A Technology-based Tool for Checking Social Story™ Comprehension

Nicholas Georgiou

4th Year Project Report
Computer Science
School of Informatics
University of Edinburgh
2018
Abstract

Children with Autism Spectrum Disorders (ASD) find it difficult to develop social and communication skills and therefore practitioners must find ways to teach them these essential skills. One way in which these skills are taught are through Social Stories™ which aims to support children with ASD to understand social interaction and cope with their own behaviour. One step during the Social Story™ intervention is focused on checking the child’s comprehension. However, in spite of being aware of the importance of checking the comprehension, practitioners¹ find it difficult, partly because of the lack of a standard tools to support that.

This project investigates the different methods in which Social Story™ comprehension can be checked and how technology can aid in checking Social Story™ comprehension. A tablet application has been designed and developed to support both practitioners and children with ASDs during Social Story™ comprehension checking. The application has been informed both by the research literature and empirical studies with four typically developing (TD) children and experts in the fields of Human Computer Interaction (HCI) and ASD.

This project has been conducted in six stages. Stage 1 was conducting a background review on the literature available, which would help inform the design of the application. The second stage was an empirical study with four TD children which was conducted to further inform the design and discover a set of requirements for the application. Stage 3 was implementing a low-fidelity prototype based on the set of requirements discovered in the previous stages. The stage also included an evaluation of the prototype with four experts in HCI and ASD. The next stage was to implement the high-fidelity prototype in Android Studio, based on the feedback obtained in the evaluation session in the previous stage. The project ended in two evaluation stages, one with 16 TD children and the other with five experts in HCI and ASD.

The results from the evaluations were very promising, and there was clear evidence, based on the feedback received from TD children and experts in HCI and ASD that the new technology could be used to aid in Social Story™ comprehension in children with ASD.

¹Teachers, speech and language therapists, nursery nurses, learning assistants
Acknowledgements

I would like to thank my supervisor, Dr Aurora Constantin, for all of her support and guidance over the duration of this research.

I would also like to thank Dr Helen Pain for her help in organising the workshops with children throughout this research project.

I would also like to thank all of the children and experts that were involved at various stages of this research. The information they provided was invaluable.
# Table of Contents

1 Introduction 9  
1.1 Autism Spectrum Disorder 9  
1.2 Interventions 9  
1.3 Social Stories 10  
1.4 Thesis Purpose and Research Questions 11  
1.5 Structure of the Paper 11

2 Literature Review 13  
2.1 Autism Spectrum Disorders 13  
2.1.1 Common Characteristics of ASD 13  
2.1.2 Prevalence and Diagnosis 14  
2.2 Interventions 15  
2.2.1 Educational Interventions 15  
2.2.2 Technology-Based Interventions 16  
2.3 Social Stories™ 17  
2.4 Reading Comprehension 18  
2.4.1 Rewards 19  
2.5 Motivation of Thesis 20  
2.6 Methodology 20  
2.7 Summary 21

3 Pre-Design Stage 23  
3.1 Design Workshop with Typically Developing children 23  
3.1.1 Aim 23  
3.1.2 Method 24  
3.1.3 Data Analysis 25  
3.1.4 Workshop Results 26  
3.2 Design Principles and Designing Technology for Children with ASD 27  
3.3 Implications 30  
3.4 Summary 31

