# A 3D Rhythm-based Serious Game for Collaboration Improvement of Children with Attention Deficit Hyperactivity Disorder (ADHD)

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*Abstract*—The "ADDventurous Rhythmical Planet" is a multimodal 3D serious game that exploits the benefits of music and rhythm to help children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) to confront important psychosocial challenges. Music is shown to significantly help children maintain focused attention as well as offer a timed structure around their actions, involving melody and tempo. The advantages of music are exploited in the game, using a tin drum. This drum is used by the player to produce rhythm and it is connected to the computer via a Makey Makey board. This board sends each drum knock as a mouse click signal to the computer. Using the drum, the player tries to reproduce a given beat, and subsequently synchronize with another player, so that they cooperatively produce an expected beat. This creates a connection between the real and the virtual world of the game. In order for the hero of the game to progress in the game, the player uses the tin drum to reproduce a number of rhythms. After completing the single-user mode, the player moves on to the multi-user mode. In this mode, the two players have to hold hands and use the tin drum to collaboratively reproduce the requested beat. For the input management and comparison of rhythms, a special algorithm was implemented. The algorithm takes the beat created by the player and compares it to the expected beat. The player completes the game level if the rhythm played is similar enough to the rhythm heard. If not, the player tries again to reproduce the expected rhythm. The player receives a visual representation of the beat played, showing the correct knocks and the wrong ones. The pilot evaluation presented confirms the effectiveness of the game and demonstrates the benefits of rhythm in order to enhance social skills and collaboration between children.

*Index Terms*—serious game, ADHD, rhythm, social skills, collaboration, music therapy, psychosocial functioning

## I. INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a behavioral disorder with a specific range of symptoms that usually appear from the age of 7. There are three types of ADHD; the Inattentive, the Hyperactive and the Combined, with their main symptoms being limited attention span, forgetfulness, and distractability for the first, inability to sit still for a specific time, appearing hyperactive and impulsive for the second, and combination of the previous two for the third ADHD type [1]. Naturally, those characteristics are transferred to the children's social lives, causing problems to their social interactions. This can happen by interrupting their peers and/or saying something irrelevant during a conversation [2], having difficulty with complying with rules and even showing aggressive behaviour [3]. As a result, the emotional, behavioural and self- management as well as inclusion are very important goals in the life of people with ADHD [4].

Based on the importance of these goals, the work reported in this paper focuses on helping children with ADHD collaborate with other children, on a playful way, employing musical rhythm in order to offer engagement and effective development of several important skills. Indeed, rhythm, as a vital part of music therapy can help to make great improvements in the social, communication, cognitive, academic, emotional and behavioural skills [5]. Furthermore, music therapy is proved to bolster attention, reduce hyperactivity and strengthen self-confidence and social skills [6], [7], [8]. Gaming based on rhythm and music has the potential to improve the psychosocial functioning of children with ADHD focusing on developing their social and collaborative skills as serious games are proven to be of great benefit for educational purposes [9]. Such games offer audiovisual and motor interaction creating an attractive environment for children, potentially leading to lower frustration rate. The requirement of task repetition raises the possibility of success [10].

The rest of the paper is organized as follows: Section II presents games targeting children diagnosed with ADHD and compares them with the "ADDventurous Rhythmical Planet"

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game. Section III presents the process followed to design the game. Its architecture and hardware components are presented in Section IV. Sections V-VI deal with issues related to the game experience including the gameplay and the game story. A detailed presentation of the game environment and related user interface is analyzed in section VII. Section VIII describes the experimental design and results of the pilot evaluation conducted including lessons learnt. Section IX concludes and presents future research challenges.

