Music Explorer - Developing A Game To Encourage Emotion Expression Through Music In Autistic Children

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Abstract

Development in the areas of social communication and interaction are crucial facets of child development which also prove to be challenging to autistic children. This can pose an obstacle in their need for self-expression. And yet, long-term suppression of self-expression can be harmful to their mental and physical health. At the same time, music is among common interests in individuals with autism spectrum condition (ASC), and can provide an effective channel for emotional communication. This research aims to iteratively design and develop an educational game to encourage emotion expression through music in children with ASC. This is supported through results of participatory design activities with typically developing children and experts from relevant domains of game development, educational technology, HCI and psychology. Evaluation with typically developing children and experts indicated that the game developed has a potential to encourage emotional expression through music in children with ASC.

Contents

Chapter 1

Introduction

1.1 Encouraging emotional expression through music

Development in the areas of social communication and interaction are crucial facets of child development which also prove to be challenging to autistic children (Levy et al., 2009). A large proportion of them are also alexithymic (Griffin et al., 2016), which affects their ability to recognise and express their own emotions. To bypass their verbal communication impairments, communication through music can be utilised as an alternative, unaffected channel, especially in the area of emotion communication (Alvin, 1991; Allen and Heaton, 2010; Geretsegger et al., 2014). It might not only be an unaffected area but one of special interest to many autistic individuals (Allen et al., 2009; Molnar-Szakacs and Heaton, 2012).

This dissertation focuses on designing, developing and evaluating a game to support autistic children in familiarising with basic musical concepts and their relationships with emotions expressed in music, with the ultimate goal of encouraging and facilitating their emotional expression. A clear distinction between expression and communication will be defined for the purpose of this research. Communication involves at least two persons whereas expression can involve only one person with support of some tool, such as a musical instrument or a game. By encouraging emotional expression, the researcher means both the use of in-game functionality for creating musical messages, which can optionally be shared with others but also as a springboard for communication about emotions, using the game as a starting point. Due to varying developmental, cognitive and intellectual levels of the autistic population, it becomes important to aid their communicative and expressive needs in an inclusive way.

1.2 Research goals

This research investigates how to design a game for children with ASC that would encourage emotion expression through music. The following research questions are to be addressed:

1. To what extent is music an appropriate tool to facilitate emotion expression in children with ASC?
2. Is a tablet based game an appropriate vehicle for encouraging emotion expression in children with ASC through music?

1.3 Dissertation structure

The rest of this dissertation has the following structure:

Chapter 2 provides an overview of relevant literature on autism spectrum condition (ASC), emotion-related impairments, technology based interventions and applications, as well as design guidelines. This chapter gives a rationale for this research and presents the necessary steps to achieve the research goals set above.

Chapter 3 presents and justifies the initial game concept development.

Chapter 4 provides an overview of participatory design activities with typically developing (TD) children and experts from relevant domains, and how these informed further game design.

Chapter 5 describes game design and development iterations, interleaved with expert interviews that further informed the game design.

Chapter 6 details evaluations of the game with TD children and experts.

Chapter 7 provides conclusions on the research, as well as suggestions for potential future work.

Chapter 2

Literature review

2.1 Autism Spectrum Condition (ASC)

Autism spectrum condition (ASC) is a lifelong, neurodevelopmental condition that affects roughly 1 in 100 people (Brugha et al., 2012). It is often said that if you have met one person with autism, you have met one person with autism: given that autism is a spectrum condition, this can be interpreted as signifying the different, unique ways in which ASC manifests itself in, and affects, every autistic individual. Still, there are several terms and profiles used to describe certain autistic profiles according to different diagnostic tools. ICD-10 and DSM-5 are the most commonly consulted diagnostic manuals for assessing autism in individuals, with the former most commonly used in the UK (The National Autistic Society, 2016). According to ICD-10, ASC is *marked by the presence of markedly abnormal or impaired development in social interaction and communication and a markedly restricted repertoire of activity and interest* (ICD10Data.com, 2018). DSM-5 similarly associates ASC with *persistent deficits in social communication and social interaction* and *restricted, repetitive patterns of behavior, interests, or activities* (APA, 2013). Despite some differences between diagnostic manuals, and various changes introduced over time to diagnostic criteria for ASC, three common areas of deficits can be identified, also commonly called the *triad of impairments*: social interaction, social communication and social imagination (Wing and Gould, 1979). Difficulties in social interaction affect social relatedness and the ability to initiate and maintain social interactions. Communication deficits encompass difficulties in understanding non-verbal cues such as facial expressions or body language, and linguistic subtleties such as sarcasm. Problems relating to social imagination, on the other hand, often manifest themselves in repetitive behaviour, especially self-stimulatory behaviour (*stimming*) as well as rigidity of thinking (Levy et al., 2009).

There are a number of common co-occurring conditions often present in autistic individuals, which can affect both symptoms of autism and the effects of treatment interventions. Many autistic people experience sensory hyper- and hypo-sensitivities, enhanced perception to sensory stimuli, and/or exhibit sensory seeking behaviours across different sensory modalities (Baranek et al., 2014). Alongside core differences asso-

ciated with ASC, sensory differences in autistic children can have a significant impact on the extent to which they participate in a variety of activities both within and outside their homes, thus affecting their opportunities for learning and development (Little et al., 2015). On the other hand, some researchers have postulated that sensory hypersensitivity in autistic individuals contributes to a unique cognitive style of processing (Baron-Cohen et al., 2009), which results in commonly observed exceptional attention to detail (Shah and Frith, 1993; Jolliffe and Baron-Cohen, 1997; O'riordan et al., 2001) and strong preference for systemising things around them (Baron-Cohen et al., 2009).

2.2 Alexithymia

Alexithymia is also among traits that have a high co-occurrence among individuals with ASC, and affects an estimated 40-65% of adults with ASC (Hill et al., 2004; Lombardo et al., 2007; Bird and Cook, 2013). Similarly as for autistic adults, alexithymia can be identified at higher frequency of occurrence in children with ASC, and awareness of this observation can be crucial in the choice of effectively tailored early interventions (Griffin et al., 2016). First systematically defined by Sifnos (1973), alexithymia is marked by reduced emotional competence, and commonly differentiated into two types: type I alexithymia associated with reduced emotional responsivenesss, and type II alexithymia, whereby emotion perception is not hindered but the ability to identify and describe one's emotions is. Type II alexithymia is the one commonly affecting autistic individuals (Berthoz and Hill, 2005). A number of studies (e.g. see meta-reviews in Bird and Cook (2013); Uljarevic and Hamilton (2013)) point towards alexithymia as the mediating factor contributing to reduced emotional recognition and expression in the autistic population. As noted by Griffin et al. (2016), alexithymia is in essence a deficit in self-referential emotion processing, and given various results suggesting overall deficits in self-concept, self-referential cognition and memory in the autistic population (Lombardo et al., 2007; Williams and Happé, 2010; Grisdale et al., 2014), both aspects can have a compounded effect on the ability of an autistic individual to understand and express her feelings. Rieffe et al. (2011) highlight the growing body of research on the co-occurrence of internalising problems, such as anxiety and depression, among the autistic population. Emotion awareness has been found to be negatively related to anxiety, depression, worry and rumination, both in typically developing (TD) and ASC population (Rieffe et al., 2007, 2008, 2011). In combination with issues associated with social communication, alexithymia can easily lead to unhealthy, and sometimes involuntary, suppression of emotions, which can negatively affect autistic individuals mentally and physically.

Among TD alexithymic individuals, psychotherapy is a commonly chosen form of treatment (Hungr et al., 2016), although symptoms of both alexithymia and ASC can prove prohibitive in deriving full benefits from typical psychoanalytic psychotherapy (Guttmacher, 1990; Klin and Volkmar, 1995). The very central parts of psychotherapy, such as sharing of subjective, emotional experiences, are also ones that alexithymic autistic individuals struggle with (Hungr et al., 2016).

It is notable that Bird and Cook (2013) collated results of multiple studies on autistic individuals using methods such as functional magnetic resonance imaging studies, evaluation of the target's group emotional competence through emotion recognition of facial expressions, as well as rating of emotionally-laden prosodic or musical extracts, and found the effects of alexithymia on impaired emotion processing in the population with ASC. A parallel strand of research has found that emotions in music are recognised and processed on the same levels when comparing neurotypical (NT) and autistic individuals. Caria et al. (2011)'s findings point towards different patterns of brain activations when ASC and TD individuals listen to music but postulate that emotion perception is relatively intact in the autistic population. Allen et al. (2013) described a study using happy, sad and scary emotional dimensions in musical extracts, which was conducted on adults, and showed that after accounting for poorer ability to articulate emotional responses mediated by alexithymia, autistic individuals perceived emotions similarly as typically developing controls. Quintin et al. (2011) also found that adolescents with ASD can recognise happy, sad, scary and peaceful music similarly as TD peers, whereby emotion labels with faces were used. In fact, Heaton et al. (1999) used happy and sad musical pieces in minor and major modes, with children asked to assign schematic faces corresponding to these two emotions, and the results showed no significant difference between the autistic and TD population. Thus, as a seemingly unimpaired channel of emotional communication, music could be utilised to provide an alternative mode of emotional expression to alexithymic autistic individuals across different chronological and developmental ages.

2.3 Music and music-related interventions

Music's inseparable connection with other domains of life, including its role in various social contexts, is indicative of music's versatility and adaptability to various settings (Bogost, 2011). It has also been suggested that children with ASC demonstrate special preference and skills in music (Allen et al., 2009; Molnar-Szakacs and Heaton, 2012). In the preface to her book, *Music Therapy for the Autistic Child*, Juliette Alvin, a significant figure in the field of music therapy research, said: *One of the reasons for the attraction of music is that it bypasses language, which is a problem for most autistic people. Another is that music is a path to the world of feeling and emotion, a world which seems alien to the world of autist* (Alvin, 1991). It has been found that music is processed by different brain areas than language or speech, thus explaining claims that music can bypass language impairments (Detmer, 2017). Therapeutic benefits of music have been known for centuries (Hadley et al., 2001), although the emergence of music therapy as an established research field happened relatively recently, in the 20th century (Fang, 2010). Whipple (2004) refers to beneficial results of music-based interventions for young autistic individuals. Notably, music therapy has been recognised as an effective approach to develop skills in emotional communication and social interaction (Baron-Cohen and Bolton, 1993; Aarons and Gittens, 2002; Geretsegger et al., 2014; See, 2012; Ghasemtabar et al., 2015). Music therapy stimulates multiple senses as in music therapy sessions, the therapist and the client often combine

singing, movement and music making on different instruments to stimulate auditory, visual and kinaesthetic stimuli (Alvin, 1991; Trevarthen, 1998); and this multimodal facet of music can help address an autistic individual's sensory preferences. Music therapy has a particularly inclusive character, as clients of different skills and abilities can learn to appreciate and actively participate in music making, both through more structured and free-form musical activities (Fang, 2010). Through observation, the therapist finds inspiration in the client's actions or utterances, replicating them in their own way to emulate the client's own non-verbal language (Alvin, 1991). This inclusive, collaborative dimension of music therapy helps the client learn to express herself and form a social bond with the therapists, which can also lead to improvements in socio-emotional domains outside of the therapeutic context (Fang, 2010). Not only is the collaborative music making a chance to practice social interaction but perhaps also to teach the client that music as a common interest can be a pretext for initiating and maintaining relationships with others, thus addressing an area that autistic people struggle with. In addition, a mixture of more structured and improvised activities embedded within music therapy session allows the autistic child to learn to how to adapt to change, a skill necessary to deal with the unpredictability of the outside world (Flower and Oldfield, 2008; Wigram et al., 2008). Among TD children, music is often used for mood regulation, enhancing focus and exploring imagery depicted in music, with reports of not only general liking of listening to music but also active use of music by the child to self-regulate emotionally (Saarikallio, 2009). Similar use of music for mood management has been reported for autistic adults (Allen et al., 2009). Among recommended uses of music for autistic children are also the use of contingent music to maintain attention and/or provide positive reinforcement, as well active music making as a form of behavioural and emotional self-regulation (Detmer, 2017). Given that music can be engaging and effective for the target population, music (not only in the context of music therapy) has been recommended widely as a therapeutic tool for improving recognition or expression of emotions (Kaplan and Steele, 2005; Katagiri, 2009; Allen and Heaton, 2010; Geretsegger et al., 2014).

In regard to specific emotion-centred musical interventions, some limited research can be found. Building on the findings suggesting music as an effective channel for communication of emotional messages, Allen and Heaton (2010) suggests a method whereby alexithymic autistic participants learn to associate pieces of music with a certain emotion – and then learn to link it with a linguistic label. Katagiri (2009) suggest that the use of background music depicting a particular emotion along verbal instruction can be used effectively to increase emotion understanding in children with ASC. Tan and Khetrapal (2016) propose an intervention where pictures from the Picture Exchange Communication System, a common communication tool used with autistic children, are to be used in conjunction with emotional music extracts to address deficits in emotional self-awareness. Authors postulate that such multisensory (visual + auditory) approach should enhance emotional experiences, which subsequently can lead to developing emotional regulation and communication skills. Interestingly, Tan and Khetrapal (2016) envision as an extension a musical app for a smart device (such as iPad) that would provide rehabilitative and/or therapeutic benefits to the autistic child both outside and within their home environments.

2.4 Technology

Over recent years, technology-based interventions and therapies have gained recognition among researchers and practitioners with respect to their effectiveness in enhancing social, communicative and behavioural skills among the autistic population (Grynszpan et al., 2014). Similarly, computer-assisted learning (CAL) approaches have been more widely used in facilitating development of a variety of skills among individuals on the spectrum (Fletcher-Watson, 2014), including social and emotional skills (Ramdoss et al., 2012). In fact, (Grynszpan et al., 2014) found significant evidence in support of technology-based interventions. Computers have a special advantage in relation to the needs and preferences of the autistic population, as they provide predictability, consistency and are free from social demands associated with interactions with other people (Moore et al., 2000; Mineo et al., 2009; Murray, 2011). (Hahna et al., 2012) also found that music therapists were more likely to use music technology with adolescents and clients who experience cognitive, developmental, intellectual and other disabilities, which could suggest that therapists try to tap into technology as a supporting tool for more effective or suitable administering of therapy, taking into account clients abilities and preferences. There is evidence that the use of computers can provide engagement and motivation when children with ASC learn from CAL systems (Williams et al., 2002). Motivation and engagement are typically linked with better learning outcomes (e.g. Rowe et al. (2011)). This has lead to the emergence of game-based learning as an independent research strand, where the purpose is to combine intrinsically motivational features of games with opportunities for learning (Malone, 1987).

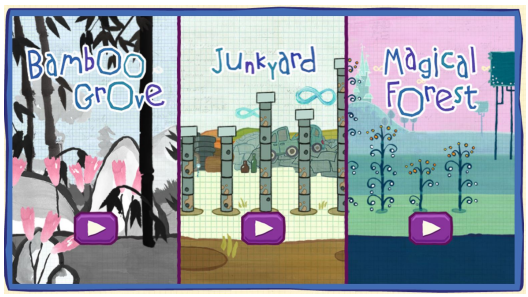
Games are also commonly of particular interest in the view of an autistic individual (Mazurek et al., 2015), which has informed the development of game-based interventions (Moore and Taylor, 2000; Ferguson et al., 2012; Grynszpan et al., 2014). Mazurek and Wenstrup (2013) find that children with ASC spend more time then their TD peers playing video games, and confirm strong preference for video games among autistic children. Among reasons suggested for this liking towards video games are: general preference towards visual stimuli, structure and ”structured flexibility” (i.e. choice from predetermined options), as well as chance for mastery, achievement and in-game rewards (Mazurek and Wenstrup, 2013; Mazurek et al., 2015). Perhaps unsurprisingly, a majority of them also like playing games simply because they bring enjoyment and entertainment (Mazurek et al., 2015). There are also suggestions that many autistic individuals turn to video games as a way to reduce stress (Mazurek et al., 2015), which can be a significant phenomenon for further research given the high co-occurrence of alexithymia, anxiety and other psychosomatic conditions among the group. On the other hand, there are mixed results relating to social reasons of playing games among the autistic population (Mazurek and Wenstrup, 2013; Mazurek et al., 2015). However, the effectiveness of technology-mediated interventions addressing social deficits offer a promise that, with the assistance of a computer, social interaction and communication might be easier for the target population.

Due to limited work on interventions and technologies that combine music and emo-

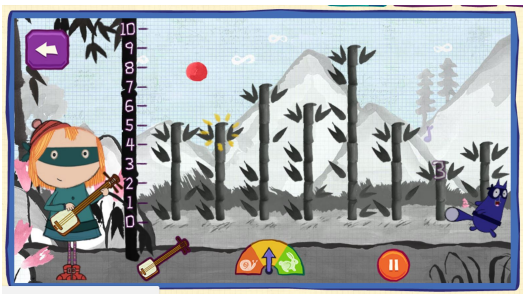
tions, and are intended for the target population, a number of solutions that allow exploration and/or self-expression through music are further reviewed.

2.4.1 Music Maker

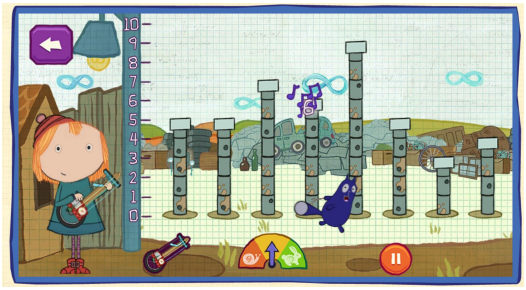
Kersten (2006) recommends music-related resources and games from PBS Kids website for children to explore various musical concepts. In particular, the *Music Maker* game was considered a particularly relevant music-centred game. *Music Maker* allows the player to explore the notion of pitch and speed and compose a short melody line. Two virtual agents appear throughout all three levels of the game and act as game companions and motivators. The presence of virtual agents have been found to contribute to better engagement in learners (Johnsen et al., 2007; McQuiggan et al., 2008b). Notably, graphical visualisations and the appearance of virtual characters changes between levels, providing variety to the game. The sceneries (i.e. bamboo groove, junkyard and magical forest) have relatively neutral connotations, lending themselves to being appropriate visual backgrounds to more free expressiveness through music made within the game.



(a) Overview of levels.



(b) Bamboo Grove level.



(c) Junkyard level.

(d) Magical Forest level.

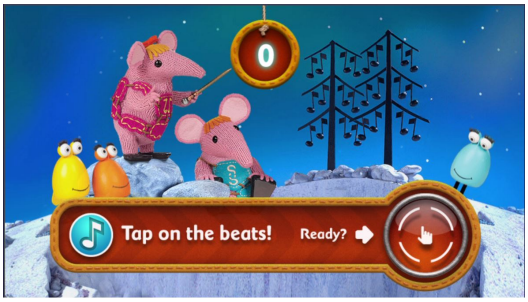
Figure 2.1: PBS Kids game - Music Maker.

2.4.2 Tiny's Tunes

Another relevant game taken from the website accompanying a kids TV channel *Sprout* is *Tiny's Tunes*. *Tiny's Tunes* is a rhythm game, quite similar in principle to the popular Guitar Hero. Rhythm games are said to have changed the ways in which people engage with music (Bogost, 2011). It has been reported that music games are a quite

commonly played game genre among young people, with as many as 20% of players developing an interest in taking up a musical instrument as a result (Ahmed, 2008). By considering rhythm games, Bogost (2011) noticed a particularly important commonality between music and games: *both are* playable, *offering their listeners and operators an expressive experience within the framework of melody and rhythm*. Within Tiny's Tunes, with a musical piece being played in the background, the user needs to press a mouse button whenever a note icon slides through a highlighted target area. When the button press is correctly synced in time with the note aligning within the target area, the target area is highlighted in green and a corresponding sound is produced, reinforcing the main melody of the background music and providing auditory feedback on the player's performance. The scoring system distinguishes between three different types of button press timing - correct (described above), which adds 1 point for each note; slightly off, where the target area is highlighted in yellow and no point is added (Figure 2.2d); and wrong, where the target area is highlighted in red and the total score is completely zeroed.

(a) Main menu.



(b) Instructions.

(c) Typical game play.

(d) Note pressed slightly off-beat – yellow outline used as visual feedback.

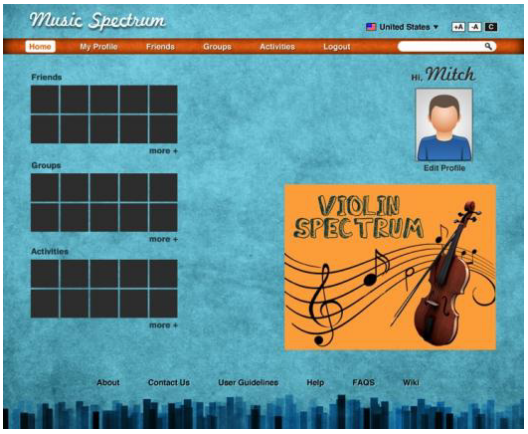
Figure 2.2: Sprout's game - Tiny's Tunes.

2.4.3 Music Spectrum

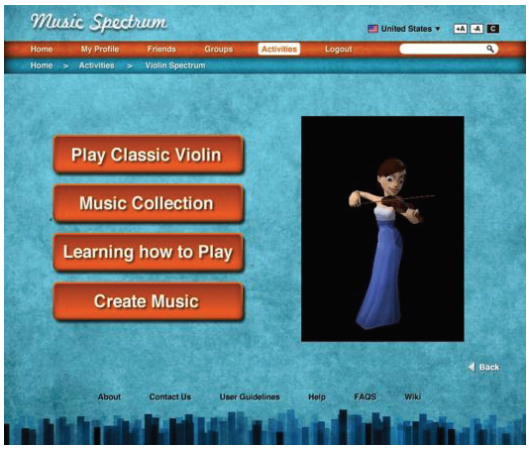
Music Spectrum is a musical game embedded in a virtual reality environment designed to promote engagement in music activities in autistic children, with the ultimate goal of developing their social interaction skills through group music making (Lima and Castro, 2012). At an initial phase of implementation, the game was developed for tablet devices. The game allows the player to explore different instruments by playing

it through the simulated environment, either as a guided or free-form activity (Figure 2.3c). As the player makes music, a musical score appears on the screen, and the composition can be saved and later retrieved (Figures 2.3c, 2.3d). Notably, the game incorporates components inspired by social networks, whereby the player can set up an account to connect with her friends and perform group musical activities with the support of the Music Spectrum app (Figures 2.3a, 2.3b).

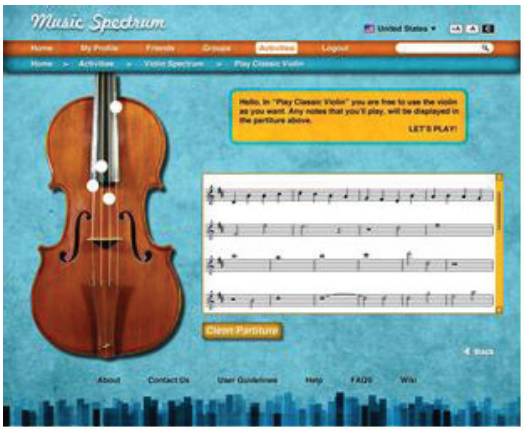
(a) Music Spectrum - login page, by David Lima and Thais Castro, 2012.



(b) Music Spectrum - initial screen, by David Lima and Thais Castro, 2012.



(c) Music Spectrum - exploring the violin, by David Lima and Thais Castro, 2012.



(d) Music Spectrum - musical score appears as the user plays the instrument, by David Lima and Thais Castro, 2012.

Figure 2.3: Music Spectrum.

2.4.4 Skoog

Skoog is an accessible musical instrument in the shape of a black cube with colourful buttons on its sides. By syncing it with music applications on iPad, such as GarageBand, Skoog can produce sounds from a wide range of traditional and electronic instruments, making it a versatile tactile game controller. Skoog was designed with accessibility in mind, making its use suitable in various settings with individuals with physical or developmental disabilities (Skoog, 2018). Skoog has been adopted by

many music therapists as part of their sessions while working with autistic patients (Schögler, 2016; Smith, 2016; Skoog, 2018). For instance, Autism Spectrum Australia, a charitable service provider for autistic individuals incorporated Skoog as part of music therapy sessions to support music creation and creative play, both in structured and more unbounded activities (Smith, 2016). Skoog can be of particular benefit as an alternative to conventional instruments in that it allows individuals with autism to express themselves musically despite their communicative deficits (Singleton, 2017).

Figure 2.4: Skoog by Skoog Music (n.d.)

