Combining Music and Puzzles to Promote Communication Between Children with ACS and their Typically Developing Peers

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Abstract

Children with Autistic Spectre Condition (ASC) face a great number of challenges in school, many connected to problems with social interactions and communication. When interviewing teachers of a school attended by a large number of children with autism along with typically developing children, one of the common problems mentioned was starting and maintaining social interactions between these two groups. The goal of this project was to create a tablet game that can serve as an ice-breaking tool and promotes communication between the two groups by using areas of shared interest, specifically puzzles and music.

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Chapter 1

Introduction

Children with Autistic Spectrum Condition (ASC) face a great number of challenges in school due to problems with social interactions [Bellini et al., 2007]. A small study, involving semi-structured interviews with teachers, was conducted by the researcher in a school attended by a large number of children with autism along with typically developing children(§3). One of the main problems mentioned by the teachers in the interviews was the lack of communication between typically developing children and children with ASC. Since technology seems to be appealing to children with autism [Goldsmith and LeBlanc, 2004], a technology-based approach was chosen, specifically a tablet game, to try and increase the amount of communication between the two groups. The reasons for choosing a tablet game are discussed in section §2.6

The research on communication (section §2.3) suggests that a suitable approach to promoting communication between typically developing children and children with ASC is to make sure that the activity, in this case the game, is appealing to both groups, and that both groups are necessary to progress. Therefore, categories that appeal to both groups , while also promoting communication, were studied. After reviewing the data from the teacher interviews, two promising topics, music and puzzles were selected. These two topics were then researched in greater depth in chapter §2.

There have been multiple puzzle games created in order to try and improve communication (discussed in section §2.5), as well as different types of music interventions (discussed in section §2.4), but there is little research into combining these two elements together.

Therefore the aim for this research was to create a game for tablet, aimed at children between 8 and 10 years, that combines elements of puzzles and music, in order to study whether it has positive effect on communication between users .

1.1 Research Objectives

The following questions are addressed in this research project :

1. Are puzzles and music valid choices of shared interest categories ?
2. Is a game that combines puzzles and music appealing to children in the target age group of 8 to 10 years ?
3. Does the game promote communication between players ?

1.2 Dissertation Structure

The remainder of the dissertation is structured into nine chapters:

- Chapter 2 presents the literature on the main topics mentioned in the introduction, specifically music, puzzles, technology and Autistic Spectrum Condition, with focus on communication. It also contains an overview of the terms used, and describes the methodology used throughout the research.
- Chapter 3 describes the pre-design phase of the research, reporting on the semi structured-interviews study that helped with choosing a direction for the research.
- Chapter 4 presents the principles and requirements that were followed during the design of the game. It also contains an overview of the design and justification of the initial low-fidelity prototype.
- Chapter 5 presents a study that was conducted in order to inform and improve the design, using a workshop with typically developing children. The results and changes made based on them are also included.
- Chapter 6 explains which tools were used in developing the game and why they were chosen. This chapter also contains a description of the high-fidelity prototype.
- Chapter 7 contains a report of a study with experts, and the redesign of the game based on the results of the study.
- Chapter 8 contains reports on evaluation studies conducted with both children and experts, as well as a discussion of the results and changes undertaken based on the results.
- Chapter 9 discusses the results in relation to the goals of the research, and potential future work to be done.

Chapter 2

Literature Review

2.1 Overview

In this chapter, the research on ASC, music, puzzles and technology is reviewed. The methodology and terminology used in this project is also reviewed.

2.2 Autism Spectrum Condition

Autism spectrum condition (ASC) is an umbrella term covering a wide range of pervasive developmental conditions, such as autism and Asperger's syndrome [Levy et al., 2009, Bryson, 1996] that are characterized by difficulties in:

- socialization, for example few or no friendships or absence of seeking to share enjoyment and interests with others;
- communication, for example impairment in expressive language and conversation;
- behaviour such as preoccupation with stereotyped or restricted interests or topics.

There is great variety in the severity, type and frequency of symptoms, from very light symptoms that do not really interfere with normal life to very severe symptoms that can lead to a lack of key skills such as language [Rogers et al., 2006, Bartoli et al., 2014]. Some of the more severe symptoms are quite widespread in the population with ASC. Research estimates that between one third [Bryson, 1996] and one half [Tager-Flusberg et al., 2005] of people diagnosed with autism have no speech. Children with autism are often less comfortable with positive affect exchanges like smiling and laughing [Kim et al., 2009]. They also have have behavioural problems such as being restless, having jerking motions or fidgeting [See, 2012] or have difficulty understanding accepted social conventions, reading facial expressions, interpreting body language, and other social interactions [Piper et al., 2006]. Another very frequent symptom of ASC is a

strong preference for repetition and sameness [Association, 1994]. Since people with ASC can exhibit so many diverse behavioural characteristics, individuals with ASC may appear very different based on what symptoms and to what degree of severity they exhibit [Koegel et al., 1994].

These conditions are much more prevalent in males than females [Christensen, 2016]. Some researchers report that as many as four times more males suffer from some form of ASC, compared to females [Ehlers et al., 1995]. One possible reason for this discrepancy is that the typical differences in brain structure due to sex may be related to ASC. These changes may be caused, among other things, by the biological effects of fetal testosterone [Baron-Cohen et al., 2011]. While the direct cause of ASC is still unknown, significant progress has been done [Tager-Flusberg et al., 2001], and it seems that the appearance of these conditions is highly genetic [Levy et al., 2009].

There has been an increase in the number of children diagnosed with some form of ASC for a long time. Research carried out by [Gillberg et al., 1991] showed an increase from 4 in 10 000 to 11.6 in 10 000 over a period of 8 years (1980-1988). This trend seems to continue, with around 60 out of 10 000 being diagnosed in 2009 [Battocchi et al., 2009, Levy et al., 2009] and around 90 out of 10 000 in 2012 [Harrold et al., 2012].However, this may be due to an increase in screening, vigilance at younger age, and improvements in diagnostic techniques that can lead reclassification of children from a different category to autism [Shattuck, 2006]. This is indirectly supported by Gillberg, since in his research [Gillberg et al., 1991], the number of people with "autism" diagnosis remained the same, and only the number of people with "ASC condition other than autism" increased. The new and improved diagnostic techniques include the Autism Diagnostic Interview (ADI) [Le Couteur et al., 1989] and Autism Diagnostic Observation Schedule(ADOS) [DiLavore et al., 1995], that is specifically aimed at children under the age of six. Both of these techniques have been further refined over the years, with ADI being reorganized and shortened, creating a new ADI-Revised (ADI-R) that uses a new algorithm score [Lord et al., 1994].

2.3 Autism Spectrum Condition and Communication

Difficulties with social development and problems with social relationships have been among the main defining characteristics of autism since the 1980s [Schopler and Mesibov, 1986]. Due to their handicapping nature, improving social skills of people with ASC has long been considered one of the most important intervention outcomes [Rogers, 2000]. Among the different social skills, communication is one of the most often affected. More recent research suggests that some degree of communication impairment appears across the whole spectrum of autistic disorder [Tager-Flusberg et al., 2001].

However, further research into communication difficulties is made harder by the fact that it is very difficult to quantify social communication. This is due to the fact that it depends on many variables, such as social partner, and context [Charman and Stone, 2008]. Some of the formal processes that can be used to gather relatively accurate data are the Early Social Communication Scale (ESCS) [Mundy et al., 1996] and Commu-

nication and Symbolic Behaviour Scales (CSBS) [Wetherby and Prizant, 2002]. The ESCS is a videotaped structured observation measure, aimed at children between 8 and 30 months of age. The CSBS uses parent interviews and direct observations during natural play, aimed at children between 6 and 24 months.

The aim of this research is to improve the communication between typically developing children and children with ASC, through playing together. Research on this subject shows that the amount of reciprocal interaction can double when contextual support is added to normal play dates [Koegel et al., 2005]. Contextual support in the experiment by Koegel consisted of two parts. First part is that the activity is mutually reinforcing for both the typically developing child and the child with ASC, which means that the interest of both are taken into account when planning the activity. The second part is setting up cooperative arrangements in the activity, which means making sure that participation of both children in the activity is essential. Some design decisions in §4 were influenced by this study, even though its sample size was quite small (only 2 children). However, previous research by Koegel et al., conducted with a larger subject sample, shows that there is a strong correlation between child-preferred activity and social avoidance behaviour [Koegel et al., 1987]. This supports the results of his more recent work. The study conducted by Baker et al. shows similar results, with activities that are mutually reinforcing for both the typically developing children and children with ASC showing greater positive effect on peer interactions between the two groups [Baker et al., 1998].

2.4 Music

There has been an increase in the use of different kinds of music therapy to help people with ASC deal with a wide range of symptoms over the last 30 years, and a lot of research has been done to test how effective it is. So far, most of the research supports the notion that music therapy is beneficial. Some researchers even suggest that all music interventions, regardless of purpose or implementation, were effective in helping children with autism [Whipple, 2004]. This is a very positive result, and so it was decided that music will be used in this project to increase the positive effects of the final game on social interactions.

There is significant evidence supporting value of music therapy in helping with many of the social, emotional and behavioural issues that children with ASC might have [Kim et al., 2009]. Of special interest to this project is the fact that therapies including music seem to improve verbal communicative skills and generalised social interaction both inside and outside of therapy [Geretsegger et al., 2014]. There is also evidence that therapy with a music element is more effective than therapy without a music element [See, 2012]. Reserarch by Gold et al. further supports the findings by See and Geretsegger et al., since in his research the music therapy sessions showed more positive impact on communication compared to ”placebo” therapy sessions [Gold et al., 2006]. Although use in a game is not an actual form of music therapy, the research shows that inclusion of a music element can have a positive effect when used by people with ASC.

All of this research supports the decision to make music a major focus of the research presented in this dissertation.especially since it seems that in general, people with ASC seem to respond well to music, and it helps them socialize and communicate more easily as well as help with some of the behavioural problems. One way that it can help is that music, and especially familiar melodies seem to be able to calm children with ASC down and make them more comfortable in stressful situations [See, 2012], such as when dealing with large group of people at school.

The main goal of the research discussed in this dissertation is to improve socialization in school setting between typically developing children and children with ASC, so music is a natural fit for this. The reason why music has all these positive effects might be partly do to with the fact that people with and without ACS seem to have almost the same basic psychological reaction to music [Allen et al., 2013]. Music can be used to help children with and without ASC bridge their differences, and to help them interact together more. It is also used as one of the common interests to leverage the benefits of contextual support, mentioned in the previous section §2.3 used in the research by [Koegel et al., 2005]. One of the main inspirations for this research was an evaluation study of different tablet apps in the Open Autism Software suit by [Hourcade et al., 2013]. This study showed that of all the apps that were evaluated, the music app and the puzzle app had the biggest positive effect on social interactions from the whole suite, especially in terms of supportive comments, as well as in general verbal interactions.

2.5 Puzzles and Games

Following the results of the research by [Hourcade et al., 2013], which suggested a positive effect of puzzle games, it was decided consider the relationship between puzzles and children with ASC.

Puzzles and games have been a part of many therapies used to help children with ASC improve their social and communication skills due to their collaborative nature, and their ability to engage children. They can also be used in classrooms by teachers to help children learn essential skills like interacting with each other and taking turns that might not come naturally to children with ASC. An example of this is a study by [Piper et al., 2006], where they built a multiplayer tabletop puzzle game, and tested it on middle school students with different kinds of ASC conditions. The results showed higher levels of engagement and team cooperation, compared to playing normal board games, an increase in positive language use, as well as decrease in aggressive group behaviour. Another study, by Brok and Barakova, filmed children with different types of Autistic conditions playing with interactive blocks. This study showed that playing and completing a collaborative block puzzle can help children move from solitary independent play and parallel activity (See section§2.8) when they do not interact with others to associative and collaborative play (See section§2.8) where they do interact [Brok and Barakova, 2010]. These findings support the original findings by [Hourcade et al., 2013] that puzzle games are indeed a good way to get children with ASC interested in an activity and getting them to interact with others. This is further supported by

the findings of the study by [Giusti et al., 2011] where, from a suite of apps tested on multiple classes of children with ASC, the puzzle app was found to be the the most engaging, in comparison to the other ones that were more action oriented.

Battocchi et al. tried using an app for a touch enabled device which was inspired by classical jigsaw puzzles to foster collaboration in children with ASC. They developed a two player jigsaw puzzle that was played on a single screen, and included some system enforced rules to support cooperation and tested it on school children with ASC. The results of this study showed that jigsaws can also in some situations, like when enforced collaboration rules are used, become tools that has a positive effect on collaboration and negotiation [Battocchi et al., 2009]. These findings are similar to those of Bulmer and Dew, who conducted a study where participants concurrently worked on a variety of jigsaw puzzles. Their findings showed that when participants put in collaborative effort during playing with the jigsaw, it can lead to an increase in communication between participants [Bulmer and Dew, 2002].

Puzzles seem especially suited as tools, since many individuals with ASC describe interest in visual games such as puzzles and are more comfortable playing with them, possibly due to the fact that since the interactions with the system are more structured and controlled than real world ones [Piper et al., 2006]. It also seems that some children find the intellectual challenge of a puzzle more engaging than more action oriented games [Giusti et al., 2011]. There seems to be overlap between effects of using music that were described in the previous section (§2.4) and the effects of using puzzles and jigsaws. However, there does not seem to be any research on using music and puzzles together in a single application. Therefore, this dissertation aims to research the effects of a game that uses both music and puzzle elements together with the goal of obtaining an amplified positive effect on the communication between children with ASC and their typically developing peers.

2.6 Technology

There is still some scepticism among teachers about using technology such as computers in school since they believe that it can lead to social isolation [Ishigaki et al., 1996]. However, further research shows that when used the right way, technology can have a large and positive impact and even increase social interaction between children [Clements and Sarama, 2003]. A more recent meta-analysis of studies on Computer-Assisted Instruction (CAI) for children with disabilities supports the theory that technology can have a positive effect [Weng et al., 2014]. Another study, targeted specifically at children with ASC, has produced similar results, but with emphasis on the fact that the technology used should be specifically designed for target population [Ploog et al., 2013]. This includes being able to personalise the experience to make it suitable to a wide range of possible users with different severity and type of conditions [Hayes et al., 2010].

This is especially important since research shows that children with ASC respond well to technology and that they find computerized games appealing [Goldsmith and

LeBlanc, 2004]. Since social interactions in the real world are often difficult for them, children with ASC find the much more structured interactions with computers and robotic toys comforting, because they do not have to worry about social conventions [Piper et al., 2006, Brok and Barakova, 2010]. Children with ASC usually prefer clear rules and "sameness" [Association, 1994], which is often present in computer games. However, there is also evidence that in some cases, small amount of unexpected change or surprise can also have positive effects on communication [Alcorn et al., 2013].

The research suggests that there are advantages to using touch screen devices as opposed to a mouse when considering interface use. Using mouse requires mapping from the screen space to the desk space, as well as clicking and holding buttons to perform actions, which allows for more errors to occur and takes more time [Lu and Frye, 1992]. This is also supported by multiple researchers, who say that since childrens fine motor skills are not yet fully developed, a touchscreen is preferable to mouse and keyboard [Chiasson and Gutwin, 2005, Shah, 2011]. Also, children seem to enjoy using touchscreens more than keyboard and mouse [Herbert, 2010].