## II. RELATED WORK

Several previous research efforts can be identified on how serious games can help children with ADHD, showing that serious games could become a significant part of children's psychosocial well-being improving their daily lives [11] [12] [13]. Such games aim to improve the underlying characteristics of ADHD as described bellow:

### A. "Adventurous Dreaming Highflying Dragon: A Full Body Game for Children with ADHD"

This game consists of three mini-games, each aiming to improve different underlying issues that children diagnosed with ADHD face [14]. The first mini-game aims at practicing attention on specific visual prompts, thus, promoting learning through focused attention. The second mini-game aims at enhancing gross and fine motor skills and seeks to improve hand-eye coordination. The third mini-game exercises the ability to hold still on a certain pose. This is a game requiring full body engagement by the players and its general purpose is to boost goal planning and dedication.

### B. "ANTONYMS: A Serious Game for Enhancing Inhibition Mechanisms in Children with ADHD"

ANTONYMS consists of three mini-games [15]. The first two mainly aim to help children pay attention to details and the other one on improving inhibition and control of impulses. The ANTONYMS game, besides its use as a rehabilitation tool, can also be used as an assessment tool. The intention of this game is to develop the children's ability to keep their attention focused during their daily lives.

### C. "ChillFish: A Respiration Game for Children with ADHD"

ChillFish is mainly a breathing exercises' tool helping children diagnosed with ADHD control their stress level [16]. The breathing exercises are communicated to the children through the movement of a virtual fish that the player moves by breathing into a sensor-mounted LEGO fish. The results reported show that ChillFish can aid the player in achieving a calm state, just like traditional breathing exercises do.

### D. The Evo Project / Endeavor RX

This game requires that the player makes fast decisions, forcing the brain to remain engaged and tune out distractions [17]. Such tasks include guiding a spacecraft through a canyon, where the players need to select only a specific color of fish appearing on the screen while ignoring the remaining, in order to move a spacecraft. The player's skills are evaluated as the game progresses and the difficulty of the game changes according to that evaluation. The evaluation results of this game show that it can help children *improve their concentration skills and progress their learning abilities* [18].

### E. "Plan-It Commander"

Plan-It Commander is a game aiming to cultivate behavioural learning, specifically the use of strategy in daily life [13]. This game consists of mini-games of increasing difficulty. The main goal of the player is to collect rare minerals. The first mini-game focuses on time management, the second on planning ahead and breaking down tasks into smaller pieces and the third one on helping teammates achieve positive social behaviour. A user satisfaction survey showed that parents and students were quite happy with the game and they would recommend it to other parents and children with ADHD.

### F. BRAVO: A Gaming Environment for the treatment of ADHD

This game uses Virtual and Augmented reality technologies to better the process of therapy for people with ADHD [19]. It detects the behavior of the patients using wearable sensors and electroencephalography (EEG) technology in order to create the profile of the player. It uses an avatar to entertain and create a friendly environment for the player. There is also a dashboard application for the therapist to get information and customize the interaction between the player and the avatar as well as the difficulty level. The aim of the "Infinite Runner", the first game, is to coach the player in regard to respecting rules, active listening and understanding of the player's limits. The second game ("Space Travel Trainer") aims to instruct the player to be proactive and interact with other teammates. The researchers suggest a 27-month assessment of the game to evaluate its results.

The games analyzed above are shown to positively affect the attention span of children diagnosed with ADHD. Although attention is an area of significance for ADHD, these games are rarely developing the psychosocial functioning on those children as such tasks are challenging to implement, especially when communication between children is required. Also, they mostly employ the visual sensory modality, requiring children to interact with mostly visual worlds and related game play. Furthermore, the enhancing role that music and rhythm can play in the process of helping children with ADHD is not utilized in any of the games. The "ADDventurous Rhythmical Planet" game presented in this paper introduces the added training benefits of including music and rhythm as essential components of the game play, engaging vision, sound and motor actions in a collaborative interactive experience. Furthermore, it targets psychosocial functioning focusing on the social collaborative skills of children with ADHD, by introducing multi-user game play.