2.4.5 Autism Emotion

Autism Emotion is an application for Apple mobile devices that uses a photo slideshow, text captions and music to provide contextualised learning about different emotions (Autism Speaks, nd). The emotions explored in the application are: happy, sad, proud and calm (Figure 2.5a). Example scenarios are presented in each slideshow, with text captions describing the situation to provide hints for the user to deduce the intended emotion (Figure 2.5b). The second to last photo is always accompanied by a question asking the user to identify the relevant emotion (Figure 2.5c). The last slide reveals what the emotion actually is, and allows the user to listen to a music piece about the emotion (Figure 2.5d). The app is audio narrated and the songs are sung and recorded by a music therapist (Autism Speaks, nd). The app draws from the work on video modelling for social skills training (Autism Speaks, nd), a method used widely to teach a range of skills in individuals with ASC (Coyle and Cole, 2004; Buggey, 2005; MacDonald et al., 2005).

2.5 Design

In order to design a game suitable for children with ASC, a number of resources relevant to the target population were consulted. Key design guidelines and recommendations can be found below.

(a) Autism Emotion - main menu with emotions that can be explored.

(b) Autism Emotion - example photo with accompanying descriptive text.

(c) Autism Emotion - question to gauge emotion recognition.

(d) Autism Emotion - final screen accompanied by a song about the emotion.

Figure 2.5: Autism Emotion.

1. **Platform**. In relation to platforms for which computer-based applications are designed for the target population, touchscreen devices are a common choice (Chen, 2012; Kagohara et al., 2013). Chen (2012) suggests a number of advantages of touchscreen devices over mouse and keyboard operated PCs. Firstly, they allow for rough motor skills and less precise manipulation. This can be more appropriate when considering the varying levels of sensory sensitivity and coordination skills found among people with ASC (Chen, 2012). Another important facet of touchscreen interfaces is that they afford direct manipulation of objects within an application, creating opportunities for communication through gestures and other non-verbal channels (Chen, 2012). Touchscreen are also said to be easier to operate by younger children (Chiasson and Gutwin, 2005).

2. **Presentation and navigation**. It is suggested that individuals with ASC process visual stimuli differently (Kemner et al., 2007; Speer et al., 2007), which, in the context of computer-based applications, can reflect on their reading and processing of graphical content. Text heavy interfaces are also less appropriate given varying literacy skills among children (Chiasson and Gutwin, 2005). Contrast between font and background is recommended, as well as use of soft, mild colours (Pavlov, 2014). Where realism is not important, use of schematic, simple graphics should be more appropriate (Pavlov, 2014; Fletcher-Watson, 2014). Clear, sans-serif fonts are also likely to be better for legibility (Pavlov, 2014). Use of clear, large, buttons with icons conforming to familiar metaphors is recommended for more intuitive use (Shneiderman, 2004; Chiasson and Gutwin,

2005; Pavlov, 2014).Simple, clear navigation is recommended (Pavlov, 2014).

3. **Consistency**. In general, interfaces intended for the target population should conform to their affinity for structure, order and routine (Hersh, 2016). However, if changes are introduced methodically, this can be well received by children with ASC (Alcorn et al., 2011). In general, engendering curiosity through inclusion of novel and surprising elements has been recommended in designing motivating learning environments (Malone, 1987).

4. **Guidance**. Instructions should be clear, compact, and easy to understand and remember, and appropriate scaffolding should be provided to support the child in task accomplishment (Chiasson and Gutwin, 2005; Pavlov, 2014). Abstract concepts should be avoided in favour of concrete representations, given difficulties in understanding non-literal communication among children with ASC (Happé, 1995; Chiasson and Gutwin, 2005). It is also recommended to structure tasks in increasing difficulty to allow for practice and gaining familiarity with the interface and required actions (Chiasson and Gutwin, 2005).

5. **Feedback**. Immediate feedback contingent on user's action also recommended to maintain user attention and focus on learning goals (Moore and Calvert, 2000; Chiasson and Gutwin, 2005). Loading of content should be fast but where not possible, visually indicating that something will be time-consuming is likely to be better (Chiasson and Gutwin, 2005; Pavlov, 2014). A computer-based game can also effectively embed rewards within its environment, something that can prove more challenging in a traditional classroom environment (Fletcher-Watson, 2014). Progress should be displayed clearly if relevant to the task (Chiasson and Gutwin, 2005).

6. **Customisation**. This relates to both customisation of content relating directly to what is being learned, as well as more incidental elements, such as rewards. For example, social stories that allow the learner to use bespoke images and text were found to be more effective (Gray and Garand, 1993). In addition, Bernard-Opitz et al. (2001) found that children with ASC were more likely than their TD peers to choose sensory rewards (e.g. animation of dynamic spirals) over natural rewards (i.e. associated with the context presented in the learning content). Customisation is important in making the technology adaptive to an autistic child's needs, preferences and interests, especially with respect to their sensory differences (Fletcher-Watson, 2014; Hersh, 2016). It can also give the child a sense of control, where the perception of control is known to have motivational benefits for learning (Malone, 1987). Druin and Inkpen (2001) also suggest that children associate fun with having control.

7. **Creativity**. Technology can provide an avenue for a child's expressive needs (Druin and Inkpen, 2001), which, perhaps contrary to the common deficits in imagination associated with ASC, are among needs of an autistic individual when interacting with computer games (Mazurek et al., 2015).

2.6 Methodology

Khaled and Vasalou (2014) highlight that in the field of serious games (which encompasses educational games), the design process often involves users, if at all, towards the end phases of game development. Some authors cite difficulty in engaging children in the whole design process due to their limited domain knowledge (Tan et al., 2011; Mazzone et al., 2008). On the other hand, Khaled and Vasalou (2014) acknowledge that children's knowledge about game mechanics can still prove beneficial in enhancing game design. Authors suggest that children can be most effective design partners in the middle stages of game development, when a more concrete boundary object exists to provide support to participants' creativity.

Participatory design (PD) is a design methodology whereby representatives of the target group are involved as equal design partners alongside core researchers and designers of a project (Floyd et al., 1989). It has been suggested that when designing technology for non-mainstream users, participatory design is recommended (Guha et al., 2013). Fletcher-Watson (2014) highlights the importance of consulting decisions around technology aimed at the autistic community, both by involving end users through participatory design, as well as consultation with their support network, such as teachers, parents, care-takers. In designing technology for children with autism, it becomes even more important to involve them in the design process, as neurotypical (NT) researchers and designers may not be aware or fully understand the experiences of this user group. Social difficulties of children with ASC mean, however, that certain components of the PD approach such as interaction with researchers and designers who might be strangers, or imagination-intensive activities like brainstorming and prototyping may prove too challenging to the target group, thus outweighing the benefits of engaging them in cooperative design efforts.

Certain methodologies devised specifically for designing with and for children with autism such as IDEAS and ECHOES have been created and successfully applied within the PD framework (Benton et al., 2011). At the same time, Benton and Johnson (2014) showed that utilising PD approaches developed to design technology with and for autistic children (such as IDEAS) can be beneficial to their TD peers as well.

Due to uncertainty around the relative advantages of involving the target group directly, it was decided that proxies will be involved instead. This will address the researcher's knowledge gaps while still benefiting from consulting opinions with relevant stakeholders through a process of triangulation of information (Herriott, 2015). In particular, parties used as proxies for children with ASC will be: typically developing children, adult individuals that either have experience of autism themselves, or have close relationships with autistic children, as well as researchers in related disciplines. The first group will further be referred to as children or TD children, whereas the rest will be referred to as experts. They will be consulted to provide different types of expertise to inform the design and development of the game. Use of proxies in addressing design requirements of children with special needs to which access might be limited has precedent in works such as Randolph and Eronen (2007)'s where TD children were consulted as proxies, and De Leo and Leroy (2008)'s where teachers of

autistic children were involved. Inspired by Benton and Johnson (2014), certain principles adapted from the IDEAS were subsequently incorporated to benefit TD child participants. These included:

1. Meeting with child participants in a quiet and familiar environment.
2. Adult support for engagement.
3. Demonstration of existing technology to scaffold design efforts.
4. Use of structure and order in the design activities, e.g. by using design templates to prompt ideation, and clear explanation of activities.
5. Flexibility - allowing for different modes of expression, e.g. writing, talking, drawing, as appropriate for participants' development stage and skills.

2.6.1 Game development plan

Due to the complexity of different ideas, perspectives and decisions to be considered throughout the game development process, a clear plan was set out to guide the research, as shown in Figure 2.6.

Figure 2.6: Game development plan

Firstly, the research focused on a comprehensive literature review to better understand the current state of research in relevant domains, identify where this research will fit, and in what way can the goals of the research be achieved most effectively (*Literature review*). To support an informed development process, the game will be designed and implemented iteratively using participatory design approaches through consultations with TD children and experts from relevant domains (*Pre-design, Design, Prototyping*). The rationale behind this approach is to incrementally refine the game idea into a concrete, tangible prototype and bridge the gap between initial game design and final implementation. In the end, the game will be evaluated by TD children and experts to assess its fitness for purpose (*Evaluation)*.

Chapter 3

Game idea development

3.1 Core goal

Considering findings from Khaled and Vasalou (2014), initial stages of game design can be challenging for children involved in participatory design sessions as these might be too open-ended and not focused enough. As such, it was decided that developing an initial game concept beforehand should help support idea generation in participatory design endeavours described in Chapter 4.

The initial goal set out for the game was to encourage emotion processing and expression through music. Informed by the approach developed by Tan and Khetrapal (2016), it was considered that first teaching about recognising emotions with support of music, and then allowing the player to apply that knowledge to express emotions musically would be an appropriate way of developing relevant skills. In other words, it would have to be a game that would teach about emotion recognition and expression through music. However, the ability to recognise emotions and express them are two distinct aspects that need to be learned. Tan and Khetrapal (2016) proposed a multimodal approach, where music was supported through visual imagery to help both in emotion recognition and further encourage communication. At the same time, narrative has been widely researched as a vehicle to support more contextualised learning opportunities (Marsella et al., 2003; Johnson, 2007; McQuiggan et al., 2008a). In addition, the work of Nelson (2016) suggested preliminary potential for enhancing emotion skills teaching to children with ASC through narrative. Narrative is known to improve motivation and involvement with the learning content (Rowe et al., 2007; McQuiggan et al., 2008a).

3.2 Game design 1

With these considerations in mind, it was decided that the game will feature a contextualised comic-story based plot that would show the main character, Timid Timmy, in

different scenarios taken from a day of his life, where he would experience certain emotions (informed by Tan and Khetrapal (2016) and Nelson (2016)). This would provide situational context to exploring emotions. Apart from that, musical minigames would introduce the notion of emotional expression through music, and the general task of the minigame would also be tied with Timmy's story, posed as a request for help from the player to support the main character in collecting clues suggesting what the emotion he felt in the scenario was. Such framing of the task is likely to result in more user engagement due to creating a sense of control (Malone, 1987). The clues would ideally be hints, such as physical symptoms of particular emotions, that could be conceptualised as compact, visual items – something akin to collectibles, a common trope from computer games. To focus the scope of the game, four emotions were chosen, based on Tan and Khetrapal (2016), and these were: *happy, sad, angry, scared*.

Furthermore, the main ideas and mechanisms from two musical games presented in Section 2.4 were considered as guidance in the initial design phase, with the aim to elicit ideas for similar musical games from child designers in the next planned stage of game development described in Chapter 4. Taking inspiration from the games *Music Maker* and *Tiny's Tunes*, musical minigames were envisioned to include multimodal cues such as visual imagery, music and vibrations, grouped through a coherent theme to reflect particular emotions, to allow the player to explore emotions in a multisensory way, attending to different sensory preferences of the target user group. The musical minigames were intended to symbolise Timid Timmy's introspection, as a kind of parallel universe of what is happening in his head, and incorporate some music therapy techniques such as customised improvisation-based communication. Although the metaphor of parallel universe could be challenging to take in given the target population's inclination to interpret communication literally (Happé, 1995), it was felt that this should not be an obstacle to understanding the purpose of the game. By including the mechanism of collecting clues about the emotion being felt by the main character, the aim of the musical minigames was to denote the process of identifying and making sense of what the emotion actually is. Returning to the comic-based story would then mean that the main character has recognised what he felt and can communicate it with others.

Chapter 4

Informing the design

Fletcher-Watson (2014) recommends consulting decisions around technology aimed at the autistic population with all relevant stakeholders. As a way of addressing the researcher's knowledge limitations, clarifying conflicting suggestions, and gaining insight into other perspectives, consultations with TD children and experts from relevant domains were scheduled to inform game design. Although they do not possess complete understanding about the experience of ASC, which would be available from an autistic child, it is hoped that assembling their partial domain knowledge together can provide useful findings to further inform the game design.

4.1 Design workshops with children

The main purpose of conducting design workshops was to inform the game design. Specifically, the two main aims were to supplement gaps in the knowledge domain and enrich initial game ideas in a way that would be more appealing to children. Children that participated in the workshops can be clustered into two distinct groups. The first group mainly consisted of children of the Informatics staff. The second group comprised children from a girl scout group ("Brownies"). Some children in both of these groups have previously participated in similar game design workshops. To the researcher's best knowledge, all of the participants were typically developing children, aged between 6 and 13. This wide age range of participants aimed to match varying developmental levels of children with ASC. Given the prevalence of autism, there was also a chance that participants knew someone on the spectrum, and so would then be able to provide insight as someone from their social circle. Workshop sessions were arranged in the format similar to focus groups. As reported in Hoppe et al. (1995), age proximity, as well as familiarity with other participants in a focus group help in creating a more welcoming and comfortable setting for participants to express their ideas. This finding guided arrangements of design sessions described further.

Since every instance of workshops was slightly different in terms of activities scheduled for the participants, these will be discussed separately.

4.1.1 Initial workshop design

The main aims of the workshops were to elicit ideas for the background story, as well as the emotion-centred musical mini-games. The activities planned for the workshops were:

Activity 1: Draw/write examples of situations when you felt scared, angry, happy and sad.

Activity 2: Discuss examples from Activity 2, how you knew this emotion was felt.

Activity 3: Draw/write down ideas for musical mini-games where hints about emotions need to be collected.

Activity 4: Discuss ideas from Activity 3.

The first part of the workshops explored examples of personal experiences of emotions of fear, anger, happiness and sadness (*Activity 1*). It was perceived that keeping the task specific to what the participants have first-hand experienced would make it easier and more specific. The first activity asked children to draw or write about an example of when they felt scared, angry, happy or sad, as emotions also chosen by Tan and Khetrapal (2016). A choice to draw or write was given to better suit preferences and developmental abilities of differently aged child participant. Afterwards, a discussion of their drawings and writings was planned (*Activity 2*). The key goal of the discussion was to entice participants to reflect about common symptoms or behaviours associated with experiencing different emotions. The second part of the workshops aimed to brainstorm ideas for the musical theme of the minigames (*Activity 3*). The participants would again be given a choice to write down or draw their suggestions on paper, after which everyone would present their ideas to the whole group (*Activity 4*). Template sheets with task statements and prompts for the activities were handed out to participants to record their ideas.

To ensure children were appropriately introduced both to the structure of the workshops and the topic of the game itself, a pre-written script was prepared (Appendix D). A list of potential follow-up questions about appealing game features and game mechanics was also prepared as a prompt for discussing participants' game ideas.

At the start of the workshops, children would be introduced to the context of the workshops, i.e. designing a game for autistic children to help with emotion recognition and expression. A quick description of the developmental area of the project's focus, as well as the initial idea for the game, were intended to draw children's attention towards the scope of the game, and also ensure that there was enough room for their imagination and elaboration. All workshops apart from Workshops 2 (which was attended by older children) were supported by at least two adult researchers. Participants were also awarded certificates as a way to show gratitude for their input.

The timings and locations of all sessions were chosen to best accommodate both the participants' and their parents' needs. Workshops 1-3 were conducted throughout a Friday and Saturday afternoon in the Informatics Forum (group IF), with participants who were primarily children of the staff working there. Workshops 4 was organised

with the Brownies unit (group B) at their usual meeting time and location.

Participant	Age	Sex	Group	Session
P1	9	F	IF	1
P2	6	F	IF	1
P3	6	F	IF	1
P4	12	F	IF	2
P5	13	M	IF	2
P6	9	M	IF	3
P7	8	M	IF	3
P8	8	F	IF	3
P9	6	F	IF	3
P10	9	F	B	4
P11	8	F	B	4
P12	7	F	B	4

Table 4.1: Child participants in design workshops.

4.1.2 Workshops 1

The 3 participants in the first session were siblings, aged 9, 6 and 6. Another researcher who also conducted her workshops with another group on the day was present for the duration of the session to provide additional support to children. The children's nanny was also present for most of the session. Unfortunately, possibly due to the timing of the workshops (i.e. after school), the two younger participants appeared to be tired, more easily distracted and to some extent less motivated than their older sibling. Although it was expected that drawing would be an enjoyable activity for younger participants, they indicated need for help in writing down their ideas by the author and the supporting researcher. The specific relationship between the participants also influenced the ideas generated, specifically by P2 and P3. Examples of situations P2 and P3 described were almost identical, and, as suggested by the nanny, some of the ideas must had been something they heard from P1 before. For instance, both P2 and P3 said that they were scared when their mum gave birth to them, and it seems quite unrealistic and unlikely for both children to independently, spontaneously generate this same idea. Similarly, after hearing P1 describe a situation when she felt angry, i.e. when one of her siblings kicked her, P2 and P3 also mentioned the same scenario for anger. On the other hand, P2 mentioned not being able to watch television or play on iPad as causing anger, whereas the same reasons made P3 sad. After prompting P2 and P3 to suggest alternative examples for the emotion of fear, P3 suggested that she felt scared when she flew for the first time to visit her grandparents, while P2 mentioned having nightmares. Later at the discussion stage, P2 suggested that she also felt sad when she had nightmares. This might indicate that P2 may sometimes struggle to

Figure 4.1: Sketches of scenarios where different emotions were felt by one of the child participants in Workshops 1.

differentiate between sadness and fear. A previously mentioned situation for being sad cited by P3 also suggests that she might confuse sadness with anger.

The discussion stage proved particularly challenging. Even before, i.e. while writing down example situations mentioned by P2 or P3 in the first activity, attempts were made to ask them in different ways how they knew that it was indeed that particular emotion that they felt. Very often, the answer would be that they do not know, or for negative emotions, they would say that the reason was because they disliked the experience or the particular cause of that emotion. For instance, when P3 was asked when she felt sad, she said: *I feel sad when I have nightmares because I don't like them*. The following is an excerpt from a similar conversation with P3 about her example for emotion *scared*:

> Researcher: *First time in [...]... Did you go there with your family? How did you know that you were scared?*
>
> P3: *Because it was... I don't know. I didn't like it.*

Although a brainstorming activity for minigames was also scheduled afterwards for this group, due to time constraints, it was not possible to conduct them in the first session. As a consequence, it was decided on the spot that the whole of Workshops 2 would be devoted to this task.

4.1.3 Workshops 2

As after the first session it was clear the two sections of activities scheduled to take place in both workshops 1 and 2 were too time consuming to appear together, it was decided the second session will be spent solely on exploring ideas for musical mini-games. Although the intention for the participants was to first draw or write their ideas for the minigames, and then share it, both participants voiced their preference for starting a discussion directly. As P4 and P5 had taken part in two workshops conducted with two other researchers prior to this session, they appeared comfortable enough for discussion in this form of a semi-structured interview. A broad open-ended question of how the musical mini-game could look like was posed first, as taken from the template sheet prepared for drawing/writing in this activity. Despite initial introduction to the focus of my game, underscoring that the aim is to help understand feelings of the autistic child itself, not of other people's feelings, P5 began giving ideas for a game covering the latter scenario. P4 then corrected her peer, showing her understanding of the aim of the activity. As she later mentioned a particular requirement for the game based on her observation of her autistic friend, it might suggest that she was more aware of alexithymia or issues associated with ASC in general. After several minutes of discussions, and participants having given various ideas for the mini-games, focus was shifted to specific features of the game.

After introducing the idea of collecting different hints in the mini-game to help in emotion recognition, and giving an example of having symbols like tears as one of the clues, P4 noted:

> P4: *Well, you're not always crying when you're sad though. (...) It would bring up an image that you think, it might make them think that every time you're sad, you have to cry. And if you're not crying, you're not sad, that sort of thing. (...) I just think you need to make sure that they don't think that they have to do one thing to make them feel sad. (...) As long as you make sure there's more than one for each feeling, I think that should work.*

Based on some game ideas given by P4 and P5 that were particularly similar to the aim of *Tiny's Tunes*, the researcher asked both participants whether combining the idea of emojis as collectibles (in place of notes that appear in *Tiny's Tunes*) would be appealing to them, and they both agreed. While the question itself should have been phrased in a more open-ended way, P4 and P5 elaborated on the idea and also suggested that timing of activities in the game should be particularly generous or non-existent, keeping the intended players' needs in mind.

When asked if it would be appealing for the mini-games to have the same purpose and structure but slightly different look to reflect different emotions, P4 said that a balance should be retained between making the visual components in the background vibrant versus monotonous, as based on what she observed her autistic friend might find distracting, and also remarked:

> P4: *Make sure it's vibrant but don't put tons and tons and tons of details in cause that'll make them look at the details.*

While P4 and P5 had varied understanding of the way difficulties associated with autism might manifest themselves, they both showed awareness of the need to tailor the content and format of the game to the specific target audience.

Participants P4 and P5 also expressed themselves emphatically about emojis, which both were not very fond of, but acknowledged that they should be considered as a feature that appeals to younger children. P5 remarked:

> P5: *Well, you could use emojis cause they're vibrant and everyone likes them. Well, most people do. (...) Well all the kids basically like them. (...) cause it would be appealing to younger children*

A particularly valuable outcome of the discussion was that P4 and P5 mentioned many examples of existing games that they played, suggesting both desirable and undesirable characteristics of games. Both participants gave a considerable number of ideas for the main task and features of the minigame, as well as requirements of the game as a whole. However, due to the initial question asking for *any* idea for a musical minigame being posed very broadly, it was felt that further workshops could benefit from a more concrete framing of this question, e.g. by introducing a proxy game as a a boundary object that would act as a starting point for participant's ideas.

4.1.4 Workshops 3

The outcomes of Workshops 1 and 2 suggested that perhaps more focused framing of tasks and questions would be more appropriate to provide necessary level of support for ideation to child participants. While participants' ages in Workshops 2 allowed for a more flexible interview-based consultation, participants in Workshops 3 were expected to require more support in idea generation. Based on the outcomes of Workshops 2, and taking inspiration from Nouwen et al. (2016)'s use of proxy technology assessment (Pierson et al., 2006) to support co-design efforts for a game that teaches music to TD children, the game *Tiny's Tunes* was introduced to provide scaffolding for participants during the brainstorming activity. Thus, after having each participant familiarise themselves with the game by playing and watching others during their turns, a brief discussion of likes and dislikes about *Tiny's Tunes* took place, after which Activity 3 and 4 were done, as per initial workshops design. As participants were very enthusiastic about presenting their ideas to the researcher, as well as being recorded, the researcher also proposed that Activity 4 would be additionally video recorded. The reasons behind video recording were to act as additional documentation of design artifacts, as well as a way to encourage the sense of importance and ownership of ideas presented by child participants (Iversen, 2002; Lamberty and Kolodner, 2005).

All participants appeared not to have played the proxy game before, though some have recognised the main character, Tiny. After a quick explanation of the game's rules by the researcher and reading through the short instructions shown before the start of the game, P9 took first turn to play. Possibly due to her inexperience, as well as younger age, she found it difficult to coordinate mouse clicks with the timing of when the notes appeared. It was quite common for other participants to spontaneously comment on

the performance or suggestions for strategy while one of them was playing. Apart from P7, all participants found the timing of the beats challenging, which they also mentioned in the follow-up discussion. Part of the challenge stemmed from a considerable systematic lag in the visuals of the game itself, which at least two participants had noticed. When asked what could be improved in the proxy game, P9 said: *It's just you had to tap on the thing a second before*. P7 appeared to have noticed that playing along the rhythm of the music instead of relying on the visual cues was more reliable in fulfilling the aim of the game (given the visual lags). Abstracting away from this specific technical flaw of the game, timed tasks such as pressing at the right time can prove particularly difficult to players with weaker motor and coordination skills. Another slightly flawed feature of the game identified by participants was the scoring system. They seemed to have closely associated doing well in the game with achieving a high score, which was challenging at times, given the game's scoring mechanisms. Despite these dislikes, all participants expressed enthusiasm towards the game, especially the musical component of it, stating that they would play it again. Notably, P6 asked how the game *Tiny's Tunes* could be downloaded, mentioning that he would like to play it again at home.