4 Low-Fidelity Prototyping 33  
4.1 Prototype Description 33  
4.2 Justification of Design Decisions 39  
4.3 Low-Fidelity Evaluation 40  
4.3.1 Aim 40
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.2 Method</td>
<td>40</td>
</tr>
<tr>
<td>4.3.3 Data Analysis</td>
<td>42</td>
</tr>
<tr>
<td>4.3.4 Results</td>
<td>43</td>
</tr>
<tr>
<td>4.3.5 Discussion</td>
<td>44</td>
</tr>
<tr>
<td>4.4 Summary</td>
<td>45</td>
</tr>
<tr>
<td>5 High-Fidelity Prototype Implementation</td>
<td>47</td>
</tr>
<tr>
<td>5.1 Implementation</td>
<td>47</td>
</tr>
<tr>
<td>5.1.1 Development Process</td>
<td>47</td>
</tr>
<tr>
<td>5.1.2 Development Platform</td>
<td>47</td>
</tr>
<tr>
<td>5.1.3 Resource Requirements</td>
<td>49</td>
</tr>
<tr>
<td>5.1.4 XML</td>
<td>49</td>
</tr>
<tr>
<td>5.1.5 Java</td>
<td>49</td>
</tr>
<tr>
<td>5.1.6 VCS</td>
<td>49</td>
</tr>
<tr>
<td>5.2 User-Interface</td>
<td>50</td>
</tr>
<tr>
<td>5.2.1 Selecting a Story Page</td>
<td>50</td>
</tr>
<tr>
<td>5.2.2 Story Pages</td>
<td>50</td>
</tr>
<tr>
<td>5.2.3 Reward for Story Completion</td>
<td>53</td>
</tr>
<tr>
<td>5.2.4 Comprehension Check Page</td>
<td>53</td>
</tr>
<tr>
<td>5.2.5 Questions and Answers Comprehension Check</td>
<td>53</td>
</tr>
<tr>
<td>5.2.6 Partial Sentences</td>
<td>57</td>
</tr>
<tr>
<td>5.2.7 Game Comprehension Check Method</td>
<td>57</td>
</tr>
<tr>
<td>5.3 Summary</td>
<td>61</td>
</tr>
<tr>
<td>6 High-fidelity Evaluation</td>
<td>63</td>
</tr>
<tr>
<td>6.1 Evaluation with TD Children</td>
<td>63</td>
</tr>
<tr>
<td>6.1.1 Aim</td>
<td>63</td>
</tr>
<tr>
<td>6.1.2 Method</td>
<td>64</td>
</tr>
<tr>
<td>6.1.3 Data Analysis</td>
<td>66</td>
</tr>
<tr>
<td>6.1.4 Results</td>
<td>67</td>
</tr>
<tr>
<td>6.1.5 Discussion on the evaluation with children</td>
<td>70</td>
</tr>
<tr>
<td>6.2 Evaluation with Experts</td>
<td>72</td>
</tr>
<tr>
<td>6.2.1 Aims</td>
<td>72</td>
</tr>
<tr>
<td>6.2.2 Method</td>
<td>73</td>
</tr>
<tr>
<td>6.2.3 Data Analysis</td>
<td>74</td>
</tr>
<tr>
<td>6.2.4 Results</td>
<td>75</td>
</tr>
<tr>
<td>6.2.5 Discussion</td>
<td>78</td>
</tr>
<tr>
<td>6.3 Discussion</td>
<td>79</td>
</tr>
<tr>
<td>6.4 Summary</td>
<td>80</td>
</tr>
<tr>
<td>7 Conclusions and Future Work</td>
<td>81</td>
</tr>
<tr>
<td>7.1 Dissertation Questions</td>
<td>81</td>
</tr>
<tr>
<td>7.2 Limitations</td>
<td>83</td>
</tr>
<tr>
<td>7.3 Future Work</td>
<td>84</td>
</tr>
<tr>
<td>7.3.1 Further Development of the Application</td>
<td>84</td>
</tr>
<tr>
<td>7.3.2 Extending the Application</td>
<td>85</td>
</tr>
<tr>
<td>7.3.3 Studies with Children with ASD</td>
<td>85</td>
</tr>
</tbody>
</table>
## Table of Contents

7.4 Contributions .................................................. 85
7.5 Conclusions .................................................. 86

**Bibliography** ................................................... 87

A Ethics Forms ......................................................... 93

B Child Information Sheet - Design Workshop ..................... 105

C Parent Information Sheet - Design Workshop .................... 109

D Child Consent Form .................................................. 115

E Certificate - Design Workshop .................................... 117

F Parent Consent Form .................................................. 119

G Child Information Sheet and Consent Form - Evaluation Workshop 121

H Parent Information Sheet - Evaluation Workshop .................. 127

I Certificate - Evaluation Workshop .................................. 133

J Social Stories™ Criteria ............................................... 135

K Social Story™ Example ................................................ 139

L High-fidelity expert evaluation questions ......................... 147
Chapter 1

Introduction

1.1 Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a group of neurodevelopmental disorders (Lord & Bishop, 2010; Baron-Cohen, 2004). Individuals diagnosed with Autism Spectrum Disorder (ASD) display impairments in three domains: social interaction, social communication and social imagination (also called restricted interest and behaviours with specific items or topics) (Lord & Bishop, 2010; CCD, 2001; Kessler et al., 2005). The current prevalence of individuals diagnosed with ASD in the United Kingdom is estimated to be around 1% (Baird et al., 2006; Fombonne et al., 2005). The economic impact of ASD in the UK is estimated at around £2.7 billion per year for children and around £25 billion per year for adults (Knapp et al., 2009). There is also an impact on the family members with a child with ASD as it adds a financial stress and leads to a deteriorated family well-being (Karst et al., 2012). Helping individuals with ASD develop their social and communication skills will provide them with the necessary basis to be in a position to develop more complex behavioural skills (Lauritsen, 2013; Moore et al., 2005).

1.2 Interventions

Practitioners and researchers have developed a variety of educational interventions which address the core impairments in children with ASD (Bellini et. al, 2007). As discussed by Jordan et al (1998), aims of these interventions include to:

- enhance the development of social/emotional, cognitive and communicative development
- motivate the child to want to interact with others and to encourage the development of social and communication skills

---

1Teachers, speech and language therapists, nursery nurses, learning assistants
• acquire key communication skills, especially initiating communication, in a social exchange

• teach skills and reduce inappropriate behaviours by shaping and rewarding correct responses

It is worth mentioning that educational interventions require a very important resource; a practitioner who is specialised in teaching individuals with ASD these skills. The number of such practitioners is quite sparse, therefore they cannot reach out to the whole community of individuals with ASD.

Recently, due to the progress in technology there has been a proliferation of interventions using technology (Goldsmith et. al, 2004). Parents and practitioners reported that children with autism seem to be attracted by technological devices. Therefore taking advantage of this fascination can be valuable (Colby, 1973). Additionally, computers allow children to work at their own pace, avoid any distractions and is consistent and predictable (Swettenham, 1996).