## III. DESIGN PROCESS

An iterative design process was followed for the design of the game. This process consisted mainly of numerous

brainstorming sessions during which psychologists, special education teachers and musicians experts on musical rhythm identified which features of a game would engage children with ADHD to participate in a game. The main idea was that children would produce rhythm patterns using drums. Such actions would be translated to game play progression in the game environment. The representatives of the targeted audience were the special education teachers who guided the design process taking into account the characteristics of children with ADHD. Based on this feedback, features of the game such as its theme and context, the rewards offered to the players and the reactions of the main hero. The participating experts provided valuable insights so that the game could attract the attention of the children, boost their self confidence and motivate them to collaborate with their teammates.

As a result, the prototype of the game was revised throughout this process, guided by pedagogical principles. Such principles included positive feedback and reinforcement learning and consisted of: (a) player rewards in the form of collected items during game play that were put in the player's suitcase at each game level; and (b) player identification using an appropriate avatar to represent the main hero. An engaging game story and environment was described. This environment was built around a colorful planet as the main scene of the game. The game scenes were designed to catch the attention of the players and excite their interest. Using a drum for player input was also a significant part of involving tangible interaction with the player, as well as an outlet for children to release positive energy and have fun. The characteristics of the game created a fun environment, kept the player engaged and created a safe place for the players to learn, enjoy themselves and collaborate with each other. More about the design process and the original ideas can be found here [20] where the former work is presented.

## IV. ARCHITECTURE AND HARDWARE

The "ADDventurous Rhythmical Planet" game was implemented using the Unity3D Game Engine as the main development platform. The game's central interaction affordances are happening through a drum-like object that the players are using to play rhythmic patterns. For the drum actions to be communicated to the visual environment of the game, an architecture using the Makey Makey board is used (Fig. 1).

Makey Makey uses closed loop electrical signals to send to the computer either a keyboard stroke or a mouse click signal. This device is connected to a tin, electrically conductive, drum-like surface. This allows for the signal to get transferred instantaneously, without any delays or missing signals. The player wears a metal covered bracelet connected to the board and becomes part of an open circuit (Fig. 2). As a result, when touching the tin drum, the circuit closes and the signal of a mouse click is sent to the computer. Then the computer uses the mouse clicks and interprets them to drum knocks so that the players' beat can be monitored and compared to the expected beat that the player is asked to reproduce.
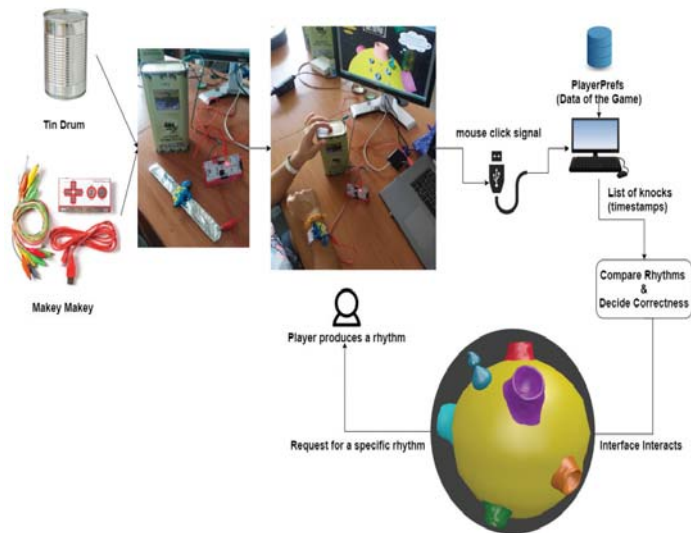

Fig. 1. Architecture of the game


Fig. 2. Circuit using the Makey Makey board

## V. THE SERIOUS GAME - "ADDVENTUROUS RHYTHMICAL PLANET"

The main game mechanism is based on the reproduction of certain rhythmic patterns using drum actions. These actions are translated to game play actions in the visual environment of the game. The game progresses only if and when the player reproduces the target rhythmic pattern requested each time in order to proceed to the next game level. The levels have an increasing difficulty.