During Activity 3, almost all participants based their ideas on existing games that they enjoy playing. This was perceived as a good thing: by relating to something familiar, they were able to elaborate on the original idea in a way that incorporated components of emotions and music, as required by the given task. Notably, P9's attention or interest for music in games or films seemed to be lower than, for instance, what P6 displayed through his ideas. This also reflected in P9's bigger difficulty in creating her own idea for the mini-game that would fulfil the requirements given at the start of activity. Although she drew her favourite Roblox game, which is a platformer containing multiple mini-games, instead of what was asked in the task, this actually pointed towards general game features that she found important. While describing the game, P9 said: *And then, like, it's really fun 'cause there's players that you could be friends with. 'Cause I'm friends with my sister [...] and I'm friends with [...], my friend and my sister's*. This social aspect of games, allowing players to connect with friends or relatives constitutes an important reason for playing video games not only among typically developing individuals but also their autistic peers (see Mazurek et al. (2015)). P9 also appeared to think that the purpose of music in a game can be solely as a musical score in the background: *You can put music in 'cause like its a nice game but you need to add something or you would just hear walking*. When P9 was asked about what makes music in Roblox interesting, she said: *because it's loud music*. On the other hand, P6 noted that he finds it particularly interesting how music changes depending on the scene and time of the day within his favourite game, Minecraft. The mention of Minecraft was particularly interesting, as anecdotal evidence suggests it is one of the most favourite games among autistic children, with certain servers such SafeCraft and Autcraft intended specifically for use by this population (Autcraft, 2015). The open virtual world offered within Minecraft offers predictability and structure to scaffold user creativity (Autland, 2014). Some researchers and practitioners have also used Minecraft to support development of social skills among children with ASC (Ringland et al., 2016b,a; Zolyomi and Schmalz, 2017). Similarly, Roblox is among games particularly recommended as appropriate for the target population, as offers a structured

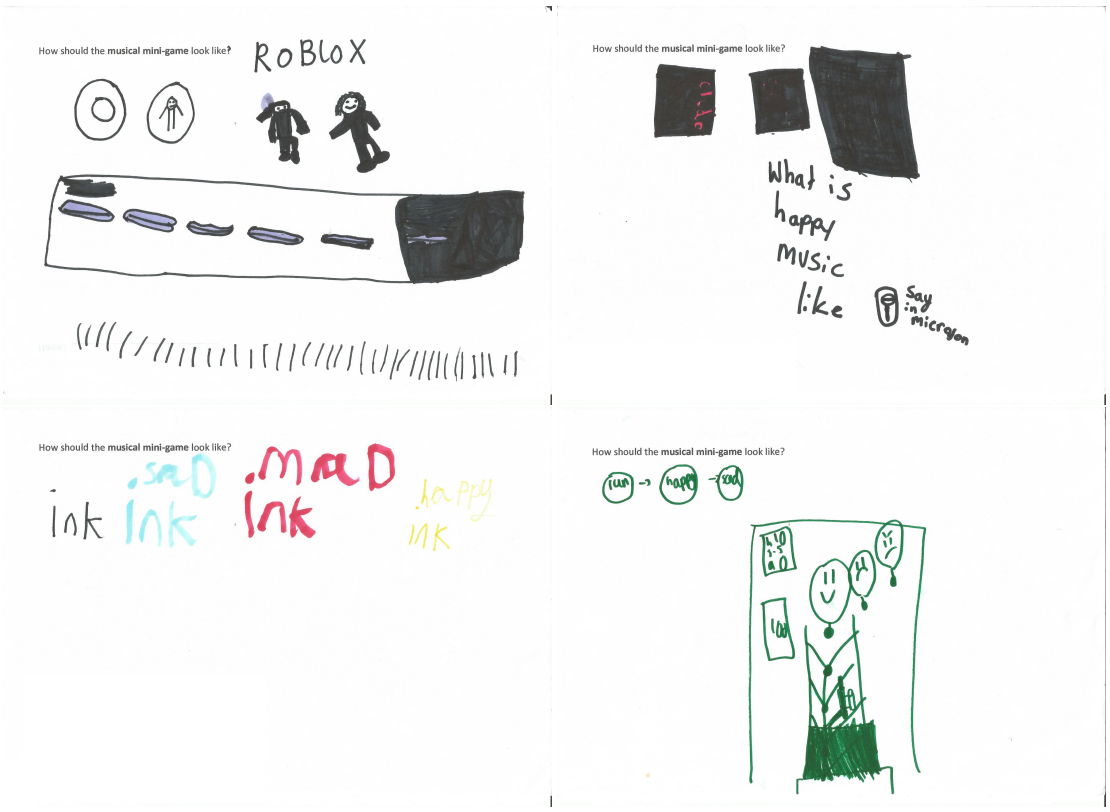


Figure 4.2: Ideas for musical minigames produced by child participants in Workshops 3.

environment to support user's creation of simple games that can be played by other players (Stuart, 2016).

4.1.5 Workshops 4

As workshops 2 and 3 generated an appropriate amount of data to guide designing most part of the musical mini-game, a gap in the researcher's knowledge was identified relating to what should constitute the hints collected by the main character in the game to help him in emotion recognition. On the other hand, workshops 1 showed that relying on participants to recall symptoms of different emotions elicited in example situations they gave did not result in anticipated answers. After a discussion with an expert in designing technology for children with ASC and a group of researchers also working on developing games for the target population, it was decided that the follow-up discussion (*Activity 4*) would be replaced with an activity inspired by *Taboo* and *Who Am I?* games. Thus, after completing Activity 1 and 2, which acted as a warm up to make them think about the settings in which they experienced various emotions, participants also undertook Activity 5:

Activity 5: *Guess the emotion*, with other participants describing what the emotion is without using emotion words.

Figure 4.3: Design workshops with children.

The goal of this activity was twofold: to see whether participants found it easier to describe how to recognise a particular emotion when not constrained to a particular example situation; and to generate ideas for the indications flagging a certain emotion, to be incorporated into the game.

While doing Activity 1, P10 and P11, who appeared to be friends, would spontaneously talk about details of the examples they were drawing. P10 drew particular attention to depicting expressive indications of emotions she described: for the sad emotion, she drew herself crying, with a large puddle of tears on the floor, and sighed as if she was crying when drawing the example. While completing Activity 1, one of the participants spontaneously drew an example for the happy emotion in the first slot, where the emotion *scared* was. Also, P11 did not provide an example for the emotion *scared*. While this might have been accidental, it also appeared that participants found it more challenging to recollect memories of some of the negative emotions.

Activity 5 made participants considerably more enthusiastic than when discussing as part of Activity 2. Although the activity was designed more as a verbal task, participants spontaneously transformed it towards what would be closer in form to charades. This outcome suggests two things: first, that, again, making the activity more concrete and gamified appealed to participants more; second, that mimicking typical behaviour and facial expressions associated with a given emotion seemed easier and more natural to them as opposed to verbal depiction.

4.1.6 Discussion

Participants provided a variety of examples for the chosen emotions (Table 4.2), with some of them spontaneously discussing the examples as they were transferring them onto paper, even though a clear discussion section was supposed to commence after they finish Activity 1. Participants had no problems recollecting examples of scenarios when they felt happy or sad, however exploring their memories of situations where

they felt angry or scared proved to be more problematic. It proved to be even more challenging when children were asked for retrospection into the indications of emotions that they provided examples for (Table 4.3). Very often, they would mention related, co-occurring emotions (e.g. feeling annoyed as an indication of anger), or states (e.g. for negative emotions – that they did not like the experience of it). Less frequently, example of associated (intentional) behaviours (e.g. wanting to hit something when they felt angry) or facial expressions were provided. In relation to co-occuring emotions or states, this is probably less likely to be helpful to an alexithymic autistic child if problems in emotion recognition are global; otherwise, awareness of accompanying feelings could provide some hint on what it is that they feel. In addition, some of the behaviours associated with each emotion appeared to be more situation specific rather than contingent on the emotion. For instance, P11 cited receiving a present for the example for *happy* and when she was asked how she reacted when feeling happy, she referred to what she did with her present. Given deficits in recognising emotions through facial expressions in others (Eack et al., 2015), and suggestions that mimicry of facial expressions helped in facial emotion recognition among autistic individuals (Lewis and Dunn, 2017), utilising facial expressions as an indication of an emotion could have been helpful. It was also found that simplifying physical or psychological indications of different emotions too much might be unhelpful, and that it is important to represent a large array of examples for better generalisation into real-life situations. Some of the younger participants displayed more difficulties in discussing how they knew they felt the different emotions mentioned in the workshops. Perhaps it is in general a complex task to isolate physical, behavioural or psychological indications of emotions that would apply in all cases, even for TD children. As it was hoped to gather data on children's perspective on this matter, and these were found insufficient, the researcher was indecisive whether there is enough research driven data to inform the design of a game that would help specifically in recognising own emotions based on these indications.

Participants displayed particular interest in music when the ideas for musical minigames were brainstormed as part of Workshops 2 and 3. Due to more explicit focus on the game in these sessions, a large number of functional and non-functional requirements were identified. These requirements are discussed in more detail in Section 4.4. Table 4.4 also summarises ideas for musical minigames given by child participants. Due to positive reception of proxy game tested as part of Workshops 2 (Section 4.1.2), several mentions of similar types of games throughout both workshops (e.g. I7, I8, I9 in Table 4.4), as well as preceding literature review on rhythm games, extending the game concept of *Tiny's Tunes* was considered as particularly relevant for further game design. Emojis were also often mentioned as a feature appealing to TD children, which is clear from the frequency with which it was incorporated into ideas for minigames. To the researcher's best knowledge, there are no findings about interventions for autistic children that incorporate emojis or emoticons to improve their emotion skills. However, given widespread familiarity with emojis, even among the youngest children, suggests that these can be a potentially appropriate visual feature to be included in the game design.

Emotion	Description
Happy	meeting with cousins given Friendship prize at end of school year ceremony getting presents flying to visit family watching TV x3 (2 gave a specific programme – Blue Planet) playing on the phone/iPad x2 mum puts headlice shampoo
Sad	leaving home in London when cat had to be given away when grandparents left after visiting when doesn't get to play on iPad/phone x2 when doesn't get to watch TV x2 had nightmares when sibling kicks being hurt/wounded
Angry	sibling annoying x6 sibling kicking in the bottom x3 tickling dad steals piece of bread when doesn't get to watch TV
Scared	during birth x2 saw a whale shark in oceanarium first time travel by plane to visit grandparents had nightmares got lost in an amusement park brother fell down the stairs and hurt his head

Table 4.2: Summary of example scenarios given for different emotions as gathered from child participants.

Emotion	Description
Happy	surprised want to yell/scream excited x2 its her favourite thing smile x2
Sad	doesn't like it makes her want to cry x2
Angry	feels annoyed want to annoy back (get revenge) want to hit/kick something/someone having loads of different feelings inside stomping grimace
Scared	doesn't like it

Table 4.3: Summary of indications for different emotions given by child participants.

4.2 Expert feedback

Consultations with experts from a number of relevant areas were intended to address knowledge gaps in research about appropriate goals and format of delivering the game being developed, and followed a format of semi-structured interviews to ensure that key areas were covered and also to allow some flexibility. Experts represent a wide range of backgrounds relevant to this project, including persons who have first-hand experience of ASC, those who have (or have had) substantial contact with autistic individuals, and researchers in the fields of computer science, human-computer interaction, educational technology and psychology. The timing of consultations was largely dependent on the experts availability and happened at different stages of design idea development. Sessions aimed at gathering feedback on design aimed to answer at least some of the following questions:

1. To what extent is the format and relationship between minigames appropriate for promoting emotion expression through music?

2. What is an appropriate format of delivery of instructions?

3. Are there any technical guidelines (e.g. platform) to implementing the game?

Question 1 aimed to validate the design ideas of the researcher. Question 2 pertained to the instructions displayed to the user, which should explain what the objective of the game was and how to engage with it. Question 3 should elicit major considerations for implementation before fully committing to particular technical specifications of the game.

Idea	Description
I1	Main character has headphones through which he can tune into other peoples thoughts and the music he hears would correspond to their feeling
I2	The game plays music representing the emotion corresponding to what happened
I3	Collecting emojis in certain areas so that they can be used later
I4	Different emojis to be collected, each says what emotion it represents and why one might feel it (description)
I5	I4 alternative, where instead of written explanations, the emojis would talk
I6	Playing different instruments and choosing one will determine the emotion
I7	Playing a song on the piano corresponding to a given emotion by pressing keys in different colours like in Simon
I8	*Synthesia*-like game
I9	I8 alternative, with colourful keys that would light up
I10	Grid of emojis, mousing over plays a song, both correspond to a given emotion
I11	Drag & drop game with emojis replacing words in sentences, e.g. I am (...) that I got ice cream
I12	Alternative with a song corresponding to a given emotion being played after the emoji was dragged into the empty space
I13	Rollercoaster-based game, with a gun to pop balloons with faces representing different emotions
I14	Platform game like Bendy and the Ink Machine, where you run around collecting buckets of inks in different colours, representing different emotions
I15	Game with songs, labelled with the emotion they correspond to, that one clicks to listen to
I16	Different cards that you when you pick them up, they play a specific type of music and you need to guess what emotion it represents

Table 4.4: Summary of ideas for mini-games generated by child participants.

Expert	Area of expertise/interest
E1	autism, accessible technology, computer science, games for autistic children
E2	educational technology, game based learning
E3	education, care-taking of autistic children, art therapy
E4	care-taking of autistic brother

Table 4.5: Experts consulted for game design requirements and choices.

4.2.1 E1

E1 obtained a Bachelor's degree in Artificial Intelligence and Computer Science (AI & CS) at The University of Edinburgh and in the past was also involved in a similar project focusing on autistic children. She currently works at a care company where she provides digital skills training to clients with varying levels of intellectual, cognitive or physical disabilities. She also has experience working with autistic children, and being on the autism spectrum herself, has first-hand knowledge of the condition.

Due to the breadth of relevant knowledge E1 had, four interviews were conducted with her before game implementation, with two sessions focusing on initial idea and requirements validation, and the latter two to gather feedback on game design.

At a very early stage of narrowing down the scope of the problem, the area of emotions and their expression in music was identified as a potential area of interest. E1 confirmed that given high co-occurrence of alexithymia in autistic individuals, addressing their emotional deficits, especially based on results from music therapy, could be an interesting research area. E1 also pointed towards music therapy resources as a potential source of inspiration, citing her previous project where certain approaches employed by teachers and therapists were adapted. She acknowledged that music can be an engaging medium for people with different communication impairments, and as an avenue to learn social skills such as turn taking and social awareness. While no concrete game ideas were discussed yet, these findings confirmed that the established overarching topic indeed has research relevance.

After first game design iteration, game design 1 was discussed to gauge its suitability for the intended target audience. E1 liked the idea of tying music and emotions with a story, which in her view should help the child put emotions into context and imagine it more vividly. The two components of the game design that were of particular focus during the interview were symbolism of emotional states in the form of multi-sensory stimuli, as well as improvisation/customisation of sounds and music. The idea of focusing on internal emotional state was confirmed by E1 to be appropriate. E1 pointed towards a recent BBC show for children, *Pablo*, which features an autistic child whose thoughts are depicted through the world of his drawings – a similar idea as the "parallel universe" metaphor of Timid Timmy's introspection. As such, the idea had a precedent used in a context of an autistic character. E1 also advised to exercise caution around connotations associated with visual imagery - for instance, a birthday party, which for TD children could stereotypically be linked to happy emotion, might be perceived as stressful for ASC children. E1 advised against using metaphors directly within the story – i.e. mentioning that the game is now switching into the main character's mind. E1 recommended that the game should be as realistic and grounded in real life as possible, as autistic children might have problems understanding abstract concepts and take language literally. E1 also cited her personal experience of unimpaired emotion recognition in music but difficulty with metaphors in language. In relation to customised/improvised musical responses in the game, E1 confirmed this is a good idea, while reminding of the need to appropriately manage surprising features by making user aware what they should expect:

> E1: *In my own experience, there's a big difference when you're in control of unexpected things, versus unexpected things happening to you. So having a point in an otherwise quiet/calm story where suddenly there is bright light/loud music would be stressful. But choosing yourself to make that happen is a different matter.*

Following an interview with E2 (described in 4.2.2), it was decided that the project will narrow down scope to focus on the musical minigames. Sketches of the game design (see Figure 5.1) were shown to E1 to gather feedback. E1 liked the structure of the game, with the different minigames looking at different aspects of music and how it connects with emotions. When introduced to the scoring mechanism in Tiny's Tunes, E1 suggested that the scoring system in the current game design should be somewhat more forgiving than the one in the proxy game. In fact, she suggested designing several random bonus point items to make the game more exciting and engaging, noting that it is common practice in various games. In regard to the second minigame, E1 suggested that instead of just dragging and matching balloons, some amount of complexity could be added "making it more of a game", as she described it. On the other hand, the level of complexity of mini-game 3 was deemed as appropriate. E1 considered the music saving feature a good idea, as that would allow for playing back the extract at school or home settings. E1 recalled a relevant study, where a picture-centred app used a similar artifact saving capacity. The app supported children with autism who have communication problems, and by allowing them to save pictures it also supported them in sharing what they have done at home or school between these two environments. In regard to the choice of 4 emotions, E1 expressed scepticism about having 3 negative emotions (sad, angry, scared) and 1 positive (happy). The researcher pointed towards the possibility of these emotions to be more commonly experienced. E1 suggested two possible solutions: replacing angry or scared with peaceful, thus alleviating partly the imbalance, or replacing scared with anxious, as E1 considered this as a more frequently experienced compared to, for instance, scared. E1 also suggested that devoting 3/4 of the game on negative emotions does not necessarily comply with the the idea of fun, as associated with games.

4.2.2 E2

E2 is a researcher at The University of Edinburgh, working specifically in the field of educational technology. She obtained a Bachelor's degree in AI & CS and a PhD in educational technology. One of her research interest areas is in designing technology with and for children, more specifically serious games for children.

E2 was consulted with game design 1 in mind to evaluate the appropriateness of the comic story and mini-game based format to teaching children with ASC about overcoming difficulties with emotion recognition. E2 indicated that the idea of visual representation of symptoms of emotions might be particularly challenging, since, if the goal is to teach a child something that needs to be transferable to real life, it should be as realistic as possible. In particular, E2 highlighted that one needs to consider metaphorical and literal understanding of the target group. E2 suggested that although nar-

rative can provide particularly engaging contextual background to the educational content of the game, designing and implementing a game that features various minigames and a well crafted supporting story line can be out of scope for this particular research. On the other hand, promoting musical expression was deemed as an interesting and broad enough arena for designing a game for ASC children. In this context, E2 noted that the design of the game should also be tied to what is most beneficial for the user. E2 suggested that perhaps a tool that facilitates music making is more beneficial than one to help identify emotions, as a music making tool could have a potential to be used in a wider range of situations. Other advice from E2 was that what is initially designed or implemented might not matter as much if rapid development cycles are a feasible game development approach, whereby the idea can be tested empirically and redefined as needed. Following E2's suggestion, it was decided that the focus of the game will only be on musical minigames.

4.2.3 E3

E3 obtained a Bachelor's degree in Education with a special focus on media and educational technology and is planning to pursue further postgraduate qualifications in art therapy. She has 3 years of experience as a care-taker to 3 autistic children who were siblings – a 10 year-old with more severe autism and 6 year-old twins with high functioning autism.

She used tablet devices both for educational and entertainment purposes while working with these children. E3 pointed towards certain patterns of preferences in that usage, such as their favourite types of games and their characteristics, and so was able to exemplify desirable game features based on that knowledge. She highlighted that the siblings liked order and predictability, and so, for instance, introducing a slight variation in the structure or settings of certain games they frequently played together would lead to their anger or frustration. She noted that the siblings enjoyed listening to music and would often repeatedly listen to and sing along their favourite songs. This habit of repeating something would often extend towards cases where the children would, for example, memorise and sing back an ending song from their favourite animated show and not realise that they are reciting end credits for producers, voice over artists, etc., almost as if not understanding what it is they repeat was less of a problem in the context of how reassuring the repetition itself was. E3 recommended that there should be some level of repetition and predictability embedded in the sound patterns incorporated into the game to address this particular preference. E5 also proposed that instead of having static textual instructions, a tutorial or trial level with an easy version of the actual game should be considered. Citing a particular tablet game that the children liked to play, she mentioned how such a simplified, well explained and interactive instruction helped even the low-functioning autistic child to learn what the mechanics of the game were, which equipped him with enough information so that he could gradually move onto more difficult levels. On a related note, E5 also suggested it is a good idea to have the complexity level of the game build up with various levels. This would perhaps guarantee better engagement with the game due to better understanding and sense of achievement from previously completed, easier levels. A chance to achieve success is

cited among important positive factors of technology based learning environments for children with ASC (Colby, 1973).

4.2.4 E4

E4 is a 23-year old student with a 9 year-old autistic brother on the lower-functioning spectrum. Although her brother cannot read or write, he can comfortably use a mobile phone, for example for playing games. He enjoys listening to music and singing along, and can quickly memorise songs. When in a stressful situation, he would eat, watch a favourite cartoon or listen to a favourite song. He has undergone a Tomatis method therapy, which uses auditory stimulation and claims to enhance motor, emotional, cognitive and communication skills. The therapy involves listening to different sounds and music, such as recordings of the patient's mother or classical music (Mozart and Gregorian chants). Patients listen to these through a set of headphones which provide the sounds after being processed through a device called the Electronic Ear (Gerritsen, 2010). The method incorporates repeated but sudden and unpredictable patterns of sounds. Neysmith-Roy (2001) and Gerritsen (2010) report mixed results on the effectiveness of therapy for patients with ASC, with estimates stating that the method leads to improvements in around 60% of patients with ASC (Tomatis, 1991). E4 stated that treatment has made her brother more aggressive and increased his need to vent. It is perhaps not surprising that the use of unpredictable sensory stimuli was not well received by the child, given the commonly experienced hypersensitivities in individuals with ASC, as well as their preference for predictability. On the other hand, E4's brother was reported to have certain favourite songs he liked to listen to, indicating that when music provided familiarity, the child would respond to it positively. Allen et al. (2009) have also reported that a number of individuals deemed classical music as their favourite, citing interesting structure and patterns of musical pieces among the reasons for listening to music. As such, negative impact of the therapy could have stemmed from the format of stimuli delivery, not their nature.

4.2.5 Discussion

Consultations with experts confirmed that the research focus being considered has relevance, and that the intended platform of delivery of the game being a tablet device should be suitable. Use of music therapy based approaches was recommended to inform the design of music-centred activities within the game. Experts highlighted the need to avoid unpredictable, surprising features that could be detrimental to the target group. E4's testimonial highlighted that although music can be enjoyable to children with ASC, it is equally important to pay close attention to how it is used, especially in the context of their preference for predictability and order. It was also brought to the researcher's attention that certain examples of scenarios where different emotions could be felt by TD children might not be applicable to the target group. There is also a need to accommodate the target group's capacity to differentiate between metaphorical and literal meaning.

4.3 Conference

Attendance at the workshop titled *Children & Technology: Toward interdisciplinary collaboration* organised by Scottish Informatics and Computer Science Alliance (SICSA) was intended to supplement knowledge on current themes and approaches in interdisciplinary research on the role of technology in child development.

Through presentations and consultations with researchers and practitioners working in the field of technology for children, a number of desirable attributes of technology were identified. Following these suggestions, technology for children is good, when it is *safe, accessible, usable, fun* and *brings cognitive/social/cultural/emotional/physical benefits*.

Notably, one of the creators of Skoog (described in Section 2.4.4), who also attended the workshops, advised that in the design of technology intended for children with ASC, the researcher should focus on what the core gains for the child are, not what the researcher desires the technology to do. Such a shift of focus was suggested as more appropriate in designing technology that is likely to benefit the target user group.

4.4 Design requirements arising

Through consolidation of ideas and recommendations from child participants and experts, the following general requirements were found.

Requirements from design workshops:

1. The game should feature an adaptive storyline that would take different branches depending on the player's choices.
2. The game should feature several minigames.
3. The game should incorporate some social aspect.
4. The game should include a variety of indications for each emotion.
5. The game should not be too easy.
6. The game should not be too difficult.
7. The game should feature songs expressing different emotions.
8. The game should allow collecting various items, such as the main character's favourite items.
9. The minigames should not be timed – or if so, then generously.
10. A scoring system should be in place to show achievement, e.g. to assess how well one reacted to a particular emotional situation.
11. Sound or music should be used to provide feedback confirming whether various actions were correct/incorrect.

12. The background visuals should not be too distracting.
13. The graphical design of the game should be very decorated.

Requirement 1 will not be further considered, as after consultation with E2, the narrative-based part of the game was removed from the design. Requirements 2 and 6 are in line with the initial game design and will be retained. Requirements 5 and 6 were provided by different participants and indicate that the amount of desired challenge from a game varies. To accommodate this, there will be some amount of support present in the game but will vary between different minigames. Item 9 will be considered with caution, as timing is an inherent part of music, but at the same time weaker motor skills of some children in the target group should be kept in mind. Requirements 12 and 13 represent contradicting views but considering information processing difficulties experienced by the target group, the game design will follow the former suggestion, with a more general approach of simplifying the interface as much as possible. Items 8 and 11 will not be included at this point, but might require further consideration. Item 8 has a potential of increasing enjoyability of the game and item 11 can possibly leading to overstimulation, given the core musical already existing in the game design.

Requirements from expert interviews:

1. The game should feature scenarios relevant to the target group.
2. There should be a balance between positive and negative emotions in the game.
3. Features of the game, especially the music, should be in line with target group's preference for predictability.
4. The game should feature different levels of difficulty.
5. Scoring system should be more generous than in the proxy game.
6. The game should incorporate random bonus points.