1.3 Social Stories

One of the educational interventions for children with ASD is Social Stories™. These are widely used interventions for improving social-communication skills in children with ASD. Social Stories™ describe a situation, skill, or concept (Gray, 2010). Social Stories™ may describe situations such as walking in line, sharing with friends, how to wash your hands, etc. Social Stories™ should be customised to meet the needs and skills of the child (Gray, 2010). Social Stories™ are developed on a set of guidelines and criteria which Gray (2010) introduced. An example of a Social Story™ which follows these guidelines can be found in Appendix K.

Checking comprehension during the Social Story™ intervention is a crucial step to ensure that children are learning and understanding the target skills. This is often skipped by practitioners though, as they find it difficult partly due to it being time consuming and the lack of a standard tool to aid them (Constantin, 2015). The comprehension check is usually done by asking the child questions at the end of the story (Crozier & Sileo, 2005), or through partial sentences (Gray, 2010).

Technology-based tools can be of aid to practitioners for checking comprehension. As discussed in the previous section, there has been a move in developing technology-based tools for children with ASD, due to the fascination children with ASD show with technology. Taking advantage of this fascination and building a tool which helps to check the comprehension of children with ASD could be a great aid for practitioners. It is therefore worth looking into the possibility of developing a technology-based tool which will aid in Social Story™ comprehension check.
1.4 Thesis Purpose and Research Questions

This thesis focuses on investigating how technology can be designed and developed to support practitioners and children with ASD in checking Social Story™ comprehension. Thus the broad research question guiding this research is: RQ: How can practitioners and children with ASD be best supported by technology in checking Social Story™ comprehension? To answer this question, three sub questions were devised as follows:

- **RQ1**: What methods of checking Social Story™ comprehension in children with ASD are currently used/recommended?
- **RQ2**: How can technology be designed to support Social Story™ comprehension checking in children with ASD?
- **RQ3**: To what extent does the new technology support children with ASD and practitioners in checking Social Story™ comprehension?

1.5 Structure of the Paper

This dissertation is comprised of seven chapters. Chapter 1 is the introduction, which gives an outline of ASD, interventions for ASD and Social Stories™, and introduces the research questions to be answered.

Chapter 2 discusses the research work which is currently available, and on which this dissertation is based on. It begins by discussing ASD, followed by a brief discussion on its prevalence and diagnosis. The chapter further discusses interventions used, both educational and technology-based. Then Social Stories™ are further discussed, followed by a discussion on reading comprehension methods. The chapter ends with the methodology used throughout the research project. Chapter 2 aims to answer the first of the three research sub-questions which was introduced in the first section “What methods of checking Social Story™ comprehension in children with ASD are currently used/recommended?”

Chapter 3 focuses on the pre-design stage which includes a workshop with four TD children. It discusses the aim of the workshop, the methodology used and ends with a discussion of the results and their implications.

Chapter 4 covers the design and exploration of a low-fidelity prototype which has been based on the literature review in Chapter 2 and design workshops in Chapter 3. The chapter includes the low-fidelity prototype design, followed by a justification of the design decisions. The chapter ends with an evaluation of the low-fidelity prototypes with four experts in the field of Human-Computer Interaction (HCI) and ASD. Chapter 4 aims to answer part of the second of the three research sub-questions ”How can technology be designed to support Social Story™ comprehension checking in children with ASD?”
Chapter 5 is a high-fidelity prototype implementation walk-through. The high-fidelity prototype was implemented in Android Studio. Chapter 5 begins by discussing the implementation process. It then follows through to display and discuss the interfaces implemented. Chapter 5 aims to answer the remaining part of the second of the three research sub-questions "How can technology be designed to support Social Story™ comprehension checking in children with ASD?"

Chapter 6 describes the evaluations of the high-fidelity prototype which were done with 16 TD children and five experts in HCI and ASD. The chapter is split into the evaluation with TD children and the experts. Both chapters discuss the aims, method, and results obtained. Chapter 6 aims to answer the third of the three research sub-questions "To what extent does the new technology support children with ASD and practitioners in checking Social Story™ comprehension?"

Chapter 7 concludes by discussing the dissertation questions asked in Chapter 1 and whether these have been answered through the research. It also describes the potential directions in which future work can take.
Chapter 2

Literature Review

This chapter discusses a review of the background research which has been the basis of the current research presented in the dissertation. This chapter is split into 7 sections. Section 2.1 discusses Autism Spectrum Disorder, and is split into two subsections. The first subsection discusses common characteristics of ASD, followed by the second subsection which discusses the prevalence and diagnosis of ASD. Section 2.2 looks into the types of interventions currently and previously used for helping individuals with ASD develop certain skills. This section is split up into the traditional educational interventions and the technology-based interventions. The next section, Section 2.3 looks into Social Stories™ which play an important role in educational interventions, and looks into how they are developed. Following on from this, is Section 2.4 which looks into reading comprehension, and the methods which are used to check both TD children and children with ASD comprehension. This section also has a subsection on rewards as they play an important role in comprehension checks as a motivating factor. Section 2.5 describes the motivation of the thesis, and the reasons behind this research. The methodology used throughout this thesis is described in Section 2.6, followed by a summary of all the findings in Section 2.7. This chapter answer the first research sub question, RQ1: "What methods of checking Social Story™ comprehension in children with ASD are currently used/recommended?"