The game has a single-user mode and a multi-user one. The game story urges the player to progress from the first mode to the second and collaborate with his/her peers. Through the single-user mode, the player learns how to use the tools of

the game and practices, by helping the hero of the game, on identifying rhythmic patterns and how to reproduce them. In multi-user mode, the players have to cooperate and collaboratively reproduce rhythmic patterns in order to complete their mission. As a result, each player, in collaboration with the other, is able to achieve a common goal and learn the value of teamwork. Based on the design of the game play, children get the opportunity to feel closer to one another and cooperate.

## VI. STORY OF THE GAME

The overall storyline of the "ADDventurous Rhythmical Planet" is centred around the main character, an extra terrestrial (Fig. 3), who crashed on a foreign planet and now has to move around the planet from one game level to the other. The different parts of the spaceship have fallen inside the craters of the planet. In order to acquire the missing parts, players have to play the beat that each crater requests. In other words, completing a game level involves players performing specific rhythmic exercises with the drum.

The players' goal, is to find the parts of the spaceship that went missing. In the single-user mode of the game, when completing each level, the character acquires a part of the spaceship. In the multi-user mode, when completing a level, the main character and her friends will get a new tool to help them repair the spaceship and to continue their journey.
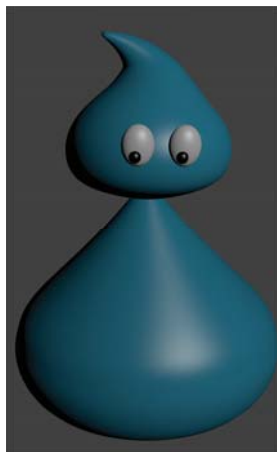


Fig. 3. Main character of the game

## VII. GAME ENVIRONMENT

The environment of the "ADDventurous Rhythmical Planet" consists of a main menu, a players' board, and also a user selection interface between single- and multi-user mode (Fig 4).

When the game starts, the player sees the Main Screen, in which the main character of the game welcomes the player, introduces the game story and asks for the player's help in a journey. The buttons available in this stage are the "Exit Game" button and the "Play" button. There is also a "Set Motifs" button to offer to the educational expert using this tool the chance to change the motifs representing specific rhythmic patterns the players are required to reproduce. As a



Fig. 4. Menu Diagram 1 - Selecting a specific player

result, when selecting the "Set Motifs" button, a menu appears including the saved motifs derived from already played game levels as shown in Figure 5. Using this feature, educational experts can adapt the game to the specific needs of children diagnosed with ADHD, thus, offering a personalized approach to the development of their psychosocial skills.

The motifs are represented in a circle as suggested in [21] since rhythm is a motif that is periodically repeated in music. There is an equilateral triangle inside the circle as all of the motifs were set to the rhythm 3/4. At the beginning, each player is either new to the game or has already played in the past. If the player is new to the game, the initial menu requests the player's name, age and whether the player is diagnosed with ADHD. If the player has played in the past, an existing
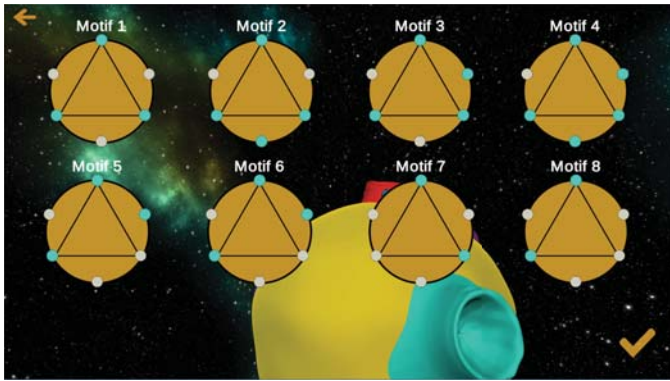
Fig. 5. Motif setting menu