Requirement 1 will not be considered as the focus of the game will no longer be in recognising emotions from example scenarios. Requirements 3-6 will be incorporated into game design. Requirement 2 will require further consideration in later stages of game development, as the researcher believed current results are inconclusive in this respect.

Requirements from SICSA conference:

1. The game should be safe.
2. The game should be accessible.
3. The game should be usable.
4. The game should be fun.
5. The game should bring cognitive/social/cultural/emotional/physical benefits.

All of the above requirements are quite general but were considered relevant for further guidance in game design.

Chapter 5

Game design and implementation

Informed by preliminary stage literature review and design consultations, the game design and implementation were further iterated based on input from experts. Results of these discussions, as well as arising design and implementation decisions are further described.

5.1 Game design 2

Following an interview with E2 (described in Section 4.2.2), it was decided that the research will narrow down scope to focus on the musical minigames. Although narrative-based games can provide significant motivational benefits and improve engagement, when designed incorrectly, overly elaborate storylines can introduce cognitive overload and distract from subject matter (Rowe et al., 2007, 2011; McQuiggan et al., 2008a). It was decided that promoting emotion expression through music will first involve introducing basic musical concepts. Just as in music therapy, the therapist would guide and provide support to the patient to improve their musical responsiveness and expressiveness through a mixture of structured and free-form activities, the game was intended to provide guidance on musical components. This was thought to be helpful in giving the child more awareness about emotional expressiveness in music before they engage in a more active and creative act of music making. At the same time, the researcher's intention was not to develop a serious music education game but rather a gentle introduction to emotions in music.

Given these requirements, game design 2 was created (see Figure 5.1) and included 3 minigames covering 4 emotions, as chosen and justified previously. The first minigame introduces the notion of rhythm, through a format adapted from Tiny's Tunes (this decision was discussed in Section 4.1.6). Thus, pressing at the right time would produce a sound from a pre-recorded melody line that reinforces the main melody of the background music (Figures 5.1c, 5.1d). The second minigame is a matching game that allows the player to explore the idea of pitch. The player is supposed to drag template icons into placeholders, which indicate the melody line also present in the corresponding version of minigame 1 (Figures 5.1e, 5.1f). Minigame 3 has a free-play mode,

where the player can compose her own melody line, which can also be saved as a file to allow later revisiting or sharing with friends or family (Figures 5.1g, 5.1h). The 3 types of minigames are tied through preset background musical pieces corresponding to the four emotions, providing necessary scaffolding. Instead of using notes as the obvious boundary objects in the game, due to the simplification assumption, balloons were chosen, based on one child participant's idea for the musical minigames (Table 4.4).

The game will also feature short introductory instructions to explain the purpose of the game and how to play it (Figure 5.1b), to ensure that the player gains necessary familiarity. The game's intended platform will be a tablet device, as it was found as an appropriate platform in Section 2.5. The game will be implemented using the game development engine Unity, chosen for the variety of associated supporting resources for developers, as well as its flexibility.

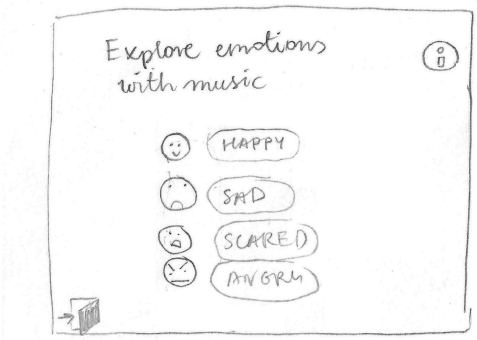
5.2 Expert interviews

Two series of expert interviews were conducted, with each series happening after one cycle of rapid iterative development. These consultations discussed a low-fidelity game prototype implemented by the researcher. Following (Sefelin et al., 2003) findings suggesting that subjects preferred computer over paper prototypes, this was implemented as a computer-based application. The purpose of these interviews was to gather feedback on the design choices implemented so far, in relation to the overarching purpose of promoting emotional expression through music. This should help identify any mistakes or shortcomings in an early prototype so that they can be fixed before fuller game evaluation. As such, only two experts were consulted at each iteration to maximise the benefits of incremental development. The experts were chosen to cover as wide domain knowledge as possible, so as to provide holistic feedback on the current state of the game.

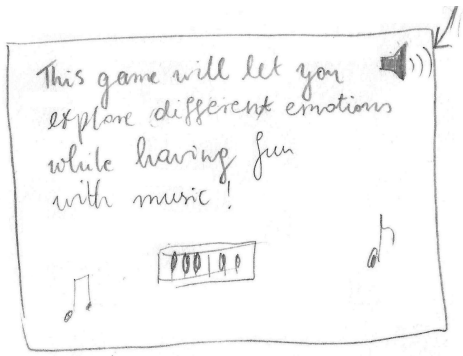
5.2.1 Expert interviews 1

The first series of interviews revolved around sketches of game design 2 (Section 5.1) and a PC-based implementation of the game from the first development cycle, with minigame 1 (*Rhythm* minigame) for happy and sad emotions (see Figure 5.2). Musical pieces having Creative Common license were searched online and chosen based on musical structural features corresponding to a given emotion, and these were found in the relevant literature review presented by Whipple et al. (2015). Musical notes were represented in the game through coloured circles, and press in the target area was animated to provide feedback to the user. A simple score measure was displayed to provide additional feedback on performance (Figure 5.2b).

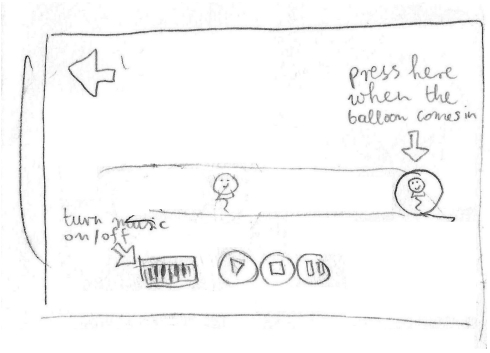
Interviews followed a semi-structured format, and were conducted in the experts' office building. The two sessions focused mainly on themes of *emotions chosen, personalisation, instructions/tutorial, platform for the game* and *audio descriptions*.



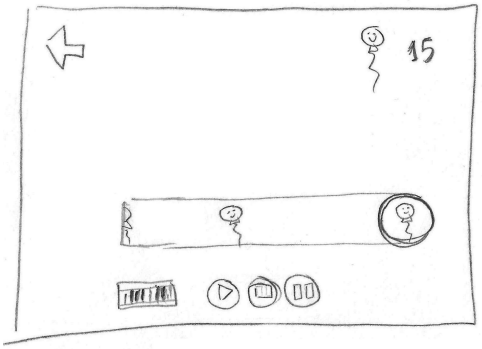
(a) Main menu.



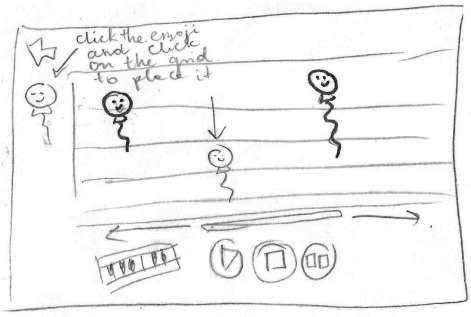
(b) Instructions.



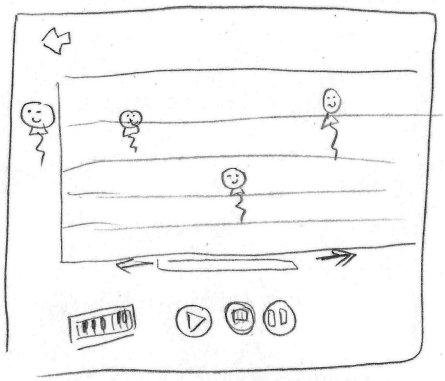
(c) Minigame 1 explained.



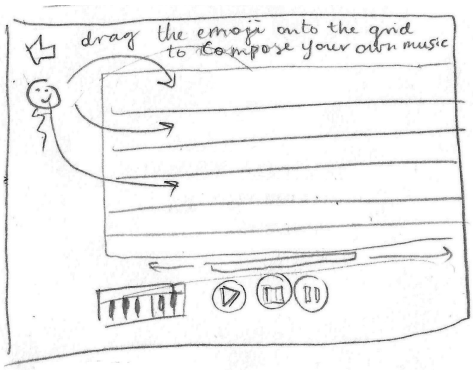
(d) Minigame 1 during play.



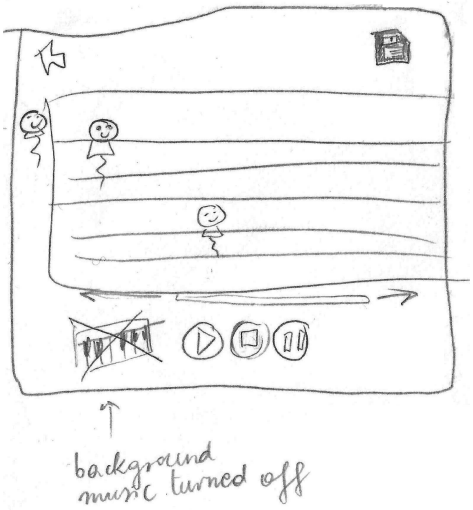
(e) Minigame 2 explained.



(f) Minigame 2 during play.

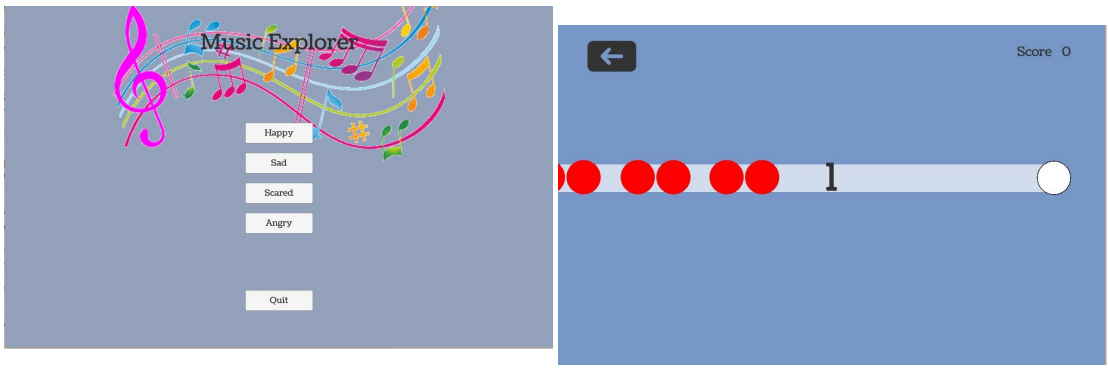


(g) Minigame 3 explained.



(h) Minigame 3 during play.

Figure 5.1: Game design 2 sketches.



(a) Main menu indicating emotions chosen for the minigames.

(b) Rhythm minigame.

Figure 5.2: Example screens of the resulting computer-based low-fidelity prototype from the first development iteration.

Expert	Area of expertise/interest
E5	HCI, usability, accessibility
E6	cognitive science, HCI

Table 5.1: Experts consulted about first version of the game - computer-based low-fidelity prototype.

5.2.1.1 E5

E5 holds a degree in Computer Science and is a 1st year PhD student specialising in the area of HCI, usability and accessibility, with previous experience designing interfaces for the elderly.

E5 confirmed that game design 2 has a plausible structure, with the first 2 minigames acting as training on how emotions are expressed in music, and then the free play stage in the 3rd minigame providing a playground for more unconstrained emotion expression. E5 suggested adding an interface feature for the 3rd minigame, where after creating and saving own composition, a balloon could pop up to let the user draw a facial expression representing the type of emotion expressed in the musical extract, similarly to the emotion expressions displayed on balloons in previous 2 minigames. E5 indicated that customisation could be introduced by allowing the user to choose alternative items being displayed in place of balloons, and that customisation could even extend to choice of music genres for the musical excerpts in the minigames. The first idea was deemed as relevant to this particular game, as it was simple and should not interfere with the content delivered in the game. On the other hand, the notion of music genres was considered slightly too complex for the understanding of a young ASC user. Schwartz (2008) suggests that children do not perceive music by trying to compartmentalise it but rather experience it holistically. As such, categorisation into music genres would probably not be particularly useful for the target user group. Another idea discussed by E5 was the inclusion of a virtual animated agent that would dance along the music and move when the notes are pressed correctly or stop when they get

it wrong. This would provide a form of feedback on how well the player is doing in the game, and could potentially provide another avenue for customisation. In the context of instructions delivery, E5 suggested that the virtual character could participate in presenting such instructions, and that these instructions could be encapsulated into a narrative, whereby the virtual agent could assume the role of a tutor. While including virtual characters in the game could provide motivational benefits and opportunities for interaction, the researcher was concerned with potential distracting effects of having such an agent within the game. For instance, movements of the virtual agent as a response to user actions could divert the user's attention from the task at hand.

5.2.1.2 E6

E6 is a cognitive science researcher at The University of Edinburgh, also specialising in HCI, and has previously conducted some research related to people with special needs and autism.

When asked to comment on the appropriateness of emotions chosen for the game, E6 suggested that constraining the whole range of possible emotions that could be expressed to only 4 is a good starting point but also noted that the exact choice of emotions being considered should be informed by the desired end result of the game. As an app that would be used mainly as a communication tool, it might need to incorporate a larger number emotions but for learning purposes, the current choice was appropriate. As a compromising solution, E6 suggested that perhaps allowing the player to first choose which 4 emotions would be considered in the game from a longer list could be considered. Such a solution was found to address some of the issues around the choice of emotions, as raised in one of the interviews with E1 (Section 4.2.1). E6 also noted that having balanced emotion pairs, "polar opposites" could be beneficial for teaching purposes, as it would allow contrasting them, instead of viewing the emotions as being completely independent. E6 also appreciated the fact that autistic children might need support with certain emotions, and that these could be negative ones. Although E6 suggested that making interfaces across all minigames look consistent could be considered, he also indicated that there might be no further need to unify their look, as certain components, such as the balloon character, is a unifying theme already. E6 identified the issue of balancing audio and visual feedback from the game, mentioning that hints about what needs to be achieved in the game (e.g. tapping at the right time when the note appears in the target area) are mostly visual, and the sounds produced might be viewed more as an interesting addition but not crucial to the progress of the game. He also noted that perhaps this might not be a serious problem as people tend to be primarily visually-inclined as well, so visual hints will be expected to some degree. E6 suggested considering musical extracts with human voices singing as a variation for the game, as it could be interesting to research whether having a human component in musical communication is relevant or positive to any extent. In regard to the format of instructions, E6 proposed including a general onboarding overview of the key aspect of the game, with more specific instruction appearing at first play just before each minigame, with a possibility to skip it for the following times the game is played. When asked if an interactive tutorial level would be an appropriate way to

present such instructions, E6 suggested a simpler, alternative solution, i.e. using short videos showing interaction points and what they mean in the given level. E6 believed that providing clear introductory instructions would reduce the confounding factors of end results of the educational component of the game, as it could better control the amount of information each user obtains before engaging with the actual game, making it easier to pinpoint potential sources of certain results.

5.2.1.3 Discussion

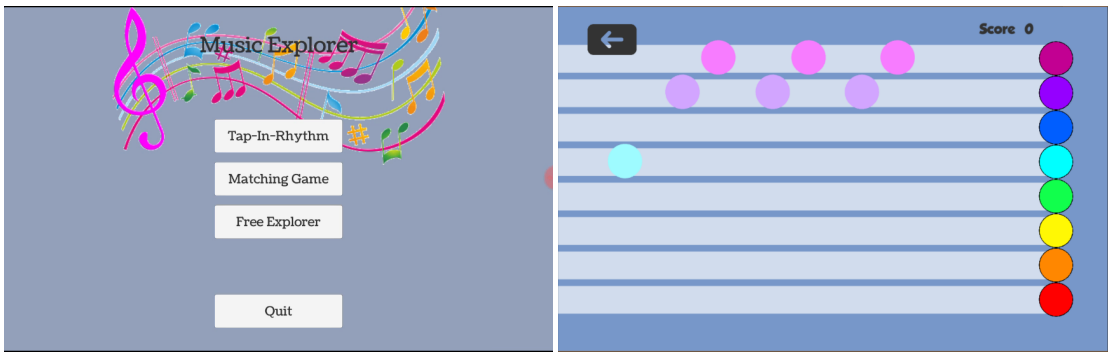
Both experts confirmed that the core structure of the game, with clear parts allowing for practice and familiarisation with emotion expression in music, as well as more unbounded self-expression, are appropriate. While there was no clear opposition to the emotions chosen for the game, E6 identified a particularly useful solution of allowing the choice of 4 emotions from a longer list to be explored in the game, which should make the game more adaptive, personalised and relevant to the player. Similarly, customisation of game components such as graphical representations of notes or musical features can allow tailoring the game to user's needs and preferences. Adaptability and customisation are important facets of computer-based educational applications, as discussed in Section 2.5. As such, the notion of customisation will be fed into further game implementation. The aspect of providing clear instructions about the game's purpose, how to play it and navigate around the interface was discussed and several alternative solutions offered. Providing clear explanation is of paramount importance to avoid confusion and surprise in end users, given their preference for order and familiarity. While this finding will be kept in mind in further implementation endeavours, more attention will be devoted to materialising minigames into implementation, so as to first settle the content that will later be explained through instructions.

Changes introduced to the game design as a result of expert interviews described in Section 5.2.1 were:

- Customisation of graphical representation of notes (to be implemented).
- Providing more salient positive reinforcement feedback (to be implemented).

5.2.2 Expert interviews 2

Another series of expert interviews was conducted to further inform implementation of the game, and discussed game design 2 sketches and a second iteration of the game prototype (Figure 5.3), with several modifications introduced as a result of previous expert consultations (Section 5.2.1). The prototype discussed with experts at this stage featured a new *Pitch* minigame, similar to minigame 1 from gamed design 2 (Section 5.1), and was implemented for an Android tablet device. This essentially marked splitting minigame 1 into two minigame designs – one focusing on rhythm and another focusing on pitch – both subsumed under the minigame category *Tap-In-Rhythm*, signifying similar playing mechanisms of tapping along the music in correct timing. As



(a) Main menu indicating the 3 minigames designed as part of game design 2.

(b) Pitch minigame added in second game development iteration.

Figure 5.3: Pitch minigame added in second game development iteration.

these two structural components of music are among most important features determining perceived emotional expressiveness of music (Gabrielsson and Lindström, 2010), it was decided that allowing the player to explore differences between musical pieces associated with each emotion with respect to these dimensions will be appropriate for increasing their understanding about emotional expression through music. Interviews with experts followed a semi-structured format, and were conducted in public places around The University of Edinburgh campus. Consultations revolved around the themes of *navigation, accessibility accommodations, customisation, virtual agents, balancing educational and playful features*.

Expert	Area of expertise/interest
E7	psychology, game based learning, e-learning
E8	accessible technology, educational technology, technology for autism, HCI

Table 5.2: Experts consulted about second version of the game –low-fidelity prototype.

5.2.2.1 E7

E7 obtained a PhD degree in Psychology from The University of Edinburgh and is a retired professor whose research focused on psychology and information technologies, specialising in game-based learning within the context of digital education. E7 has an autistic grandson.

After playing two of the minigames implemented, E7 said: *It's fun!* He acknowledged that emotion perception in music is quite natural and that making the player aware that affect can be perceived in music in different ways can be a useful thing to do. E7 mentioned that the goal of the game can be reasonably embedded in the theory of music as a communication device and, as such, has a potential to bring certain social impact to address an autistic child's deficits. E7 believed that for those who have not had a chance to engage with music, the game could be an interesting form of instrument to master and play with. When the issue of how to strike balance between raising awareness of main musical concepts in understanding affect in music and maintaining the

application's intended purpose as a playful game, E7 responded by mentioning the notion of *learning by stealth*. Stealth learning refers to an educational approach, where learning is disguised in a playful and fun form, such as through games, and so the learning happens "unexpectedly" (Sharp, 2012). As such, in E7's opinion, the game could provide an opportunity for stealth learning. E7 also cited Sylvia Weir's work on the use of LOGO-environments with autistic children (Weir and Emanuel, 1976; Weir, 1981), whereby one of the children would talk to the turtle but clearly addressing the communication to one of his instructors. He believed that playing a game could similarly be used as a catalyst for communication, in that the child could be encouraged to seek communication with others to get help in progressing through the game. Thus, E7 touched upon an important issue pertaining to the game's intended purpose: encouraging emotional expression through music should not be solely reduced to direct use of the game to produce musical messages, but also as an indirect tool to incentivise communication outside of the game.

He also regarded the use of the visual metaphor of height of notes on the screen for pitch as "interesting" in the context of how metaphor is perceived by autistic people. He believed that the metaphor of tapping for rhythm is appropriate and suggested sliding across the screen as an alternative action for exploring pitch, as when sliding through piano keys to produce a glissando. The researcher then mentioned an idea considered at initial design stage, whereby a character could be directed through a maze, and that character's location within the maze would signify the height of the pitch. The researcher also acknowledged that this might possibly require modification of other minigames to unify them in look and principle. In reply, E7 noted that having a character would then introduce the idea of narrative into the game. When asked about the idea raised by E5 of having virtual characters within the game, and whether this would be motivating or distracting, E7 replied that without empirical testing, it might be hard to make an appropriate decision on this issue. E7 admitted that it might become complex to predict what would be engaging for an autistic child, given how difficult it can sometimes be to introduce something to the child that she did not have interest in before. In general, E7 recommended instead of making pre-emptive decisions to implement these and empirically test, acknowledging that not everything can be anticipated and that it is a good thing if the design gets critiqued by children. E7 suggested that currently communication was more between the player and the game and indicated it is important to determine how the game could be used within a wider context. In his terms, this encompassed both how a teacher or parent could embed this game in their activities with the child, and how the game could be used between two or more players to express emotions to one another. In regard to instructions, E7 agreed to E1 and E3's suggestions of having an interactive tutorial, stating that this is likely to be better than purely textual instructions. He also recommended having two distinct tutorials for the child and the adult (teacher/parent), where the former would prime the child in playing the game, and the latter would explain how the game could be used as a teaching tool. E7 also highlighted the expertise effect, whereby depending on the expert level of the user, the perceived clarity of instruction would be different. Here, E7 also highlighted that the game instructions could play a certain role in addressing both audiences selection criteria, where the teacher would look for specific learning gains from the game, whereas the child could primarily consider, whether the game is

fun and worth spending time on. E7 believed that while an interactive tutorial level should be more useful in general, care should be taken to make it clear whether it was a tutorial or the actual game.

5.2.2.2 E8

E8 obtained a PhD degree in Informatics from The University of Edinburgh and continues her research at her alma mater, focusing on educational technology and assistive technology, particularly in participatory design with children with ASC and special needs.

E8 was sceptical whether the game in fact teaches the player about emotions in music. E8 suggested the use of facial expressions in the game, either on the notes to be tapped or in place of the target areas for tapping, to reinforce the connection between music and emotions. E8 also raised concerns about children who might have mobility issues and find the need to tap in time quite challenging. She remarked that the minigames for the sad emotion featured notes that moved much faster than for the happy emotion, and suggested keeping both levels at the same speed. E8 suggested increasing the size of target areas for tapping. She also noted that these are placed too close to each other, suggesting instead to reduce the number of lines from 7 to 3 or 5 lines in the Pitch Happy level. The researcher then explained that currently 7 lines correspond to straightforward mapping of different heights of notes, to which E8 replied that it might still not be as necessary – just display 3 lines and still somehow show the height. E8 recommended incorporating in-game rewards to help the player track their progress and provide feedback when correctly tapping the notes. To provide more customisation, E8 advised that it could be a particularly good idea to allow the player to use their favourite person's or character's face in place of the notes, as this would cater to the target group's inclination towards familiarity. E8 reported that she noticed some sound feedback when play testing the games but that the distinction between the background music and the foreground music (i.e. what the player taps) was not very obvious. In regard to the design of the Matching game, E8 suggested that providing some feedback about correctly dragged notes would be a good idea. She also proposed displaying the progress in the game to the player, i.e. how many placeholders were left to fill. E8 commended the idea of allowing the player to save their composition in the Free Explorer minigame.

5.2.2.3 Discussion

Discussions with experts resulted in mixed opinions about how the game's implementation reflects the intended purpose. It might be the case of how the experts perceive the prototype - whether it is trying to convey a general gist of the game, and support discussion about high-level design, or represent actual implementation, where the focus is more on the technical details. It might also be possible that experts have different views on what level of external support (e.g. adult supervisor) can be assumed in the ultimate context where the game will be used. Alternatively, experts might have dif-

fering expectations about the target group's ability to work with more abstract versus more concrete (e.g. with other cues such as facial expression) depiction of emotions in music necessary to support the learner. Anyhow, E8's suggestion about including facial expressions will be considered further through the use of emojis. Emojis have been mentioned in several ideas gathered in design workshops (Section 4.1.6) as something that children like in general. As they conform to the design guidelines about using schematic graphics and are known widely, it is very likely that children with ASC will also find this appropriate.