When it comes to display position, the spatial orientation has a role in structuring the activity of the users [Tang, 1991]. Specifically, orientation is critical in how users comprehend information, how they coordinate their actions, and how they mediate communication [Kruger et al., 2004]. Vertical displays such as tablets seem especially well suited for the study and improvement of social skills, compared to horizontal displays [Battocchi et al., 2009]. Vertical displays are also supported by other research which shows that horizontal displays can lead to problems with one person being considered "in charge, which makes cooperation harder [Ståhl et al., 2002]. Face-to-Face interaction which is promoted by vertical displays also supports more communication and participation than Shoulder-to-Shoulder interaction promoted by horizontal displays [Rogers and Lindley, 2004].

Using technology also allows the use of computer-enforced rules, such as voting buttons that require all users to participate in the decision-making process. These rules can be used to steer users in the right direction, to avoid one individual taking control of the whole group, or to set up a cooperative agreement, mentioned in section §2.3. When used they can have positive effect on collaboration and encourage cooperative work by forcing the users to reach a consensus without bothering the users [Battocchi et al., 2009, Piper et al., 2006], since constraints that are part of the game structure are much likely to be accepted by children with ASC compared to constraints imposed by people [Giusti et al., 2011].

2.7 Methodology

There are a number of concerns specific to creating software that need to be taken into account when using general methodologies. Therefore, the methodology adopted in this research was inspired by the work of Scaife and Rogers that focuses on design of virtual environments that support various learning activities [Scaife and Rogers, 2001].

This methodology adopts some features of the Participatory design (PD). Participatory design is an approach to design in which the end user plays a critical role in designing the product that he will be using [Schuler and Namioka, 1993]. The influence of PD can be see in the use of ”informants” to inform and develop the design of the product. In this research, the informants were typically developing children, serving as proxies for children with ASC, and experts from different fields related to this research. They were asked for input at multiple stages of the research. Some of the activities during the design workshop in the design stage were also influenced by the Cooperative Inquiry (CI) techniques proposed by researchers in [Druin, 1999, Guha et al., 2013].

1. **Preliminary Stage**
   In this stage the aim was to answer the central question: what are we building and why. The researcher's experience of dealing with children with ASC as well as an interview with teachers that teach children with ASC was used to answer these questions, and to come up with the basic game idea. The problem that is targeted by this project, as well as possible improvements from this project were determined in this stage.

2. **Design and prototyping stage**
   At the beginning of this stage, an initial low-fidelity prototype was created by the researcher, based on the reviewed literature connected with the main parts of the project such as music and puzzles and data from the preliminary stage. This was done in order to make it easier for the design informants to comment and make changes to the design. Design principles and initial requirements were also decided in this stage.

3. **Informing the design stage**
   A number of design workshop sessions using CI-inspired activities were run in this stage. The design from stage 2 was used in these workshops, with the aim of informing and improving the design. Another aim of the session was to evaluate usability of the design for the target users. A list of design changes and improvements was generated. The improved design was then evaluated by an expert to gather additional feedback.

4. **Implementation Stage**
   At the beginning of this stage, a high-fidelity prototype was implemented, following the revised design from the previous stage. This prototype was then used in multiple interviews with experts from different fields, in order to gather more data on how well it functions and how it can be further improved. This data was then analysed and used to redesign the prototype. The prototype was then rebuilt into a more advanced, improved version.

5. **Evaluation Stage**
   A number of evaluation sessions with both experts and children were run in this stage in order to evaluate the game from different perspectives

2.8 Terms

- **Solitary independent play**
  The child plays on its own, independently from other children.
- **Parallel activity**
  The child is situated among other children and plays with toys that are like those which the other children are using, but does not try to influence/modify the activity of the nearby children.
- **Associative play**
  The child plays with other children. There is a greater level of awareness of peers and there is a borrowing and loaning of play material. There is an evident inter-action, for instance following one another with trains or wagons.
- **Collaborative play**
  Similar to associative play, but there is clear exchange of play objects.
- **Intervention**
  In medicine, a treatment or action taken to prevent or treat disease, or improve health in other ways.

Chapter 3

Preliminary Stage Interviews

3.1 Overview

This chapter reports an interview with experts which was conducted in order to gather more information about the specific problems that potential target users run into in the real world, as well as to get to better understand the target population who were the focus of this research.

3.2 Aims

The aim of these interviews was to gather information from teachers that work with mixed classes of both typically developing children and children with ASC. The main focus was on how children with ASC coped with attending class alongside typically developing children, and the interactions between these two groups.

3.3 Participants

The participants were three Gymnasium (similar to UK secondary school) teachers from Prague, who have taught mixed classes of typically developing children and children with ASC, for more than 4 years.

3.4 Settings

The interviews took place in the staff room of a Gymnasium in Prague, Czech Republic, during a lunch break of a normal weekday. They were conducted by the researcher.

3.5 Materials

Only pens and paper were used during the interviews.

3.6 Procedure

After explaining the goals and motivations behind the unstructured interview, the participants were individually taken aside and interviewed. These interviews were unstructured, but some questions were given to all participants, while others were changed and influenced by the responses to previous parts of the interviews. The individual interviews took between 15 to 20 minutes and were recorded on paper by the interviewer. There were no recordings taken. Before the start of each interview, the participants were asked whether they consent to the researcher taking taking notes. The participants were then informed that findings from the interviews might be published. At the end of the last interview, participants were asked if they have any questions and thanked for their participation by the researcher.

3.7 Questions Asked

Since the interviews were mostly unstructured, the questions asked varied from participant to participant. However, all participants were asked questions concerned with what they thought about the interactions between typically developing children and children with ASC in their classes and the attitude of children with ASC towards technology. These were used as base question that influenced the rest of the interview. The rest of the questions usually expanded on responses to the base questions received from the particular participant.

3.8 Analysis

The general consensus from all participants was that there was not enough interaction between the typically developing children and children with ASC. The two groups apparently coexist in the class with very little interaction between them. It also seems that children with ASC are very sensitive to changes in the ways that class is taught, which limits the ways teachers can experiment with ways to try and increase the amount of communication between the two groups. However there was evidence that both groups share interest in technology, especially games. While some children with ASC apparently have problems using mouse and keyboard, they have no problem using touch-based devices. It seems that tablets and computer games are actually one of the main objects of shared interest and serve as a basis for a lot of the interaction that takes place, as well as topic for communication. Playing computer games together can therefore be considered a mutually reinforcing activity, as described in section §2.3. Another topic

of common interest was music, and one participant mentioned that from all classes, the most positive interactions by far happened during music classes. All participants agreed that a game which is easy to use and involves more than one player might help to increase the amount of interaction between the two groups by giving them more topics and activities in common.

3.9 Summary

In this chapter, an interview with three experts was conducted. Their area of expertise is teaching mixed classes of children with ASC and typically developing children. The main findings from the data collected were:

- There is very little communication between children with ASC and their typically developing peers.
- Both groups share interest in music and technology, especially computer games.
- Some children with ASC have problems using mouse and keyboard.

Chapter 4

Design

4.1 Overview

This chapter describes the design and HCI principles followed during the design of the game, as well as the design requirements. The initial design for the low-fidelity prototype is also described and discussed.

4.2 Design Principles

The design principles used in this project are informed by the research by Chiasson and Gutwin who have collected and analysed a wide range of research about designing technology for children. They came up with general principles for designing for children [Chiasson and Gutwin, 2005], some of which are relevant to this project. To find which are relevant to this project, information from the paper by Bartoli et al. about design guidelines is also used [Bartoli et al., 2014]. Their research is focused on touchless interactions, which makes parts of his research unusable for this project, but some of the findings can be applied to all software aimed at children with ASC, which helps to understand which guidelines aimed at developing software for typically developing children can be also used to develop software for children with ASC. The findings from research by Shneiderman, who focuses on how to make interface more fun and enjoyable is also used [Shneiderman, 2004], since those are essential qualities for a good game.

- Principles supported by [Chiasson and Gutwin, 2005] are marked CG.
- Principles supported by [Bartoli et al., 2014] are marked B.
- Principles supported by [Shneiderman, 2004] are marked S.

The principles used are listed below:

1. *Interfaces should be strongly visual, avoiding text as much as possible and reducing cognitive load (CG,S,B).*

2. *Content specific metaphors are useful in helping children navigate interfaces (CG,S).*
   Both of these principles are relevant to this project since research shows that children with ASC are good at processing visual information, while text might give them trouble [Battocchi et al., 2009], and making it easier to navigate might make the experience less stressful. Also, since the project is aimed at young children, their literacy levels cannot be guaranteed.

3. *Children are impatient and need immediate feedback showing that their action have had some effect, otherwise they will repeat the action until some outcome is perceived (CG,S).*
   The final project should be highly interactive, which makes it more fun and enjoyable. Interactivity is also important to keep the attention and concentration of the user focused.

4. *Interfaces should provide scaffolding and guidance to help children remember how to accomplish tasks (CG,B).*
   Since the goal of this project is to create a puzzle game, making sure that the user does not get lost or demotivated is very important.The importance of scaffolding when designing for children with autism is also mentioned by [Kerr et al., 2002].

5. *Icons should be visually meaningful to children (CG,B).*
   This principle is tied to the first two, making sure that the game is easy to use, and gives as much information as possible visually.

6. *Children are accustomed to direct manipulation interfaces, their actions should map directly to the actions on the screen (CG).*
   This principle is directly supported by research by Lu and Frye on using touch screens. Their research supports the use of direct manipulation via touch compared to using indirect manipulation such as mouse and keyboard [Lu and Frye, 1992].

7. *Technologies should give children the ability to define their experiences and be in control of the interaction (CG,B).*

8. *Supportive reward structures that take into account childrens developmental level and context of use to help keep children engaged (CG,S,B).*
   Both of these guidelines are very important when designing for children with ASC, due to the large differences in their conditions. What can be rewarding for some can be unpleasant to others, so high level of customizability is very important [Bartoli et al., 2014].

4.3 Design Requirements

A set of design requirements was derived from the interviews in the pre-design chapter and the literature review, as well as the design and HCI principles. The aim of this project was to create a jigsaw-inspired puzzle game, where two children cooperate to put back together a melody that was split into pieces. It was aimed at children between

8 and 10 years, and should be playable with minimal adult supervision. This means that the game needs to be simple enough to be understood and played by children in that age range while still being engaging enough for them to keep playing. This also means that, the use of text should be minimized, to make it possible to play even with limited reading skills.

It will be played on a touchscreen device rather than a computer due to reasons explained in the Technology section §2.6 of the literature review. The fact that the target deployment is in school, where touchscreen devices are widely available also supported this decisions.

According to the principles, bright colours and animation should be used where possible. However, to make sure that it is flexible enough to be used with a wide variety of children with ASC, there have to be extensive customization options for both colour and animation. There should also be clear reactions to player actions, to make the game feel responsive and engaging. To make sure that both players have a say during the play, there are two voting buttons included in the design, which act as a type of system-enforced rule, similar to the ones found in studies by [Battocchi et al., 2009, Piper et al., 2006, Giusti et al., 2011]. These buttons also serves as a form of cooperative arrangement [Koegel et al., 2005].

To minimise confusion, all the main game elements such as the melody and parts of the melody should be large and easily recognised. Also, to make the game easier, a repeat button to play the whole melody and a play button to play the parts of the melody that are in place should be included.

Requirements are summarized as follows:

1. The game should be playable by children between 8-10 with minimal instructions from adults.
2. The use of text should be minimal throughout the game.
3. The game should run on a touchscreen tablet device.
4. Bright colours should be used where possible.
5. Animations should be used when interacting with the game.
6. All player actions should have a clear response in the game.
7. There should be an options to change the colours used in the game.
8. There should be an options to turn the animations on and off.
9. There should be a clear visual representation of the whole melody.
10. There should be a clear visual representation of the parts of the melody.
11. There should be a clear visual representation of the replay button.
12. There should be a clear visual representation of the play button.
13. There should be a clear visual representation of the voting button.

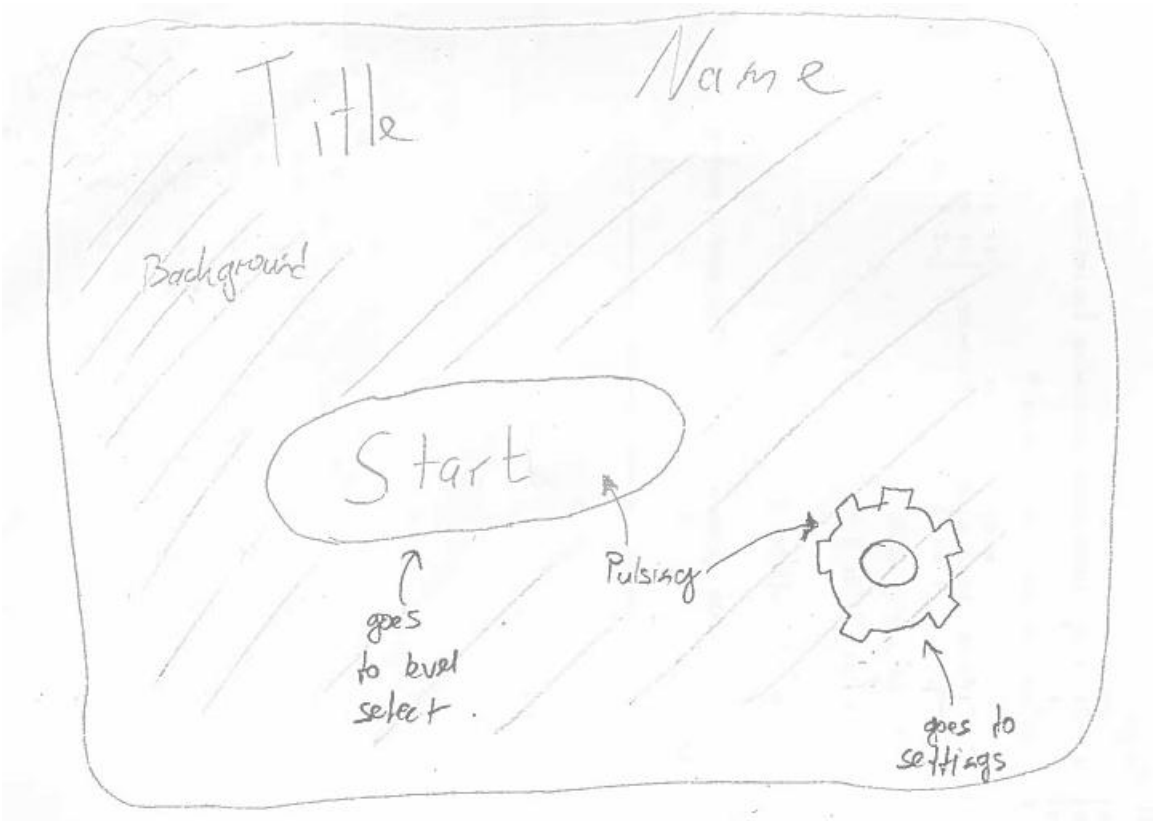

Figure 4.1: Title Screen Design

4.4 Application Structure

4.4.1 Title Screen

After clicking on the game icon, the user is taken to the title screen (figure §4.1. This screen includes the a start button and a settings button. The settings button is represented by a cogwheel icon, which was selected for its clear meaning, as it is commonly used to represent settings in a wide variety of applications. Both are clickable and animated. Both the buttons and the background are brightly coloured, and clicking on either of the buttons takes the user to the relevant screen.