name of previously logged players can be selected from a list, also including scores in descending order. This way a player can resume a previous game session. The selection to delete an existing player from the list is also available. Finally, the player chooses whether to play in single-user or multi-user mode (Figure 6). After traversing the initial menu, the
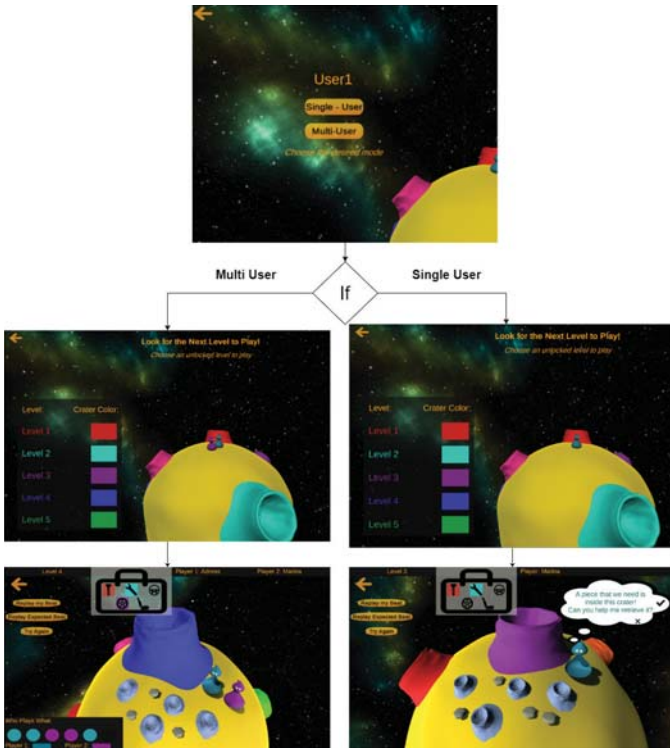


Fig. 6. Menu Diagram 2 - Single-user and Multi-user modes

alien is placed on the planet accompanied by a color-coded panel that shows which level corresponds to which crater. As a result, the player needs to walk/hop the alien to the desired color-coded crater. The player moves the alien around using the arrows on the keyboard looking for active craters through active exploration creating a sense of adventure and discovery. When the player reaches an active crater, the corresponding level of the game loads (Figure 7). A crater is active when

the player has already achieved up to its corresponding level. As a result, the players can play only up to the levels they have conquered and not above. The choice to just click on the selected crater is also available.
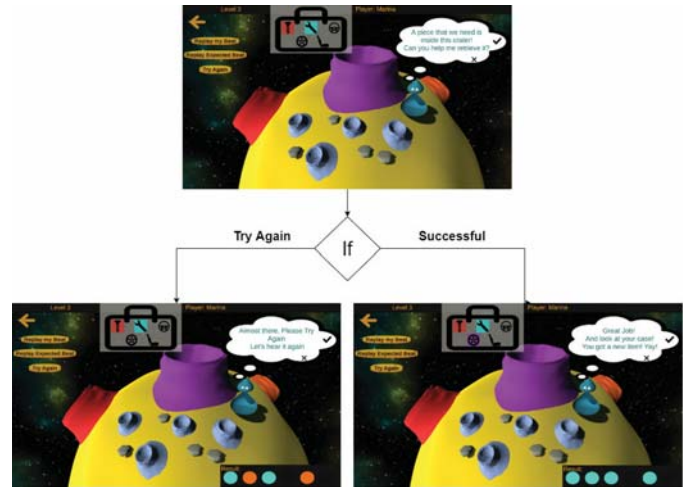


Fig. 7. Menu Diagram 3 - Successful or unsuccessful effort

Every new player starts in single-user mode, which is the introductory part of the "ADDventurous Rhythmical Planet". After successful completion of all levels in single-user mode, the player can move on to multi-user mode. Consequently, all participating players are introduced to the environment, the main character and the plot of the game before entering the multi-user mode. Game levels are gradually unlocked as the player progresses. At a certain point, the player can freely select any of the currently unlocked levels to continue.