2.1 Autism Spectrum Disorders

2.1.1 Common Characteristics of ASD

Autism Spectrum Disorder (ASD) is a group of neurodevelopmental disorders characterised by impairments in three core domains: social interaction, social communication and social imagination (Wing et al., 2011). Individuals also show a triad of strengths: preference for details, strong and particular interests, and advanced skills in specific areas (Baron-Cohen, 2004). The degree of difficulties varies from one individual to another, which makes the individuals with autism an extremely heterogeneous group (Baron-Cohen, 2004).
ASD includes: Autistic Disorder, Asperger Syndrome, Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS), Rett Syndrome and Childhood Disintegrative Disorder (AAP, 2001). Individuals with ASD without a learning disability usually receive a diagnosis of either Autism, Asperger Syndrome or PDD-NOS (Paul et. al, 2009; AAP, 2001). Individuals are diagnosed with autism if they show symptoms of language delay and also significant symptoms in the three main areas of the triad of impairments (Paul et. al, 2009; AAP, 2001). Individuals are diagnosed with Asperger Syndrome if they do not show any language deficits, have a cognitive development within the normal range, but show a significant deficit in the triad of impairments (Paul et. al, 2009). Individuals are diagnosed with PDD-NOS when all criteria for autism are met (Paul et. al, 2009; AAP, 2001). Rett syndrome is associated with severe motor and coordination problems, in combination with an impairment in language and social skills (AAP, 2001). Childhood Disintegrative Disorder (CDD) is characterised by severe impairments in communication, social interaction and motor skills. Some experts consider CDD as a low-functioning form of autism (MacPartland & Volkmar, 2012).

Social interaction deficits come from the difficulty individuals with ASD have in developing social skills. Social skills impairment is a core feature of the ASD (White et. al, 2007). Therefore, individuals with ASD have difficulties in understanding some otherwise common social situations which may lead them to misunderstanding and/or reacting in unusual ways (White et al., 2007). These difficulties impact the way individuals with ASD socialise with others, and leads them to frustration, where this frustration can increase as the individuals grow up and are subject to more complex social situations (White et al., 2007). Social interaction deficits in individuals with ASD can come in various forms, including not being able to make eye contact with others when having a conversation, or not being able to understand the gestures of other individuals.

As discussed by Mandel (2009) communication deficits vary, from no speech skills at all, to fluent communication. One of the social communication deficits is with language comprehension, especially when an individual needs to assume other people’s intentions to understand what they mean (Gold & Faust, 2012). This difficulty creates problems in understanding non-literal or sarcastic language (Gold & Faust, 2012).

Social imagination is defined as the ability to detach from normal routines and look at them from a different perspective (Mills, 2000). Individuals with ASD have a more rigid and repetitive thought process and therefore have an impairment in social imagination as they are not flexible in approaching ideas from different perspectives. This impairment adds to the difficulties faced by individuals with ASD to interact with others in a social context.

2.1.2 Prevalence and Diagnosis

Establishing a diagnosis of ASD is a challenging and complex task. There are two major steps in the comprehensive assessment of a child who is suspected to have ASD: 1) making a diagnosis based on the DSM-IV (Diagnostic and Statistical Manual of
2.2 Interventions

Mental Disorders, 4th edition) criteria (APA, 2000) and 2) finding etiologic disorders associated with ASD (CCD, 2001). According to CCD (2001) pediatricians must be up to date with their training around detecting ASD and parents need to detect unusual behaviours in their children and raise their concerns to their pediatrician.

Several tools are used to aid in diagnosing ASD. One such tool is the Checklist for Autism in Toddlers which is a screening instrument used to identify children under the age of 18 months who are at risk of autism (Baron-Cohen et al. 1992). Another tool is the Pervasive Developmental Disorders Screening Test (Siegel, 2013) which is used for early screening of ASD in children from 18 to 48 months old. This test is based on positive (such as some language and cognitive abilities) and negative (such as social difficulties and emotional liabilities) signs shown by the children. The tool is used by parents who report on signs which their child may show. The increase in the number of available tools for parents and of the pediatrician’s knowledge leads to a significant increase in the number of individuals diagnosed with ASD over time (CCD, 2001). The number of people diagnosed with ASD lie at around 1% of the UK population. (Baron-Cohen, 2009; Baird et al., 2006)

2.2 Interventions

No medical treatment is available which can cure ASD. Therefore, it is important that researchers come up with ways to target the impairments caused by ASD. These methods are called educational interventions. The overall goal of interventions is to minimise the effect of the core difficulties of ASD (e.g. impairment in social skills, social communication and social imagination) to allow individuals to lead an independent life (Lauritsen, 2013). Educational interventions aim to reduce the effects of ASD and guide individuals to build the necessary skills needed for society which will improve their quality of life.

