

Improvisation music game for therapists and autism children

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1 Introduction

Autism spectrum disorder (ASD) is a developmental disorder that affect about 1 in 44 children. While the symptoms of each autistic child is different on the spectrum, some of them are commonly observed, such as deficits in social communication and interaction, and restricted, repetitive behaviors, interests, or activities. However, when some of these symptoms are so significant that they can cause a lifelong disability. Autism is a lifelong condition, and a wide variety of treatments can help support people with ASD. An early intervention is of major importance as it both delivers the best results and parents of children with ASD adapt their environment to the children's needs.

We choose to delve into the use of music therapy as a treatment, and wished to give therapist a tool they could use to help them during their therapy session. To do so, we focused our research in three directions: autism therapy, music therapy, and how those two subjects work together.

2 Literature Review

2.1 Overview on autism

Autism Spectrum Disorder (ASD) is a neuro-developmental disorder that manifests itself differently in each individual [Wing et al. 2011]. Common symptoms of autism include difficulties with social communication, impaired interaction skills, repetitive or restricted interests or behaviours, etc [Seltzer et al. 2003].

Autism is usually identified in childhood and, as the data shows that one in every 100 children has autism in the world [Zeidan et al. 2022]. Even in the United States, one in every 44 children aged 8 years had ASD in 2018 [Maenner et al. 2021]. Therefore, the prevalence of autism in children is not low.

Intervention and treatment for autism is quite important because autism can lead to lifelong disabilities as well as people with autism are likely to bring heavy stress to their families and society [Thurm and Swedo 2012]. Research has shown that early intervention is highly effective for children with autism and can lead to better outcomes [Corsello 2005]. Therefore, we target the group to children with autism.

2.2 Music Therapy

Music Therapy is a systematic process of intervention wherein the therapist helps the client to promote health, using musical experiences and the relationships that develop through them as dynamic forces of change [Geretsegger et al. 2014]. Existing music therapies generally involve children interacting with music in several ways: composing, singing, moving to or listening to music [Peters 1987]. Music therapy has a wide range of benefits for people, such as promoting health, managing stress, reducing pain, expressing emotions, enhancing memory, improving communication and promoting physical healing, and so on [Davis et al. 2008].

2.3 Applications of music therapy on autism

The existing data suggests that music therapy is already being used in the treatment of some children with autism [Evers 1992]. Music therapy can help children with autism to improve their skills in social interaction, verbal communication, active behaviour and social-emotional reciprocity [Geretsegger et al. 2014]. In particular, also a few research programs have shown that music therapy is used to improve the social skills of children with autism [Simp-

son and Keen 2011], specifically, music therapy increases more eye contact [Wimporly et al. 1995]; [Kim et al. 2008]; in addition, music therapy helps children improve their ability to encode and decode emotions and behaviours [Katagiri 2009].

3 Motivated design

Based on all our research until now we came up with the concept of creating a Serious Game using Augmented Reality, with the purpose to help users benefit from all types of psychotherapy mentioned above in our research. [Kordaki and Gousiou 2017] mention in their paper that digital card games have positive effects for education and that augmented reality help enhance players' real world experience with additional visual and audio information and encourage intuitive interactivity and collaboration, which is a major challenge of ASD therapy. Augmented reality also allow teachers and therapists to take advantage of its customisation possibilities to fit their approaches. Based on this information, we developed an Augmented Reality Card Game with two themes, based on music therapy.

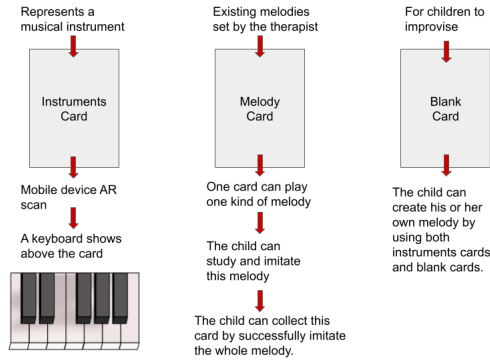
The game is designed as follow (see Figure 1 & 2) : The therapist on their system decide which theme will be used for the session. When the patient begin the session, their are given instrument cards and a stick, and the therapist uses the same item. When their device scan the card, it will display the instrument above. When the stick touch and slide on the model of the instrument, notes are played. Some cards contain preexisting melodies. When a user successfully replicates the melody, they can claim the card and add it to their collection. When blank cards are used, the user can create their own melody using the instrument card, and record it in a specific blank card to be reused later on. Based on the theme chosen by the therapist, each melody card correspond to a different model with their associated with animations. The user can then assemble 5 or more cards to create a garden or a train circuit, depending on the theme.

