps players to differentiate certain things in a manner that more similarly matches the comprehension skills of nonautistic kids.

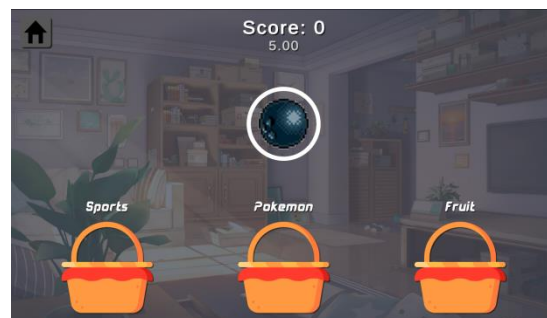


Figure 2. Screenshot of the game 1

```

void Update()
{
    if(startTimer) currentTimer -= Time.deltaTime;
    timerText.text = currentTimer.ToString("F2");
    scoreText.text = "Score: " + currentScore + "";

    if(currentTimer <= 0)
    {
        startTimer = false;
        currentTimer = 0;
        finalScoreText.text = "Final Score: " + currentScore + "";
        winPanel.SetActive(true);
    }
}

public void Play()
{
    startTimer = true;
    PopulateNewItem();
}

public void SortToBasket(int index)
{
    if(currentBasket == index)
    {
        currentScore++;
        PopulateNewItem();
    } else currentTimer -= 5;
}

void PopulateNewItem()
{
    currentBasket = Random.Range(0,3);
    itemPicture.sprite = currentBasketList[currentBasket].items[Random.Range(0, currentBasketList[currentBasket].items.Count)];
}

```

Figure 3. Screenshot of code 1

As we enter the sorting mini-game scene, we have a play button that calls the Play() method that will start the countdown for the whole game and give you an item to sort using the PopulateNewItem() method. This method picks basket 1, 2, or 3, which is randomly given a category at the start of the game, to be the currentBasket the new item gets sorted into. Then the item icon in the middle of the screen gets assigned a random item from the chosen current Basket's category. The player can click on one of the 3 baskets that calls the SortBasket(int index) method where each basket has index 1, 2, and 3 respectively. If the currentBasket matches the clicked basket index, then the player's score increases, and if not, the countdown decreases by 5 seconds. The game ends when the countdown reaches below zero and a UI shows up with a final score of the amount of correctly sorted items.

Arguably, the most essential aspect of the app is the storyline itself. With a purpose of adopting better decision making skills through positive reinforcement, players who interact with this game will naturally understand the importance of making the correct decisions, ultimately leading to better actions in the real world.



Figure 4. Screenshot of game 2

```

Unity Message
void Update()
{
    if(currentIndex <= stringDialogue.Count - 1 && currentIndex >= 0 && stringDialogue.Count != 0)
    {
        dialogueText.text = stringDialogue[currentIndex];
    } else dialogueText.text = "";
}

doneButton.SetActive(stringDialogue.Count != 0 && currentIndex == stringDialogue.Count - 1);
previousButton.SetActive(stringDialogue.Count != 0 && currentIndex > 0);
nextButton.SetActive(stringDialogue.Count != 0 && currentIndex <= stringDialogue.Count - 2);
}

public void StartDialogue()
{
    dialogueActive = true;
    panel.SetActive(true);
    playerCam.SetActive(false);
    firstPersonController.Instance.allowLook = false;
    firstPersonController.Instance.allowMove = false;
}

public void PerformScroll(int amount)
{
    currentIndex = Mathf.Clamp(currentIndex+amount, 0, stringDialogue.Count - 1);
}

public void FinishTalk()
{
    dialogueActive = false;
    playerCam.SetActive(true);
    firstPersonController.Instance.allowLook = true;
    firstPersonController.Instance.allowMove = true;
}

panel.SetActive(false);
}

```

Figure 5. Screenshot of code 2

As we enter the adventure mini-game scene, we are able to walk around in first-person. Our first encounter in this scene is an NPC that stands by next to a forest that talks to you [13]. Interacting with an NPC opens up a dialogue UI that shows the dialogue text and arrows that navigate through the conversation. In the code, we have a List of strings called "stringDialogue" that is filled in the inspector with dialogue that is unique per NPC. We have an integer called "currentIndex" that keeps track of the current "stringDialogue" that is displayed on the dialogue UI. The "currentIndex" increases or decreases with the navigation buttons on the dialogue panel using the PerformScroll method that takes in an integer "amount". During Update(), what string is displayed on the UI is by array indexing "stringDialogue" with currentIndex. StartDialogue() and FinishTalk() methods show or hide the dialogue panel, change the camera from player to interaction camera, and allow players to move or not.

The implementation of a matching game to the app was vital, as it trains their memory, differentiating, and attention skills. Especially since autistic kids tend to lose attention quickly, by giving them incentive to maintain their attention, it will help with their ability to be attentive to other things. The other skills are just as necessary when navigating their daily life.