4.4.2 Settings Screen

The settings screen (figure §4.2), accessed by clicking the cogwheel button on the title screen is where all the customization options are accessed. There is an animated picture of a cogwheel in the upper left corner, to make the screen more appealing, and options for selecting colour and turning animations on and off. The colour selection option shows the currently selected colour and, when clicked, brings up a sub-menu with all the available colours. The On/Off option for the animation is represented by a ✓for on and an X for off that are green and red, respectively. The currently selected

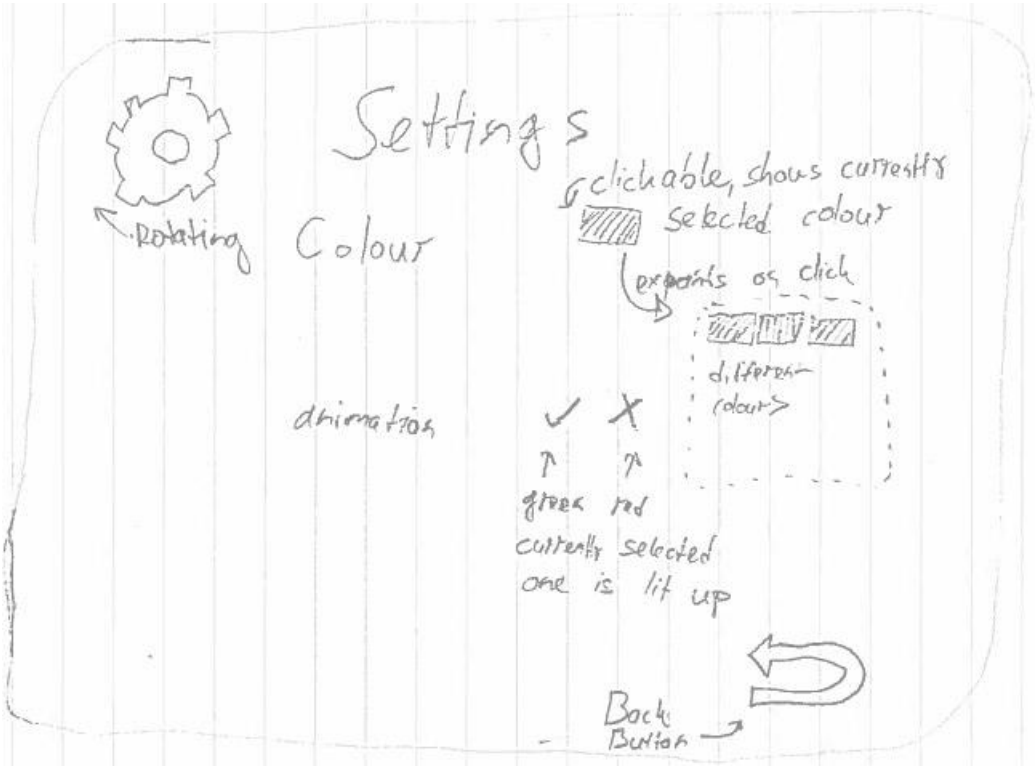

Figure 4.2: Settings Screen Design

option is lit up. There is also a back button in the bottom right corner, represented by an arrow icon. Again, the background is brightly coloured.

4.4.3 Level Select Screen

The level select screen (figure §4.3) is accessed by clicking the start button on the title screen. This is where the user selects which level he or she wants to play. Different levels will have different melodies that need to be put back together. The levels are represented by colourful buttons with numbers on them. Clicking on any of them takes the user into the game screen for that level. There is again a back button in the bottom left corner, which is the same as the back button in the settings screen.

4.4.4 Game Screen

The game screen is where the user will be spending most of his or her time with the app. The main game loop happens on this screen, and therefore it received most of the design time. The first prototype version, created by the researcher can be seen in figure §4.4. This prototype was used in a series of designed workshops with children, that were run with the goal of informing and improving the design. The whole melody is represented by a series of blocks in the middle of the screen. The blocky design was inspired by the design of the musical app from [Hourcade et al., 2013]. The blocks

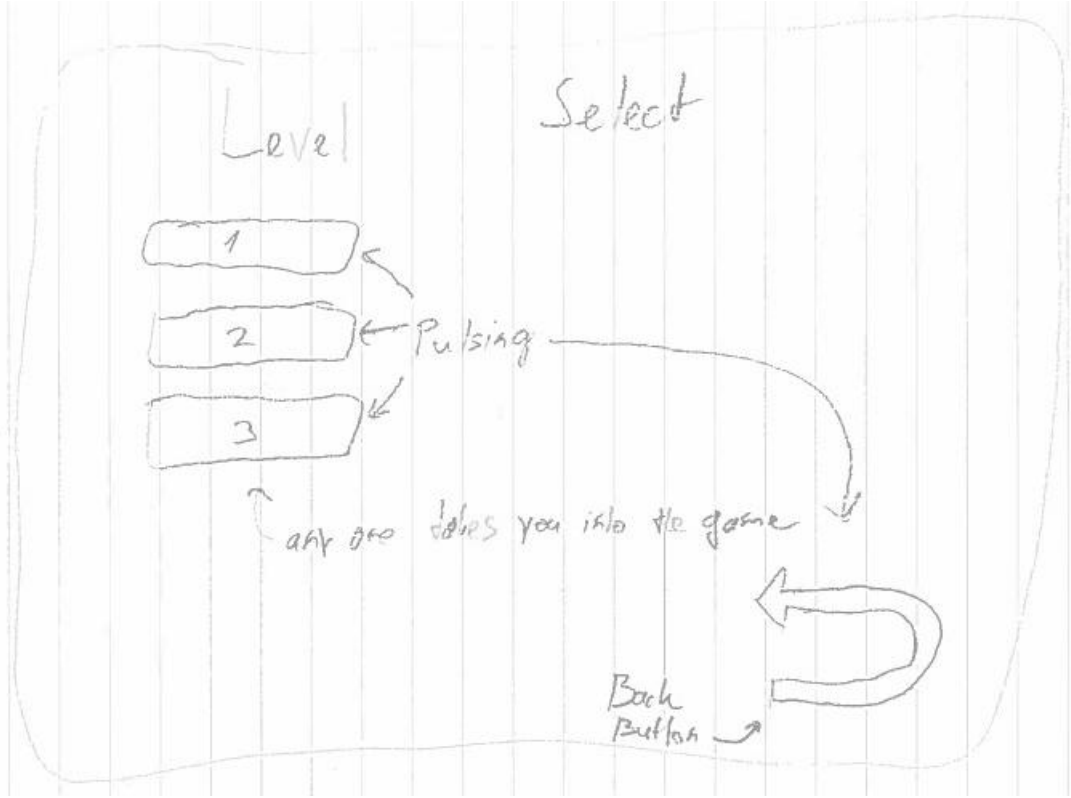

Figure 4.3: Level Select Screen Design

light up when a piece of melody, in this prototype represented as star, is inserted inside the block. The actual graphical representation of the melody parts was undecided at this point and was not be decided until after the design workshop (section §5.2). The different pieces of the melody will play their associated sound when tapped. There is the replay button on the left of the blocks, with a fully coloured music note symbol on it. On the right of the blocks, there is the play button with partly coloured music note symbol on it. On the top and bottom of the screen are the two voting buttons, one for each player, with a V on them. The parts of the melody can be moved around, and inserted or taken out of the melody blocks by simple dragging and dropping actions.When all slots are filled in, and both players agree on the final melody, the level is finished and the user is returned to the level select screen.

4.5 Design Justification

This section describes how the requirements from section §4.3 were fulfilled and how the design adheres to the principles from section §4.2.

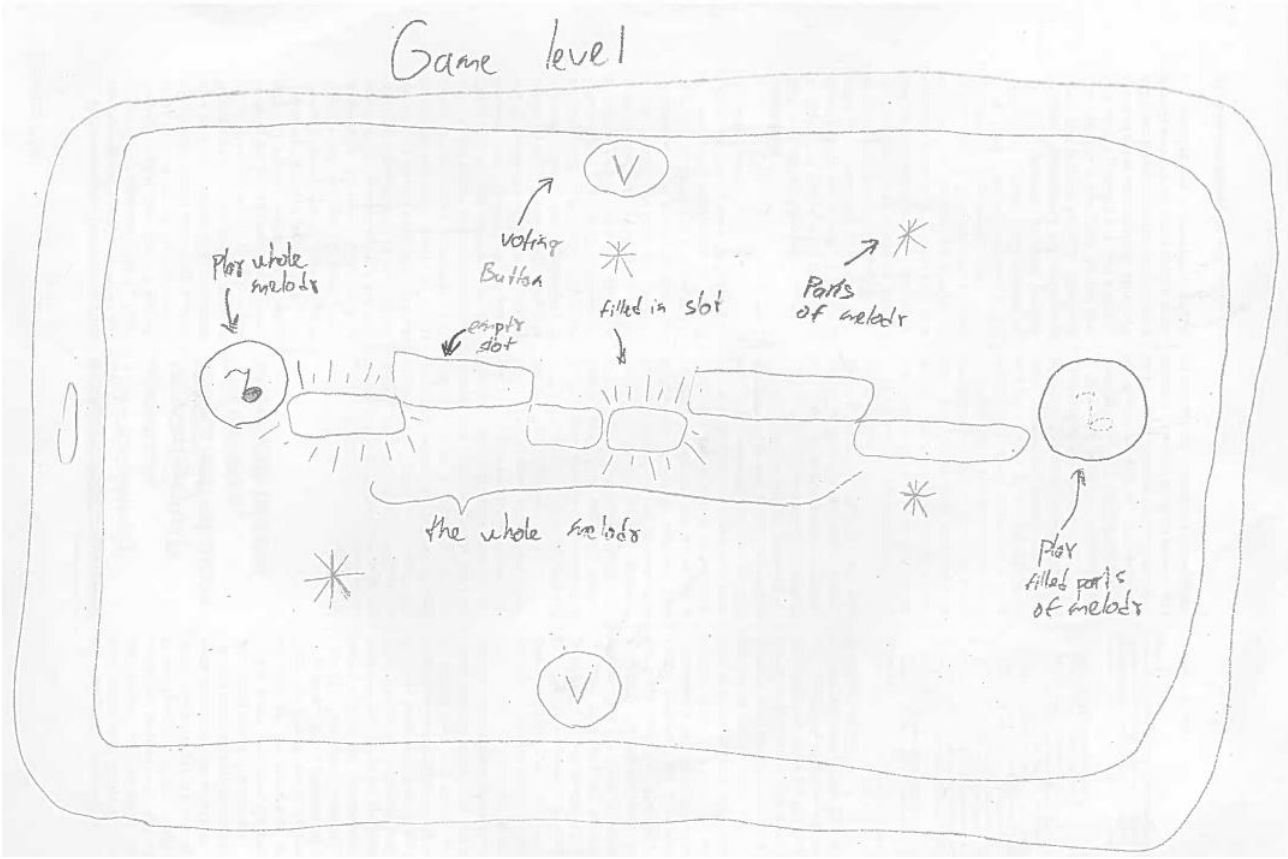

Figure 4.4: Game Screen Design

4.5.1 Requirements

All the design requirements from section §4.3, except 10 have been incorporated into the design. However, requirements 9,11 and 12 will be tested during a design workshop to make sure that the "clear part of the requirements is fulfilled with respect to target population. Requirement 10 will be incorporated into the design after the workshop, once the graphical representation of the parts of the melody has been decided.

4.5.2 Design Principles

DP 1: Interfaces should be strongly visual, avoiding text as much as possible and reducing cognitive load.
This principle is followed throughout the design, by bright colours for the buttons and backgrounds, and text is avoided by using icons instead of buttons with text where possible. When text is included, it is only in places where it does not affect the functionality of the game

DP 2: Content specific metaphors are useful in helping children navigate interfaces

DP 5: Icons should be visually meaningful to children
These two principles were followed during the creation of the back and settings buttons, by using large icons that use common metaphors that have similar meaning in a large variety of other applications that the end users might have used.

DP 3: Children are impatient and need immediate feedback showing that their action have had some effect, otherwise they will repeat the action until some outcome is perceived

DP 6: Children are accustomed to direct manipulation interfaces, their actions should map directly to the actions on the screen
The application is aimed at touchscreen devices that allow direct manipulation, and all actions that can be taken in the game have immediate graphical feedback, such as the the blocks that represent the melody lighting up when they are filled in with a piece of melody.

DP 4: Interfaces should provide scaffolding and guidance to help children remember how to accomplish tasks
Common metaphors are used for most of the buttons make them intuitive to use, and navigation button placement is consistent throughout the design. The replay button and the pieces of melody playing their associated sound when tapped are also included as types of guidance.

DP 7: technologies should give children the ability to define their experiences and be in control of the interaction
The settings screen allows different parts of the game experience, like colours to

be personally customized.The different levels also give more control to the user over the experience they will have with the game

DP 8: Supportive reward structures that take into account childrens developmental level and context of use to help keep children engaged.
Animations and bright colours are used throughout the game to keep the end users engaged.

4.6 HCI Principles

A number of Human-Computer Interaction (HCI) principles from [Dix et al., 2003] were also considered when justifying the design. The focus of [Shneiderman, 2004] on fun and enjoyment are similar to the Usability Goals in [Sharp et al., 2011], which are focusing on making the product easy to learn and effective and enjoyable to use by the user. Since that is the aim for the design of the game, the design was also justified in relation to these principles. They can be broken down into the criteria below:

1. **Effectiveness (how effective it is at what it does) :**
   The aim is to make the two users interact with one another. To achieve this, there are puzzle elements, as well as voting buttons that force interaction to complete the game.

2. **Efficiency (how efficient to use it is) :**
   There is no extra functionality or steps in the game, to make it as efficient as possible.

3. **Safety (is it protecting the user from undesirable situations and dangerous conditions) :**
   The game is designed to have very clear structure with immediate feedback and no irreversible action or dead-end states to make it safe.

4. **Utility (it it providing the user with the proper functionality for the task):**
   All goals in the game have clear steps that can be taken to achieve them.

5. **Learnability (how easy is the system to use):**
   This principle is similar to DP 1, 2 and 4. Consistent placement of large icons with clear metaphorical meanings as well as immediate feedback were used in the game design to make it easy to use.

6. **Memorability (how easy is the system to remember after learning how to use it):**
   This is again similar to DP 4. Simple to use design with minimal number of steps and easily recognisable buttons was used to make it memorable.

4.7 Summary

Multiple research papers on software design were compared and used in order to come up with design principles for the game. The design requirements and HCI principles were also described and discussed. The decisions during the creation of the low-fi prototype were justified against the principles and requirements, and the current state of the prototype was described.

Chapter 5

Informing the Design

5.1 Overview

In this chapter, the four session of the design workshop are reported. This workshop was conducted in order to inform and improve the design described in the previous chapter. Changes to the design from section §4.4 based on the data collected are also discussed.

5.2 Design Workshop

5.2.1 Aims

The main aims of this workshops were:

1. gather ideas for the graphical design of the game elements and additional features
2. find out the preferred control scheme
3. test how easy the design is to understand
4. test the type of music that will be used in the game

5.2.2 Participants

The target population, children with ASC was were not used as participants due to availability and ethical concerns. Instead, typically developing male and female children aged between 7 and 11 were used as participants, to act as proxies for children with ASC. In total, 15 participants took part across 4 sessions. Participants in sessions 1, 2 and 4 were children that were related to the Informatics staff, and most had previous experience with this type of activity. Participants in session 3 were members of a Brownies group.

Session	ID	Gender	Age
Session 1	Participant 1	Male	7
	Participant 2	Male	9
	Participant 3	Male	7
	Participant 4	Female	9
Session 2	Participant 5	Female	11
	Participant 6	Female	9
	Participant 7	Female	8
	Participant 8	Male	11
	Participant 9	Female	9
	Participant 10	Male	7
Session 3	Participant 11	Female	9
	Participant 12	Female	9
	Participant 13	Female	7
	Participant 14	Female	7
Session 4	Participant 15	Male	7

Table 5.1: Design workshop participants

5.2.3 Setting

Sessions 1, 2 and 4 took place in the Informatics Forum of University of Edinburgh, while session 3 took place in the Brownies club room.