Changes introduced to the game as a result of expert interviews described in Section 5.2.2 were:

- Reduced speed of notes in the sad minigames.
- Progress bar added.
- Visual icons added along textual descriptions in the menu and minigames.
- Icon to switch background music on and off.
- Correct tap feedback through particle effects around the target area.
- Customisation through
  - Choice of balloons and emojis for the note characters.
  - Choice of stars and bubbles for particle effects.
  - Choice of 3 different instruments for sound of tapped notes.

5.3 Implementation details

Following two cycles of rapid iterative development, a fuller version of the Music Explorer game was implemented for formative evaluation described in Chapter 6. Figures 5.4 and 5.5 display screenshots of the game's version used for evaluations with children and experts. All graphics and icons used in the game were found through Google Search Engine and had a Creative Commons licence. Justification for musical pieces incorporated in the game were given earlier in Section 5.2.1.

Minigame 1 from game design 2 (Section 5.1) was renamed to *Tap-In-Rhythm*, and consisted of two minigames – *Pitch* and *Rhythm*. These were implemented for emotions happy and sad. Implementation of all chosen emotions was infeasible, and having one positive and negative emotion to demonstrate differences and similarities between the minigames was deemed as appropriate for a proof-of-concept prototype. Screenshots of the minigames implemented for testing are in Figures 5.4f, 5.5a, 5.5b and 5.5c.

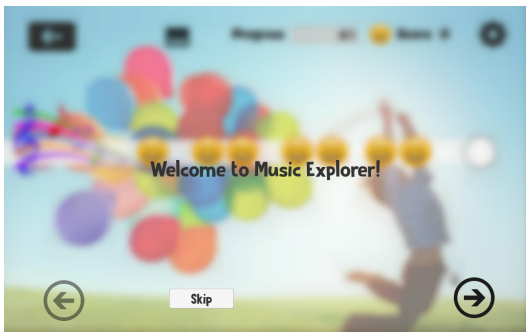
A tutorial level was implemented for evaluation by participants in Workshops 4-7 and expert evaluations with E1, E7, E9, E10 and E11 (Figure 5.4a). This was based on a set of screenshots showing the Happy Rhythm minigame's interface. The tutorial

explained customisation options in the game - i.e. muting/unmuting the background music and changing the appearance of notes, particle effects and sounds of instruments. A narrated voice read out all textual descriptions in the tutorial to improve accessibility. Workshops 4-7 and experts E7, E9, E10 and E11 also evaluated the game with audio descriptions of the labels in the main menu.

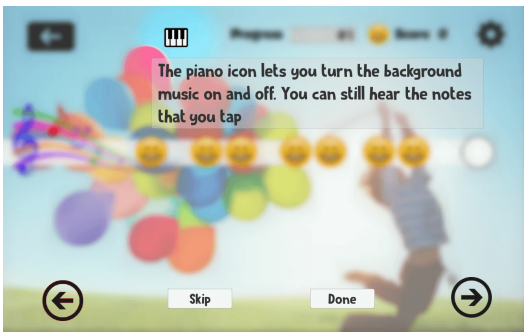
A colourful background graphic in the main menu was supposed to draw the user's attention and entice positive initial impression. Although too vivid visual stimuli can be an issue with the target population, as discussed in Section 2.5, in the case of the menu, it was deemed not to pose a particular problem. Emojis and other visual icons were added next to buttons with textual labels to support younger users and/or those with poorer reading skills. Similar combinations of graphical and textual descriptions can be found within the minigames.

Within the minigames, clear semi-transparent lines, on top of which notes appear, were implemented to help the user keep track the notes as they move towards the target area (circle) at the end of the line. A small graphic of musical staves with a treble clef and notes was added on the left hand side of the semi-transparent line to focus the user's attention around the area in which the notes will start to appear on the screen. When tapping the target area, there is both normal tap animation, where the colour of the circle changes from white to black, and back to white, as well as more salient visual effects in the form of bubbles or stars animation when a note is pressed correctly in rhythm (see e.g. Figure 5.4f). In addition, emojis are the default choice for note appearance, following advice given by E8, but can be changed to balloons, which was inspired by P6's idea. The use of different colours for Pitch minigames were based on P5's idea I9 presented in Table 4.4. Both the height of the notes as well as their colour were used to reinforce the difference in pitch between the notes. Other customisation options are available in the settings, accessible through the cog icon – a familiar interface metaphor. Figure 5.5f shows the customisation options available to the user: namely, they can change the appearance of notes, particle effects providing immediate positive visual feedback upon correct tap, and instruments whose sound can be heard at correct tapping. The *Progress* bar shows the percentage of notes out of the total possible that were correctly tapped (see e.g. Figure 5.4f). A similar measure - *Score* counts how many notes were tapped correctly. Although these measures duplicated the same information, it was hoped that through evaluation, children and experts will provide feedback on which measure is more informative, so that one of them will be kept. Tracking the progress in the game was found to be important through literature review on design guidelines for the target group. There is also a piano icon in each minigame, allowing the user to mute the background music and only hear the notes that she taps, which gives the user further control and flexibility beyond the customisation options explained above. All screens display a clear back button, which allows the player to exit whenever they do not want to continue an action.

As a reward for playing the whole minigame, and loosely relating to the suggestion for randomness given by E1 in 4.2.1, a rocket animation appearing at the end of a level was also included (Figure 5.5e). Tapping the rocket causes an explosion animation, which is a bonus visual effect. Otherwise, the rocket continues moving across the screen until it disappears. At first play, the rocket animation might appear surprising. Although it



(a) Instructions.

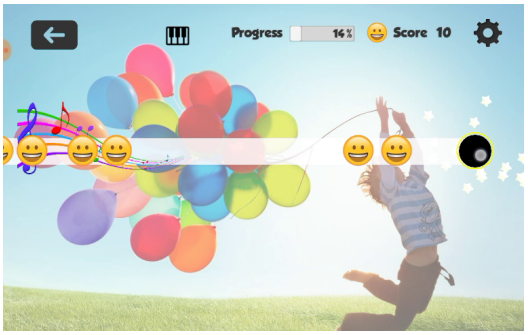


(b) Example of further instruction slides.

(c) Main menu with minigame choice.

(d) Main menu - emotions.

(e) Tap-In-Rhythm minigames.



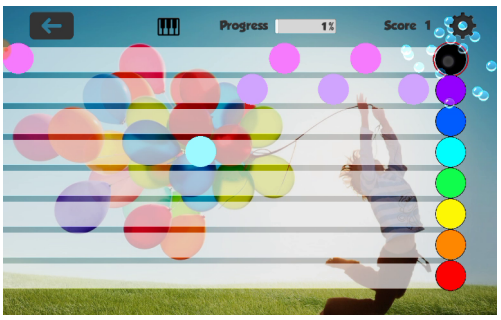
(f) Happy Rhythm minigame.

Figure 5.4: Music Explorer - 3rd iteration, before evaluation.

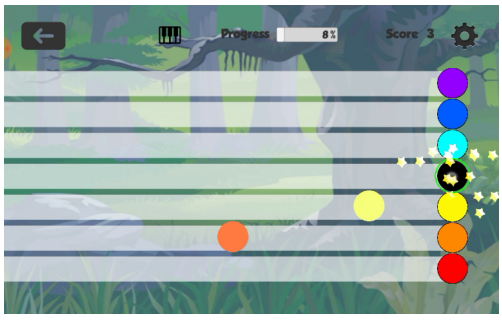
is known that the target group dislikes unexpected things, it is hoped that the rocket will be perceived as not only manageable but also enjoyable. After the minigame is over, a *Win screen* is shown, displaying the raw score achieved by the player, as well as an achievement prompt: *You rock!* (Figure 5.5d). This provides further positive reinforcement to the player. At this point, the player has a choice of replaying the minigame, returning to main menu, or leaving the application entirely (Figure 5.5d).

Matching Game (Figure 5.5h) and *Free Explorer* (Figure 5.5i) correspond to minigames 2 and 3 from game design 2 (Section 5.1). Due to technical difficulties and time constraints, these have not been finalised before evaluations. Instead, a modified version of the Free Explorer was implemented after some evaluation consultations.

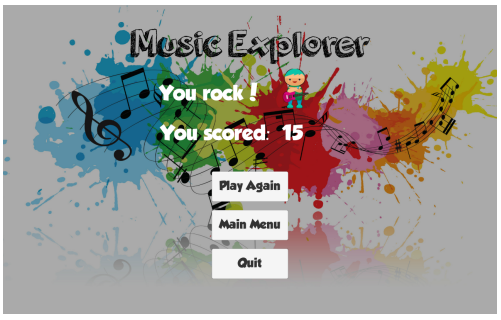
(a) Sad Rhythm minigame.



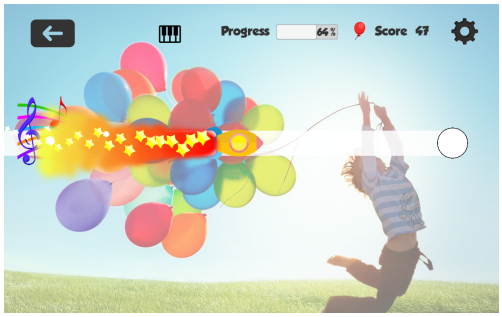
(b) Happy Pitch minigame.



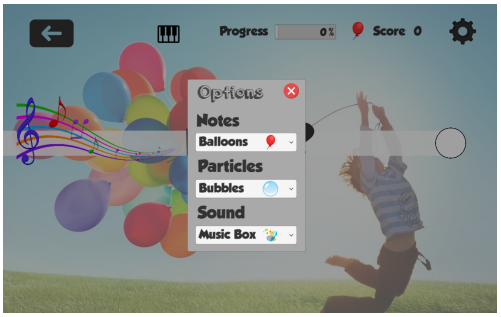
(c) Sad Pitch minigame.



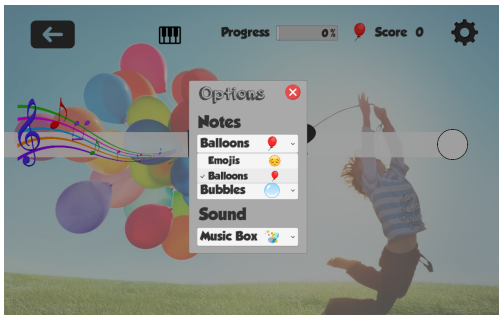
(d) Win screen with achievement prompt.



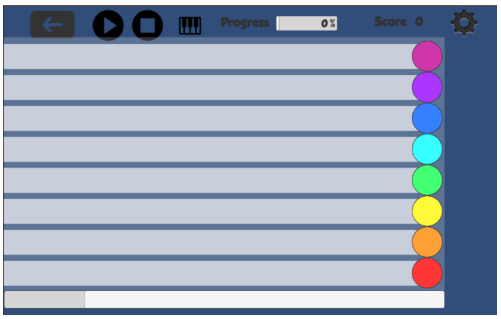
(e) Rocket animation.



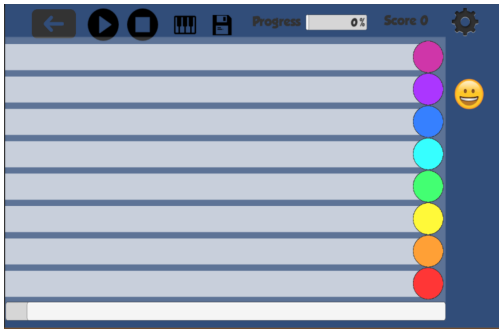
(f) Options menu with customisation options.



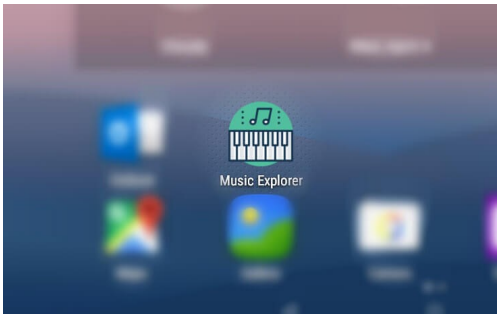
(g) Options menu with example customisation options for the appearance of notes.



(h) Partially implemented Matching Game.



(i) Partially implemented Free Explorer.



(j) Logo and the name of the game.

Figure 5.5: Music Explorer - 3rd iteration, before evaluation ctd.

Chapter 6

Evaluation

In order to evaluate the game's usability and fitness for purpose of encouraging emotion expression, evaluations with TD children and experts were conducted and analysed. Suggested issues, modifications, as well as changes introduced as a result of these evaluations are also presented.

6.1 Evaluation workshops

The main aims of the evaluation study with children was to assess the usability of the game and its fit for the purpose of encouraging emotional expression. Evaluation sessions took place in the same settings as before, i.e. in the usual meeting place for Brownies unit, as well as the Informatics Forum. Again, the locations and timings were chosen to best suit the child participants and their parents. Evaluation sessions were conducted through semi-structured interviews and focus groups of 1-4 participants, depending on their availability. The common questions explored within the study were:

1. To what extent does the game developed have a potential for encouraging emotion expression through music?
2. Is the game fun to play in general?
3. What are the most liked and least liked elements of the game, and what should be changed?
4. How effective are the following features within the context of the game:
   (a) Musical pieces chosen
   (b) Length of levels
   (c) Difficulty
   (d) Progress bar
   (e) Score

(f) Rewards

(g) Customisation

5. Are there any usability issues in the implementation, and how should they be rectified?

Although participants' understanding of the goal of the game was expected not to be conclusive for the target group of children with ASC (Question 1), it was hoped that they can still provide preliminary feedback on the game's fitness for the purpose of encouraging emotional expression from their point of view. As enjoyability is an important factor for games aimed at the target age group, Question 2 sought to explore children's opinion on this matter. Question 3 was asked to provide support in eliciting feedback about the game from participants. Questions 4 and 5 were aimed more at the interface design and game mechanics. Not all of these questions were posed directly as presented here but acted as support for eliciting feedback from participants.

6.1.1 Procedure

Evaluation workshops followed the plan attached in Appendix F. Firstly, the researcher introduced herself and asked for consent to audiorecord participants responses and capture the screen of the tablet to record their interactions. After that, a brief description of the research focus of the game was introduced. Participants were then queried about their previous use of mobile and tablet devices, especially in the context of playing games. This was followed by an introduction to main user interface components of the game, as well as the main in-game tasks. For sessions 1-3, this was done with a set of supporting screenshots, described by the researcher in an ad hoc manner. For session 4-7, a tutorial level explaining these components was implemented into the game itself, allowing the user to go back to it as needed. Afterwards, game testing proceeded, whereby each participant in the focus group played at least one minigame from the Tap-In-Rhythm category, i.e. Rhythm - Happy, Rhythm - Sad, Pitch - Happy or Pitch - Sad. Participants were asked what they liked most and least in the game, what they would like to change, as well as a discussion of some of the themes mentioned in Section 6.1. A similar discussion based on screenshots of the Matching Game and Free Explorer minigames commenced afterwards. At the end of the session participants were thanked for their feedback and given certificates as a form of appreciation for their input.

6.1.2 Participants

Similarly as for design workshops described in Section 4.1, TD children were used as proxies for the target user group. Again, participants came from two groups: Brownies unit and children of the Informatics staff (and their friends). As most participants knew each other before and the sessions took place in a setting that was familiar to them, this allowed for more comfortable discussion around the game.

Participant	Age	Sex	Group	Session
P13	8	F	B	1
P14	8	F	B	1
P15	9	F	B	1
P16	9	F	B	1
P11	8	F	B	2
P17	9	F	B	2
P18	9	F	B	2
P19	9	F	B	3
P20	9	F	B	3
P21	9	F	B	3
P22	8	M	IF	4
P23	10	M	IF	4
P24	12	M	IF	5
P25	12	M	IF	5
P7	8	M	IF	6
P26	12	F	IF	7

Table 6.1: Child participants in evaluation sessions.

All participants except for participants P13 and P14 have previously partook either in some game evaluation or design sessions in previous years, and P7 and P11 have also previously contributed ideas at the design stage described in Chapter 4. All participants have used tablet devices before to play games. All participants except for P7 said they liked listening to music. 10 out of 16 participants stated that they knew how to play at least one musical instrument.

6.1.3 Discussion

6.1.3.1 Goal of the game

Participants enjoyed playing the game in general, with a large proportion of them indicating interest in playing the game again or asking if the game will be made available for downloading to their personal tablet devices. They could generally see the connection between music and emotions, and appreciated its focus on encouraging emotional expression through music, believing that it has a potential to promote such communication. Some of the responses regarding this aspect were particularly insightful. Similarly, P23 said: *There's actually this person who's too shy to speak but then music sort of brought her to it*, and P22 exclaimed: *Music changed the world!* P23 also said: *It would be quite helpful I think, because for children that have autism, it might be quite hard for them to learn musical instruments like that. This game might just encourage them to get into how good music actually is. And then they might be more willing to*

learn musical instruments. Other responses follow:

> P16: *Cause you can play and hear what it sounds like and everything. (...) Yeah, cause you can have like a really upbeat, fast song and it can make you very happy and then a really quiet one, a song that you don't really like and it kind of makes you feel sad.*
>
> P15: *My dad makes music and he said when he was younger, he used to make music, if he was feeling a different emotion, and if he'd already made a song that goes along with that emotion, then he would play it.*
>
> —
>
> P24: *Most of the time, if you're happy, listening to happy music could help that, or even sad music... it wouldn't really change that much... but with sad, if you didn't know how to explain it, I think if you listened to music, especially the kind of plain but good music that's in the game, I think that could help them explain it better*
>
> —
>
> P20: *I really like these types of games.*
>
> Researcher: *What do you mean?*
>
> P20: *Like music games, where you kind of have to tap.*
>
> P21: *Yeah, cause it kind of shows you, like, what kind of music they'd show as sad music, and how you can express yourself in music. Like, I watch this thing, Newsround, which is a child's news programme. And it said this boy had about 4 things that he needs to focus on, like 4 mental issues and he had an autistic thing. And music made him express and talk and actually express himself using piano or guitar or something. And he managed to start to speak and start to express himself using music.*

P21 also shared that she had a peer with ASC in class, and that she was aware of the child's problems with emotional expression:

> P21: *Yeah, in our class at school we have an autistic child named [...] and he doesn't really talk to anyone and he doesn't really, again, express his emotions. And he only expresses the emotions to the teacher. And we ask him if he wants to play, he doesn't say he wants to or he doesn't want to exactly, or he isn't saying why, or how he's feeling or something. Cause he looks quite sad on his own sometimes so that's why we always ask him, like, what he feels like on his own but he doesn't want to tell us.*

P21 reaction showed a genuinely curious, accepting and inclusive attitude towards the communicative differences between her and her autistic friend. In addition, the game also elicited a very strong emotional response from P21 herself, suggesting that the message conveyed by the game clearly resonated with P21.

P26 liked the fact that music and emotions were linked within the game and also noted that she has not seen a game that does that before. She believed that the game could

help someone with autism express themselves through making own music both within and outside the game. P26 also thought that one can learn a lot about music through the game, as she noticed a clear correspondence with actual musical staves and notation. She believed it could fit well for use in supporting learning about music at school, especially the Free Explorer level.

P13 also mentioned that her cousin with ASC liked listening to music but was unsure whether the game would be fun for him to play as he is now 16.

Participants generally believed that the game serves the purpose of encouraging emotional expression through music, and although this cannot be taken at face value, is still a valuable finding.

6.1.3.2 Interactions between the participants

Spontaneous interactions between child participants, as well as various verbal and non-verbal responses catalysed by the game itself suggested that the game encouraged communication and emotional reaction in general, and about emotional expression through music in particular. Participants would spontaneously comment on each other's performance, comparing themselves to other children, and/or providing encouragements. At some point while testing the game, one of the children suggested to the rest of the group that everyone can just tap a couple of notes and pass the tablet on to the next person in the group. After one such game, they started planning out whose turn would come after each couple of notes in the next game. This spontaneous turn taking signified a natural embedding of the game into a collaborative activity between participants.

6.1.3.3 Musical pieces chosen

Participants were generally very positive about the fit of musical pieces chosen for depicting respective emotions, with some of them citing the music as the best feature in the game. Some participants spontaneously hummed or moved rhythmically along the music. P21 also asked: *How long did it take you to come up with these tunes?*, indicating appreciation for the music chosen for the game. On the other hand, P7 believed that sad music was less to his liking and slightly too slow: *Yeah, it's quite a relaxing tune. Yeah, like, just make it a little bit more lively, so that they, like, stay awake and not fall asleep in the middle of doing it*.

6.1.3.4 Length of levels

No issues were found regarding the length of the levels, with participants generally believing this to be appropriate. P24 said: *Because's it's long enough to get into it, but you could just start again if you want to do more. But it kind of gives stopping to it*.

6.1.3.5 Speed/difficulty

A large proportion of participants displayed difficulty playing the Pitch minigames, especially the one for emotion happy. Participants cited the speed (i.e. the number of notes they had to tap in a unit of time), as the main factor contributing to difficulty. While they were aware of the difficulty, most of them still enjoyed the level of challenge. For instance, when P16 was playing the Pitch sad level, she said: *Its hard (...) it's funny*. However, when P7 picked the Happy Pitch level as the first minigame to play, he appeared quite overwhelmed with the speed of the notes, as he started to tap on multiple targets frantically, and said: *[grimaces] Ahh, oh God, what do I do?* After 20 seconds, said: *No, that's it, I'm going back, I'm doing Rhythm*. On the other hand, at the Rhythm minigames, he appeared to view the level of challenge to be low, as he started pretending to snore while playing one of these minigames. When the researcher asked if that meant that the game was boring, P7 replied: *Yeah, I guess after the kids play, like, at least 15 minutes they're like 'Ok, yes, it's quite good, I'll go back to it like tomorrow or something. Just like, go back to it tomorrow.'*

There were mixed opinions among participants on whether the game would be easier or more difficult for someone with bigger hands. From observation, children appeared to have no problems pointing at the target areas, suggesting that their size is likely to be appropriate.

Some participants suggested having different levels with different speeds, where the music itself would not change, just the speed. Another frequently mentioned fix was to allow changing the speed of the music within the minigames. P7 found the speed of the Happy Pitch level challenging and suggested it should be decreased: *Yeah, you can actually kind of slow those down, you know, like the super hard mode, so like the fingers aren't going crazy trying to tap them. Kind of slow it down, so the kids with autism aren't going like 'Aaaarrgh!', tapping their fingers rapidly trying to hit it*. Another suggestion was to change the number of lines in the Tap-In-Rhythm minigames. What can be generally inferred from participants responses is that a larger variety of levels should be offered to cater to different opinions on what constitutes optimal challenge. This also means a possibility to build up skills by practice, and provide a chance to experience success, something that was previously mentioned by one of the experts consulted for game design requirements.

6.1.3.6 Other minigames

MATCHING GAME. Participants believed that the minigame would be fun to play and fitted well within the whole game, as it would provide more variety and another level of challenge. P26 liked that the game helps practice coordination skills.

FREE EXPLORER. Participants believed that the idea of creating own music is good, with some voicing an opinion that the Free Explorer minigame was a natural continuation of the other minigames. Some suggested that the minigame could provide a chance for someone less experienced in music making to explore different sounds,

and that it could again provide more of a challenge. At least two participants suggested as an extension for the Free Explorer level that the player should be able to create a musical script, which could then be tapped along just like in the Tap-In-Rhythm minigames. This was considered as a particularly interesting idea that would fit well with the rest of the game while still maintaining the general goal of the Free Explorer minigame.

OTHER EMOTIONS AND EMOIJS. P22 asked about the angry and scared levels, and when the researcher stated that these have not been fully implemented yet, P22 replied: *It's gonna be quite good when they are!*

Emojis were mentioned by some participants as their favourite feature in the game. P7 suggested adding more emojis into the game, such angry, scared, emoji blowing the kiss, mindblown emoji, where for the last emoji, there should be a dedicated level: *Like a mindblown emoji, just like a very crazy song where everything is coming like superfast you know, like, mindblown. Yeah, that should actually be a level, like mindblown level*. In the context of the game, adding more emojis would necessarily mean including more affective dimensions. Providing a variety of emotions for exploration through music could be helpful in acquiring better understanding of emotion expression through music.

6.1.3.7 Feedback, progress and rewards

SOUND AND VISUAL EFFECTS. While playing one of the minigames for the second time, and after tapping the rocket for it to explode, P22 indicated he expected to hear an explosion sound: *"I can't hear the rocket though!* P23 suggested that when the balloons-notes are popped, they could also make a popping sound. P23 also suggested another effect when correctly tapping a note, which would be a jagged graphic with a big "BANG!" label. P23 believed it would be a good idea if the music line graphic at the left hand side of the central line in the Rhythm minigames was animated and swaying like a river. In addition, upon correctly tapping one of the notes, it burst into bubbles and made a sound, to which P24 reacted with positive surprise. On the other hand, upon tapping the rocket, P24 showed surprise as it only made a visual effect, suggesting that a corresponding sound effect was anticipated.