2.2.1 Educational Interventions

Various educational interventions have been designed which help reduce the core difficulties in individuals with ASD. McConnell (2002) discussed a number of interventions used with children with ASD. These include Ecological Variation Interventions, Collateral Skills Intervention, Child-Specific Intervention, Peer-Mediated Intervention and Comprehensive Intervention. Ecological interventions promote the development of individuals’ skills through their physical and social environment, usually by interacting with others (McConnel, 2002). Collateral skills interventions are similar to ecological interventions but are more specific in the ways they try and develop social skills, such as through social participation or play (McConnel, 2002). Child-Specific interventions are much more specific in that they contain instructions for the children to carry out behaviours which will improve their social skills (McConnel, 2002). Peer-Mediated intervention procedures are based around instructions once again, but in this case it is between the child with autism and their peer, where the responsiveness to
gestures the TD child carries are tracked (McConnel, 2002). Comprehensive interventions include two or more of the previously discussed intervention methods. The goal of this is to investigate whether a combination of the intervention methods can be more effective (McConnel, 2002).

### 2.2.2 Technology-Based Interventions

There is an increasing number of technology-based interventions targeting the difficulties faced by individuals with ASD. Technologies that have been used include: Virtual Reality (VR), Augmented Reality (AR), music technologies, video technologies and robotics.

Computer-based interventions are particularly successful with children with ASD, due to the interest that most of these children have toward computers. Additionally, researchers, practitioners and parents highlighted that in general technology-based interventions are engaging, rewarding and motivating for children with ASD (Goldsmith and LeBlanc, 2004).

Swettenham (1996) discussed how computers allow the users to work at their own pace without the usually external distractions that occur in other environments, and also provide similar environments for the users and predictability. There is also the advantage of computer-based interventions not being as impatient as humans and therefore the user feels more relaxed when using the software (Williams et al., 2002). With these benefits in mind, there has been extensive research into different computer-based methods which could be used.

Hagiwara (1998) designed a multimedia Social Story™ intervention using visual symbols, Social Stories™ and computer assisted instructions. The Social Story™ followed Gray’s criteria (see section 2.3). The results of this study revealed an increase in the skill levels of all the participants. Generalisation of the skills across settings was observed in one of the participants. This illustrated the potential use of technology for the Social Stories™ interventions.

Another form of technology that has been investigated to support children with ASD is through mobile technology (Mintz, 2012). A particular mobile technology has been developed within the HANDS project (Mintz, 2012). It aimed at helping teenagers with ASD to develop their social and life skills (Mintz, 2012). The HANDS project used persuasive technology to change the child’s attitude or behaviour through persuasion and social influence (Mintz, 2012).

Parsons and Mitchell (2002) investigated the potential of using visual environments (VE) to teach social awareness and social behaviours to individuals with ASD. The VE was used by setting up an environment in a cafe where the child could learn about different social skills such as greeting others, personal space and others. The results of their study was promising as it showed positive results in the development of these skills in individuals with ASD.

The Aurora Project (2000) explored using robotic technologies in developing social
interactions in individuals with ASD. The aim of this project was to use robots to help children learn about turn-taking, emotions and communication, and interaction skills. This approach is targeted to children with ASD and is to be used as an assistive technology where the child works with the robot to develop new skills.

2.3 Social Stories™

A particular example of an educational intervention which is widely used by practitioners and parents is Social Stories™. They address the social interaction and communication difficulties encountered by children with ASD. Social Stories™ are short stories which describe social situations, social skills or concepts which are written following ten specific criteria (Gray, 2010) (See Appendix J).

For this research project three out of the ten criteria will be described, which are related to this project:

Types of Sentences

Social Stories™ contain seven types of sentences (taken from Carol Gray (2010)), including:

- Descriptive present factual, objective statements, free of opinions or assumptions. For example "There are many stars in the sky at night".

- Perspective sentences which describe a person’s internal state or their opinions, motivation and their physical condition or health. For example "Adults may think it is polite to ask before taking a cookie from the jar".

- Sentences that coach are used to guide the behaviour of an audience or of a team. These sentences are comprised of three types of sentences: sentences that coach the audience (for example, "I will try and write between the lines"), sentences that coach the team (for example, "My mum will help me with the washing") and self-coaching sentences (for example, "I can use a paper chain to help me keep track of the number of days until my birthday").

- Affirmative sentences enhance the meaning of statements and express an opinion within a specific culture. They are usually used to enhance an important point. For example "To stay safe, children take turns going down the slide. This is very important".

- Partial Sentences follow a fill-in-the-blank format which are used to check comprehension or encourage the audience to make a guess as to what the next part of the story is. Partial sentences provide an opportunity for the child to participate in the review of a Story.

Ratio Between Sentences

To create a Social Stories™, a ratio of the types of sentences use, introduced previously must be followed. This is known as the Basic Social Story™ Ratio (Gray, 1998). This ratio states that for every 0-1 directive and control sentences there should be 2-5
descriptive, perspective, affirmative and coaching sentences when writing Social Stories (Gray, 2010).

**5W+H Questions**

Social Story™ answers relevant “5W+H” questions, which are important in describing information about a specific topic. The 5W+H questions (who, what, when, where, why and how) outline the information about specific topics.