5.2.4 Materials

The materials used for this study were: coloured pens and papers for the participants, pen and paper for the researcher, a Samsung smartphone used for audio recording, an Apple macbook used for playing music and consent forms for both parents (Appendix B) and participants (Appendix A). There were also participation certificates for the participants (sample certificate can be seen in Appendix D).

5.2.5 Procedure

On arrival, the consents sheets were collected from the parents or guardians of the participants. The participants were then walked through their information sheets and consent forms, and asked if they have any questions. They were also reminded that they can stop and leave at any time without giving a reason, and that the session will be audio recorded. The participants were then taken to a separate room (in case of session 3, they were taken to a corner of the room where the session took place), where the project and the workshop activities were explained to them. The first activity was a short discussion about what kind of music the participants liked. This was mainly to help them relax and get used to working with the researcher. However, data was still

collected to inform the choice of music that will be used in the game. In session 1 and 2, the participants were then asked to listen to a short clip of music by the researcher and asked for their thoughts on the clip. The main activity took place after the listening, or, in case of sessions 3 and 4, straight after the discussion. The change in procedure was due to the fact that the data collected from the listening part of the workshop were deemed not useful enough after the first two sessions by the researcher.In the main activity, participants were asked to work alone (session 3 and 4) or in pairs (sessions 1 and 2) depending on the size of the group. They were given a blank sheet of paper and coloured pens and asked to draw how they imagine the game to look like. They were told they can draw it in any way they liked, but a list of main features that must be included was given to them. This list included: Main melody, parts of the melody, voting button, and play button. When they were finished, the participants were asked to present their design to the rest of the group. The researcher then presented the prototype from chapter §4 and a group discussion about the merits and features of the different prototypes was held. This activity was inspired by the CI techniques described in [Guha et al., 2013]. The other screens of the game, apart from the game screen were discussed, but not shown by the researcher. The mechanics and control schemes for the different prototypes were also discussed. Some of the topics and ideas discussed in this part in the later sessions were influenced by answers from the previous ones. The purpose of this activity was to gather data on the types of graphics and features the target population might like in the game, as well as to figure out the most natural control scheme for the game. The whole workshop session took between 20 to 30 minutes, and at the end the participants were asked if they have any questions. They were thanked for their participation and presented with a participation certificate.

5.2.6 Results

1. *Ideas for the graphical design of the game elements and additional features*
   Out of the 13 designs created by the participants, 10 used blocks to represent the main melody and/or the parts of the melody. The musical notes were also frequently used, appearing in 8 prototypes, 5 times as melody pieces and 3 times as background motif. During the discussion, all participants agreed that blocks are the best way to represent the main melody, and that notes should be used to represent the parts of the melody. Most of the participants also liked the idea of using the notes as part of the background, while 2 (P15,P2) prefered sky as the background. The idea of animated background came up 7 times, and was liked by most of the participants, but some of them feared it might be too distracting. However, after the researcher mentioned the option to turn the animation off, all participants agreed that the animated backgrounds should be included.

   In terms of colours, blue was mentioned 3 times (P11,P4, P15), and yellow 2 times (P14,P11).

   The idea that unfilled blocks should be grey, proposed by P15 and P4 was liked by all participants, as well as the idea that filled blocks should change colour. P4 also came up with another idea for the settings screen: The unselected option

Figure 5.1: Participant 14 design

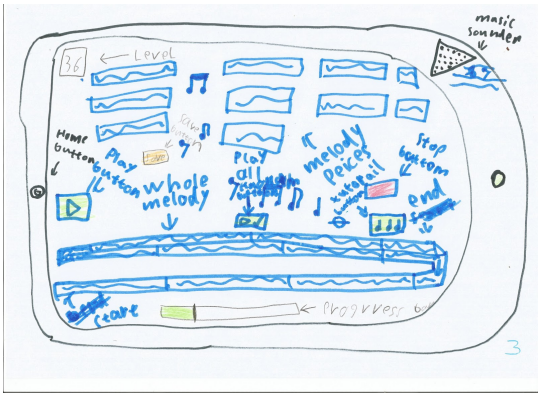

Figure 5.2: Participant 3 design

for the animation should also be grey. The main additional features that the participants came up with were a progress bar, proposed by P4, that shows how many pieces are in the right place, and an expandable menu button, proposed by P3. The progress bar was universally liked by all the subsequent participants when it was mentioned during discussion by the researcher. The menu button was liked by 8 participants, while the rest thought it was unnecessary. When the game options were discussed, all the participants agreed on the option to change the colours in the game, as well as choosing between animated and static background.

The ending of the game level was seen as too abrupt by some of the participants, and P4 suggested that some sort of "level finished" screen should be included, instead of going straight back to the level selection screen. This was supported by the rest of the participants in her session, and by all the subsequent participants in later sessions as well. In session 3, P11 suggested that all the blocks should change colour to green when the original melody is reconstructed, and some kind of "win" animaton should be played.

2. *Preferred control scheme*
   During the discussion of the game mechanics used in the game, all participants agreed on the drag-and-drop method of manipulating the pieces, with exception of P15 who preferred clicking on the pieces and unfilled blocks. The idea that you can hear the melody piece by clicking on it came up 4 times, and was universally liked by all participants, as well as the idea of having a button that plays the currently filled parts of the melody that was proposed by the researcher.

3. *Game understanding*
   Most participants had no problems understanding the design and participating in the activities. Participants 7 and 15 needed extra explanation of the main activity and how the game will be played, but after it was provided they also took part without any problems. However, the play whole melody button, that appeared in 10 of the participants prototypes, was marked with the word play in 5 of the prototypes, and with the play triangle icon in the other 5. The replay button was skipped in almost all of the designs, only appearing in 4 out of 13. When discussed though, almost all participants liked the idea. Some of the participants

also said that the button style proposed by the researcher is not very clear when it comes to the play and replay button functionality. When the other screens were discussed, none of the participants had any problems understanding the icons for setting and back buttons. When it came to the voting button, 10 out of 15 participants felt that an agreement button is a better term, and all participants agreed that the V in the researchers design should be replaced with a ✓ symbol, which changes colour when pressed.

4. *Music test*
   During the discussion about music, every participant gave a different answer, so no trend could be discerned by the researcher. The data gathered from the listening activity during sessions 1 and 2 showed that none of the participants disliked the type of melody created by the researcher. However, the participants were unable to give a prediction on the difficulty of putting the melody back together, since they could not actually try to do it. Therefore, this activity was scrapped by the researcher after the second session in favour of spending more time on the main activity.

5.3 Changes to the prototype based on Design Workshop Data

A number of changes were made to the initial prototype after the workshop sessions. All the changes to the prototype have been based on the analysis of the data from the workshop participants. Each change also includes which Design Principles (DP) and Requirements (Req.) the change follows. With the changes listed in this chapter, all the requirements have been fully implemented in the design.

5.3.1 Graphical Design

- The parts of the melody will be represented by musical notes, as suggested by the workshop participants. This is in line with Design Principles 2 and 5, as well fulfilling Requirement 10
- An animated background will be used in the game.
- The blocky representation of the main melody stays the same, but unfilled block will now be grey, as suggested by the workshop participants. This is in line with DP 1 and 2.
- The default colour scheme was decided to be be blue and yellow, based on the workshop results. This is in line with DP1 as well as fulfilling Req. 4
- An animated progress bar will be added to the game screen. This is in line with DP 1 as well as Req. 2

- Two victory animations will be added to the game screen when a level is finished. One for when both end users agree on a melody that is the same as the original melody, and one for when they both agree on a melody that is different from the original. This is in line with DP 3 and 8, as well as Req. 5 and 6.
- The design of the replay button was changed from a musical note to the play triangle. This is in line with DP 1,2 and 5, as well as Req. 2 and 11.
- The design of the voting button was changed from the letter "V" to the "✓ "symbol. This is in line with DP 1, 2 and 5, as well as Req. 2 and 11.

5.4 Summary

This chapter covered a design workshop conducted by the researcher. The results were discussed, and the changes that were made to the prototype based on them were justified against the principles and requirements from chapter §4.

Chapter 6

Implementation

6.1 Overview

In this chapter, the choice of technology used during the implementation of the high-fidelity prototype is discussed. The implemented high-fidelity prototype is also described, and the changes made during the implementation are discussed.

6.2 Framework

A decision was made to develop the prototype on an Android device. The Apple iPad running iOS was also considered. However, since a much wider variety of tablets and other touchscreen devices run the Android operating system, it was decided to focus on Android OS instead of iOS. This means that once created, the prototype will run on multiple types of devices from different manufacturers without any changes. The actual machine used for developing and testing the prototype was a Samsung Galaxy Tab A tablet, running the Android version 6.0.1.

After taking into account the requirements, principles and design of the project (§4.3), as well as the researcher's previous experience, the Unity 5 game engine was chosen as the main tool to develop the game. Another possibility was to use the Java programming language and Android studio software, but it was decided by the researcher that recreating some of the functionality that is already included in Unity through using Java would take a lot of time that could be more productively used elsewhere. Also, using Android Studio would make porting the game to other platforms much harder, since Unity has an integrated porting functionality. Therefore, Unity 5 was chosen([Unity Technologies, 2017]), for the following reasons:

- It is both powerful and flexible, with many built-in functions for manipulating objects and working with animations, as well as C# scripting support.
- It is available on both Windows and Mac operating systems for free, allowing development on machines running different operating system at no extra cost.

- Games built in Unity can be easily ported to different platforms such as iOS and Windows which allows an easy way to expand this project to other platforms in the future.

- The researcher has previous experience with using Unity which reduces the time needed to learn how to use the software.

To create the music in the game, the Audacity 2.1.2 software was used [Dominic Mazzoni, 2017]. It is free and easy to learn, but still allows manipulation of multiple music tracks through mixing, splitting and merging. These functions were used to create the melodies and melody parts used in the puzzles. The actual music files used were gathered from incompetech.com, which has a collection of royalty-free music files([MacLeod, 2017]).

Some of the graphics used in the project were created by an associate of the researcher, while the models were created using the Maya 2017 3D modelling software [Autodesk, 2017]. It is one of the most widely used modelling softwares on the market, and it is free for students.

All of the code for the game was written by the researcher, using the C# programming language.

6.3 High-fidelity Prototype

After analysing data from the design workshop, the first functional iteration of the high-fidelity prototype was developed. This iteration closely followed the design from chapter §4, while incorporating the changes from section §5.3.1. This prototype was used for further testing in chapter §7.

6.3.1 Title

As mentioned in the list of changes in subsection §5.3.1, the main colour theme is blue and yellow. The background motif is again musical, in order to keep the aesthetics of the game uniform. The teal background motif is animated (moving from left to right), with an option in the settings screen (subesction §6.3.2) to turn the animation on or off.

The main change from the design at the title screen (figure §6.1) is that the start and settings buttons are not animated. This is because it was decided by the researcher that the button animations clashed with the background animation and made the scene too visually stimulating. This decision was supported by some of the experts in chapter §7). The icon for the settings was also changed, from a single cogwheel to a group of three cogwheels, which the researcher considered to be more visually appealing.

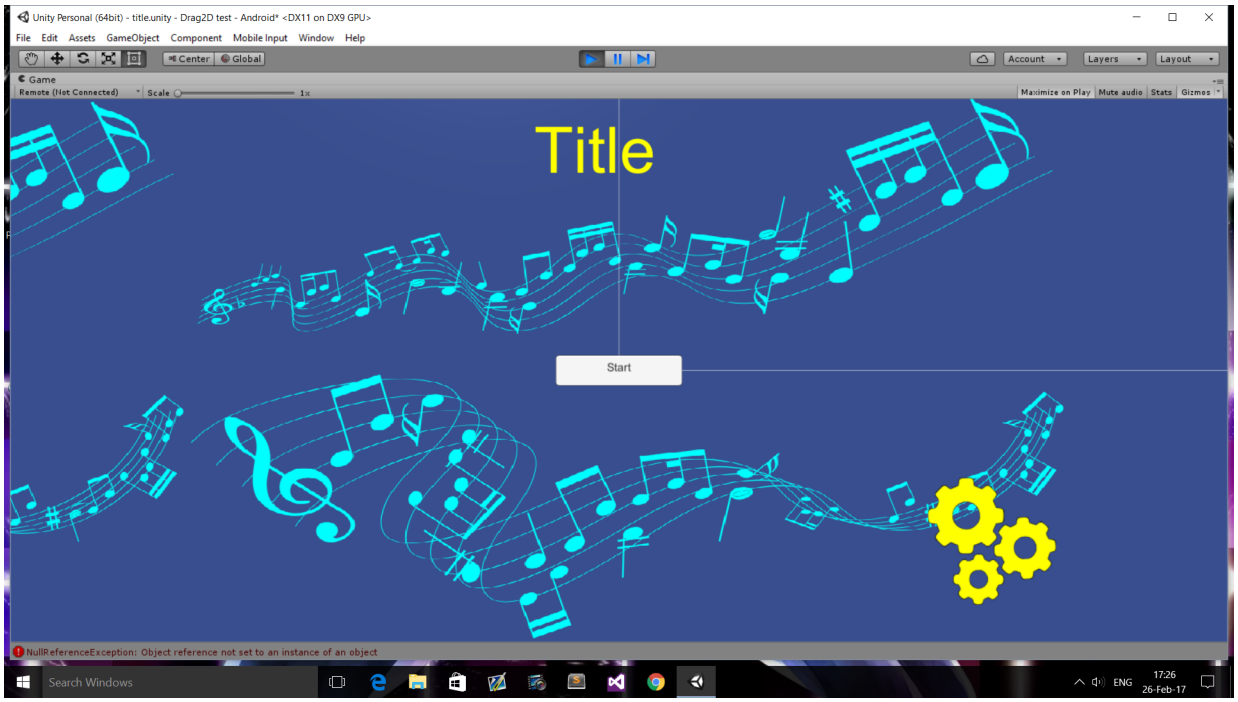

Figure 6.1: Title Screen

6.3.2 Settings

The main changes in the settings screen (figure §6.2) is the absence of the cogwheel button in the top left corner. This change made in order to keep the responses from the game uniform. Since this icon was used as a button in the title screen, it was decided by the researcher that using it again, but with no functionality might cause confusion. Also, the colour selection is now directly accessible from the screen without having to go through a sub-menu, to make the design and navigation more streamlined and easier to use.

6.3.3 Level Selection

The level selection screen (figure §6.3) remained unchanged, apart from removing the button animations to make the scene less visually stimulating. There are 3 full levels with melodies that contain increasing number of pieces, each with the same basic layout structure.