SCORE AND PROGRESS. Participants believed a performance measure such as the current *Score* is helpful:

> P11: *You can try and beat your last one. You could try and see if you could get better next time.*
>
> P18: *Cause some games, they don't show your score, they just tell you at the end, so you don't really know how well you're doing.*

P24 suggested that raw score might not be sufficient for the target group in indicating achievement within the game: *I would find it quite cool if you did x amounts of notes in a row, it would come up and say 'Well done' or just encourage some of the younger people*. The idea of providing different levels of feedback on performance can indeed

be particularly informative.

The progress bar provided confusion to some participants. For instance, P25 asked whether it was the percentage of the points or percentage of how far one is in the game, and believed the latter definition would be more informative.

ROCKET. The rocket animation appearing at the end of each minigame was mentioned several times in interactions between participants. Some participants would excitedly anticipate the rocket coming at the end the element of unexpected surprise and delight brought by the rocket indicates that it draws positive interest in the players. P23 suggested that in the Pitch minigames, the rocket should span over three lines.

WIN SCREEN. Participants were generally encouraged by the positive reinforcement offered when a minigame finished, with some of them laughing, cheering or clapping along. When asked whether she liked it, the P16 remarked: *It makes you feel good about how you played*. Similarly, P22 also clapped along the cheering and clapping, suggesting that the current audio feedback on player's achievement is an enjoyable feature.

FAILURE FEEDBACK. Some participants also realised that they could repeatedly tap the target area to get the notes instead of only tapping once as the note slides through the target area. At a second time playing one of the Rhythm minigames, P23 began repeatedly tapping on the target area, with an intention to illustrate that such incorrect pressing should cause losing points, which he believed should be a feature in the game. While flagging up that an action is incorrect or undesirable, or preventing it altogether would be better to provide feedback contingent on player's action, the researcher was undecided about the use of such failure feedback as it could potentially be overwhelming to the target user. One should consider that there are many other sensory stimuli in the game, so this could prove challenging to process by an autistic child.

6.1.3.8 Customisation

The majority of participants cited customisation options as the most liked feature in the game. P24 said: *I think that's a good, so you're not the same thing over*, while P25 commented: *And it could make people feel that they slightly personalised it*. Participants had different preferences regarding playing with the background music being muted or not. For instance, P25 believed that the background music made it easier to play, and that turning it off introduced a form of a challenge. On the other hand, P24 believed that without the background music, it was easier to see what one was doing, as one could more easily pick out the sound that goes along the note being tapped. As such, the flexibility offered at this point was deemed appropriate in catering to different needs and preferences.

6.1.3.9 Instructions

Despite scarce explanation of the game interface and how to play it, children intuitively understood how to navigate the game and what they needed to do in the Tap-In-

Rhythm minigames. However, from interactions with the tutorial level implemented and shown in the later evaluation workshops, it appeared not to be as effective as was hoped. Specifically, confusion about interactivity of different features of the interface in the tutorial level could be observed among most participants. This suggested that some degree of interactivity could be included, especially for the interface items being described. Some participants would also pause for a short period when first opening the game, indicating that the tutorial interface should provide clearer affordances for interaction (e.g. highlighting that the arrows should be pressed to progress through the slides). One of the participants explicitly suggested there should be a *Help* button:

> P16: *Or you could have, like, a help button. So you, like, you click it. So if it's, like, if someone's just playing it and then you get on to it and then you're like 'How do you play this?' cause they don't know.*

Most participants also needed prompting to suggest exploring customisation in the game. It also appeared that the absence of explanation on how to play the game led to confusion, even if this was explained by the researcher verbally before children started playing. The researcher was aware that both explaining what the game is about, as well as how to interact with the interface are important, but due to time constraints, both could not have been implemented appropriately.

6.1.3.10 Navigation

All of them were right-handed and so the interface's assumption of the placement of target areas on which the user needs to tap was in line with their expectations. P23 pressed unintentionally pressed the *Quit* button twice (at least once at the Win screen) and suggested that the button should not appear there and only in the Main menu.

6.1.3.11 Settings

After exploring the options in the settings panel, P18, had minor problems closing the options menu, slightly missing the "x" button when trying to press it a few times, indicating a small navigation issue. P23 recommended that the options panel should be bigger and instead of being grey, to be semi-transparent, for more clarity that it is referring to the current screen.

6.2 Expert interviews

Similarly as in the previous stages where initial game design and implementation were critiqued, semi-structured interviews with experts from different domains relevant to the research topic were conducted with an aim of evaluating the high-fidelity game prototype. The timing and location of these consultations were chosen to suit the experts' preferences. The major aims of expert interviews were to address the following questions:

1. To what extent does the game developed have a potential for encouraging emotion expression through music for children with ASC?
2. Are there any usability issues in the implementation?
3. How effective are the following features within the context of the game:
   (a) Tutorial
   (b) Musical pieces chosen
   (c) Length of levels
   (d) Difficulty
   (e) Progress bar
   (f) Score
   (g) Customisation
4. Are there any specific suggestions for improvements to increase usability of the game and its fitness for purpose?

Question 1 aimed to validate that the game prototype developed so far demonstrated suitable features for the goal of encouraging emotional expression through music. Question 2 and 3 focused more on interface design and game mechanics. Question 4 sought to elicit suggestions for possible fixes to bring the game more in line with the overarching purpose of the game, as well as technical expectations of the target user group.

6.2.1 Procedure

Evaluation interviews followed a similar structure as evaluation workshops with children. After the researcher introduced herself and asked for consent to audiorecord verbal responses, as well as capture interactions on the tablet' screen, a brief description of the research focus of the game was presented. Apart from E8, experts tested the game where it included the tutorial that introduced certain interface features. Again, experts had a chance to play the Tap-In-Rhythm minigames and provide feedback on them, as well as discuss mockups of Matching Game and Free Explorer minigames. Only E11 tested an implemented the Free Explorer minigame. Interviews were conducted either in the experts' offices, or elsewhere within or nearby university campus.

6.2.2 Participants

Experts who provided evaluative feedback on the game prototype stemmed from a number of relevant domains. Experts E1, E7 and E8 have also provided feedback at previous stages of the research. E10 also provided advisory support throughout the length of the research.

Expert	Area of expertise/interest
E7	psychology, game based learning, e-learning
E1	autism, accessible technology, games for autistic children
E8	accessible technology, educational technology, technology for autism, HCI
E9	game design, computer science
E10	autism, educational technology, technology for autism, HCI
E11	HCI

Table 6.2: Experts consulted for evaluating the low fidelity prototype. The order here reflects the order in which experts were interviewed.

6.2.3 Discussion

6.2.3.1 Goal of the game

All experts except for E9 believed that the game demonstrated the goal of encouraging emotion expression through music. Accessibility of the game was generally assessed as appropriate, especially due to the audio descriptions and simplicity of the interface. Experts also believed the game is fun and engaging, with E7 asking if he could get the game for his iPad. E9 was concerned about the game not being fully implemented yet so as to showcase the extent to which it could help in communication about emotions. E9 acknowledged that maybe he did not fully understand what the purpose of the game was but felt that what the game does and what the intended purpose is are in dissonance:

> E9: *At this point it doesn't feel very communicative. It's just like they play with music. And especially considering that, at least from what I remember from my research, is that one of a big problems that autistic children have is putting names to their emotions and understanding them. Even the fact, if it's gonna be played just by them, even the fact that you make them choose the emotion they wanna play with is already kind of... I don't wanna say "defeating the purpose"... but kind of like... If they know what emotion they feel – happy, sad, and things like that – that's already past the point of the problem, which I think you're trying to fix with this.*

E11 was also unsure whether the target group would understand the purpose of the game from the way it is currently implemented:

> E11: *I'm really wondering if a child going to see the depth that you're trying to add in here without, like, being explicitly told. They might just see it as a fun 'let's tap this'-game, and maybe as a side effect they don't actually need to see the depth.*

This comment conjures E7's reference to stealth learning as a way of embedding unexpected learning opportunities in a game (Section 5.2.2.1). It has to be noted that when presenting the goal of the research to E9, the researcher (slightly erroneously) described it as aiming to encourage communication about emotions through music. There

is certainly a difference between expression and communication. Self-expression does not always have to be directed at an audience whereas communication usually would. In addition, E9's response seemed to reflect his strong belief about what constitutes acceptable proof-of-concept. E1 and E10 (and to some extent E7) are most knowledgeable about ASC, and they agreed that the game serves the purpose of encouraging emotional expression through music well. While there is no universal agreement among expert opinions, it is believed that the game demonstrates preliminary potential for encouraging emotion expression through music.

A number of interesting activities and instructions to be included alongside the game were suggested. E1 believed that after appropriate extension, the game could be an interesting starting point to discussing different emotional or mental issues of autistic children, suggesting that their parents might sometimes have little knowledge about the experience of ASC other than that their child is autistic. E1 suggested that the application could then incorporate guidance to teachers and parents about why the child might find it hard to express their feelings. This could further help parents and teachers in encouraging children with ASC to communicate about their emotions and allow parents and teachers to know more about the experience of emotions in autism.

E7 also raised the issue that learning usually involves interaction with another party – that could be a computer or a human. Creating a composition could then entice the player to share it with somebody and see how they react. In such a setting, learning then could stem not only from the act of creation but also seeing how someone else reacts. Similarly as in previous interview, E7 thus highlighted the game's role as catalyst for interpersonal communication and/or interaction.

6.2.3.2 Musical pieces chosen

Experts believed the musical pieces chosen for the respective emotions were appropriate, with some experts displaying particularly positive attitude towards the music. While play testing one of the levels with the happy emotion for a second time, E10 started humming along the melody and said:

> E10: *I've actually got the tune in my head now. (...) What you should get them [the children] to do is to hum along to it.*

6.2.3.3 Speed/difficulty

Some experts expressed concern about the speed of the Pitch minigames, suggesting that the speed of the in-game music tracks should be adjustable to accommodate children with poorer motor skills. E7 also raised the issue of what constitutes optimal challenge, which could vary between players. E10 suggested that slowing down the happy song could be helpful while acknowledging that this might change the happy feeling of it. When playing the game for the first time, E11 was baffled about what to do. After a period of inactivity (indicating her confusion), the researcher explained that E11 needed to tap in the target area, to which she replied: *Why was that not in*

any of the instructions?. E11 also found the Happy Pitch minigame challenging. E11 believed that in general, the minigames were not difficult to understand. However, E11 believed the levels required better onboarding instructions, which would explain what the game is about and how to play it.

6.2.3.4 Other minigames

MATCHING GAME. There were mixed opinions about the Matching Game among experts. E1 and E7 believed that providing a more structured way of exploring sounds intended for this minigame was understandable, and that it would be fun and playful activity. E1 was initially positive about the drag and drop-based mechanism used for interaction but later acknowledged that the game might feel long and tedious as the user needs to drag and drop all of the individual notes into placeholders before being able to hear the whole melody. E10 displayed disapproval for the drag-and-drop based mechanics of the Matching Game, remarking: *I find that a real hassle*. Instead, she suggested that tapping on the source and target locations should be used instead. E10 noticed a contradiction between the in-game music notation and formal music notation. E10 found the direction of the music slightly counterintuitive and confusing, as music is usually read from left to right, with the beginning being at the left and the end on the right, whereas the opposite is the case here. She turned the tablet upside down, highlighting that due to such rotation, it ”suddenly makes more sense”, also noting that the staves were then the wrong way round. She also noted the way Matching Game was designed was conditioned on the format of the previous levels, where the direction was guided to fit a right-handed user. As such E10 could not conclusively suggest a reconciling modification to combat this contradiction.

FREE EXPLORER. Experts were positive about the unbounded exploration mode of this minigame, and how this fits in relation to other minigames. The presence of the background music was also considered a good learning opportunity to explore what works and doesn’t work (e.g. is consonant or dissonant). Similarly as for the Matching Game, E10 recommended replacing the drag-and-drop mechanism. E10 suggested that instead of dragging the notes onto the lines, one could just tap the target areas, and as one creates the notes by tapping, these would appear on the staves in the right order. E10 believed that this minigame could then have a potential for engaging another person in collaborative play, whereby one person would create the song for someone else to later tap along. This idea coincided with suggestions given by some child participants in evaluation workshops, as well as the principal aim of the game Roblox mentioned by one of the children in design workshops (Section 4.1.4). Such design of the minigame could not only give an avenue for creativity in the realm of music, but also in essentially creating a game to be played. As a result, the researcher modified the design of the Free Explorer minigame and implemented it as specified by E10 and children (cf. Figures 6.1g and 6.1h). This implementation was tested by E11.

When it comes to usability issues in Free Explorer, E11 suggested the list of recorded pieces should not appear as one of the options in the settings but rather when one presses the *Play* button. She pointed out that the tutorial did not mention this, and that

the options shown originally in that place were the character (note) options.

A number of alternative extensions to the Free Explorer were also mentioned, which generally put the artifacts produced within the game in the role of shareable objects. An alternative extension suggested by E10 was that the background music would not be present in the level, and so the child could choose the emotion they want to express, and then the collaborator could not only play the game but also guess what the emotion was. E1 suggested an additional minigame that would bridge the gap in difficulty between the Matching Game and Free Explorer minigames, whereby the user could modify a pre-set set of notes to explore the music, again with respect to the background music pieces corresponding to each emotion. E11 on the other hand suggested that another, more structured minigame which would precede the Free Explorer level could be added to the game. Such minigame would feature a set of more structured challenges or prompts that would still allow the child to be creative. E11 mentioned that, for instance, the child could *compose a song that might feel like you have just gotten a present on your birthday and you really liked it*.

6.2.3.5 Feedback, progress and rewards

SOUND AND VISUAL EFFECTS. E10 noticed that listening to the music helps more than just using the visual cues in anticipating when the notes should be pressed. She found herself performing better in the minigames when using the auditory cues rather than visual. She believed it to be interesting that the game expects the player to use music as guidance in playing to tap along the rhythm, but then there is also a certain degree of focus on the pressing when the note reaches a certain spot (target). ROCKET. The rocket animation was generally positively rated. E10 believed that the rocket's indication that the game finishes was good.

LOADING SCREEN. The loading screen was considered as useful in providing feedback on the progress of loading a minigame.

POSITIVE VS NEGATIVE FEEDBACK. E1 assessed the use of positive (i.e. when the note was tapped correctly, in time) visual and audio feedback as good. E1 was hesitant in suggestion of having a similar failure feedback – she believed that it could be overwhelming, especially in the Rhythm minigames, were all feedback would be concentrated on the one line, but perhaps less so in the Pitch levels, as with more lines, one would naturally shift focus to other parts of the screen. E1 suggested conducting A/B testing to query responses to the failure feedback feature.

PROGRESS AND SCORE. Experts expected that the progress bar meant how far through the game one is, not the percentage of notes one got correctly out of total possible. E9 asked: *Why is progress at 89% when it's ending?* E1 and E10 suggested that knowing how much one has left would be desirable for children with ASC. In general, experts did not have a strong opinion on whether a raw score count or a percentage score is better. If the latter would be retained, experts recommended rephrasing it from the current *Progress* to *Score*.

REWARD. E8 noticed the use of effects around the target area as a reward for correct

tapping, and suggested another achievement reward feature. Namely, the achievement performance could be graded depending on the overall percentage of points collected out of the total possible, similar to one used at school. This could be done through achievement prompts or certain items that could be collected:

> E8: *60% – good, work more and you'll be very good, 80% – just a little bit and it's going to be excellent, and at 100% you can give them a rocket or piano as a reward.*

This suggestion was subsequently incorporated through auditory (cheering and clapping sounds) and five levels of verbal (text + voice) achievement prompts based on user performance, and presnted in the *Win screen*.

COUNTDOWN. E9 found it surprising that the countdown at the start of a minigame finishes after the first notes have already appeared on the screen, and suggested fixing this.

GAME RESPONSIVENESS. E9 found the speed of the minigames for the happy emotion challenging, and raised the issue that children with ASC might become easily frustrated by this. On the other hand, while playing the Sad Pitch minigame, E9 believed the tap detection on that level was more responsive. He suggested a more generous margin of error for tap detection around the target area, as well as adding an option to vary the speed of the song.

6.2.3.6 Navigation

QUIT AND BACK BUTTONS. E1 thought that the *Quit* button in the main emotions screen would take her back to the main menu (i.e. what the *Back* button would do). This resulted in her unintentionally leaving the game twice. E1 noted that the back buttons in the main menu and main emotions screens (Figure 5.4d) were not visible enough. To mitigate the confusion, E1 suggested displaying a dialogue prompt upon clicking the *Quit* button to confirm that the user actually wants to quit the game.

E9 also believed that upon pressing the *Back* button that leads from the minigame to the Main menu should display a dialogue prompt to confirm that the user wants to leave the level, noticing that a similar one already exists for the *Quit* button.

SETTINGS. E8 noticed that the settings panel provides no feedback on whether the chosen options were actually saved. To address this, she suggested adding a *Done* button to the panel to make it clearer to the user that their choice was noted. In addition, E8 found the naming of one of the options (i.e. *Particles*) to be unclear, and so she suggested rephrasing it to *Effects* or *Hit effects*. E8 believed that placing the *Settings* within the label rather than main menu was a sensible choice:

> E8: *I guess it's more intuitive for you to have it here [in the level]. And you don't have many buttons. I guess it's easier to make it here, as you did, because when you talk about effects and so on, you can understand better after you've tried a little bit, you know? Here, you can change at*

> *any moment. You may say: "Ok, let's do that with something else and see what happens" and you don't need to go back.*

E8 also suggested implementing the functionality of closing the settings panel by clicking outside of the panel, and not only through the standard "x" icon in the top right corner, as she noted that redundancy here is better. As this was a minor fix to introduce, it was also introduced before evaluation with E11.

E10 believed that it is good to be able to switch the background music on and off, and that customisation of different features was possible. E10 identified an issue with the alignment of an expanded dropdown list, as it appeared to continue onto the option item below. E10 suggested that either the option items should be realigned to avoid this overlap issue, or be expanded to the side.

E11 commented that the dark colour of the settings menu suggested that it is non-interactable or in the background. In her view, this was even more apparent in the tutorial, where the *Done* and *Skip* below the settings panel would appear in the same grey colour. E11 approved of the font size and style used in the settings panel, and found the use of small icons next to each option item helpful and informative, especially in the context of users with reading or any other language related difficulties.

One issue identified with the navigation side of customisation options is that settings are currently located within the game, and while the game is automatically paused when the user tries to change any of the options, closing the settings resumes the game automatically. On the other hand, changing settings within context of the minigames was deemed appropriate by most experts, as it allowed the player to immediately see the effect of their choices. As a mitigation of this issue, two experts suggested that there should be explicit control buttons to play and pause the game. Due to the important musical component of the game and associated timing, this suggestion appears to be appropriate.

PAUSE FUNCTIONALITY. E9 advised introducing a pause functionality, noting that it has already been implemented for when the user opens the *Settings*. He said a possible use case scenario for this would be when the user is interrupted while playing the game, so that would allow later continuing where one left.

PITCH. While play testing the Pitch level, E10 highlighted issues pertaining to rotation preferences and "gaming" the interface. After playing one of the Pitch minigames once, E10 turned the tablet vertically and started playing that way, stating that she finds it easier to do it vertically. Instead of pressing only once per each note, she also started hitting the target buttons repeatedly, saying:

> E10: *If I just do that all the time... That's my most accurate! I'm totally ignoring the timing. If I just hit it at the right frequency, I get it right every time. And I'm totally disregarding... I guess you've had other people doing that?*

6.2.3.7 Customisation

Experts commended customisation possibilities in the game, and that user choices persisted across different levels. In particular, E1 was very positive about the choice of different instruments, noting that there could be scope for discussion with a teacher or parent whether any of the instruments sounded more indicative of a certain emotion, e.g. sad or happy. When exploring the capacity to switch the background music on and off, some experts stated that without the background music, they could play the game in a more comfortable, controlled way and/or that they were more accurate.

E8 suggested changing the piano icon used to mute and unmute background music to a speaker icon, as well as adding another similar icon to allow for turning off the sound of the notes that one taps. To avoid confusion, E8 suggested adding labels *Background* and *Notes* to these icons, noting that the interface currently features similar labels for *Progress* and *Score*. In addition, E8 suggested that using separators between the resulting set of items would be helpful in making the interface clearer.

6.2.3.8 Voiceover

Experts approved of the use of voiceover in general, although a number of issues were found. The game version tested by E1 did not feature voiceover outside of the tutorial, and so E1 suggested adding voice description to menu item labels when these are clicked, citing a particular solution used in ClevelCogs software for large tablet devices for users with accessiblity needs and literacy difficulties: i.e. that the text is read out when the user taps on an item, indicating in this way whether they made a correct choice. E11 recommended that it should be able to turn the audio descriptions on and off. On the other hand, E10 expressed a negative attitude towards the current voice used in the audio descriptions. E10 believed that the voice is too high, too fast, and not very clear, and that she did not always understand what the voice said. She suggested that for the target group, this could prove even more challenging, given their tendency to have information processing difficulties. As audio descriptions were recorder by the researcher, it should be acknowledged that potentially sourcing a native-speaking voice artist would be more appropriate.

6.2.3.9 Tutorial

Most experts showed certain confusion about which parts of the tutorial interface were interactive. E9 indicated that children might find the tutorial overwhelming upon opening the game for the first time and not fully understand what it is about. E11 highlighted the need to provide context beforehand to the interface elements being introduced, as otherwise the user would not know which of the information to retain and what is relevant for the goal of the game itself. On the other hand, E1 remarked that the tutorial itself is good and that information about the interface is given concisely and clearly in small bits, with one piece of information in each sentence. E7 acknowledged that

despite the slides provided very limited information, children are usually used to interacting with games that usually do not have a lot of instructions, so they need to ascertain the navigation and goals of the game by trial and error.

There were numerous suggestions for improving the tutorial. To help distinguish parts of the tutorial interface from the screenshots used in the slides, E9 suggested adding a semi-transparent panel below tutorial interface items (i.e. *Back*, *Next*, *Skip* and *Done* items). Regarding the second slide in the tutorial, E1 and E11 suggested that after some period of inactivity, some affordance should be incorporated to suggest what the user needs to do: be it a voice or animation of buttons, so as to prompt action from the user, as it was not very clear what to do at that point. E10 also suggested that the static format of the slides should be improved with some interactivity, especially for the buttons being explained. After this functionality was added (before E11's evaluation), E11 stated that it was good that the settings could be changed in the tutorial since this allowed the user to interactively explore the interface.

Experts also suggested that the tutorial icon in the main menu should be made more visible, for example by renaming it as *Tutorial* instead of the small icon, and changing its placement to align with the central column of buttons (e.g. just above the *Quit* button).

6.2.3.10 Interface design

Experts liked the graphics in the game, and believed that the background images in the minigames fitted well with the emotions. Still, experts identified a number of small issues with parts of the graphics and colour schemes not being clean or consistent: parts of the background graphic in the Main menu overlaps with the game logo at the top of the screen, as well as instrument icons next to Rhythm and Pitch labels (e.g. the drumstick in the icon next to Rhythm appeared as continuation of the part of the background graphic nearby); also the icon that directed to the tutorial level from the Main menu is not in line with the general black-and-white colour scheme of other labels within the game. E11 noted that the settings panel is grey, which seems suggests that it is part of background or inactive, and recommended changing the colour to avoid confusion.

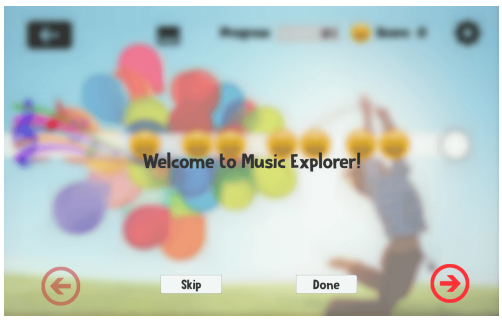
6.3 Summary of findings

A substantial majority of children and experts interviewed stated that the game demonstrates its fitness for purpose of encouraging emotion expression through music. Only E9 had strong concerns whether the game reflects the research goal undertaken, and despite the relative value of his feedback in other areas, slight miscommunication about the game's goal might have resulted in misinterpretation on his side. The game also prompted spontaneous communication and interactions among children. The game was considered as fun and enjoyable to play, with many respondents expressing that they would like to replay the game. Customisation of different aspects of the game,

accessibility, feedback contingent on user actions, as well as different rewards were well received.