Figure 6. Screenshot of game 3

```

void MatchManager()
{
    if(matchCheckList.Count == 2)
    {
        if(matchCheckList[0].cardName.Equals(matchCheckList[1].cardName))
        {
            Debug.Log("Match!");
            matchCheckList[0].hasMatched = true;
            matchCheckList[1].hasMatched = true;
            matchCheckList.Clear();
        }
        else
        {
            StartCoroutine(matchCheckList[0].TimerFlipBack());
            StartCoroutine(matchCheckList[1].TimerFlipBack());
            matchCheckList.Clear();
        }
    }
}

public bool AddToCheckList(PictureCard card)
{
    if(matchCheckList.Count < 2)
    {
        matchCheckList.Add(card);
        return true;
    }
    return false;
}

```

Figure 7. Screenshot of code 3

The matching game has orderly placed 3 by 4 cards spread across the screen where it starts off with the back of the card facing towards the user. Players can then click on a card to flip it around and flip another one around to check if they match. If the pictures match, they stay flipped around showing the picture side of the card. If they don't match, they flip back around showing the back of the card. Every time a user clicks on 2 cards, they both get added to a list named "matchCheckList" using the AddToCheckList() function. When there are 2 cards on the list, the MatchManager() function recognizes this and checks if the two cards on the list have the same card name, then they stay as is, but if they don't match, the coroutine "TimerFlipBack" gets called on each card that plays a card flipping back animation. After these sequences, the list is cleared and the user is there to try again for another match.

4. EXPERIMENT

4.1. Experiment 1

Being able to easily navigate the app is, without a doubt, the most important aspect of an app. Even with the greatest possible content, if the app's navigability is suppressed, the entire app is fruitless. Therefore, as it is our goal to make this app playable for autistic people, one must consider how easy it is for an autistic person to navigate the app.

The approach to this possible blind spot is rather difficult as it is not possible to get direct and concrete data from giving autistic kids the game because they are not able to properly communicate their thoughts on how easy it was to navigate the app. As a result, the approach to this possible blind spot would be to survey people who are more knowledgeable about autistic people and have them navigate the app to see for themselves if they believe that autistic people would have a difficult time navigating the app. This would be done on a scale of one to five with one being the hardest and five being the easiest.

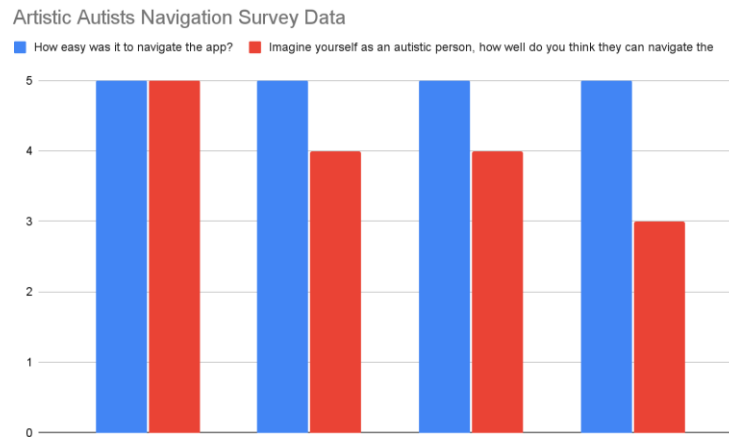


Figure 8. Artistic Autists Navigation Survey Data

For non-autistic people, navigating the app was extremely easy, with an average of 5 (being the easiest) throughout. This data was expected as the app was intentionally designed to be minimalistic so that the navigability of it would not be too big of an issue for autistic people, much less non-autistic people. On the other hand, responders believed that autistic people may have a slight difficulty in navigating the app, with the average being 4 out of 5 and with the highest value being 5 and lowest being 3. This data too met our expectations as the lack of attention and understanding in autistic people would cause them to mindlessly do things without any real intent, such as navigating the app. However, considering that every autistic person is distinct, with different challenges and different strengths, this could be the reason to the fluctuation of the results, ranging from 3 to 5.

4.2. Experiment 2

In addition to the navigability, the adventure game is also an important aspect that dictates the functionality of the app. For this reason, assessing how probable it is for autistic people to finish the adventure game is vital as it is important for the purpose of the game to be clearly demonstrated.

The approach to this blind spot is similar to the previous approach, in which the same people (who are knowledgeable about autistic people) play the adventure game and get surveyed on two different questions: how easy was it for them to finish the game and how easy they believe finishing the game would be for autistic people. Again, it is done on a scale of one to five with one being the hardest and five being the easiest. These results would be affected by a variety of factors such as the player's comprehension skills, the game's functionality, the game's attractiveness, etc, all of which responders should take account of and complete the survey based on those.