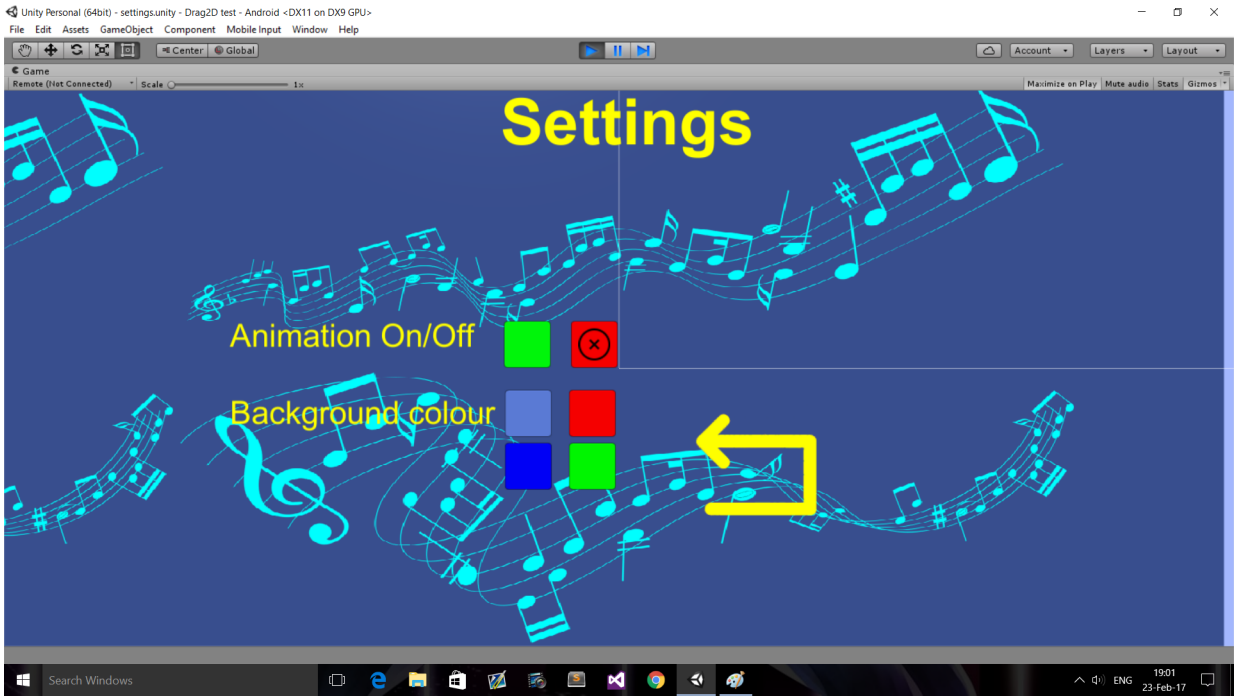

Figure 6.2: Settings Screen

6.3.4 Game Level

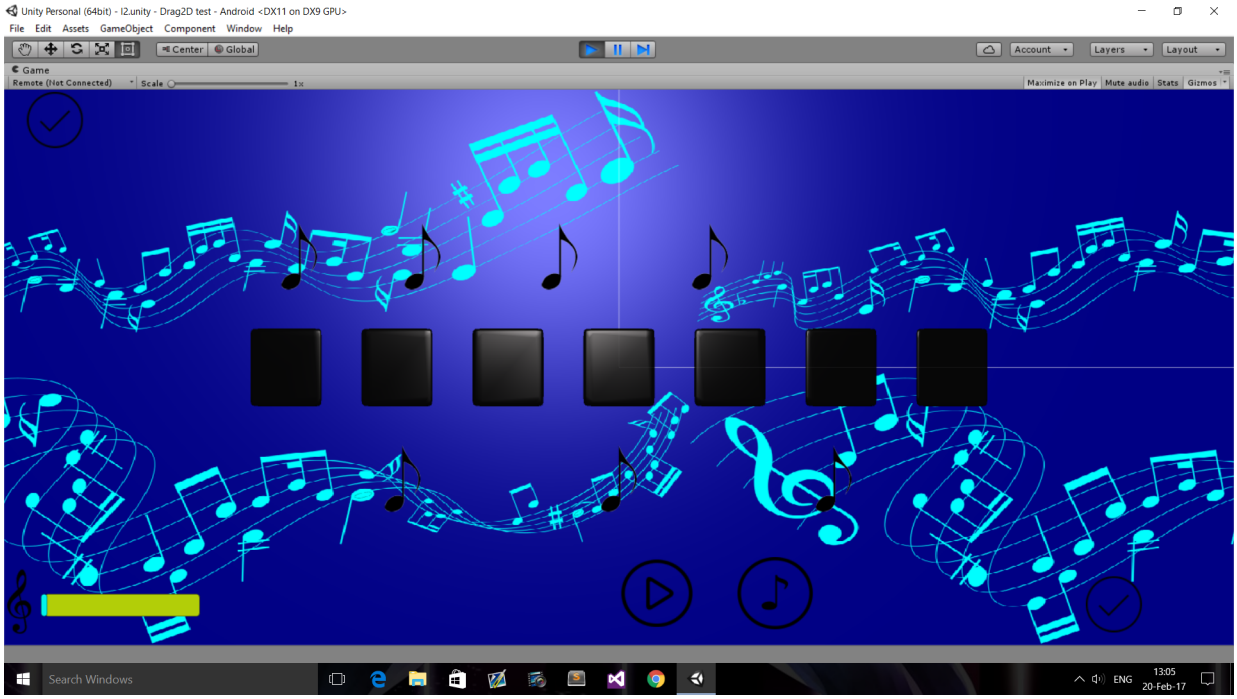

Figure 6.4: Game level

The game levels (figure §6.4) were reworked the most since the design stage. The progress bar in the bottom left corner was added, to visually show the progression

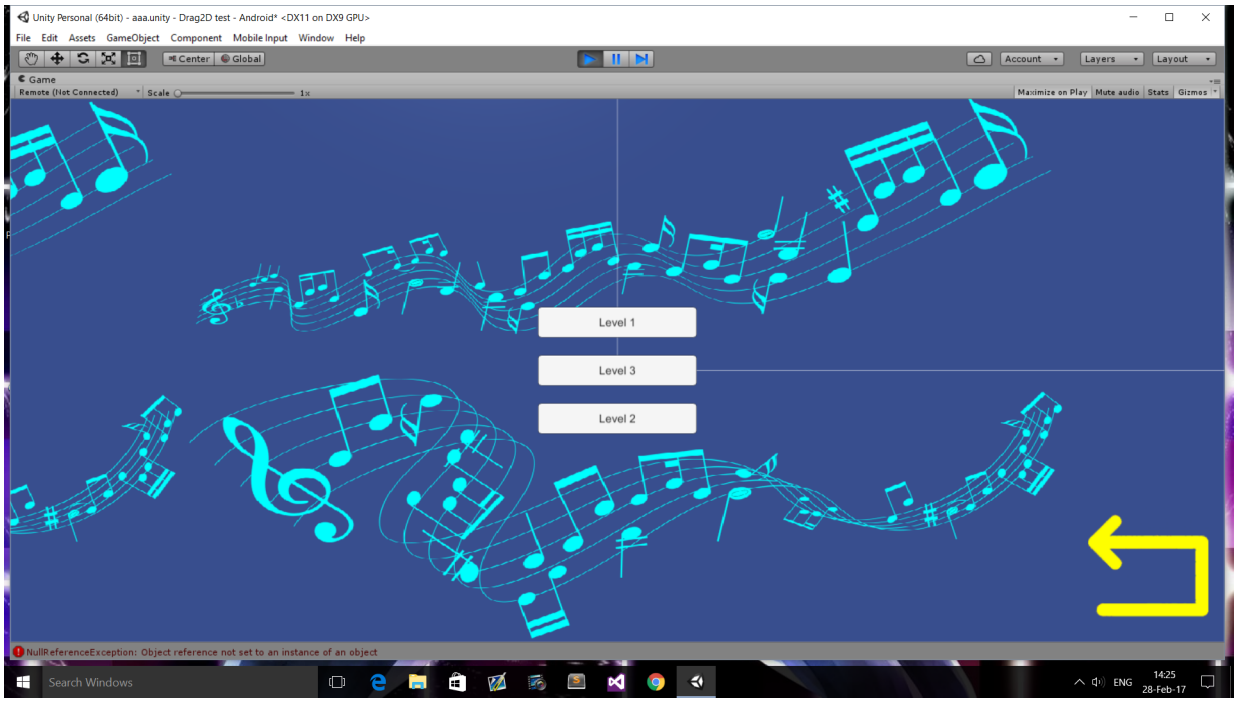

Figure 6.3: Level Selection

through the level. Parts of the melody are now represented by the note icons, and the voting buttons, as well as the buttons to play the whole melody and its parts have been changed and repositioned, in line with the changes described in §5.3.1. In simpler levels with less parts, the boxes where the melody pieces are placed are in one row. In higher levels with more pieces, the boxes are arranged in a staircase-like pattern, descending from left to right.

Additional functionality, in form of the boxes lighting up in different colours to represent whether the piece that is put in is correct or not has been added. This is shown in figures §6.5 and §6.6. Also, the melody pieces, when picked up, increase in size and shrink when dropped, to make them more reactive, and offer visual feedback to the player. These changes were implemented in accordance with design principles 3 and 6 from section §4.2.

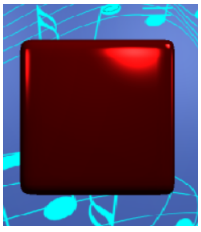

Figure 6.5: Wrong choice

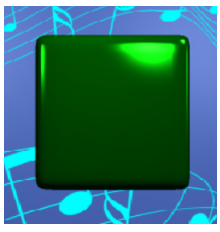

Figure 6.6: Right choice

A victory screen was not implemented at this stage, because it was decided by the researcher that more data is needed to create it.

6.4 Summary

In this chapter the reasons behind the choices of the technology used to create the high-fidelity prototype were explained. The implementation of the changes outlined in chapter §5 was described, along with the current state of the game prototype.

Chapter 7

Expert Interviews

7.1 Overview

A total of six semi-structured interviews with experts were conducted by the researcher. Experts with different fields of expertise were chosen to gather a wide variety of data on the prototype implemented in section §6.3. In this chapter, the semi-structured interviews with experts conducted by the researcher are reported, as well as the analysis of the data that was gathered from them. This chapter also includes an overview of the changes and improvements made to the prototype based on the data gathered.

7.2 Aims

The aims of these semi-structured interviews were focused to obtain feedback on the current state of the game prototype (as described in section §6.3), if it achieving the goal of stimulating communication and to gather data on how to improve it, specifically:

1. How easy it is to use the application, and understand the rules of the game
2. Does it support communication between players, and how could the the amount of interaction between players be increased
3. What changes and improvements could be introduced to the game

7.3 Participants

All the participants have expertise that is closely related to this project. Apart from E1, who is a high school teacher in Prague, all the other participants are academics associated with University of Edinburgh.

Participant	Position	Area of expertise
E1	Secondary School teacher, Gymnasium J.G.Jarkovskeho	Teaching children with autism and typically developing chlidren
E2	Usability Testing Assistant, School of Informatics	Usability testing, developing games for children with ASC, teaching children with autism
E3	Lecturer on HCI, School of Informatics	Human-Computer Interface
E4	Personal Chair in Interactive Learning Environments, School of Informatics	Interactive learning environments,developing games for children with ASC
E5	Research Postgraduate Student, School of Informatics	Children with ASC observation,developing games for children with ASC
E6	Programme Director for Design and Digital Media , College of Art	Sound Design, Game development

Table 7.1: Experts details

7.3.1 Settings

The interview times were arranged beforehand by email, and the interviews with all participants took place in their offices, except for E2, who was interviewed in one of the University's public areas.

7.4 Materials

The materials used for these interviews were: pen and paper for taking notes by the researcher, a Samsung smartphone to serve as an audio recorder, a Samsung Galaxy Tab A tablet running the Android OS for presenting the prototype and a consent form to gain formal consent (Appendix C).

7.5 Procedure

At the start of each interview, the project and its goals were explained to the participant. They were then presented with a consent form , and asked for permission to be audio recorded. After being granted permission, the recorder was turned on. The researcher walked the participant through the prototype, and explained all of the different screens and controls. The tablet with the game was then handed to the participant to try out the game. Afterwards, a discussion was held, with the main points being the aims listed in section §7.2. Some of the feedback from previous interviews was iteratively

implemented into the prototype, so not all the experts were presented with exactly the same prototype. At the end of each interview, the participants were informed that the audio recorder is being switched off, and they were thanked for their time and input.

7.6 Results

1. *How easy it is to use the application, and understand the rules of the game*
   During the first two interviews, participants E1 and E2 agreed that it would be good to add some sort of a tutorial level to the game. Therefore, a basic tutorial level was implemented. In the subsequent interviews, all remaining participants agreed that it should be included. Almost all participants (except E1) felt that the buttons inside the game levels can be hard to see and should have a higher contrast, possibly by using white colour. Half of the participants (E1, E3, E4) also said that adding a return button to the game levels would improve navigation. During the first interview, E1 suggested a different layout for the game levels that was implemented before the rest of the interviews, and all the other experts agreed that the new layout was an improvement over the old one (the new layout can be seen in figure §7.4). E4 was also strongly in favour of bigger buttons and text throughout the game.

2. *Does it support communication between players, and how could the the amount of interaction between players be increased*
   E2 and E5 said that more enforcements to turn-taking might increase the amount of communication. E2 and E4 both came up with a suggestion to use coloured notes to represent parts of the melody. Half of the experts (E2, E5, E6) suggested adding “free-form” levels, where there is no “right melody” and users just use the melody pieces provided to create a melody of their own.

3. *What changes and improvements could be introduced to the game*
   E2 came up with a win screen design that again used a music motif. This was subsequently implemented by the researcher, and there were no complaints during any of the subsequent interviews, but the displayed text was changed from “You won” to “Good Job” after E5 suggested that “Good Job” would feel more rewarding to the target audience. E4 suggested adding another light-up colour, yellow, that would indicate that the melody piece is not in the right place, but it is close. Most of the experts (E1, E2, E3, E4) also said that showing when the voting button is locked in more clearly would improve the game. E5 suggested that another way to increase difficulty in later levels might be to introduce ”fake” parts of the melody that are not actually part of the melody the user is trying to complete. Most of the participants (E3,E4,E5,E6) said the note icon representing the melody piece should not dissapear when inserted into a box, and suggested either making the boxes transparent, or replacing the boxes with something else, like braces (E3). E6 also suggested that since the game is mainly targeted to be played by two people, some kind of support of online multiplayer should be included.

7.7 Redesign

The data collected from the interviews in chapter §7 was analysed, and the results used to make extensive changes to the prototype. All the changes that were undertaken, as well as explanations of why some of the suggestions were not implemented are covered here. An overview of all the changes can be seen in table §7.2 below. Screenshots and comments on all of the major alterations to the prototype from section §6.3 are also included in this section.

	Change	Undertaken	Justification
C1	Bigger Buttons and Text	Yes	This was a rather simple change that makes navigation and control easier.
C2	Tutorial	Partly	A simple level was added that can be used for explaining the game, but no in-game instructions were included
C3	See-through boxes/braces	Yes	See-through boxes were tested by the researcher, but the required graphical shaders did not work on the target device. Therefore, the braces, proposed by E3 were used instead instead
C4	Extra light-up colour	Yes	A yellow light-up colour was added, to indicate that the melody piece is in a wrong place by one position
C5	Higher contrast buttons	Yes	The colour of the in-game buttons was changed to white to make them more visible
C6	Home Button in game	Yes	A home button was added to all the game levels, to improve navigation, and add more control
C7	Victory Screen	Yes	A victory screen with an animation and text was added at the end of all the game levels, to serve as a motivation and reward to the player
C8	Game Layout	Yes	The game layout was changed to improve usability, and to avoid one player having a rotated view of the game
C9	Clearer Voting	Yes	The voting button icon changes when the vote is locked in to make the communication between players about their votes easier
C10	Fake notes	No/future work	After discussing the difficulty of the game with experts, it was decided to not add this feature to the current version of the game.
C11	Turn-Taking enforcement	No/ future work	While this was considered a good feature, the device used for development cannot recognise or identify different touches, therefore making implementation of meaningful turn-taking enforcement impossible at this stage.
C12	Coloured notes	No	This feature was tested by the researcher, but it was decided that it leads to more confusion and clutter on the game screen, and was therefore dropped

C13	Free form level	No/ future work	A very good idea. Unfortunately, to be implemented properly, some kind of functionality to save the created melodies would be needed, which was out of the scope of the project.
C14	Online Multiplayer	No	The aim of this project was to increase real-world communication and interaction between players, therefore online multiplayer, that promotes virtual communication and interaction, was not relevant to this project

Table 7.2: Changes to prototype

7.7.1 Title Screen, Level Selection, and Settings Redesign

Only a few changes were made to these screens, since most of the changes were aimed at the actual game levels. The main changes to these three screens were C1 in both title and level selection screens, an a new buttons for C2 and Level 4 in the level selection. Apart from the changes described in C1, buttons now also light up with a different colour when pressed, to give more immediate feedback, in line with Design Principles 3 and 6 from section §4.2.