- Where - describing the context
- When - time-related information
- Who - relevant people
- What - important queues
- How - basic activities, behaviours or statements
- Why - Reasons and/or rationale behind them

Social Stories™ are implemented to improve the social understanding of children with ASD and celebrate the child’s achievements (Gray, 2010). Although the child may read the Social Story™, there is no guarantee they have understood the concept. Therefore it is important to test the child’s understanding through a comprehension check method. A comprehension check method will also aid in celebrating the child’s achievements as they can be rewarded (Gray, 2010).

### 2.4 Reading Comprehension

Comprehension occurs as a reader builds a mental understanding of the information they have just read (Nation, 2005). The reader’s mental model, of how they perceive things in real life also plays an important role in comprehension (Nation, 2005). Reading comprehension is the ability to process a piece of text, understand its meaning and to combine it with their current knowledge to interpret the meaning of the text. Reading comprehension is a good way in which to test whether the reader has understood the body of text they have just read.

There are various methods in which teachers test the comprehension of typically developing (TD) students, the most common being asking questions about the piece of text that has been read. Methods include asking general questions about the topic, such as who the characters were or the context of the story. Other methods include using True/False questions or by using pictures to answer questions.

Individuals with ASD, have impairments regarding word recognition, oral language and social concepts which are constraints when it comes to reading comprehension (Ricketts et al., 2013). These impairments lead to children with High-Functioning Autism to not perform at their age level on the Neale Analysis Ability Test, where the greatest deficit was found to be in reading comprehension (Venter et al., 1992).
Due to these difficulties in reading comprehension, there has been research into finding methods which work well for individuals with ASD. One form of questions which has been found to be successful is the use of "5W+H" questions, for example "What", "Who", "Where", "Why", "When" and "How" (Aking & MacKinney, 2004), and also asking questions at the end of story (Crosier. This method is sometimes used by practitioners (Constantin, 2015). There is also evidence that the "5W+H" (where, when, what, why and how) approach has been considered appropriate as it is in line with one of Gray’s (2010) criteria for writing Social Stories™. Another method for testing comprehension is using partial sentences which are part of Social Stories™. Partial sentences are incomplete sentences where the reader must fill in the gaps (Gray, 2010). The sentence is based on the story the reader has just read. This method also increases the motivation of children in reading and learning from Social Stories (Gray, 2004).

Due to the increased popularity of technology and video games among children, there has been research into whether computer-based video games can be used to improve the learning skills of children (Chuang, 2007). The study conducted by Chuang (2007) showed that a computer-based video game improved the TD children’s recall process and also improved their problem-solving skills. The main reason for the problem-solving skills improvement was due to the video game allowing for multiple solutions. A study conducted by Habgood and Ainsworth (2011) looked into how educational games could be used to motivate children to improve their mathematics skills. The study looked into using the educational game as an intrinsic motivator, which means that the children would use it as it is enjoyable to use. The study showed that children learned more through using the educational game and also spent their free time using it (Habgood and Ainsworth, 2011). There has also been research into using computer-based educational games for teaching children with disabilities skills such as reading skills (Charlton et al., 2005) Therefore from these studies it can be thought that computer-based games can be useful in checking comprehension. Videogames have shown several benefits, as they provide interactivity which can enhance learning, can help practitioners measure performance and can also be fun and enjoyable for the children to use (Griffiths, 2002).

As mentioned in the previous section, the achievements of the children must be celebrated to increase their motivation. Therefore, rewards can play an important part in this.

### 2.4.1 Rewards

It has been found that motivation plays a key role in the learning procedure (Gray, 1998), therefore it is always an important factor to have some sort of motivation to complete tasks, especially in education. Individuals, as the word itself describes are quite different from each other and therefore may vary in the amount and type of motivations they need (Deci and Ryan, 2000). Deci and Ryan (2000) identified a basic distinction between two types of motivation, intrinsic and extrinsic motivation. Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable, where extrinsic motivation refers to doing something because it leads to a
Chapter 2. Literature Review

There has been a range of research on the type of rewards children prefer including (Humphry, 2011), looking into the type of rewards children with autism like. Currently teachers rely on paper rewards such as stickers (Constantin et al, 2017) but this procedure can be very time consuming and require lots of effort from the teacher. Since every teacher will have a different reward system using the stickers, this leads to inconsistency across the field (Constantin et al, 2017). Researchers have began to look into digital rewards and the impact they could have, since children seem to be more receptive to digital awards, as these can be personalised for the child (Constantin et al, 2017). Digital rewards also provide a larger range of choices for the children which can also increase the motivation, rather than just having a single reward as is the case with the paper rewards.

2.5 Motivation of Thesis

Social and communication skills play a very important role in the development of more skills later on in life. One way to teach these skills is through Social Stories™ which were discussed in Section 2.3. An important step in Social Stories™ is checking the comprehension of the child, a step which is often missed. Practitioners skip these comprehension checks due to them being time consuming and having limited support through tools.

This lack of checking comprehension by practitioners shows how there is a gap here which needs addressed. Technology has been shown to be well suited for children with ASD, and supporting practitioners. Therefore this project investigates how a technology-based prototype can be designed and developed to support practitioners and children in performing Social Story™ comprehension check. This will benefit both the children and the practitioners, as the children will have the opportunity to enhance their learning experience through the application, and the practitioners will be able to check whether the children are understanding the concepts introduced to them.