Additionally, each payer has a suitcase of the acquired items (Figure 8). This suitcase is shown in each level and when the



Fig. 8. Suitcase of items that indicate the levels passed by the player

player successfully completes a level a new item lights up inside the player's suitcase. The suitcase signifies the reward that the player will receive, which encourages the player to continue into more challenging levels offering a goal for the player to pursue. Each item in the suitcase is rendered with the same colour as the colour of the level's crater. This creates a flow through the game and also keeps the player engaged. An important element of the user interface, which appears in multiple stages of game play, is a pop up, which appears close to the main hero, offering instructions, explaining the game, encouraging and guiding the player's next move. That keeps the player engaged and helps avoid frustration (Figure 9).

Fig. 9.  Level3 'Try again'

When entering each level of the game, the player sees the main character, the large crater that indicates the current level and a few small craters that represent the player's beat by glowing when the player knocks on the drum. A bar is placed at the top of the screen offering information about the current level, on the left, and the player's name, placed on the right. The suitcase is placed at the center top of the screen. The user interface includes buttons for (a) returning to the previous menu; (b) replaying the expected beat; (c) replaying the player's beat; and (d) trying again.

When the multi-user mode is active, both the names of the players are shown at the top left side of the toolbar together with information about each player's level (Figure 10). This
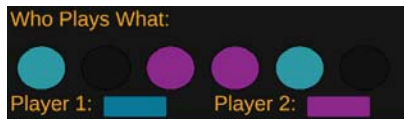


Fig. 10.  Who plays what panel

panel shows which parts of the given beat are assigned to which player using color indicators. For example, at Figure 10 player 1 should play the first and last knocks of the beat and player 2 should play the second and third.Also, a pop-up is shown that gives instructions to the player. Once the pop-up is read, the player hears the beat expected to be reproduced and at the same time, the small craters light up in sequence in order to offer a visual sense of the beat. Afterwards, the player reproduces the given beat by knocking on a drum. At the same time, at each drum knock, a small crater lights up and a sound is heard. After the player finishes playing, the game evaluates the player's beat and produces a result line as visual feedback, showing in color the beats that the player was expected to play (Figure 11). In cyan color are the ones that where considered correct and in orange color the ones that didn't comply with the requirements of the played beat being similar to the expected one.

The game mechanics related to learning [22] that this game uses are visual. In relation to the learning activity, the player is memorizing concepts, such as rhythm patterns, and in order



Fig. 11.  Result panel

for this to happen, examples are shown in audiovisual form so that the requested pattern is fully understood by the player. The player is represented by an avatar and the rules and process of the game are explained through bubbles of text. The player receives audiovisual feedback regarding what was right and what was different than the expected motif in each attempt and positive scoring is earned each time, as the levels of the game progress.

## VIII. Pilot Evaluation

A pilot evaluation of the game has been conducted using two types of questionnaires, one targeting children of 8-12 years old and the other targeging expert educators. The aim was to see whether the game is understood by the players and whether it promotes collaboration and communication among children of varied abilities. The overall goal of the pilot evaluation was to gather feedback aiming to improve the overall look and functionality of the game. For this purpose, an open-ended, qualitative analysis was used. For this evaluation, four children and four educators were selected. There were three male and one female child. Two of the children were diagnosed with ADHD. All of them were 8-12 years old. Two of the participating educators were specialized in special education.

### A. Evaluation metrics

Both questionnaires used were specifically developed for this research, mostly based on the think-aloud method and recording of actions and reactions while playing or guiding a child to play the game. The questions are divided in four parts for both children and expert educators. The first part refers to the first impression, the second to the experience of the player/educator while playing the game, the third dealt with the difficulties faced when playing and the fourth was related to the general impressions from the game after completing it. The questionnaires were filled out by the researcher running the evaluation for both children and expert educators.