Cards have different models, a choice motivated by the fact that therapy for autism include learning to socialise, and such a design can encourage the trading of the cards between the patient and the therapist, or between multiple patients depending on the goal of the session. By distributing the cards in an uneven manner, the therapist can encourage their patient to take the initiative to interact with each other in order to make a trade or build a deck of cards together. Furthermore, as cards are easy to produce and to create, sometime only needing printing, the therapist can gives their patient the cards that they used during the therapy session and reuse them during a future session, to increase the motivation of patients and their interest in the therapy.

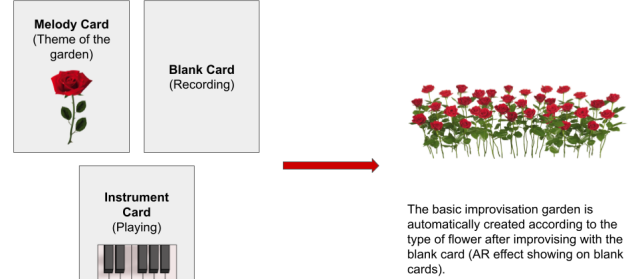
4 Scenario

As indicated from Anna et. work [Baglione et al. 2021], during the ASD therapy session, we need to focus on two types of users: the therapy who prepare and manage the therapy session, and ASD kids who are receiving the therapy guided by the therapist. In each stage there are different demands we need to focus on, therefore, we divide the session into mainly three stages:

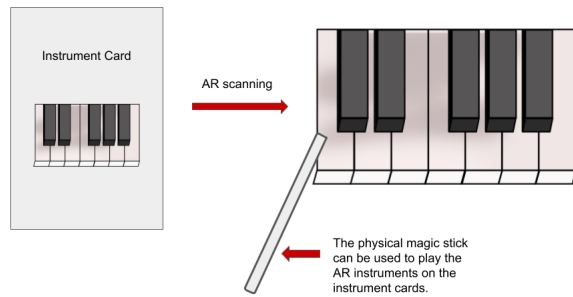
- **Prepare the session** In this phase, only the therapist will access our well-designed system. They need to prepare necessary materials for next therapy sessions due to variations of hobbies and mental states from ASD Kids [Simpson and Keen 2011].



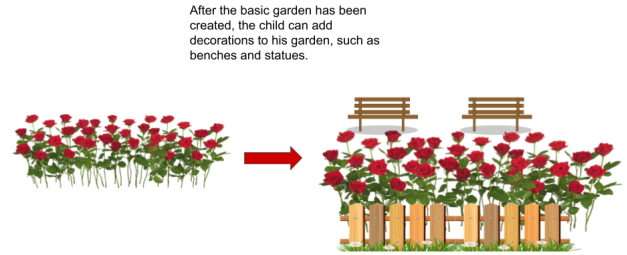
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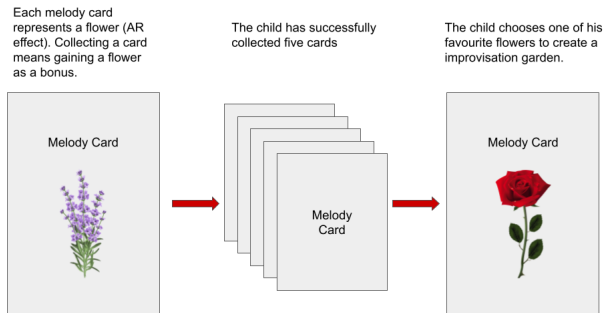
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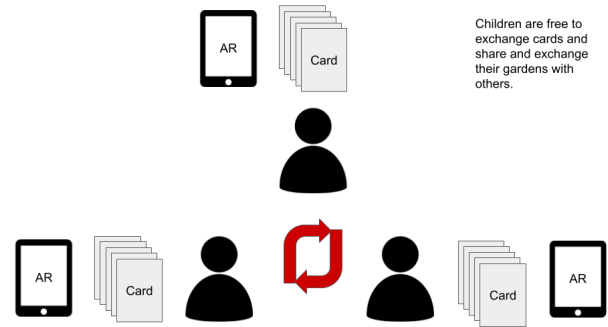
(b)



(b)



(c)



(c)

Figure 1: The workflow of our design I (here with gardening theme)

Figure 2: The workflow of our design II (here with gardening theme)

- **Proceeding the session** This is the main therapy session. The therapist and several ASD kids will join the activity. During the session, the therapist may use our system to begin a music-based game.
- **After the session** As soon as the therapy session is finished, the system should store the current state and prepare for the next therapy session. The therapist may also need to managing different session records and scenes, and adjust them according to therapy results.