Another change, not suggested by the experts was also added. An extra level (Level 4) which does not contain colour hints for extra difficulty, was added by the researcher. This was done to test out how helpful the colour hints are, as well as to add more playable content to the game.

The settings screen was not changed in any way, except now the background animation is switched off by default. This was proposed by the experts E3. It can still be switched on and off at will.

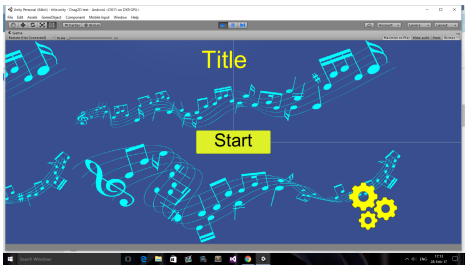

Figure 7.1: Redesigned Title screen

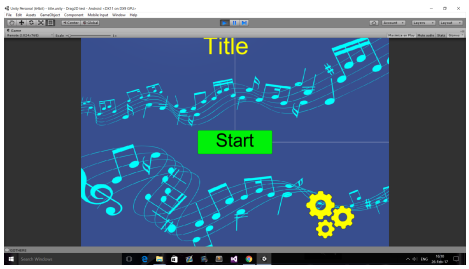

Figure 7.2: Title screen with button pressed

Figure 7.3: Level Selection Redesigned

7.7.2 Game level Redesign

This is where the majority of the changes were carried out. Changes C3-C9 were all done to this part of the game. Figure §7.4 shows the tutorial level (C2), which was kept very simple, so that it can be used to explain the rules and controls of the game. It has the new layout (C8), with both voting buttons on opposite sides of the bottom of the screen. The progress bar was moved to the middle at the top of the screen, and the play melody and play parts buttons were moved to the middle bottom of the screen. This new layout is more balanced and symmetrical, thus making the level more aesthetically pleasing, according to both experts and the researcher. The new white higher contrast buttons are used (C5), and the boxes were replaced with braces, so that the melody piece stays visible after being slotted in (C3). Voting buttons now have two different icons (C9), that change depending on whether the vote is locked in (figure §7.5) or not (figure §7.6). There is also the new return button (C6), in the top right corner, that looks the same as the return buttons used in other screens, to keep the visual style uniform. The new yellow light-up colour (C4), as well as how the melody pieces slot into the braces, can be seen in figure §7.7. The last change to this screen is the victory screen (C7). At the end of each level, when both players press their respective voting buttons, a victory screen was added. The background turns black, and an animated note appears which floats around for a few seconds, before coming to a stop next to a ”Good Job” text and a return button. The victory screen at the end of the animation can be seen in figure §7.8. Two different victory screens were not introduced, contrary to the decision made in subsection §5.3.1. The victory screen stays the same, irrespective of the result. This was done in order to avoid discouraging the player, as well as due to

the fact that the melody making part of the game that was initially intended to be part of all the levels was moved to the dedicated ”free-form” levels.

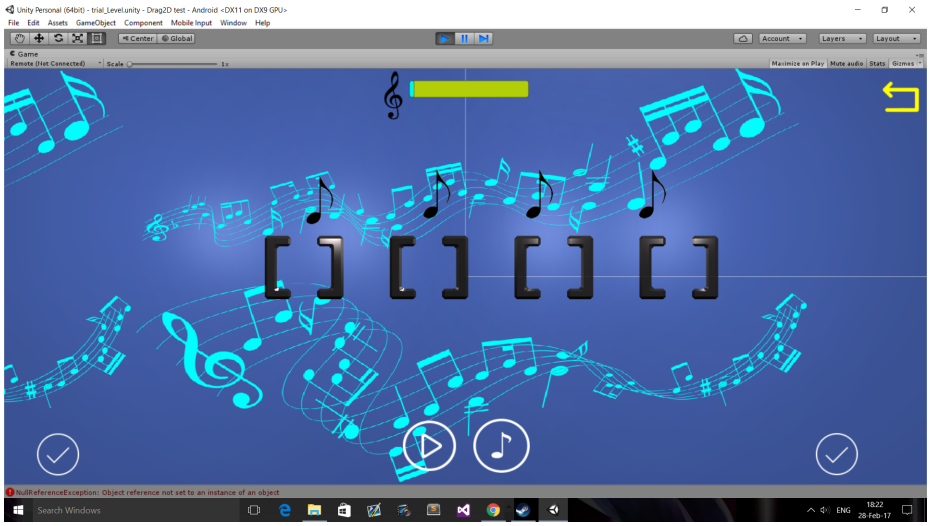

Figure 7.4: Redesigned game level

Figure 7.5: Locked

Figure 7.6: Unlocked

Figure 7.7: New colour

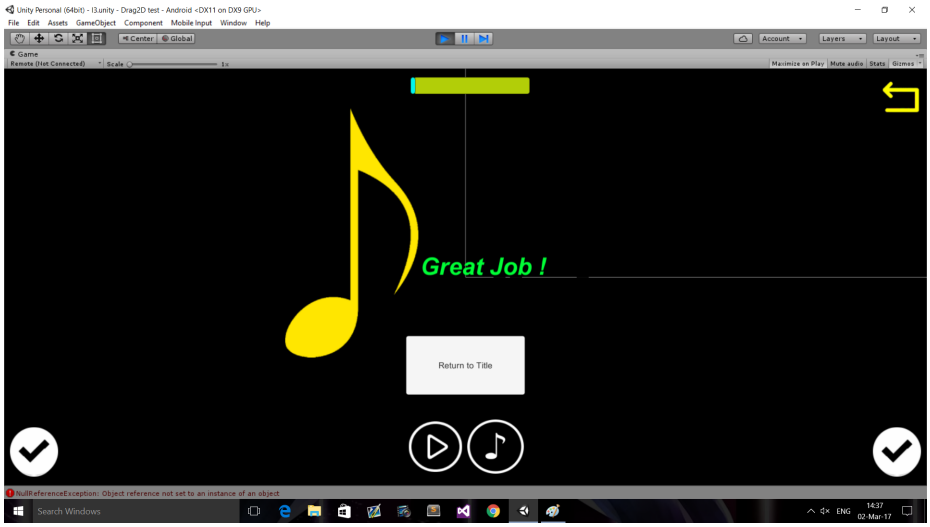

Figure 7.8: Victory screen

7.8 Summary

In this chapter, the high-fidelity prototype was used in a number of interviews with experts from different fields in order to gather data on its current performance and further improvements. A list of improvements was generated from the results of the interviews, along with a justification of which will be implemented. The resulting changes made to the prototype were then described.

Chapter 8

Evaluation

8.1 Overview

In this chapter, the 6 sessions of an evaluation workshop are reported. This workshop was conducted in order to evaluate the game, using typically developing children as proxies. Two semi-structured interviews with experts that were conducted in order to evaluate the game from adult perspectives are also reported here. At the end of the chapter, the overall results of both studies as well as the the decisions on suggested improvements are discussed.

8.2 Evaluation workshop

8.2.1 Aims

The aims of this evaluation study were to evaluate the game, see how it is received by children, if it promotes communication, and gather more data for possible improvements, specifically:

1. Find out what did the participants liked the most, and least about the game
2. Gather data on the amount of communication promoted by the game
3. Find out what further improvements could be made to the game
4. Evaluate the length of the levels, appropriateness of the melodies
5. Evaluate how much the participants liked the game as a whole

8.2.2 Participants

The participants were again typically developing children, serving as proxies for children with ASC. Apart from sessions 3 and 4, all participants were children related to

the Informatics staff, that have previous experience with game testing and evaluation. Children in sessions 3 and 4 were members of the same Browines group as participants in §5.2.

Session	ID	Gender	Age
Session 1	Participant 1	Male	7
	Participant 2	Male	9
Session 2	Participant 3	Female	12
	Participant 4	Female	11
Session 3	Participant 5	Female	9
	Participant 6	Female	9
Session 4	Participant 7	Female	9
	Participant 8	Female	10
	Participant 9	Female	8
Session 5	Participant 10	Male	8
Session 6	Participant 11	Male	7
	Participant 12	Female	9

Table 8.1: Evaluation workshop participants

8.2.3 Setting

Sessions 3 and 4 took place in the Brownies club room. All the other sessions took place in the Informatics Forum of the University of Edinburgh.

8.2.4 Materials

The materials used for this study were: pen and paper for note-taking, a Samsung smartphone for audio recording, a Samsung Galaxy Tab A tablet running the Android OS with the game prototype installed, as well as consent forms and participation certificates for participants (a sample certificate can be seen in Appendix E).

8.2.5 Procedure

At the beginning of the workshop, participants were walked through the consent forms by the researcher, and asked if they have any questions. After giving their consent, the researcher informed the participants about turning on the audio recording. The researcher then explained the game to the participants, using the tutorial level for demonstration. Participants were not informed that the goal of the game is to promote communication, in order to try and collect data on how much communication the game "naturally" promotes. After the demonstration, the tablet with the game was handed to participants, to play the first level, and the fourth level of the game. This was done in order to evaluate both levels with the colour hints enabled (levels 1,2 and 3) and

the level with the colour hints disabled (level 4). While participants were playing the game, the researcher was taking notes on the amount of verbal communication that was happening between them. Depending on the amount of time it took the participants to finish these two levels, they were either asked to play a level of their choice, followed by a discussion, or the researcher moved straight to the discussion. The main points in the discussion were the aims listed in subsection §8.2.1. After the discussion, participants were asked if they have any questions,they were thanked for their participation and the audio recording was switched off. At the end of the workshop, the participants were presented with a participation certificate.

8.2.6 Results

1. *What did the participants like the most, and least about the game*
   A majority of the participants (7 participants), when asked about what they liked the best about the game simply said that they liked all of it. When asked for more specifics, the most popular answer was the melodies (5 participants), followed by the background animation (P1, P2, P10), and the default blue yellow colour scheme (P1, P7, P8). When asked what they liked the least, some participants were a little hesitant, repeating their previous answer that they liked everything, or that there is nothing they did not like. After the researcher reassured them that it is fine to say what they do not like, more participants answered, but only 7 came up with a concrete example. The game not having enough levels was the least liked feature according to P11 and P12. P3 did not like the melodies in the game, while P2 did not like having to go back to the title screen at the end of each level. P7 and P8 did not like being unable to change the colour of the background motif, and P10 did not like that during the workshop, some bugs were discovered in the game.

2. *Amount of communication facilitated by the game*
   The amount of verbal interactions between the participants in each session can be seen in table §8.2. In this context, verbal interaction means that the participants talked to each other about or due to the game. This includes question like ”Where do you think this one is going ?” or comments like ”I don’t think that one is right”. Session 5 was conducted with just one participant, and therefore the number of interactions is 0. Also, during session 4, participants decided on turn-taking where each participant tried to slot one part of the melody, without any input from the researcher. However, there were many uncontrolled variables during this study, such as how well the participants knew each other, which may have had an effect on the amount of verbal interactions. Therefore, while this data suggest that the game does indeed promote communication, it cannot be used as conclusive proof.

Session	Number of verbal interactions
Session 1	13
Session 2	7
Session 3	20
Session 4	12
Session 5	0
Session 6	4

Table 8.2: Verbal interactions during workshop session

3. *Further improvements to the game*
   There were many suggestions for improvements. The most popular was being able to change the colour of the background motif (5 participants), followed by different texts on the victory screen depending on the score (P2, P7, P8, P9), more instructions in the tutorial level (P1, P2, P7, P8), and more background colours in the settings (P2, P3, P4, P6). Other improvement suggestions included being able to hide the progress bar (P2, P8, P9), more levels (P10, P11, P12) and adding a button to go straight to the next level on the victory screen (P2). The researcher also asked the participants about the possibility of introducing ”fake” notes in later levels, which was proposed by some of the experts in section §7.6. This idea was liked by just under half of the participants (5 participants).
4. *Length of the levels and appropriateness of the melodies*
   Most participants (9) agreed that the length of the levels was good, while P5, P10 suggested that the levels should be longer and P9 suggested they should be shorter. The melodies were very well received, being the most liked part by almost half of the participants, and only one participant did not like them.
5. *How much the participants liked the game as a whole*
   The game was received well by the participants. All participants, except P11 and P12 seemed very engaged with the game with 5 participants (P5, P6, P7, P8, P9) asking to play more at the end of the workshop, and no participant saying they did not like the game. P8 even asked if it would be possible to get a copy of the game to play at home.

The decisions on the suggested improvements are discussed in section §8.4

8.3 Expert Evaluation

8.3.1 Aims

The semi-structured interviews with experts conducted by the researcher were aimed at gathering a more high-level opinion on the game as a whole. Specifically:

1. Gather data on the overall impression of the game

2. Evaluate the overall design of the game
3. Evaluate whether it has the potential to promote communication between the target users
4. Gather data on further improvements to the game

8.3.2 Participants

The participant in the first session was the same as E2 in the Expert Interviews (Chapter §7) while the participant in the second session was the same as E5. Therefore, they will be referred to as E2 and E5 in this section as well. The details about the experts and their field of expertise can be found in table §7.1.

8.3.3 Setting

Both sessions were arranged by email, and took place in public places at the University of Edinburgh.

8.3.4 Materials

Materials used in this study were: pen and paper for note taking, a Samsung smartphone used for audio recording, a Samsung Galaxy Tab A tablet running the Android OS for presenting the game, and a consent form to gain formal consent (Appendix C).

8.3.5 Procedure

At the begging of each interview, the aims of the study were explained to the participant. The participant was then asked if they have any questions, and presented with a consent form to sign .The were informed that the audio recorder is being switched on. The researcher then explained all the main changes done to the game since the last round of expert interviews (chapter §7). The researcher then handed the tablet with the game to the participant, so that they could try out the game. A discussion with the participant was then held, with the main topics discussed being the aims in subsection §8.3.1. At the end of each interview, the participants were informed that the recorder is being switched off, and thanked for their time and input.

8.3.6 Results

1. *General impressions of the game and the overall design*
   The general impression of the game was very positive, with both experts liking the gameplay, saying that the game is engaging. E5 especially continued to

play with the game throughout the interview, which suggests that the game is appealing to adults as well as children. The overall aesthetic of the game was also liked, with both experts liking the consistency of the layout and buttons. They also liked the clear, uncluttered design and customization options. However, E2 felt that the background motif in the game levels might be too distracting for some children. The lack of text and use of icons was liked by both experts, considering the age of the target audience.

2. *Potential to promote communication*
   E2 said that the game does not have a large potential for promoting communication. This was due to the fact that in E2's opinion, the game does not offer enough incentive to promote communication between the users, with only the voting buttons at the end of a level forcing the users to actively communicate and work together. However, E5 said that the game does have good potential to promote communication, since working together on a puzzle in the game is enough of an incentive to communicate on its own.