2.6 Methodology

The methodology in Figure 2.1 shows an adapted methodology taken from Scaife & Rogers (2011), and has been inspired by Dragomir (2013). The methodology used is an adaptation of the informant design introduced by Scaife & Rogers (1997), which allows experts and children to act as informants at the various stages in the design.

**Step1: Background Research** The aims at this stage were to review the background research literature, and clarify what the problem might be, to review the current technology used, to identify existing methods of checking comprehension, to identify methods of comprehension check, and to identify an initial set of ideas of how the
2.7 Summary

This chapter presented a critical evaluation of the relevant literature and identified a gap in the literature in comprehension check methods. It began with an overview of ASD, its prevalence and diagnosis. Next it introduced what kind of interventions are

---

**Step 2: Design Workshops** The aims at this stage were to discover some of the requirements for the application. This stage involves a workshop with TD children between the ages of 7-11, who will aid in informing the design of the application. The TD children are used as proxies for the children with ASD. This stage is covered in Chapter 3.

**Step 3: Low-Fidelity Prototyping:** The aims at the stage were to implement a low-fidelity prototype based on the requirements gathered in the previous two stages. At this stage, evaluations with experts in HCI and ASD were also carried out to evaluate the low-fidelity prototype, and help inform the design further. This stage, in combination with the previous stage also aim to answer the second research sub-question discussed in Section 1.4. This stage is covered in Chapter 4.

**Step 4: Implementation:** The aim at this stage was to develop the high-fidelity prototype based on the requirements collected in the previous stages. This stage follows an iterative development process until the final prototype was developed. This stage is covered in Chapter 5.

**Step 5 High-fidelity Evaluation Stage** The aim of this stage was to evaluate the high-fidelity prototype with TD children and experts to determine the usability of the application, and its overall likeability. This stage also aims to answer part of the third research sub-question discussed in Section 1.4. This stage is discussed in Chapter 6.
currently used, both educational and technology-based. Social Stories\textsuperscript{TM} were then introduced and how these are used with children with ASD, followed by what methods of comprehension are used in both typically developing children and children with ASD. The comprehension check methods found were asking ”5W+H” questions at the end of a story (Aking & MacKinney, 2004; Crozier & Sileo, 2005), partial sentences (Gray, 2010) and using computer-based games (Charlton et al., 2005; Chuang, 2007). Based on this information the application will have three methods for checking comprehension: ”partial sentences”, ”questions and answers”, and a ”game-based method”. The chapter ended with an overview of the methodology and the five stages involved and in which chapters each stage is covered in. The next chapter discusses the pre-design stage which involves a design workshop with four TD children.
Chapter 3

Pre-Design Stage

In the literature review three methods of checking comprehension were identified, "Partial Sentences" suggested by Gray (2010), "5W+H Questions at the end of story reading" (Aking & MacKinney, 2004; Crozier & Sileo, 2005), and the use of computer-based games (Charlton et al., 2005; Chuang, 2007). The research reviewed in regards to methods of comprehension, and how games are being implemented inspired the three methods chosen for checking comprehension in this study. This chapter presents a workshop carried out with four TD children before designing the low-fidelity prototypes for the application, and discusses the design principles chosen. Based on the results from the workshop, the literature review, and the design principles chosen, the initial design specification has been derived. The studies in this chapter and the next chapter answer the second research sub question: **RQ2: "How can technology be designed to support Social Story™ comprehension".**

3.1 Design Workshop with Typically Developing children

3.1.1 Aim

The overall goal of this study was to inform the design of the application in general, with a focus on the game. Specific aims of this study were to identify:

- what characters children like.
- what kind of rewards children like.
- a story-line for the game.
3.1.2 Method

3.1.2.1 Participants

The participants were four typically developing children between the ages of 7-11 (three males and one female). To ensure anonymity, I have named the children "P1", "P2", "P3" and "P4" as show in Table 3.1. The participants were recruited via email. Thus an email was sent (including details about the study to the staff in the University of Edinburgh Informatics department to ask if their children would be interested in participating in the design workshop. The email contained the information sheet (see Appendix C) and consent forms (see Appendix F) for the parents. Ethical approval had been obtained for all the studies following the guidelines of the ethics procedure of the School of Informatics 2017 (see Appendix A).

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>7</td>
<td>Male</td>
</tr>
<tr>
<td>P2</td>
<td>10</td>
<td>Male</td>
</tr>
<tr>
<td>P3</td>
<td>10</td>
<td>Male</td>
</tr>
<tr>
<td>P4</td>
<td>11</td>
<td>Female</td>
</tr>
</tbody>
</table>

Table 3.1: Participants used in the workshop.