Therefore, in our system, the therapist tweak the game rule and game contents for personalized therapy demands. Both the therapist and ASD children are the participants and players of the game. And the therapist will guide children to finish their game in a stable way.

We also notice that there are other possible scenarios for our systems. A common case is home-based music therapy provided by non-professional people, like the parents of ASD kids. However, because the external environment is hard to control due to implicit unstable factors[Pasiali 2004]. Thus, we focus on a stable scenario, and a classroom environment may also help ASD children to know each other, and prompt them to build social relationships.

5 Implementation of Design

Based on our design, we decide to implement with Unity and Vuforia (AR SDK) for our prototype. We mainly focus on interaction implementation, so we only complete the necessary functions in the demo.

5.1 Cards

As mentioned in the previous sections, we classify card into two types: Instrument card and Sheet card.

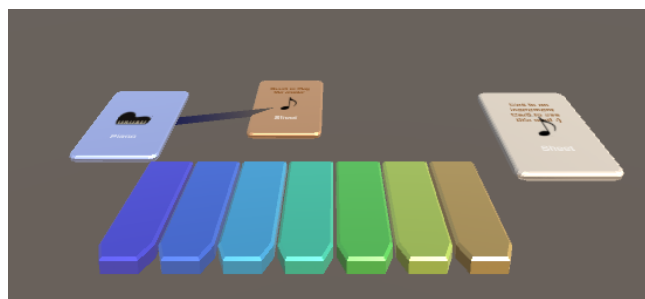


Figure 3: Different cards in our design. The blue card is the instrument card, it also represents the 7-key piano at the same time. The orange card is a normal sheet card. It contains a predefined sheet that can be played by touching it. The white card is an empty sheet card. The user can touch it to begin and stop the recording, in order to create a new sheet. Once the recording is finished, it will turn into an orange sheet card. Also, the blue card and orange card are linked as they are put together, while the white card is not linked due to far distance. Only linked sheet card can manipulate the instrument.

Instrument card is linked with a virtual object, when the user put the card in their view field, it will display a playable virtual instrument above the card. In the prototype, we implement a 7-key piano card, each key represents a basic note. The user can click to play the piano and enjoy the visual feedbacks.

For Sheet card, it should have 3 functions: play the sheet, begin the performance game, record the improvisational performance. To play or record the sheet, the user needs to link the sheet with an instrument card, by put two cards together. Once the link is established, the user can manipulate the sheet with the virtual instrument.

For each initial empty sheet card, when the user touches the card, it begins to record. During the recording, the card will record any manipulation to the instrument. Then, if the user touches the sheet card again, it will finish the record, and turn into a normal sheet card.

For a normal sheet card, it has two functions: play the music and begin the game with the sheet. To embedded two functions into the card, we design two card state based on flipping. If the user touches the front of the card, it will play the music. If the user touches the back of the card, it will begin the performance game.

For sheet play and sheet performance game, both will display a dynamic sheet above the virtual instrument. Each note represent as a tiny crystal, once it falls on the key of the instrument, it will play the sound and disappear. Thus, the user has an intuition perception of the sheet, and they no longer require to read and understand the form of different music symbols.

5.1.1 Sheet play

Sheet play is similar to regular music play. When the user touches the front of the card, it will display a dynamic sheet and automatically replay the sheet. The dynamic sheet consists of note crystals for each instrument keys. When the music plays, the note will approach the key and disappear smoothly as soon as they hit the key. The user can touch the card while playing if they want to stop it.