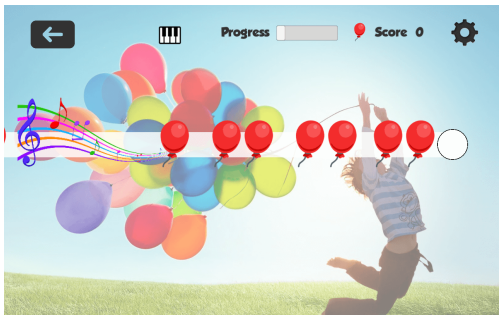
Navigation was generally perceived as intuitive but a large proportion of issues identified by participants seemed to be related to instructions. The tutorial level was confusing to almost all testers, which could potentially be rectified by including timed progression through slides, prompts for action and modifications to improve distinction between screenshots used in the tutorial, as well as the buttons used to navigate through the slides. Being arguably the most frequently criticised part of the game, the tutorial level requires redefinition to provide appropriate explanation and avoid unexpected surprises or confusion among the target group users. This was in fact envisioned in game design 2 (Figure 5.1b) but was not implemented due to time constraints. A number of minor issues were also noted about the interface design and presentation but legibility and visibility of the most important interaction points were deemed appropriate.

As a result of evaluation sessions with child participants and experts, a number of suggested improvements were identified and some of them incorporated into the game, and these are summarised in Table 6.3.

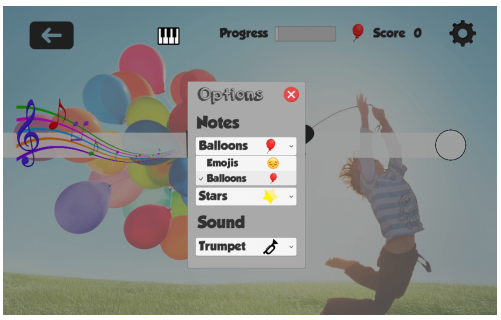


(a) Tutorial level with arrows changed from black to red for better visibility.

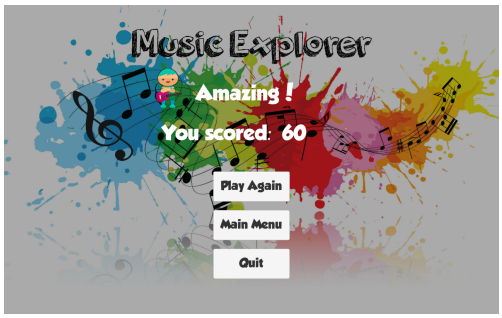
(b) Colour of back button in main menu changed from black to white for better visibility.



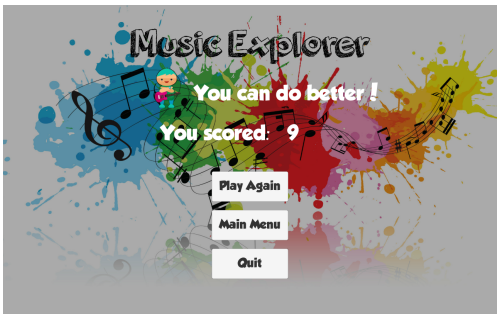
(c) Piano icon appearance changed for better visibility, progress redefined to represent duration of track.



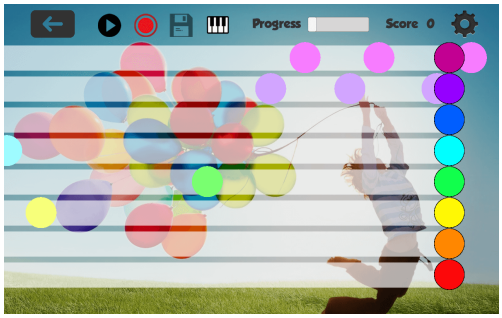
(d) Spacing between option items increased for better legibility.



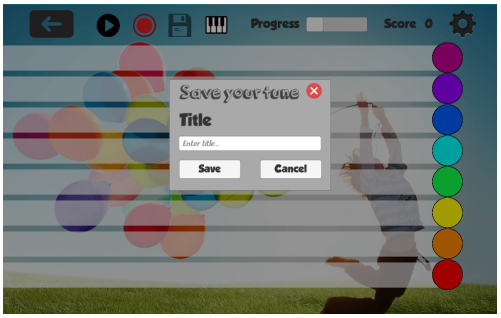
(e) Win screen with positive achievement prompt.



(f) Win screen with "negative" achievement prompt.



(g) Free Explorer minigame – playing recorded piece.



(h) Free Explorer minigame – saving recording.

Figure 6.1: Music Explorer - changes introduced to final version.

Issue/suggested modification	**Fixed?**	**Comment**
Tutorial icon in the main menu not visible enough	No	E11 suggested alternative placement but this might need consulting with other child participants/experts
Tutorial icon in the same colour scheme	Yes	More unified look should be more appropriate for the target group's liking for order and predictability
Interactivity in tutorial level	Yes	Allowing the user to explore the interface interactively was considered important
Tutorial level prompts for action when there is a period of inactivity	No	Not implemented due to time constraints
Adjustable speed of tracks	No	Direct modification of the speed of music can alter perception of the emotional content of the piece
Failure feedback on incorrect tapping	No	Mixed opinions on whether such indication would be more detrimental or beneficial
Increased contrast between back button in the main menu and the background	Yes	Making the interface cleaner and font more legible is important for younger users
Voiceover introduced to all menu items	Yes	Accessibility accommodations were deemed important for children with poorer reading skills
Redefined progress bar to signify duration of the track	Yes	Common confusion flagged a discrepancy between user expectation and designer's conceptualisation of progress
Use of a clearer, slower and lower voice in audio descriptions	No	Audio descriptions were recorded manually by the researcher, and no better alternative voice was available at that time
Settings option *Particles* renamed to *Effects*	Yes	*Particles* were a name taken from Unity's nomenclature rather than something generally understood
Spacing increased between items in the settings panel	Yes	This should help resolve ambiguity
Settings panel should be in non-grey colour	No	Not implemented due to time constraints
Spacing increased between items in the settings panel	Yes	This should help resolve ambiguity
Performance level based achievement rewards	Yes	Simple textual and audio achievement prompts for different levels of performance were added to enhance motivation
Separate buttons to turn off background and main music	No	Not implemented due to time constraints
Adding a *Done* button in settings panel	No	Not implemented due to time constraints
Removing *Quit* button from Win screen	Yes	The button was more confusing than helpful, and leaving the application is just one step away through the Main menu button

Table 6.3: Suggested modifications.

Chapter 7

Discussion and conclusions

7.1 Conclusion

The aim of this research was to investigate how to design a game that supports children with ASC in learning about emotion expression through music. Care was taken to explore the needs and perspectives of an autistic child, through literature review, consultation with neurotypical children, those who either have ASC themselves or had experience being in their immediate social circle, as well as researchers from related domains of educational and assistive technology, HCI, game design and psychology. The game was developed iteratively, with support of children and experts. To reiterate, the research was guided by the following objectives:

1. *To what extent is music an appropriate tool to facilitate emotion expression in children with ASC?*
2. *Is a tablet based game an appropriate vehicle for encouraging emotion expression in children with ASC through music?*

Regarding the first objective, it was found, primarily through literature review, that evidence exists in support of using music to facilitate emotion expression in children with ASC. Findings from design workshops and interviews with experts provided further grounding about the attractiveness and appropriateness of musical games and how they can combine affect to encourage articulation of emotions in the target population.

Further, evaluation of with children showed that the game developed by the researcher elicited spontaneous emotional expression, strong musical responses, as well as various verbal and non-verbal interactions between participants and with the researcher. Children considerably enjoyed playing the game and its focus on emotions and music. One expert was hesitant about the extent to which the game can encourage emotion expression in children with ASC; however, due to slight misinterpretation of the game's objective, the researcher believes that this expert's view should not be taken at face value. In general, experts believed that the game was fun, accessible and saw the game's potential in eliciting emotional expression in children with ASC. A large proportion of them clearly envisioned the game's role in a wider communicative or

educational context, providing further evidence that the game can support the intended goal. With Free Explorer's redefinition based on feedback from experts and children, the game provides scope for more interaction with other parties apart from the player, which could have further bearing on the development of emotion expression skills in the child.

7.2 Limitations

Despite the virtually universal agreement on the game's fitness for purpose, these findings should be considered with care, as only proxies for the target population were consulted in the process of designing, developing and evaluating the game. Thus, it would be valuable if further consultations with autistic children were conducted to conclusively validate the potential of the game found in this work.

In addition, the implementation of the Free Explorer minigame was only evaluated by one expert – compared to the rather comprehensive approach to gathering feedback on the game throughout the whole research, this should have been done with children as well. Even though the game implementation screenshots were shown to and discussed with child participants, previously mentioned results suggest that more concrete ideas are likely to be more appropriate given (both TD and ASC) children's cognitive abilities. These shortcomings can ultimately be attributed to time constraints imposed on the research.

7.3 Future work

Review of relevant literature, as well as discussions with TD children and experts produced a number of suggestions for extensions and improvements for the game itself, as well as activities that could be undertaken roundabout the game.

The most natural extension of the game would involve incorporating more affective dimensions. A smaller number of them could swapped in and out of the game to focus on a manageable number of emotions. This could be done by an adult supervisor who would gauge which emotions require more attention and exploration. The learner could also choose the emotions based on own needs and preferences. However, such flexibility is likely to be better once the player understands expressive differences between more basic emotions.

A number of alternative, similar musical activities to ones existing in the game design were also suggested by children and experts. For instance the player could be asked to create music (through a mechanism similar in Free Explorer) that would correspond to a certain memory or experience – such as first day at school. Such an activity would then not necessitate fixing the emotion to be expressed through music beforehand, as is the case currently.

Thompson et al. (2014) mention the benefits of involving families in collaborative music-making to strengthen relationships between family members. E1 suggested that the game could be used as a starting point for discussion about emotional or mental issues of autistic children. Raising awareness of various, perhaps less commonly discussed, problems faced by a child with ASC is likely to contribute to better understanding of the condition, and better inform choice of required interventions. It would then be particularly valuable to further collaborate with psychologists or child development specialists to develop instructions for parents or teachers.

Similarly, Kern and Aldridge (2006) highlight the role of teachers in music-centred or music-supported activities. The game was not designed strictly for use in a traditional classroom or music therapy sessions but there is evidence that music therapists are likely to use technology, even if not designed specifically designed for their use, when working with clients with developmental deficits, including ASC. The mixture of more structured and free-form activities in the game could potentially lend themselves well to being incorporated as a support tool by practitioners.

In addition, the use of narrative in conjuction with the musical minigames could be interesting to explore, as was set out initially for this research.

Appendix A

Child information sheets and consent forms for Design and Evaluation studies

New computer games to help children
(to be read aloud to the child)

This page is for children. It is about some people who are organising an **event at University of Edinburgh**. It says who they are, and what they will do **during the event**.

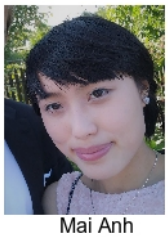
The organisers will ask for your help. You can help by playing a new computer game, **participating in different activities**,listening to some music and answering a few questions. You can decide if you want to say "yes" or "no" to helping, and can change your mind at any time.

The researchers on this project and their contact details are as follows:

- Ms. Mai Anh Nguyen, lead researcher
  - s1456537@sms.ed.ac.uk; 07405886454
- Prof. Helen Pain, research advisor (helen@inf.ed.ac.uk)

Who is organising the event? This is Helen and Mai Anh. Their job is to learn about how children use computers, and how to make computer games that can help children. They will ask you to help them by playing a new computer game, participating in different activities and answering a few questions.


Helen


Mai Anh

Why are we organising this event?
Some children might find it difficult to understand and describe what they are feeling. By using music, they can get more comfortable with their emotions and learn to identify them. In this event, you can help me understand how you know about and behave when you feel different emotions. I can then use your ideas to teach other children do the same in my game.

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What is the game?
In this game, you will follow a character that has problems understanding his emotions. You will follow his story, where different situations will happen and the character needs to find out how to describe what he is feeling. To find out what the emotion is, you will help him in musical mini-games, where he will collect different clues.
In the workshop, you will help me come up with examples of situations where you would feel happy, sad, angry and scared, which I can use in the main character's story.

What will happen if I help?
They will prepare a workshop at the University of Edinburgh. When you arrive, you will be told more information and then you will go to one of the areas that will be set up. There, you will get to play with game prototypes, take part in design workshops and participate in other activities.

You can tell Helen or one of the researchers if you want to stop doing any of the activities. You do not have to tell them why. Please tell them if you need the toilet, or if you want to take a break. You can also say you do not want to be a game developer any more, and that is OK. They will always listen to you.

The researchers will ask if it is OK to make an audio recording of you playing the game, and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to the recording later to help them understand what you said, and what happened when you played the game.

What will happen after I am finished helping?
They will learn a lot about children and computers from the things you make, do and say when you play with the games, take part in the design workshops and do other activities. After all the children have finished participating in activities, the workshop will be over. They will listen to the recordings of children playing with the prototype, taking part in the design workshops and doing other activities. They will write about what they have learned. Sometimes they will show people recordings of children taking part in the different activities.

Your mum or dad said it is OK for you to help us.

Do you want to be a games developer? You can say "yes" or "no". It is OK to say "no". It will not hurt the researchers' feelings.

Do you want to ask a question about being a games developer? It is OK to have more questions. You can ask them as many questions as you want about being a game developer. Ask your mum or dad to help you call them on the phone or write an email with your question.

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 games developer.

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

I can decide to stop taking part or take a break if I want to.

I do not have to say why.

It is okay if I change my mind later, and say I do not want to be a games developer anymore.

It is okay 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 developer? **YES** ☐ **NO** ☐

Mai Anh and Helen will listen to/watch the recordings later.

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

Is it okay to take audio/video recordings? **YES** ☐ **NO** ☐

Write your name: _____

THANK YOU!

Appendix B

Parent information sheets and consent forms for Design and Evaluation studies

Designing Educational Games for Children with Autism

Information sheet for parents and guardians

This information sheet is for parents and guardians; it explains a research project at the University of Edinburgh, in which we would like your child to participate. It gives information about the project in the form of questions you might have and their answers. If you have further questions, we are happy to discuss them and give you more information.

The researchers on this project and their contact details are as follows:

- Ms. Mai Anh Nguyen, lead researcher
  - s1456537@sms.ed.ac.uk; 07405886454
- Prof. Helen Pain, research advisor (helen@inf.ed.ac.uk)

University of Edinburgh,
School of Informatics
Informatics Forum
10 Crichton Street
Edinburgh
EH8 9AB

Please return the parent consent form to one of the researchers if you give permission for your child to participate in the project.

Overview of the project

We are four UG4 and one UG5 students from the University Of Edinburgh working on educational games for children with autism as a part of our Honours projects. Each student pursues research in their chosen area and will develop their own game.

What is the goal of the project?

A very high proportion of people with autism spectrum condition (ASC) have a co-occurring condition called alexithymia, which makes it difficult for them to identify, describe and process their emotions. At the same time, they do not experience similar problems identifying emotional content in music, and often have a special interest in music due to its characteristics. This project aims to tap into this affinity to help children with ASC better understand and cope with their emotions through the use of music.

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What is the purpose of the workshop?

The workshop will help in gathering examples of situations where emotions of sadness, anger, happiness and fear might occur and how one can identify those. The role of music in symbolic depiction and enhancement of emotional states will be explored to see their relevance towards children. This information will be incorporated into designing the game.

How can my child help?

The workshop will help in investigating what kind of situations elicit emotions of fear, happiness, sadness and anger, which will be done by the child through drawing or writing. These examples will be used to discuss more generally how one can identify such emotions in themselves. The child will also participate in brainstorming ideas for music-centred mini-games.

Workshop Information

What happens during the workshop?

We will always spend some time before the workshop session to talk to the children, in order to get to know them better and allow them to get to know us, with the aim to make them more comfortable. At an agreed time, we will walk your child from the main area to a quiet place where a particular workshop stand will be set up. Your child will get to participate in a design workshop, play with the prototype or participate in related activities for 15-20 minutes, as well as participate in other activities, or until they want to stop (whichever is first). If your child is willing to talk to us about the activities, we will ask them a few questions.

Video recordings

We would like to video record the session, to provide a record for later analysis and allow us to freely interact with your child during the session without worrying about taking notes. If you prefer that we do not use videos or pictures of your child for publications, presentations or teaching purposes, you can indicate this on the permission form. In that case, the video would be seen only by us during the analysis. If you're not comfortable with your child being videoed at all, then your child should not participate in this particular study.

Additional Study Information

Will this project teach my child new skills?

This project is not a type of therapy or intervention. We will not be teaching children new skills or improving existing skills. The information we learn from this project may be used in future games/websites that could help children with ASC.

What happens when the project is over?

After the study has finished and we have analysed the information we collected, it will be used to evaluate and further develop the design of the game/website and eventually be presented in a final report. This report along with the data and recordings may be shared or presented in scientific journals or conferences. We never share children's names, schools or other personal information.

How will personal information be protected?

Confidentiality is extremely important to us. Recordings and other information (such as forms with children's names) will be stored safely on password-protected computers or in locked cabinets. Access will be limited to the people involved in the research (listed above). Recordings and other information will be identified only by participant codes or pseudonyms, and will be separated from identifying information (such as name or birth date).

Can I have a copy of the games?

The game prototypes your child would play with in this study are merely proof-of-concept; that is, they are pieces of research software designed to help answer specific questions. They do not have the same type of functionality, amount of content, or style of documentation that you may expect from commercial games. However, once the study is over the games may be made publicly available online, for free unlimited use. If so we will send you a link and instructions for installation.

Who paid for this research?

This study is part of the undergraduate work for the main researchers (listed above). It is indirectly paid for by the University of Edinburgh and the funding is not attached to a specific project or to any outcomes of that project. Conducting this research brings no financial benefit to the researchers or to the university.

Would you like to participate?

We ask parents to read this information sheet so you can make an informed decision about whether participation as a game designer is a good idea for your child.

If you say "yes" when returning the permission form, we will explain the game developer role to your child, and ask him/her if he/she wants to help. We will remind your child that they can stop being a developer at any time, without having to give any reason, and that we will always listen to them. We will check that the child agrees to be audio recorded. This explanation will be based on the child information sheet included in this packet. We feel strongly that children should be given a real choice about whether to participate. Even if you say "yes" on the permission form, your child may still say "no" if s/he does not want to be a game developer. We will respect your child's decision.

If you say "no", we will not contact you again about this study and will not speak to your child about being a games/web designer.

Once again, this study is completely voluntary and you and your child are under no obligation to take part. Even if you say yes now, you may withdraw your child from the study at any time and for any reason by contacting us. Your child may also withdraw at any time by saying that s/he does not want to be a game developer any more.

Thank you for taking the time to read this.

If you would like to know more about this research and/or if you have questions, please contact one of the main researchers listed above.

Research consent 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

Child certificate for Design study

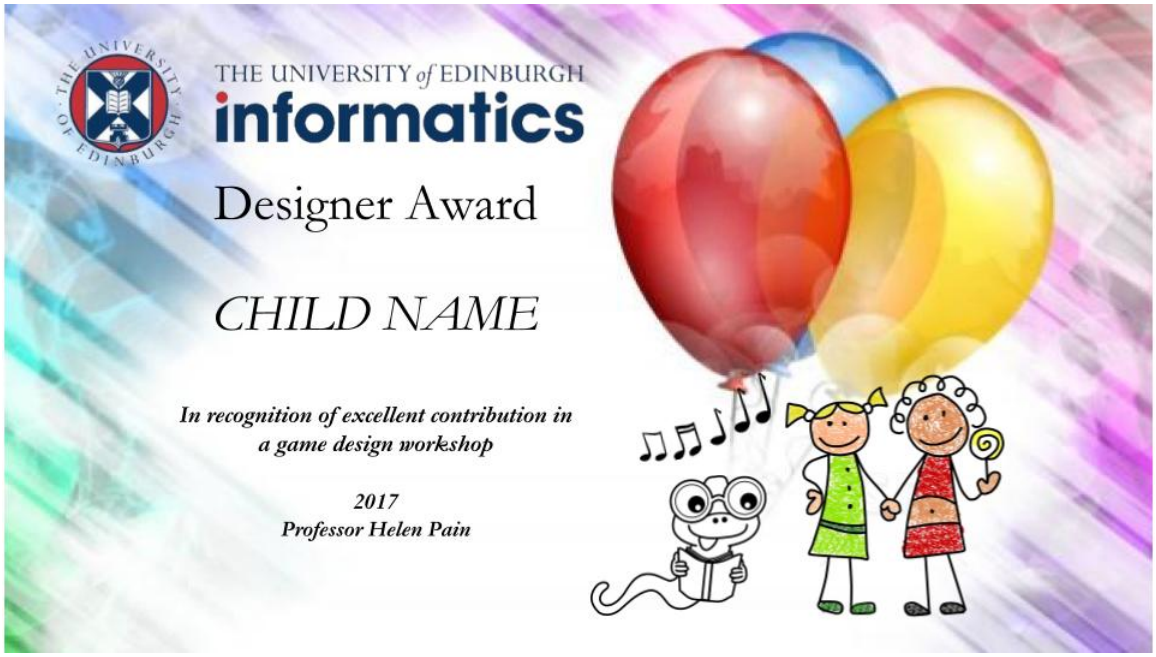

Figure C.1: Template for the certificate given to children in the design workshops

Appendix D

Researcher script for Design study with children

1. Introduction (2 min)
   (a) what the game is about
      i. emotions recognition/identification
      ii. using music to aid emotion identification and regulation
2. Draw/write situations when different emotions were felt (5-6 mins)
3. Discuss each of the emotions in the context of examples of situations (5-6 mins)
   (a) How did they know they felt that? Did they feel like doing something as a result?
4. Ask if they like music and when they like to listen to or make music? (5-6 mins)
5. Ask what type of music is in their favourite games?
6. Some children might find it harder to describe their emotions the way that you did.

Hello everyone, thanks for coming to my workshop today! My name is Mai Anh and I'd like to know your names too. Could you quickly introduce yourselves? Brilliant.

So today youre going to help me design a video game for autistic children. Do you know what autism is? You might have met someone like that before, maybe at school or at some after school clubs. They would be very similar to you but perhaps find it more difficult to talk to others and they might have problems understanding what they feel, how to describe it to someone else or maybe how to deal with such feelings. So they might know that they are feeling something but not exactly what - it is very confusing for them.

So that's why they might need some special clues and hints to know what the emotion is that they're feeling and a lot of them really like music, so that can help them understand or even describe their emotions.

So in my game, you will read through a comic story of a main character Timid Timmy and throughout the story, different things happen that make him feel happy, sad, angry or scared. But because he gets very confused when those emotions come up and doesn't know how to react, you'll get to help him recognise what he's feeling by using music.

At different points of the story, you will help him by playing mini-games, and each of the mini-games will be about a different emotion. These mini-games could all have the same rules but their goal should be to collect hints about what Timmy is feeling. The clues could be signs that tell you how you might know that you feel a certain emotion. So if in the story, Timmy should be happy because he's Mum is taking him to a Christmas fair and he really loves those tiny pancakes they serve them, he might know that he's happy because he can only think how long till he's going to the Christmas fair with his Mum. Or he might know that he's happy because he feels very bubbly, almost as if bubbles are filling him from the inside and making him float from happiness.

So what kind of musical mini-games or challenges should he complete to collect those clues?

What kind of games do you like where you can collect things?

What do you have to do there?

How could you turn that game into a musical game?

How could you make collecting the things more fun?

What do you think about an idea for an opponent in the game?

Opponents? Rewards?

How to connect it to music?

Appendix E

Child certificate for Evaluation study

Figure E.1: Template for the certificate given to children in the evaluation workshops.

Appendix F

Researcher script for Evaluation study with children

1. Introduction (2 min)
   (a) Introduce self and thank participants
   (b) Ask about consent forms and permission to record
   (c) Explain what the game is about
      i. show how different emotions can be represented through music
      ii. the player can modify and create music
2. Questions before game-testing (1-2 min)
   (a) Have you used a tablet or a smartphone device before?
   (b) Have you played any games on a tablet or a smartphone?
3. Explanations (1-2 min)
   (a) This is a demo version of a full game
   (b) As you play, look out for things that you like and dont like
   (c) Ill explain how to navigate the game
4. Explain how to play the game (3 min) maybe have some screenshots of the game state to show before playing
   (a) Tap-In-Rhythm
      i. Notes move from left to right, need to tap when they appear at the target area
   (b) Matching game
      i. Drag template note into placeholders this activates the note and will later be played along background music
      ii. Hit play to listen to music with added notes
5. Game testing (10-15 min)
   (a) Test Tap-In-Rhythm – Rhythm – Happy & Sad
   (b) Test Tap-In-Rhythm – Pitch – Happy & Sad

   (c) Discussion of mockups for Matching Game and Free Explorer

6. Questions after game-testing (5-10 min)
   (a) What did you like most about the game?
      i. If no concrete answers, can narrow down to individual games
   (b) What did you like least about the game?
      i. Same as above
   (c) Was the game easy/difficult?
   (d) Like or dislike:
      i. How the game looks in general
      ii. Progress bar
      iii. Score
      iv. Customisation
   (e) What would you change or add?
7. Do you think this game could help someone that has problems with understanding and expressing their own emotions?