3. *Further improvements*
   Both experts agreed that the victory screen could be made more "rewarding", either by adding a sound (E5), or by adding more animations (E2). E5 further suggested that the UI(User-Interface) elements in the game levels should be turned off in the victory screen. Another suggestion from both experts is an inclusion of a plain background option in the setting, for children that find the current background too distracting. There was also a suggestion, again from both experts, that some of the buttons should be reworked to further improve navigation in the game. Firstly, the return button, both the in-level one and the one that appears in the victory screen, should take the user back only one step instead of two. This means that instead of returning the user to the title screen, which is two clicks away from the level screen, the buttons would return the user to the level selection screen which is only one click away. Secondly, a new "next level" button should be added to the victory screen. This would allow the user to progress through the game quicker, with less menu navigation required between levels.

The decisions on the suggested improvements are discussed in the next section (§8.4).

8.4 Evaluation Results and Improvements Discussion

The reception of the game by both children and adults was very good. They seemed engaged by the game, and genuinely enjoy playing it. However, when it came to the question about whether it serves its intended purpose (i.e. promoting communication between users), the results are less clear. While there is evidence that the game promotes communication between the users (table §8.2), there is no data on how much communication would happen naturally if the participants were to just play together, without the game. When it comes to the experts, their opinions are very different. While both agree that the game has some potential for promoting communication, E2

said that the potential is quite low, while E5 said that the potential is large.

There were many suggestions for improvements, both from the children and the experts. An overview of the suggested improvements as well as action taken and justification can be seen in table below (table §8.3).

	Improvement	Implemented	Justification
I1	Changing the background motif colour	No	While this improvement was considered a addition to the customization options, it was not implemented due to time constraints
I2	More instructions in tutorial	No	Adding text to the tutorial would go against the design principles (section§4.2). The tutorial is meant to be used by an experienced user to demonstrate the game
I3	Different victory screen texts	No	This suggestion was made by both some workshop participants as well as E5. Unfortunately, it was not implemented due to time constraints.
I4	More background colours	Yes	Two more colours (purple and grey) were added to the game to add more customization options.
I5	Hiding the progress bar	No	It was decided by the researcher, after consulting with the experts, that the level of difficulty in the game is adequate, and should not be increased.
I6	Next level button	Yes	This was suggested by both experts, as well as one workshop participant, and is in line with the HCI principles of learnability and memorability (section§4.6)
I7	More levels	No	No additional levels were added to the game due to time constraints
I8	More rewarding victory screen	Yes	A short sound clip was added to the victory screen to make it feel more rewarding to the user. The suggestion by E5 to add sound was chosen over the suggestion of E2 to add more animations, because some children might find more animations unpleasant or distracting.
I9	One-step return	Yes	The return buttons were reworked, as suggested by both experts, to make the game navigation more intuitive
I10	Plain Background	No	It was decided by the researcher that adding this option would ruin the aesthetic of the game, and make it less appealing to the user.

Table 8.3: Suggested improvements

8.5 Redesign

The two implemented improvements that were focused on the victory screen (I6 and I8) can bee seen in figure §8.1.

The setting screen improvement (I4) can be seen in figure §8.2 .

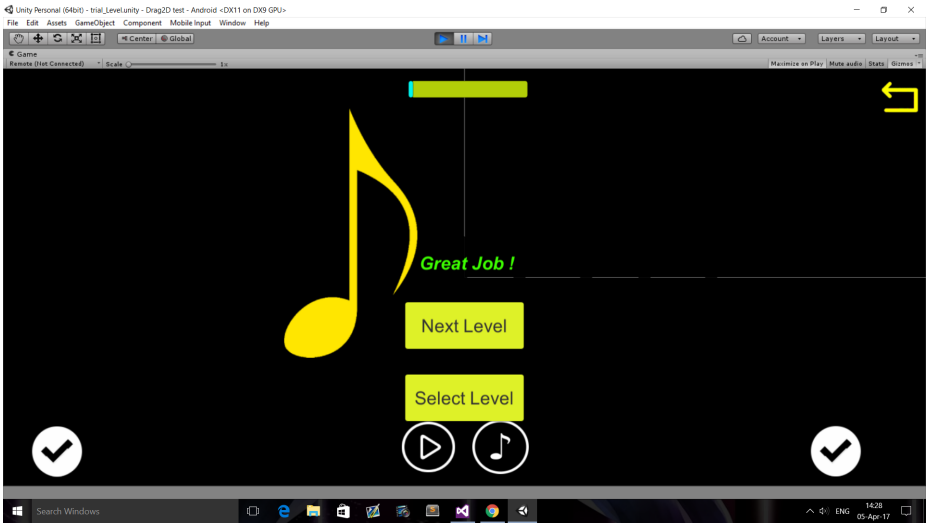

Figure 8.1: Improved Victory Screen

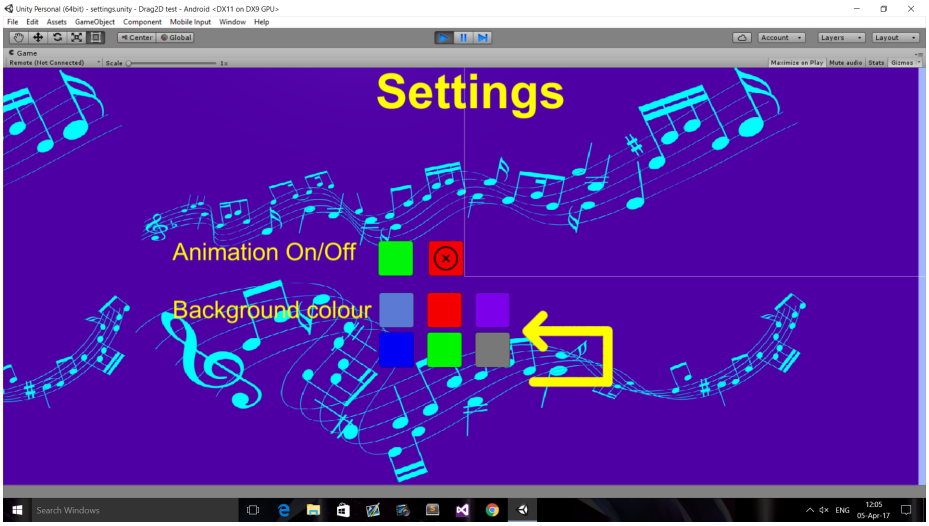

Figure 8.2: Setting Screen with more colours

8.6 Gameplay

The basic gameplay can be described in 6 steps (as seen in figure §8.3)

1. *Step 1:*
   The player picks up one of the note pieces by touching and holding it. When

picked, the selected note becomes larger, to indicate that it is being manipulated, and plays the part of the melody that is associated with it.

2. *Step 2:*
   When a note piece is dropped over a pair of braces, they turn a corresponding colour (green/ yellow/ red) depending on the correctness of the note piece placement. In case of the diagram, the note piece was placed correctly, therefore the braces turned green and the progress bar started filling up.

3. *Step 3:*
   The player keeps placing notes inside the braces.

4. *Step 4:*
   If the note was placed incorrectly, the braces turn red and the progress bar does not move (if the not is placed incorrectly by one spot, the braces turn yellow).

5. *Step 5:*
   When all the notes are in their correct places (as demonstrated by the full progress bar), the players can vote on finishing the level. In the diagram, a completed level where one player locked their vote in can be seen.

6. *Step 6:*
   When both player lock in their respective votes, they are taken to the victory screen, where a short music clip and an animation is played as a reward. From there they can either go back to the level selection screen or continue straight to the next level.

8.7 Summary

In this chapter, an evaluation workshop conducted with the aim of evaluating the game by children was covered. Two expert interviews, conducted with the aim of evaluating the game by adults, were also covered. A discussion of the combined results was held. A number of improvements that were gathered from the results were also discussed, along with a justification of whether they will be implemented or not. The changes made to the game based on the implemented improvements were described, and an overview of the gameplay was also included.

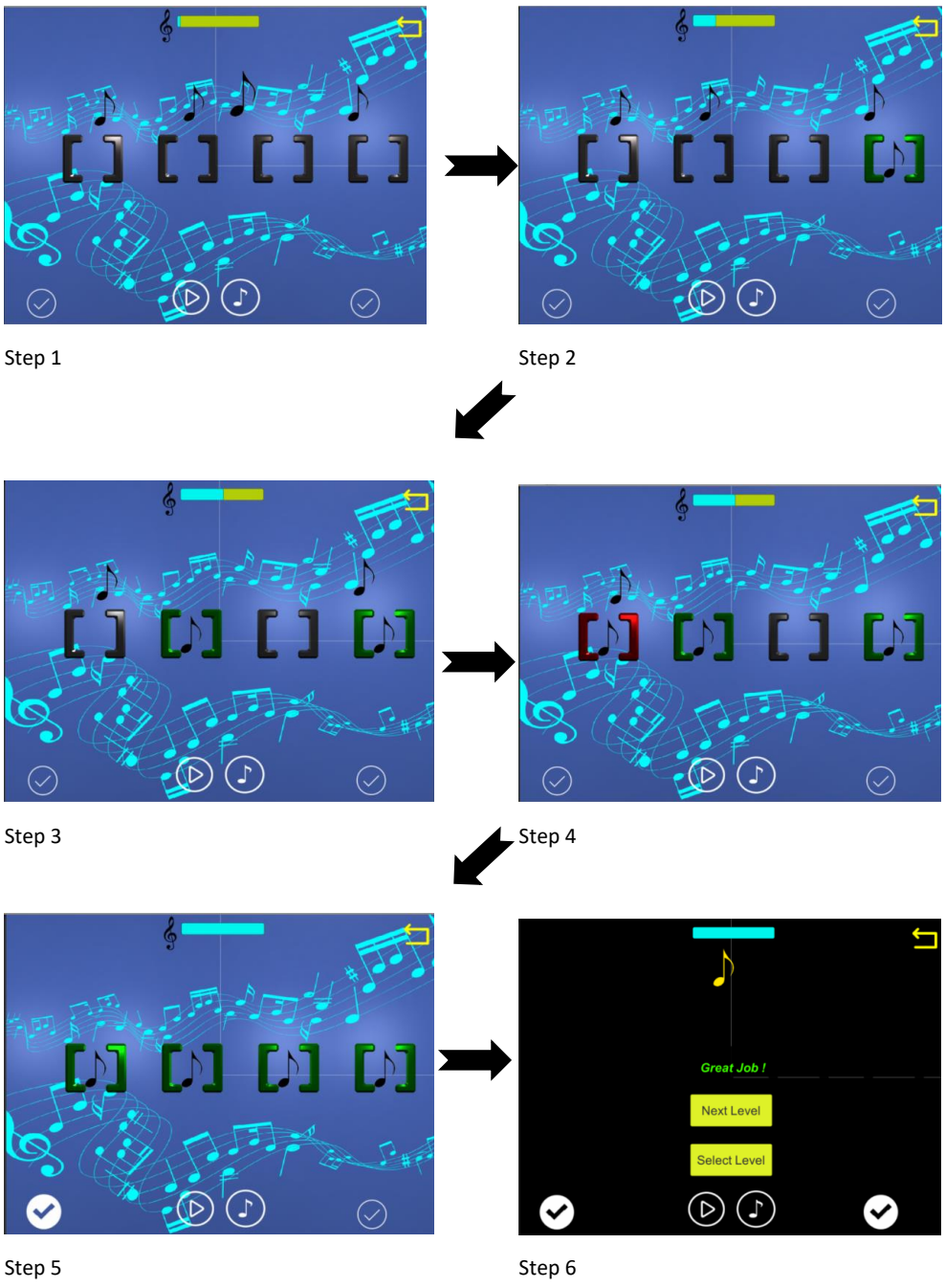

Figure 8.3: Gameplay Diagram

Chapter 9

Conclusion

The aim of this research was to explore the possibilities of increasing the amount of communication between children with ASC and their typically developing peers through the use of a game that combines puzzles and music. The specific questions the researcher set out to answer and corresponding results are listed below:

1. *Are puzzles and music a valid choice of shared interest categories ?*
   The choice of music and puzzles as shared interest categories is supported by the results of the pre-design study in chapter §3 as well as the research reviewed in sections §2.4 and §2.5. During the expert interviews in chapter §7 and expert evaluations in section §8.3, all experts agreed that the use of puzzles and music was a valid choice. During the design workshop with children in section §5.2, participants did not show much enthusiasm for the puzzle elements. However all participants said that they liked music and most of them seemed interested in the musical elements. During the evaluation sessions in section §8.2 the participants seemed to enjoy the way the puzzle and music elements were combined together.

   Therefore, it can be concluded, that based on the data collected in this research, puzzles and music seem to be a valid choice for shared interest categories. However, since typically developing children were used as participants, the data collected can not be directly used to conclude that children with ASC will share the same interests.

2. *Is a game that combines puzzles and music appealing to children in the target age group ?*
   The results of the evaluation sessions in section §8.2 show that the game, which combines puzzles and music, is indeed appealing to children that are of target age, or close to it. The game was very well liked, and with exception to one session in which the participants got distracted (session 6), all participants found the game very engaging, with no major complaints.

3. *Does the game promote communication between players ?*
   This question was the most important, and the hardest to answer. The difficulties of communication research is discussed in section §2.3. In this case the main problems were the fact that no comparative study was done to compare the

amount of communication that takes place with and without the game, and that no actual children with ASC were used as participants. However, the average amount of verbal interactions across all evaluation sessions with more than one participant was 11.2, which, considering the relatively small period of time spent playing the game (on average about 15 to 20 minutes per session), shows that the game has good potential to promote communication. This is supported by one of the two experts, who agreed that the game has good potential for promoting communication. The other expert was less supportive, but still agreed that the game has limited potential to promote communication.

Ultimately, no definitive conclusions can be drawn about whether the game promotes communication or not without further research. However, the game shows promise, and confirms that using shared interest is a good way to get children engaged and communicating.

9.1 Further Work

The main area for future work would be more to run more studies in order to gather data that would allow to draw a more definitive conclusion about the ability of the game to promote communication. A comparative study where children engage in a different activity and a study with combination of children with ASC and typically developing children would be ideal to better evaluate the game and its potential to promote communication.

From a technical perspective, there were many improvement and feature suggestions from both the design and evaluation workshops as well as from the studies with experts that did not make it into the game. The main feature that was not implemented into the game due to time constraints, but was considered valid addition by the researcher, was more levels, possibly ones that would contain ”fake” notes. This was suggested by experts in chapter §7, and the idea was well received by the children during the evaluation workshop in section §8.2. A whole section of features worth considering for future development is more turn-taking enforcement, which was not implemented due to technical limitations of the target platform, and the possibility of adding free-form levels. Both of these features were suggested by experts in chapter §7.

There are also numerous small, mostly visual, improvements suggested for the game, that would make the game more appealing and customizable. These were not implemented due to time constraints. Improvements included different texts on the victory screen, which was suggested by both children and experts in chapter §8, and the option to change the colour of the background motif.

Even in its current state, the application was well liked, and was able to promote communication in the user sample it was tested on. With more work, both theoretical and practical, it could become a valuable tool in helping children with ASC to communicate with their typically developing peers.

Bibliography

[Alcorn et al., 2013] Alcorn, A. M., Pain, H., and Good, J. (2013). Discrepancies in a virtual learning environment: something worth communicating about for young children with asc? In *Proceedings of the 12th International Conference on Interaction Design and Children*, pages 56–65. ACM.

[Allen et al., 2013] Allen, R., Davis, R., and Hill, E. (2013). The effects of autism and alexithymia on physiological and verbal responsiveness to music. *Journal of autism and developmental disorders*, 43(2):432–444.

[Association, 1994] Association, A. P. (1994). *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition: DSM-IV-TR®*. American Psychiatric Association.