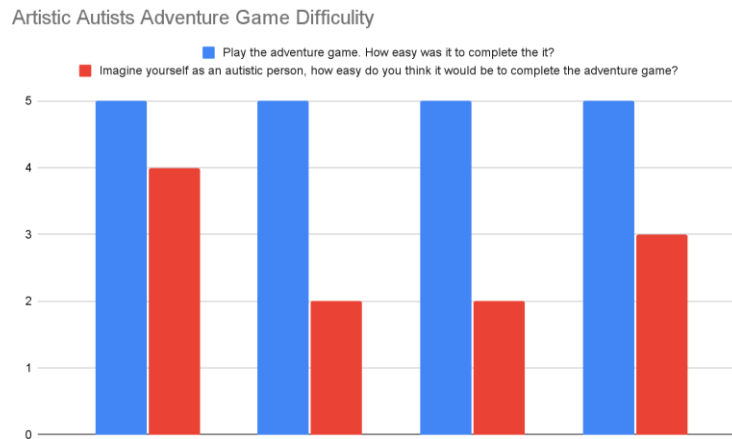


Figure 9. Artistic Autists Adventure Game Difficulty

Likewise, for non-autistic people, completing the game was no trouble, with an average of 5 throughout. Again, this data met our expectations as the game is extremely straightforward as there are clear instructions with easily avoidable obstacles. Besides, the purpose of the game itself is super self explanatory - carry as many apples back to the village while avoiding obstacles that may decrease the amount of apples you have in your carriage. On the other hand, it is believed that autistic people may have a harder time finishing this game, with an average of 2.75 out of 5, with the highest being 4 and lowest being 2. This data was expected as well because when considering the worse comprehension skills of autistic people, it would make sense for them to possibly not understand the instructions, and, as a result, not understand the premise of the game. This also may result in them playing the game in the incorrect way, such as walking into the obstacles or just not being able to find the end point. Obviously, however, these factors were considered and changes were made accordingly to accommodate for the autistic person's possible inability to properly play the game.

5. RELATED WORK

Bangladeshi author, Arshia Zernab Hassan, collaborated with his colleagues to design a personalized game that is based on a story-telling concept to help children (from ages 9-14) with autism to understand the use of money [4]. This solution is particularly clever because story-telling is a better way of engaging the kid's interests rather than straight up informing these kids what the use of money is, which may be a dull and tedious task for them. This is similar to our solution, which uses the concept of adventuring and rewards to persuade the kids to make better decisions. The only difference lies within our goals of creating such games: one is centered around the understanding of money, whereas the other is centered around the success of the kids' decision making skills.

German researcher, Ahmed Hassan, developed forty serious games to improve the social behaviors of autistic kids, with each game having a slight focus on emotion recognition [5]. A reward system, adaptability and customization will be a part of every game to effectively bring out their goals: improving their social behavior and understanding their emotions in regards to when they play the serious games [5]. Much of the goals that Dr. Hassan has for these games are similar to the goals of ours, as both utilize a reward system to improve social behaviors, which in our case is more specific: to better their decision makings whether it is in their social behaviors or just during their daily life experience. Along with that, our other minigames serve to

accommodate for times when they may find themselves bored, which is alike to the adaptability feature presented in these forty games that were meticulously designed.

Iranian author, Taheri, began using humanoid robots to treat kids with autism [6]. The humanoid robots were programmed to elicit their imitation of the autistic kid and the autistic kid's imitation of them [6]. His goal with this was to improve joint attention and imitation of the autistic kids[6]. Our solution was rather different from Taheri's solution as it had nothing to do with imitation and did not implement humanoid robots for the treatment. However, in a sense, both ours and his solution worked to improve the attention span of autistic kids, for our solution did this by attempting to match with their interests, while his solution was done through the imitation of humanoid robots and the autistic kid.

6. CONCLUSIONS

The project approached the problem great, but the execution of it was rather limited, to say the least [14]. In other words, the app as a whole definitely does improve comprehension, decision-making, and restrictive behaviors, but how effectively the app brings this out is limited and questioned. A reason for this is the inability for us to see in the lens of an autistic person, leaving out many small but important details that may be crucial to the functionality of the app. Although a possible solution to this would be to give the app to an autistic person and let them try it out, it is hard to find an autistic person who can properly communicate their opinions on it. However, even if they were to properly critique the app, the psychological aspect of it is questioned because it would mean that their comprehension skills are already better than the majority of autistic people, causing many varying answers on how effective the app is for autistic people [15]. To simply put it, every autistic person is distinct and has their own strengths and struggles, making it hard to perfect the app. Despite this, the app could still be improved through the addition of games that have an even more established approach on ways to better comprehension, decision-making, and restrictive behavior.

Many factors and complexities have to be considered when creating such a project, but with such little time, some factors have to be ignored to produce the best possible content in that period of time. Even if this app may not be particularly helpful for autistic people, it is a great way to garner attention and awareness for people with autism and the need for the problem to be addressed.

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