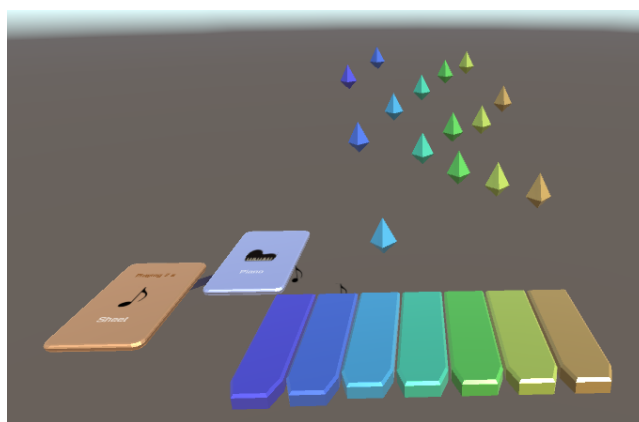


Figure 4: Dynamic sheet representation.

5.1.2 Sheet performance game

The sheet performance game is similar to common music game, the user needs to press the corresponding key as soon as the note fall to the instrument key. The game also has a score system with a full score of 100. If the player obtains a score above 60, they will be rewarded with a themed item.

5.1.3 Therapist interface

For the therapists, we decide to give them a Unity like editor to set up the therapy environment. The therapist can define an environment for each therapy session. Before the session, they can edit cards and rules. Additionally, we have made some predefined card to help therapist modify the session in an easier way. For instance, a predefined sheet card is provided for external sheet music. The therapist only needs to type some simple notation to define the sheet. We also provide button-based tools to test and record in the editor, so they can simply copy and paste, or modify the values to create a new card.

For the sheet performance game, the therapy can edit the game difficulty to ensure that it suits variation of participants. There are also

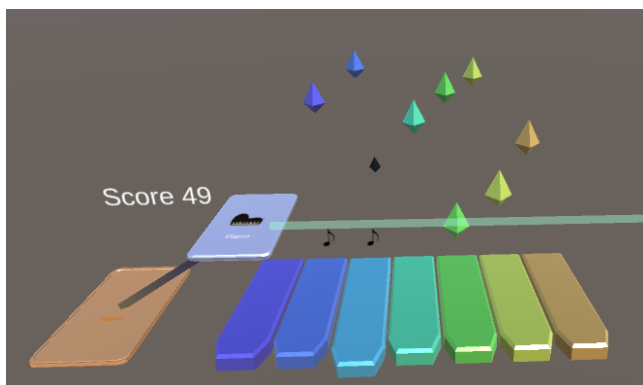


Figure 5: The scene of sheet performance game. Crystal notes will give the feedback whether the player has an accurate hit of the note (The black note means a bad hit). The therapist can tweak the game difficulty by modifying the tolerance of hit delay.

some simple customized theme components for the game reward. They can simply put some image resources to customized special theme for different kid interests.

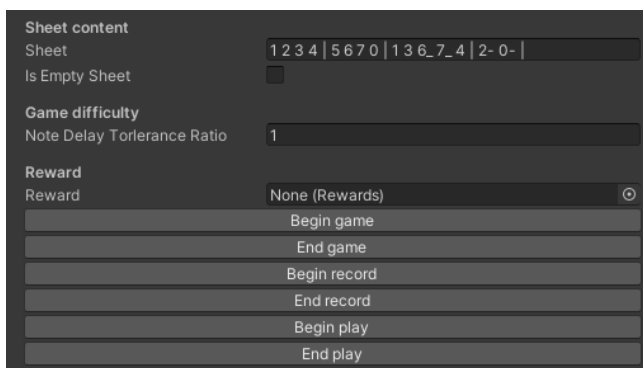


Figure 6: The editor of the card, it helps therapist to set up the card in a quick way. They can also use common notation in the music field to write a simple sheet.

5.2 Themes

The major storyline of the game is for players to play the sheet and fix the virtual world with the cards collected through their sheet performance. We currently have two themes - garden and train - for therapists to choose when they begin therapy. Due to the time limit, we have only made the prototype for the garden theme, as presented previously. For the train theme, the cards that players can collect through sheet performance are parts and facilities of the train such as the engine, the restaurant wagon, the passenger wagon, and the cargo wagon.