*1) Children's questionnaires:* In relation to the question-naire recording children's reactions to the game, at the begin-ning, the questionnaire asks for some demographic elements to be recorded. Such demographics are the sample number, the date that the questionnaire was filled out, the year of the player's birth, the gender, whether there is a diagnosis of ADHD, whether there is adequate knowledge of the English language and pre-existing knowledge of music. The data collected is stored anonymously.

The first part of the questionnaire refers to initial impres-sions at first encounter with the game's environment and the main character. This part also captures whether there was need for further instructions when navigating the environment. In the second part of the questionnaire, the players' experience

is described. The questions record the degree of reported difficulty by the player and the level that the player has reached. Questions about whether further guidance is needed for the player to proceed through the levels are also included.The third and fourth part record difficulties faced and the general impression of the player after playing the game.

*2) Educators' questionnaires:* In relation to the educator's questionnaires, the demographic elements recorded are the sample number, the date that the questionnaire was filled out and whether the expert educator was a special education teacher or not. Demographic elements are significantly fewer than the children's questionnaire because gender, age and musical and English language knowledge are of less significance when referring to adults. These questionnaires, similarly to the children's questionnaire, are divided into four parts.

The first part refers to the educators' first impressions. The opinion of the educators is requested before playing the game regarding the environment of the game. Additionally educators are asked if they think a child with ADHD would be attracted to the "ADDventurous Rhythmical Planet", and if that game could, based on their experience, promote collaboration. After the educators played the game, their opinion concerning improvements and the level of difficulty of the game are recorded. In the third part, the educators put forward an informed opinion on the difficulties that might be faced by the children during the game and if the multi-player part of the game would promote collaboration. Finally, the educators record their general impressions of the game and potential improvements.

### B. Results

*1) Children's Questionnaires Results:* Children liked playing the game which evidently promoted team spirit. The environment was colourful and generally quite attractive for them. They liked the fact that the game was placed in space and they adored the bouncing effect of the main hero. The degree of difficulty was judged to be manageable.

The majority of players completed five levels of the game's single-user mode, except from one player who only reached level three due to technical difficulties. Those who where given the opportunity to play the multi-user mode completed all five levels of this mode too. The main difficulties that appeared were related to the pauses of the requested rhythms. Finally, children reported they were really excited to play the game and they particularly enjoyed the multi-user mode. All children involved wished to share the game with a friend as part of a joint activity and not as part of a competitive process. Playing this game was a pleasant experience for the children. The game was particularly engaging for children of the target age range, 8-12 years old, as there were no drop out players, meaning that no child got tired or bored and stopped playing.

Two out of the four children involved in this pilot evaluation had been diagnosed with ADHD and their reaction should be noted. Both of them were fascinated by the environment and the process of the game and it was apparent that, at the beginning, they seemed quite impatient. They waited for the researchers instructions and they complied easily to the rules and tasks of the game. As it wasn't possible for neither of them to play the multi-user mode with a peer, the researcher volunteered and played the multi-user mode with them. The first child playing the multi-user mode with the researcher got deeply engaged with the game and excited about the rewards in the suitcase, staying focused for twenty minutes straight. The second child diagnosed with ADHD played up to the third level of the single-user mode due to lack of time. In summary, the experience was joyful demonstrating that a child with ADHD would be excited enough to play this game staying engaged for as long as it takes to finish it.

*2) Educators' Questionnaires Results:* Educators were particularly positive about the game. During their first contact with the game, they found the environment interesting and engaging and expected that children with ADHD would also be attracted to it due to the interesting space theme and colorful planet scheme used. On top of that, they anticipated that this game could promote collaboration since it is asking children to collaboratively create a rhythm and that would appeal to children's playful attitude. The difficulty of the game was deemed of medium level by the educators. The suggestions they made about possible improvements were centred on translating the menu from English to Greek (all participants were Greeks), offer players the opportunity to select the sound of their drum and also have more instructional pop ups so that the children need no further instructions by the researcher monitoring their activity.