[Autodesk, 2017] Autodesk (2017). Maya (2017).

[Baker et al., 1998] Baker, M. J., Koegel, R. L., and Koegel, L. K. (1998). Increasing the social behavior of young children with autism using their obsessive behaviors. *Journal of the Association for persons with Severe Handicaps*, 23(4):300–308.

[Baron-Cohen et al., 2011] Baron-Cohen, S., Lombardo, M. V., Auyeung, B., Ashwin, E., Chakrabarti, B., and Knickmeyer, R. (2011). Why are autism spectrum conditions more prevalent in males? *PLoS Biol*, 9(6):e1001081.

[Bartoli et al., 2014] Bartoli, L., Garzotto, F., Gelsomini, M., Oliveto, L., and Valoriani, M. (2014). Designing and evaluating touchless playful interaction for asd children. In *Proceedings of the 2014 conference on Interaction design and children*, pages 17–26. ACM.

[Battocchi et al., 2009] Battocchi, A., Pianesi, F., Tomasini, D., Zancanaro, M., Esposito, G., Venuti, P., Ben Sasson, A., Gal, E., and Weiss, P. L. (2009). Collaborative puzzle game: A tabletop interactive game for fostering collaboration in children with autism spectrum disorders (asd). In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces*, ITS '09, pages 197–204, New York, NY, USA. ACM.

[Bellini et al., 2007] Bellini, S., Peters, J. K., Benner, L., and Hopf, A. (2007). A meta-analysis of school-based social skills interventions for children with autism spectrum disorders. *Remedial and Special Education*, 28(3):153–162.

[Brok and Barakova, 2010] Brok, J. C. and Barakova, E. I. (2010). Engaging autistic children in imitation and turn-taking games with multiagent system of interactive lighting blocks. In *International Conference on Entertainment Computing*, pages 115–126. Springer.

[Bryson, 1996] Bryson, S. E. (1996). Brief report: Epidemiology of autism. *Journal of autism and Developmental Disorders*, 26(2):165–167.

[Bulmer and Dew, 2002] Bulmer, L. and Dew, P. (2002). A study of collaboration using jigsaw puzzles. In *Proceedings of the 4th international conference on Collaborative virtual environments*, pages 157–158. ACM.

[Charman and Stone, 2008] Charman, T. and Stone, W. (2008). *Social and communication development in autism spectrum disorders: Early identification, diagnosis, and intervention*. Guilford Press.

[Chiasson and Gutwin, 2005] Chiasson, S. and Gutwin, C. (2005). Design principles for children's software. *Computer Science Department, University of Saskatchewan*.

[Christensen, 2016] Christensen, D. L. (2016). Prevalence and characteristics of autism spectrum disorder among children aged 8 years—autism and developmental disabilities monitoring network, 11 sites, united states, 2012. *MMWR. Surveillance Summaries*, 65.

[Clements and Sarama, 2003] Clements, D. H. and Sarama, J. (2003). Young children and technology: What does the research say? *YC Young Children*, 58(6):34–40.

[DiLavore et al., 1995] DiLavore, P. C., Lord, C., and Rutter, M. (1995). The prelinguistic autism diagnostic observation schedule. *Journal of autism and developmental disorders*, 25(4):355–379.

[Dix et al., 2003] Dix, A., Finlay, J. E., Abowd, G. D., and Beale, R. (2003). *Human-Computer Interaction (3rd Edition)*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA.

[Dominic Mazzoni, 2017] Dominic Mazzoni, Roger Dannenberg, A. T. (2017). Audacity (2.1.2).

[Druin, 1999] Druin, A. (1999). Cooperative inquiry: developing new technologies for children with children. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 592–599. ACM.

[Ehlers et al., 1995] Ehlers, S., Gillberg, C., and Schowalter, J. E. (1995). The epidemiology of asperger syndrome: A total population study. *Year Book of Psychiatry & Applied Mental Health*, 1995(3):40–41.

[Geretsegger et al., 2014] Geretsegger, M., Elefant, C., Mössler, K. A., and Gold, C. (2014). Music therapy for people with autism spectrum disorder. *The Cochrane Library*.

[Gillberg et al., 1991] Gillberg, C., Steffenburg, S., and Schaumann, H. (1991). Is autism more common now than ten years ago? *The British Journal of Psychiatry*, 158(3):403–409.

[Giusti et al., 2011] Giusti, L., Zancanaro, M., Gal, E., and Weiss, P. L. T. (2011). Dimensions of collaboration on a tabletop interface for children with autism spectrum disorder. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3295–3304. ACM.

[Gold et al., 2006] Gold, C., Wigram, T., and Elefant, C. (2006). Music therapy for autistic spectrum disorder. *The Cochrane Library*.

[Goldsmith and LeBlanc, 2004] Goldsmith, T. R. and LeBlanc, L. A. (2004). Use of technology in interventions for children with autism. *Journal of Early and Intensive Behavior Intervention*, 1(2):166.

[Guha et al., 2013] Guha, M. L., Druin, A., and Fails, J. A. (2013). Cooperative inquiry revisited: Reflections of the past and guidelines for the future of intergenerational co-design. *International Journal of Child-Computer Interaction*, 1(1):14–23.

[Harrold et al., 2012] Harrold, N., Tan, C. T., and Rosser, D. (2012). Towards an expression recognition game to assist the emotional development of children with autism spectrum disorders. In *Proceedings of the Workshop at SIGGRAPH Asia*, WASA '12, pages 33–37, New York, NY, USA. ACM.

[Hayes et al., 2010] Hayes, G. R., Hirano, S., Marcu, G., Monibi, M., Nguyen, D. H., and Yeganyan, M. (2010). Interactive visual supports for children with autism. *Personal and ubiquitous computing*, 14(7):663–680.

[Herbert, 2010] Herbert, M. (2010). The ipad—breaking new ground in special education @MISC.

[Hourcade et al., 2013] Hourcade, J. P., Williams, S. R., Miller, E. A., Huebner, K. E., and Liang, L. J. (2013). Evaluation of tablet apps to encourage social interaction in children with autism spectrum disorders. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3197–3206. ACM.

[Ishigaki et al., 1996] Ishigaki, E. H., Chiba, T., and Matsuda, S. (1996). Young children's communication and self expression in the technological era. *Early Child Development and Care*, 119(1):101–117.

[Kerr et al., 2002] Kerr, S. J., Neale, H. R., and Cobb, S. V. (2002). Virtual environments for social skills training: the importance of scaffolding in practice. In *Proceedings of the fifth international ACM conference on Assistive technologies*, pages 104–110. ACM.

[Kim et al., 2009] Kim, J., Wigram, T., and Gold, C. (2009). Emotional, motivational and interpersonal responsiveness of children with autism in improvisational music therapy. *Autism*, 13(4):389–409. PMID: 19535468.

[Koegel et al., 1994] Koegel, L. K., Valdez-Menchaca, M. C., and Koegel, R. L. (1994). Autism: Social communication difficulties and related behaviors. In *Advanced abnormal psychology*, pages 165–187. Springer.

[Koegel et al., 1987] Koegel, R. L., Dyer, K., and Bell, L. K. (1987). The influence of child-preferred activities on autistic children's social behavior. *Journal of Applied Behavior Analysis*, 20(3):243–252.

[Koegel et al., 2005] Koegel, R. L., Werner, G. A., Vismara, L. A., and Koegel, L. K. (2005). The effectiveness of contextually supported play date interactions between children with autism and typically developing peers. *Research and Practice for Persons with Severe Disabilities*, 30(2):93–102.

[Kruger et al., 2004] Kruger, R., Carpendale, S., Scott, S. D., and Greenberg, S. (2004). Roles of orientation in tabletop collaboration: Comprehension, coordination and communication. *Computer Supported Cooperative Work (CSCW)*, 13(5-6):501–537.

[Le Couteur et al., 1989] Le Couteur, A., Rutter, M., Lord, C., Rios, P., Robertson, S., Holdgrafer, M., and McLennan, J. (1989). Autism diagnostic interview: a standardized investigator-based instrument. *Journal of autism and developmental disorders*, 19(3):363–387.

[Levy et al., 2009] Levy, S. E., Mandell, D. S., and Schultz, R. T. (2009). Autism. *The Lancet*, 374(9701):1627–1638.

[Lord et al., 1994] Lord, C., Rutter, M., and Le Couteur, A. (1994). Autism diagnostic interview-revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of autism and developmental disorders*, 24(5):659–685.

[Lu and Frye, 1992] Lu, C. and Frye, D. (1992). Mastering the machine: A comparison of the mouse and touch screen for children's use of computers. In *International Conference on Computer Assisted Learning*, pages 417–427. Springer.

[MacLeod, 2017] MacLeod, K. (2017). incompetech.com.

[Mundy et al., 1996] Mundy, P., Hogan, A., and Doehring, P. (1996). A preliminary manual for the abridged early social communication scales (escs) 1996. *Unpublished manuscript, University of Miami, Coral Gables, Florida*.

[Piper et al., 2006] Piper, A. M., O'Brien, E., Morris, M. R., and Winograd, T. (2006). Sides: A cooperative tabletop computer game for social skills development. In *Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work*, CSCW '06, pages 1–10, New York, NY, USA. ACM.

[Ploog et al., 2013] Ploog, B. O., Scharf, A., Nelson, D., and Brooks, P. J. (2013). Use of computer-assisted technologies (cat) to enhance social, communicative, and language development in children with autism spectrum disorders. *Journal of autism and developmental disorders*, 43(2):301–322.

[Rogers, 2000] Rogers, S. J. (2000). Interventions that facilitate socialization in children with autism. *Journal of autism and developmental disorders*, 30(5):399–409.

[Rogers et al., 2006] Rogers, S. J., Hayden, D., Hepburn, S., Charlifue-Smith, R., Hall, T., and Hayes, A. (2006). Teaching young nonverbal children with autism useful speech: A pilot study of the denver model and prompt interventions. *Journal of autism and developmental disorders*, 36(8):1007–1024.

[Rogers and Lindley, 2004] Rogers, Y. and Lindley, S. (2004). Collaborating around vertical and horizontal large interactive displays: which way is best? *Interacting with Computers*, 16(6):1133–1152.

[Scaife and Rogers, 2001] Scaife, M. and Rogers, Y. (2001). Informing the design of a virtual environment to support learning in children. *International Journal of Human-Computer Studies*, 55(2):115–143.

[Schopler and Mesibov, 1986] Schopler, E. and Mesibov, G. B. (1986). *Social behavior in autism*. Springer Science & Business Media.

[Schuler and Namioka, 1993] Schuler, D. and Namioka, A. (1993). *Participatory design: Principles and practices*. CRC Press.

[See, 2012] See, C. (2012). The use of music and movement therapy to modify behaviour of children with autism. *Pertanika Journal of Social Sciences and Humanities*, 20:1103–1116.

[Shah, 2011] Shah, N. (2011). Special education pupils find learning tool in ipad applications. *Education week*, 30(22):1–16.

[Sharp et al., 2011] Sharp, H., Rogers, Y., and Preece, J. (2011). *Interaction Design: Beyond Human-Computer Interaction*. John Wiley.

[Shattuck, 2006] Shattuck, P. T. (2006). The contribution of diagnostic substitution to the growing administrative prevalence of autism in us special education. *Pediatrics*, 117(4):1028–1037.

[Shneiderman, 2004] Shneiderman, B. (2004). Designing for fun: how can we design user interfaces to be more fun? *interactions*, 11(5):48–50.

[Ståhl et al., 2002] Ståhl, O., Wallberg, A., Söderberg, J., Humble, J., Fahlén, L. E., Bullock, A., and Lundberg, J. (2002). Information exploration using the pond. In *Proceedings of the 4th International Conference on Collaborative Virtual Environments*, CVE '02, pages 72–79, New York, NY, USA. ACM.

[Tager-Flusberg et al., 2001] Tager-Flusberg, H., Joseph, R., and Folstein, S. (2001). Current directions in research on autism. *Developmental Disabilities Research Reviews*, 7(1):21–29.

[Tager-Flusberg et al., 2005] Tager-Flusberg, H., Paul, R., Lord, C., Volkmar, F., Paul, R., and Klin, A. (2005). Language and communication in autism. *Handbook of autism and pervasive developmental disorders*, 1:335–364.

[Tang, 1991] Tang, J. C. (1991). Findings from observational studies of collaborative work. *International Journal of Man-machine studies*, 34(2):143–160.

[Unity Technologies, 2017] Unity Technologies (2017). Unity(5.4).

[Weng et al., 2014] Weng, P.-L., Maeda, Y., and Bouck, E. C. (2014). Effectiveness of cognitive skills-based computer-assisted instruction for students with disabilities: A synthesis. *Remedial and Special Education*, 35(3):167–180.

[Wetherby and Prizant, 2002] Wetherby, A. M. and Prizant, B. M. (2002). *Communication and symbolic behavior scales: Developmental profile*. Paul H Brookes Publishing.

[Whipple, 2004] Whipple, J. (2004). Music in intervention for children and adolescents with autism: A meta-analysis. *Journal of Music Therapy*, 41(2):90.

Appendix A

Child Consent Form

Child Consent Form

To be used as a guide for securing consent or refusal, after the child has had a chance to get information about the study. The child may mark (or be helped to mark) this form, or the child's consent/refusal may be video-recorded.

I can choose to be a game/web developer.

I do not have to help if I don't want to.

I can decide to stop participating or take a break.

I do not have to say why.

It is OK if I change my mind later, and say I do not want to be a game/web developer any more.

It is OK if some parts of the game are hard for me!

There are no wrong answers to questions.

Anything I can do is helpful.

Do you want to be a games/web developer ? **YES □ NO□**

Kim and Helen will listen/watch to the recording later.

They will show it to other people who make games for children.

Is it OK to take an audio/video record? **YES □ NO□**

Write your name: _____

THANK YOU!

Appendix B

Parent/Guardian Consent form

Research permission form (for parents)

	Please circle
Have you read the information sheets?	YES / NO
Have you received enough information about the study?	YES / NO
Do you understand that participation is completely voluntary and your child can leave the study at any time, without having to give a reason?	YES / NO

Please sign this page to indicate that you understand and accept the conditions of this study, including audio and video recording. By signing, you agree that the researchers may explain the study to your child and invite him or her to take part as a game/web designer.

With reference to further anonymous use of photographic,audio or video data, please circle yes or no in response to the following:

I AGREE that short videos/images of my child can be used as examples in documents and presentations for research and/or teaching purposes.
YES / NO

If you give permission for this study, please return this form to the researchers.

If you DO NOT wish to give permission, you do not need to return this page. We will not ask your child to participate.

Full name of participating child:

Child's date of birth (DD/MM/YYYY): _____/_____/_____

Your relationship to the child:

Your name (please print clearly

Contact telephone number: _____

E-mail address: _____

Best time and method to reach you?

Signature:

Date: _____/_____/_____

Appendix C

Expert Consent Form

Participant Consent Form

Developing Educational Games for Teaching Children with ASC

You may withdraw from the research study at any time without explanation. You can ask any data you have supplied to that point be withdrawn/destroyed. You can omit or refuse to answer to any question that is asked of you. Please, feel free to ask any question related to this study at any time.

All recorded data will be anonymised for reporting purposes, and only used in the scope of this project.

Have you been informed about the project by the researcher ?	YES / NO
Have you received enough information about the study ?	YES / NO
Are you taking part in this research voluntarily ?	YES / NO
Do you agree to be voice recorded during the session ?	YES / NO

Participant's Signature:

Date: _____/_____/_____

Appendix D

Children Participation Certificate 1

Appendix E

Children Participation Certificate 2