Plants and trains are two of the common elements when it comes to the intervention of autistic children. Interacting with plants makes autistic children engaged and relaxed while having the potential to improve their memory and cognitive abilities [Seo et al. 2015]. Train, on the other hand, could be effective when it comes to motivating autistic children to play the game. This is because individuals with autism typically have circumscribed interests around particular objects that are associated to vehicles and mechanical systems such as trains [N. E. Scheerer and Iarocci 2021]. However, too much interest could also do harm because research has shown associations between circumscribed interests and repetitive behaviours, which is one of the most common symptoms among autistic indi-

viduals [South et al. 2005]. Therefore, we proposed two themes and would make more themes in the future, so that therapists could choose the theme according to the situation of the specific children. We have plans to evaluate the effectiveness of different themes in the future as well.

6 Proposition of Evaluation Method

6.1 Research Hypothesis

H0: Playing the ARISE serious game will not result in significant improvements in communication skills in children with autism.

H1: Playing the ARISE serious game will result in significant improvements in communication skills in children with autism.

6.2 Participants

For the evaluation, 30 children between 6 to 9 years old would be recruited for our system. Their characteristics should be neutralized as much as possible: no age/gender/handedness difference etc. We would give them and their representative a detailed explanation of how the study would be conducted, as well as ask them their permission to be filmed during the experiment.

6.3 Experimental design

The 30 children will be divided into two groups, with group A testing a garden-themed game and group B testing a train theme.

Before the experiment begins, a detailed assessment is made of the current condition of the 30 children, such as the child's current joint attention, positive emotional/musical/non musical communication. After assessing the severity of each child's symptoms, a detailed record will be made for each child.

At the beginning of the experiment, 30 children will be given 8 hours per week to play the game. The music therapist will be present to assist while the game is being played. Each 4 weeks the 30 children will be tested in the same detail as initially for 12 weeks. Some follow-up visits will be made to the children during the 6 months at the end of the experiment. We will also conduct some interviews with the music therapists in the experiment to get more detailed information about the effectiveness of the game.

At the end of the experiment, the data from the 4 assessments (including the initial one) will be analysed and the results of the 4 assessments will be compared to determine the effectiveness of the game. If the game is not effective, adjustments will be made at a later stage based on the data.

Finally, the effectiveness of the garden and train will be compared against the experimental data from groups A and B.

6.4 Intervention & Measures

Duration of the intervention: A total of 12 weeks, with 8 hours of playtime per week for the child. Every 2 hours will be a play session and 48 sessions will be played throughout the course of the treatment, each at an interval of up to 3 days.

Group Assignment: In both experimental groups A and B, each group will be divided into small groups of 3 children for multiplayer play, with a total of 10 groups in both experimental groups A and B. The members of small groups for each game session are random.

Administration of the game: We will explain in detail to the children and their guardians what the game is about and how to play it. For the children, we will incorporate sounds and diagrams and allow the therapist to guide and explain the game so that the children become familiar and engaged with it. The familiarisation process is recorded and the children are tested before and after learning. Finally, we help the children and the therapist to set up all the equip-

ment needed so that problems with the equipment do not affect the results of the experiment.

Monitoring and support: A combination of therapist assistance and remote monitoring will be used with the consent of the guardian, child and therapist. Therapist assistance will allow for accurate and smooth play, and remote monitoring will allow us to keep track of the progress and status of the play. These interactions will be recorded and stored for subsequent screening and analysis.

Measures: To measure the improvement of the patients, we have the therapists fill in the commonly used ATEC form by [Rimland and Edelson 1999] every session. This form consist of four subtests, regarding speech and language communication, sociability, sensory and cognitive awareness and finally health, physical and behavior. We will draw our conclusions based on the result of those forms and on the feedback of the therapists.

7 Video Demo

Our Video demo is uploaded to the Google drive:

"https://drive.google.com/file/d/1AxjyY3fY5GPp9g-3YfO9Qv8-qSrsyF1g/view?usp=share_link"

8 Conclusion

In summary, autism is not uncommon worldwide and it is usually detected in childhood. Autism affects the social and interactive skills of the patient, among other things, and can easily cause inconvenience to the patient's life and even a burden to the family and society. Therefore, early intervention for autism is necessary. With music therapy as one of the universal autism intervention methods, we decided to start from there and design a music therapy game for children with autism.

Based on the needs of children with autism, we designed the ARISE card game as a music therapy aid to help children improve their social skills as well as their language skills. The game uses AR technology to allow children to imitate and compose music, with the addition of card exchange sessions and thematic play narratives such as a garden or a train. The card exchange session will further improve children's social skills and the thematic games will better engage children's interest.

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