Appendix G

Resources used in the game

Resource type	Resource	Author	URL
Music	Happy soundtrack	Bensound	https://www.bensound.com/royalty-free-music/track/ukulele
	Sad soundtrack	Endersniper123	https://freesound.org/people/Endersniper123/sounds/215767/
Graphics	Main menu background	Media Farmers Market	http://mediafarmersmarket.com/another-great-market-this-week/music-colour-splash/
	Colourful music line in Rhythm minigames	pngimg.com	http://pngimg.com/download/22048
	Background graphic in Happy minigames	seriy-man	http://www.goodwp.com/other/28497-balloon-joy-boy-jump-field-summer.html
	Background graphic in Sad minigames	brgfx / Freepik	https://www.freepik.com/free-vector/four-scenes-of-forest-and-river_1046801.htm
	Icons	Various	https://www.flaticon.com/ https://www.iconfinder.com/free_icons

Table G.1: Resources used in the game.

Bibliography

Aarons, M. and Gittens, T. (2002). *The handbook of autism: a guide for parents and professionals*. Routledge.

Ahmed, M. (2008). Guitar hero leads children to pick up real instruments. Retrieved from http://technology.timesonline.co.uk/tol/news/tech_and_web/gadgets_and_gaming/article5266959.ece.

Alcorn, A., Pain, H., Rajendran, G., Smith, T., Lemon, O., Porayska-Pomsta, K., Foster, M. E., Avramides, K., Frauenberger, C., and Bernardini, S. (2011). Social communication between virtual characters and children with autism. In *International Conference on Artificial Intelligence in Education*, pages 7–14. Springer.

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.

Allen, R. and Heaton, P. (2010). Autism, music, and the therapeutic potential of music in alexithymia. *Music Perception: An Interdisciplinary Journal*, 27(4):251–261.

Allen, R., Hill, E., and Heaton, P. (2009). The Subjective Experience of Music in Autism Spectrum Disorder. *Annals of the New York Academy of Sciences*, 1169(1):326–331.

Alvin, J. (1991). *Music therapy for the autistic child*. Oxford University Press.

APA (2013). Diagnostic and Statistical Manual of Mental Disorders (DSM-5). Retrieved from https://www.psychiatry.org/psychiatrists/practice/dsm.

Autcraft (2015). Autcraft. Retrieved from http://www.autcraft.com/.

Autism Speaks (n.d.). Autism Emotion. Retrieved from https://www.autismspeaks.org/autism-apps/autism-emotion.

Autland (2014). Minecraft? swietna gra dla autystykow. Retrieved from http://www.otld.pl/minecraft-swietna-gra-autystykow/.

Baranek, G. T., Little, L. M., Diane Parham, L., Ausderau, K. K., and Sabatos-DeVito, M. G. (2014). Sensory features in autism spectrum disorders. *Handbook of Autism and Pervasive Developmental Disorders, Fourth Edition*.

Baron-Cohen, S., Ashwin, E., Ashwin, C., Tavassoli, T., and Chakrabarti, B. (2009). Talent in autism: hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1522):1377–1383.

Baron-Cohen, S. and Bolton, P. (1993). *Autism: The Facts*. Facts (Oxford, England). Oxford University Press.

Benton, L., Ashwin, E., Johnson, H., Grawemeyer, B., and Brosnan, M. (2011). Ideas: An interface design experience for the autistic spectrum. In *CHI EA 2011 - 29th Annual CHI Conference on Human Factors in Computing Systems, Conference Proceedings and Extended Abstracts*, Conference on Human Factors in Computing Systems - Proceedings, pages 1759–1764. Association for Computing Machinery (ACM), New York. 29th Annual CHI Conference on Human Factors in Computing Systems, CHI 2011. 7-12 May 2011. Vancouver, BC, Canada.

Benton, L. and Johnson, H. (2014). Structured approaches to participatory design for children: can targeting the needs of children with autism provide benefits for a broader child population? *Instructional Science*, 42(1):47–65.

Bernard-Opitz, V., Sriram, N., and Nakhoda-Sapuan, S. (2001). Enhancing social problem solving in children with autism and normal children through computer-assisted instruction. *Journal of autism and developmental disorders*, 31(4):377–384.

Berthoz, S. and Hill, E. L. (2005). The validity of using self-reports to assess emotion regulation abilities in adults with autism spectrum disorder. *European Psychiatry*, 20(3):291 – 298.

Bird, G. and Cook, R. (2013). Mixed emotions: the contribution of alexithymia to the emotional symptoms of autism. *Translational Psychiatry*, 3(7).

Bogost, I. (2011). *How to Do Things with Videogames*. Minneapolis: University of Minnesota Press.

Brugha, T., Cooper, S., McManus, S., Purdon, S., Smith, J., Scott, F., Spiers, N., and Tyrer, F. (2012). Estimating the prevalence of autism spectrum conditions in adults: extending the 2007 Adult Psychiatric Morbidity Survey. Retrieved from https://digital.nhs.uk/catalogue/PUB05061.

Buggey, T. (2005). Video self-modeling applications with students with autism spectrum disorder in a small private school setting. *Focus on autism and other developmental disabilities*, 20(1):52–63.

Caria, A., Venuti, P., and de Falco, S. (2011). Functional and dysfunctional brain circuits underlying emotional processing of music in autism spectrum disorders. *Cerebral Cortex*, 21(12):2838–2849.

Chen, W. (2012). Multitouch tabletop technology for people with autism spectrum disorder: A review of the literature. *Procedia Computer Science*, 14:198–207.

Chiasson, S. and Gutwin, C. (2005). Design principles for childrens technology. *interfaces*, 7:28.

Colby, K. M. (1973). The rationale for computer-based treatment of language difficulties in nonspeaking autistic children. *Journal of Autism and Childhood Schizophrenia*, 3(3):254–260.

Coyle, C. and Cole, P. (2004). A videotaped self-modelling and self-monitoring treatment program to decrease off-task behaviour in children with autism. *Journal of Intellectual and Developmental disability*, 29(1):3–16.

De Leo, G. and Leroy, G. (2008). Smartphones to facilitate communication and improve social skills of children with severe autism spectrum disorder: special education teachers as proxies. In *Proceedings of the 7th international conference on Interaction design and children*, pages 45–48. ACM.

Detmer, M. R. (2017). Music therapy in educational settings. In Yinger, O. S., editor, *Music Therapy: Research and Evidence-based Practice*, chapter 3, pages 29–45. Elsevier Health Sciences.

Druin, A. and Inkpen, K. (2001). When are personal technologies for children? *Personal and Ubiquitous Computing*, 5(3):191–194.

Eack, S. M., Mazefsky, C. A., and Minshew, N. J. (2015). Misinterpretation of facial expressions of emotion in verbal adults with autism spectrum disorder. *Autism*, 19(3):308–315. PMID: 24535689.

Fang, E. R. (2010). Music in the lives of two children with autism: A case study. Master's thesis, San Jose University.

Ferguson, M. B., Anderson-Hanley, P. C., Mazurek, M. O., Parsons, S., and Warren, Z. (2012). Game interventions for autism spectrum disorder.

Fletcher-Watson, S. (2014). A targeted review of computer-assisted learning for people with autism spectrum disorder: Towards a consistent methodology. *Review Journal of Autism and Developmental Disorders*, 1(2):87–100.

Flower, C. and Oldfield, A. (2008). *Music therapy with children and their families*. Jessica Kingsley Publishers.

Floyd, C., Mehl, W.-M., Resin, F.-M., Schmidt, G., and Wolf, G. (1989). Out of Scandinavia: Alternative Approaches to Software Design and System Development. *HumanComputer Interaction*, 4(4):253–350.

Gabrielsson, A. and Lindström, E. (2010). The role of structure in the musical expression of emotions. *Handbook of music and emotion: Theory, research, applications*, pages 367–400.

Geretsegger, M., Elefant, C., A. Mssler, K., and Gold, C. (2014). Music therapy for people with autism spectrum disorder. *Cochrane Database of Systematic Reviews*.

Gerritsen, J. (2010). The effect of tomatis therapy on children with autism: Eleven case studies. *International Journal of Listening*, 24(1):50–68.

Ghasemtabar, S., Hosseini, M., Fayyaz, I., Arab, S., Naghashian, H., and Poudineh, Z. (2015). Music therapy: An effective approach in improving social skills of children with autism.(original article). *Advanced Biomedical Research*, 4(1).

Gray, C. A. and Garand, J. D. (1993). Social stories: Improving responses of students with autism with accurate social information. *Focus on autistic behavior*, 8(1):1–10.

Griffin, C., Lombardo, M. V., and Auyeung, B. (2016). Alexithymia in children with and without autism spectrum disorders. *Autism Research*, 9(7):773–780.

Grisdale, E., Lind, S. E., Eacott, M. J., and Williams, D. M. (2014). Self-referential memory in autism spectrum disorder and typical development: Exploring the ownership effect. *Consciousness and Cognition*, 30:133 – 141.

Grynszpan, O., Weiss, P. L. T., Perez-Diaz, F., and Gal, E. (2014). Innovative technology-based interventions for autism spectrum disorders: A meta-analysis. *Autism*, 18(4):346–361. PMID: 24092843.

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.

Guttmacher, L. B. (1990). Treatments of psychiatric disorders: A task force report of the american psychiatric associationwashington, d.c., american psychiatric association, 1989, 4 volumes, 3,068 pages, $275. *Psychiatric Services*, 41(5):568–568.

Hadley, R. T., Hadley, W. H., Dickens, V., and Jordon, E. G. (2001). Music therapy: A treatment modality for special-needs populations. *International Journal for the Advancement of Counselling*, 23(3):215–221.

Hahna, N. D., Hadley, S., Miller, V. H., and Bonaventura, M. (2012). Music technology usage in music therapy: A survey of practice. *The Arts in Psychotherapy*, 39(5):456–464.

Happé, F. G. (1995). Understanding minds and metaphors: Insights from the study of figurative language in autism. *Metaphor and symbol*, 10(4):275–295.

Heaton, P., Hermelin, B., and Pring, L. (1999). Can children with autistic spectrum disorders perceive affect in music? an experimental investigation. *Psychological Medicine*, 29(6):14051410.

Herriott, R. (2015). The use of proxies: lessons of social co-design for inclusive design for people with cognitive disabilities. *Journal of accessibility and design for all*, 5(2):100–124.

Hersh, M. (2016). Designing effective learning technologies for autistic people. In *International Conference on Computers Helping People with Special Needs*, pages 475–482. Springer.

Hill, E., Berthoz, S., and Frith, U. (2004). Brief report: Cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *Journal of Autism and Developmental Disorders*, 34(2):229–235.

Hoppe, M. J., Wells, E. A., Morrison, D. M., Gillmore, M. R., and Wilsdon, A. (1995). Using focus groups to discuss sensitive topics with children. *Evaluation Review*, 19(1):102–114.

Hungr, C., Ogrodniczuk, J., and Sochting, I. (2016). Alexithymia and Locus of Control among Psychiatric Outpatients. *International Journal of Mental Health and Addiction*, 14(6):1047–1051.

ICD10Data.com (2018). 2018 ICD-10-CM Diagnosis Code F84.0. Retrieved from http://www.icd10data.com/ICD10CM/Codes/F01-F99/F80-F89/F84-/F84.0.

Iversen, O. (2002). Designing with children: The video camera as an instrument of provocation. In *Bekker, Markopoulus & Kersten-Tsikalkina,Interaction Design and Children, Proceedings from the international workshop, Eindhoven, The Nederlands*.

Johnsen, K., Raij, A., Stevens, A., Lind, D. S., and Lok, B. (2007). The validity of a virtual human experience for interpersonal skills education. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1049–1058. ACM.

Johnson, W. L. (2007). Serious use of a serious game for language learning. *Frontiers in Artificial Intelligence and Applications*, 158:67.

Jolliffe, T. and Baron-Cohen, S. (1997). Are people with autism and Asperger syndrome faster than normal on the Embedded Figures Test? *Journal of Child Psychology and Psychiatry*, 38(5):527–534.

Kagohara, D. M., van der Meer, L., Ramdoss, S., OReilly, M. F., Lancioni, G. E., Davis, T. N., Rispoli, M., Lang, R., Marschik, P. B., Sutherland, D., et al. (2013). Using ipods® and ipads® in teaching programs for individuals with developmental disabilities: A systematic review. *Research in developmental disabilities*, 34(1):147–156.

Kaplan, R. S. and Steele, A. L. (2005). An analysis of music therapy program goals and outcomes for clients with diagnoses on the autism spectrum. *Journal of music therapy*, 42(1):2–19.

Katagiri, J. (2009). The effect of background music and song texts on the emotional understanding of children with autism. *Journal of Music Therapy*, 46(1):15–31.

Kemner, C., Van der Geest, J., Verbaten, M., and van Engeland, H. (2007). Effects of object complexity and type on the gaze behavior of children with pervasive developmental disorder. *Brain and cognition*, 65(1):107–111.

Kern, P. and Aldridge, D. (2006). Using embedded music therapy interventions to support outdoor play of young children with autism in an inclusive community-based child care program. *Journal of Music Therapy*, 43(4):270–294.

Kersten, F. (2006). Inclusion of technology resources in early childhood music education. *General Music Today*, 20(1):15–28.

Khaled, R. and Vasalou, A. (2014). Bridging serious games and participatory design. *International Journal of Child-Computer Interaction*, 2(2):93–100.

Klin, A. and Volkmar, F. R. (1995). Aspergers Syndrome: guidelines for assessment and diagnosis. *Learning Disabilities Association of America. Available online at http://www. aspennj. org/guide. html*.

Lamberty, K. and Kolodner, J. L. (2005). Camera talk: Making the camera a partial participant. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 839–848. ACM.

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

Lewis, M. B. and Dunn, E. (2017). Instructions to mimic improve facial emotion recognition in people with sub-clinical autism traits. *The Quarterly Journal of Experimental Psychology*, 70(11):2357–2370. PMID: 27734764.

Lima, D. and Castro, T. (2012). Music spectrum: A music immersion virtual environment for children with autism. *Procedia Computer Science*, 14:111–118.

Little, L. M., Ausderau, K., Sideris, J., and Baranek, G. T. (2015). Activity participation and sensory features among children with autism spectrum disorders. *Journal of autism and developmental disorders*, 45(9):2981–2990.

Lombardo, M. V., Barnes, J. L., Wheelwright, S. J., and Baron-Cohen, S. (2007). Self-referential cognition and empathy in autism. *PLOS ONE*, 2(9):1–11.

MacDonald, R., Clark, M., Garrigan, E., and Vangala, M. (2005). Using video modeling to teach pretend play to children with autism. *Behavioral Interventions*, 20(4):225–238.

Malone, T. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude, learning, and instruction*, 3:223–253.

Marsella, S., Johnson, W. L., and LaBore, C. (2003). Interactive pedagogical drama for health interventions. In *11th International Conference on Artificial Intelligence in Education, Sydney, Australia*, pages 341–348.

Mazurek, M. O., Engelhardt, C. R., and Clark, K. E. (2015). Video games from the perspective of adults with autism spectrum disorder. *Computers in Human Behavior*, 51:122–130.

Mazurek, M. O. and Wenstrup, C. (2013). Television, video game and social media use among children with asd and typically developing siblings. *Journal of autism and developmental disorders*, 43(6):1258–1271.

Mazzone, E., Read, J. C., and Beale, R. (2008). Design with and for disaffected teenagers. In *Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges*, pages 290–297. ACM.

McQuiggan, S. W., Rowe, J. P., Lee, S., and Lester, J. C. (2008a). Story-based learning: The impact of narrative on learning experiences and outcomes. In Woolf, B. P., Aïmeur, E., Nkambou, R., and Lajoie, S., editors, *Intelligent Tutoring Systems*, pages 530–539, Berlin, Heidelberg. Springer Berlin Heidelberg.

McQuiggan, S. W., Rowe, J. P., and Lester, J. C. (2008b). The effects of empathetic virtual characters on presence in narrative-centered learning environments. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1511–1520. ACM.

Mineo, B. A., Ziegler, W., Gill, S., and Salkin, D. (2009). Engagement with electronic screen media among students with autism spectrum disorders. *Journal of autism and developmental disorders*, 39(1):172–187.

Molnar-Szakacs, I. and Heaton, P. (2012). Music: a unique window into the world of autism. *Annals of the New York Academy of Sciences*, 1252(1):318–324.

Moore, D., McGrath, P., and Thorpe, J. (2000). Computer-aided learning for people with autism–a framework for research and development. *Innovations in Education and Training International*, 37(3):218–228.

Moore, D. and Taylor, J. (2000). Interactive multimedia systems for students with autism. *Journal of Educational Media*, 25(3):169–177.

Moore, M. and Calvert, S. (2000). Brief report: Vocabulary acquisition for children with autism: Teacher or computer instruction. *Journal of Autism and Developmental Disorders*, 30(4):359–362.

Murray, D. K. (2011). Autism and information technology: therapy with computers. In *Autism and Learning (Classic Edition)*, pages 98–113. Routledge.

Nelson, M. (2016). A game to teach emotion skills to children with ASD through technology and narrative. Bachelor thesis, The University of Edinburgh.

Neysmith-Roy, J. M. (2001). The tomatis method with severely autistic boys: Individual case studies of behavioral changes. *South African Journal of Psychology*, 31(1):19–28.

Nouwen, M., Schepers, S., Mouws, K., Slegers, K., Kosten, N., and Duysburgh, P. (2016). Designing an educational music game: What if children were calling the tune? *International Journal of Child-Computer Interaction*, 9-10:20–32.

O'riordan, M. A., Plaisted, K. C., Driver, J., and Baron-Cohen, S. (2001). Superior visual search in autism. *Journal of Experimental Psychology: Human Perception and Performance*, 27(3):719.

Pavlov, N. (2014). User interface for people with autism spectrum disorders. *Journal of Software Engineering and Applications*, 7(02):128.

Pierson, J., Jacobs, A., Dreessen, K., Van den Broeck, I., and Lievens, B. (2006). Walking the Interface: Uncovering Practices Through 'Proxy Technology Assessment'. In *Proceedings of EPIC 2006: The Second Annual Ethnographic Praxis in Industry Conference*, pages 40–54. National Association for the Practice of Anthropology.

Quintin, E.-M., Bhatara, A., Poissant, H., Fombonne, E., and Levitin, D. J. (2011). Emotion perception in music in high-functioning adolescents with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 41(9):1240–1255.

Ramdoss, S., Machalicek, W., Rispoli, M., Mulloy, A., Lang, R., and OReilly, M. (2012). Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. *Developmental neurorehabilitation*, 15(2):119–135.

Randolph, J. J. and Eronen, P. J. (2007). Developing the learning door: A case study in youth participatory program planning. *Evaluation and Program Planning*, 30(1):55–65.

Rieffe, C., Oosterveld, P., Miers, A. C., Terwogt, M. M., and Ly, V. (2008). Emotion awareness and internalising symptoms in children and adolescents: The emotion awareness questionnaire revised. *Personality and Individual Differences*, 45(8):756–761.

Rieffe, C., Oosterveld, P., Terwogt, M. M., Mootz, S., van Leeuwen, E., and Stockmann, L. (2011). Emotion regulation and internalizing symptoms in children with autism spectrum disorders. *Autism*, 15(6):655–670. PMID: 21733959.

Rieffe, C., Terwogt, M. M., Petrides, K. V., Cowan, R., Miers, A. C., and Tolland, A. (2007). Psychometric properties of the emotion awareness questionnaire for children. *Personality and Individual Differences*, 43(1):95–105.

Ringland, K. E., Wolf, C. T., Boyd, L. E., Baldwin, M. S., and Hayes, G. R. (2016a). Would you be mine: Appropriating minecraft as an assistive technology for youth with autism. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility*, pages 33–41. ACM.

Ringland, K. E., Wolf, C. T., Faucett, H., Dombrowski, L., and Hayes, G. R. (2016b). Will I always be not social?: Re-Conceptualizing Sociality in the Context of a Minecraft Community for Autism. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 1256–1269. ACM.

Rowe, J. P., McQuiggan, S. W., and Lester, J. C. (2007). Narrative Presence in Intelligent Learning Environments. In *Intelligent Narrative Technologies, Papers from the 2007 AAAI Fall Symposium*, pages 127–134.

Rowe, J. P., Shores, L. R., Mott, B. W., and Lester, J. C. (2011). Integrating learning, problem solving, and engagement in narrative-centered learning environments. *International Journal of Artificial Intelligence in Education*, 21(1-2):115–133.

Saarikallio, S. (2009). Emotional self-regulation through music in 3-8-year-old children. In *Proceedings of the 7th Triennial Conference of European Society for the Cognitive Sciences of Music (ESCOM 2009) Jyvskyl, Finland.*

Schögler, B. (2016). Autism, music therapy and the scope of Skoog - Dr John Biddulph. Retrieved from http://skoogmusic.com/blog/autism-music-therapy-and-the-scope-of-skoog-dr-john-biddulph/.

Schwartz, E. (2008). *Music, therapy, and early childhood: A developmental approach*. Barcelona Pub.

See, C. M. (2012). The use of music and movement therapy to modify behaviour of children with autism. *Pertanika Journal of Social Sciences & Humanities*, 20(4):1103 – 1116.

Sefelin, R., Tscheligi, M., and Giller, V. (2003). Paper prototyping-what is it good for?:

a comparison of paper-and computer-based low-fidelity prototyping. In *CHI'03 extended abstracts on Human factors in computing systems*, pages 778–779. ACM.

Shah, A. and Frith, U. (1993). Why do autistic individuals show superior performance on the block design task? *Journal of Child Psychology and Psychiatry*, 34(8):1351–1364.

Sharp, L. A. (2012). Stealth learning: Unexpected learning opportunities through games. *Journal of Instructional Research*, 1:42–48.

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

Sifnos, P. E. (1973). The Prevalence of 'Alexithymic' Characteristics in Psychosomatic Patients. *Psychother. Psychosom.*, 22(22):255–262.

Singleton, H. (2017). Music, Autism and Skoog. Retrieved from http://skoogmusic.com/blog/music-autism-skoog/.

Skoog (2018). How can Skoog support children with autism? Retrieved from http://skoogmusic.com/blog/can-skoog-support-children-autism/.

Smith, C. (2016). How we play within lines - skoog and structure. Retrieved from http://www.autismpedagogy.com/blog/2016/3/9/skoog.

Speer, L. L., Cook, A. E., McMahon, W. M., and Clark, E. (2007). Face processing in children with autism: Effects of stimulus contents and type. *Autism*, 11(3):265–277.

Stuart, K. (2016). How i connected with my autistic son through video games.

Tan, J. L., Goh, D. H.-L., Ang, R. P., and Huan, V. S. (2011). Child-centered interaction in the design of a game for social skills intervention. *Computers in Entertainment (CIE)*, 9(1):2.

Tan, M. and Khetrapal, N. (2016). Music inspired framework for remediating emotional deficits in autism. *Procedia Computer Science*, 88:469–474.

The National Autistic Society (2016). Autism profiles and diagnostic criteria.

Thompson, G., McFerran, K., and Gold, C. (2014). Family-centred music therapy to promote social engagement in young children with severe autism spectrum disorder: A randomized controlled study. *Child: care, health and development*, 40(6):840–852.

Tomatis, A. (1991). *The conscious ear: My life of transformation through listening*. Barrytown, N.Y. : Station Hill Press.

Trevarthen, C. (1998). *Children with autism: Diagnosis and interventions to meet their needs*. Jessica Kingsley Publishers.

Uljarevic, M. and Hamilton, A. (2013). Recognition of emotions in autism: A formal meta-analysis. *Journal of Autism and Developmental Disorders*, 43(7):1517–1526.

Weir, S. (1981). LOGO as an Information Prosthetic for Communication and Control. In *IJCAI*, pages 970–974.

Weir, S. and Emanuel, R. (1976). *Using LOGO to catalyse communication in an autistic child*. University of Edinburgh. Department of Artificial Intelligence.

Whipple, C. M., Gfeller, K., Driscoll, V., Oleson, J., and McGregor, K. (2015). Do communication disorders extend to musical messages? an answer from children with hearing loss or autism spectrum disorders. *Journal of music therapy*, 52(1):78–116.

Whipple, J. (2004). Music in intervention for children and adolescents with autism: A meta-analysis. *Journal of music therapy*, 41(2):90–106.

Wigram, A. et al. (2008). Therapeutic dialogues in music: Nurturing musicality of communication in children with autistic spectrum disorder and rett syndrome.

Williams, C., Wright, B., Callaghan, G., and Coughlan, B. (2002). Do children with autism learn to read more readily by computer assisted instruction or traditional book methods? a pilot study. *Autism*, 6(1):71–91.

Williams, D. and Happé, F. (2010). Representing intentions in self and other: studies of autism and typical development. *Developmental Science*, 13(2):307–319.

Wing, L. and Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. *Journal of autism and developmental disorders*, 9(1):11–29.

Zolyomi, A. and Schmalz, M. (2017). Mining for social skills: Minecraft in home and therapy for neurodiverse youth. In *Proceedings of the 50th Hawaii International Conference on System Sciences*.