Educators assumed that the main difficulties the children would face would be the language and the pauses that the rhythm requests. Educators believed that the game would promote collaboration because it motivates the players to cooperate in order to progress further down the gameplay. Collaborating would be the only way to complete the game. The way the game is structured could also help children learn how to wait for their turn. Lastly, the educators expressed their enthusiasm for the game and their willingness to use it with children with ADHD individually and as a part of the learning process in a classroom. They unanimously considered the environment to be impressive, engaging and appropriate for the target group.

### IX. Conclusion & Future Work

#### A. Conclusion

The proliferation of serious games with numerous applications in education creates new opportunities to develop extremely helpful tools and introduce playfulness into all forms of learning. The work reported in this paper explores their applicability for children diagnosed with ADHD. Their number is rapidly rising, thus, there is an urgent need to address effectively the difficulties they are facing. These difficulties could be managed if given the required attention and care in order to help these children become fully functional and accepted by their peers.

The "ADDventurous Rhythmical Planet" game presented in this paper seems to enable children to improve their social

skills and learn to cooperate with other children. It can be used by typical children as well, but it mainly focuses on children diagnosed with ADHD, since they appear to face more often social discrimination and loneliness. This game uses rhythm as the main tool to achieve that, as rhythm and music are inherent and natural forms of expression, which is one of this game's main innovations. From the current research, it appears that there is a limited amount of serious games aiming to help children with ADHD so far, and that the introduction of rhythm in a visual game has the potential to effectively address those children's needs. The "ADDventurous Rhythmical Planet" is the first game that aims to improve the psychosocial challenges faced by children diagnosed with ADHD using rhythm by engaging children in playful activities during which they are asked to reproduce certain rhythmic patterns.

The game presented in this paper uses a story, a playful main character and an engaging environment, attracting the player to the game. The player gets introduced to the gameplay while logging data and choosing a desired game level. The player starts in single-user mode and becomes familiar with the functionality of the game and the main tools such as the presentation of the rhythmic patterns, the tin drum and the bracelet. The player gets rewards, as the game advances so that it is easier to stay focused.

When the single-user mode is completed, the player selects another player to collaborate with, and moves on to the multi-user mode. While in this mode, the participating players cooperate and each one waits for their individual turn to play. At each game level completion, new rewards are received. The two players collaborate to reproduce certain rhythmic patterns in an interactive way. This succession of interactive playing helps a child diagnosed with ADHD to learn not to interrupt peers and wait for its turn. Additionally, it gives the opportunity to the two players to communicate and help each other to correct their mistakes. Furthermore, these characteristics of the game also seem to result in enhancing the mood for participation and interaction.

During the first pilot testing with educators and children both typical and diagnosed with ADHD, the results demonstrate that the "ADDventurous Rhythmical Planet" keeps players engaged and bolsters collaboration. The children were excited to play and the educators were particularly interested in applying this serious game to a larger sample group or even in classroom activities. Since the game fascinated the players and educators, it could be expanded with a range of varied game levels.

*B. Future Work*

Following the results of the first pilot testing that validated the usefulness of the "ADDventurous Rhythmical Planet" game, future work will address a number of issues and features that may provide an enhanced learning experience to children with ADHD.

- More clear instructions could be administered and the menu of the game could become available in a wide range of languages.

- Animation and visual effects could be added to the game, such as movement of the player and the craters at critical moments.
- Customization of the game could be available mainly regarding the difficulty of the motifs and speed of beats.
- A wireless implementation for the connection of the game to an actual drum would be desirable and intuitive for the players.
- Extensive evaluation of the game where multiple groups of children will be involved especially in multi-user mode and psychosocial evaluation will take place under the responsibility of special education teachers. The Strengths and Difficulties Questionnaire (SDQ) [23] will be used for this purpose. SDQ is a brief behavioural screening questionnaire for children 3-16 years old. It exists in several versions to meet the needs of researchers, clinicians and educationalists.

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