3.1.2.2 Materials

The materials required for this workshop included:

1. Coloured pens and pencils
2. A4 and A3 blank sheets of paper
3. Coloured post-it notes
4. Tablet for my notes
5. Two voice recording devices
6. Child consent forms
7. Child Information sheet
8. Certificates for the children

3.1.2.3 Procedure

The workshop took place in the Informatics Forum at the University of Edinburgh. This location was familiar for the children as it is the location of the children’s parents work and the children had visited it before. That helped them be more comfortable. Upon
3.1. Design Workshop with Typically Developing children

arrival of the children, the researcher\(^1\) introduced themselves and presented them with the information (see Appendix B) and consent forms (see Appendix D). The workshop began with a small ice breaker where the children were asked to name their most favourite and least favourite food. The researcher participated in this ice breaker with the children as it allowed them to feel more comfortable and confident.

After the ice breaker, and once it was visible the children were feeling more comfortable, the researcher explained the aim of the project, and handed out the materials which would be used by the children (colourful pens, post-it notes and blank paper). The researcher then invited the children to come up with story lines for teaching children about different topics which they chose, and design characters which they would like telling the story. The researcher was present in the room with the children but tried to have minimal input which allowed the children to come up with their own ideas. The researcher only gave input when the children seemed to get stuck and were not writing or drawing up any ideas. Once the children had finished their drawings and writing, the researcher asked them to present and explain their ideas, and to share them with each other and provide feedback to each other. After each presentation the other children were asked to add to the ideas presented. This interesting discussion among the children, created more ideas.

When the children left, photographs were taken of their work. The study was audio recorder and field notes were taken.

The overall workshop took between 30-40 minutes which is a good time to aim for as children usually become either bored or tired after this point. At the end of the workshop the children were thanked and given a certificate (see Appendix D) in a small ceremony.

### 3.1.3 Data Analysis

As discussed in the previous section, during the workshops with the TD children field notes and recordings were taken during the workshop, in addition to photographs of the children’s work. Once the workshops had finished, the researcher transcribed the recordings collected from the workshop and combined them with the field notes taken during the workshop.

The transcription of the recordings combined with the field notes taken resulted in a large amount of text. Therefore, to be able to collect data from it a method of qualitative data analysis was needed. The researcher chose a method similar to open coding (Saldana, 2013), a method in which concepts are attached to the data which is being analysed. The reason for this was because the researcher was looking for specific information from the data, such as characters, rewards and story-lines.

A table has been drawn and each important statement and the corresponding code were inserted on the same row (see Table 6.4).

\(^1\)The author of the present dissertation
Chapter 3. Pre-Design Stage

<table>
<thead>
<tr>
<th>Child Participant 1</th>
<th>Open Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The character I have drawn is an elephant”</td>
<td>Elephant Character</td>
</tr>
<tr>
<td>“You must walk through the forest”</td>
<td>Location - forest</td>
</tr>
<tr>
<td>“You collect fruit as rewards”</td>
<td>Rewards - fruit</td>
</tr>
<tr>
<td>”You then give these to your character”</td>
<td>story-line</td>
</tr>
<tr>
<td>“This helps you build a strong friendship”</td>
<td>Reward - friendship</td>
</tr>
</tbody>
</table>

Table 3.2: Excerpt from the Open Coding worksheet

Then these labels were grouped using axial coding (Saldana, 2013) in conceptual categories. Pre-determined categories were used based on the aims of the study: characters of the games, rewards which were suggested and story-line of the games.

The results are discussed in the next section.

3.1.4 Workshop Results

Based on the data analysis presented in the previous section, the following results were discovered.

Characters

The workshop was useful to determine the types of characters that children liked and how they portrayed them in a game scenario. There was an obvious lean towards animal characters such as an elephant and an owl where these animals were portrayed as "friends" or "side-kicks". Participant 1 remarked:

"I would like to be friends with an elephant and go on adventures with it. We’ll go through a forest where I’ll collect fruit for it and the more fruit I collect the better friends we become".

Figure 3.1 shows some of the sketches of the ideas the children came up with in the workshop. This helped inform the design for the application as to what types of characters should be used in the game comprehension check method.

Rewards

The workshop was also an opportunity for the researcher to investigate what kinds of rewards children between the ages of 7-11 enjoy. To discover this information, the researcher had to ask the children during the workshop what kind of rewards they would have enjoyed in a game. The responses involved having a medal given, a star based reward system or building a friendship. Participant 2 remarked:

"It would be nice to build a friendship with the character as you complete tasks, and then also find more characters to build friendships with”.

Participant 3 remarked:

"A gradual reward system where each time you complete a task you get more gold which gradually adds up, and the more gold you have the more add-ons you can buy.”.
3.2 Design Principles and Designing Technology for Children with ASD

Usability cannot be defined by one factor, and therefore there are a series of design principles which can be addressed to increase the usability of a system. The following design principles, have been considered for this application. (Dix, 2009).

- **Robustness** refers to how the user is supported to achieve their goals. It includes being able to recover from an accidental mistake such as pressing the “Back” or “Next” button by mistake, being able to understand when they have got the correct or wrong answer, and being provided with feedback as a response to an action. Robustness is affected by specific principles, three of which are **recoverability, observability** and **responsiveness**.

Game Story-line

The researcher also used the workshop to investigate a potential story line which could be used for the game comprehension check method in the application. Table 3.3 (see next page) shows an overview of the game ideas the children came up with, the characters they chose and the location in which the story took place. This information would help the researcher inform the design of the game in deciding the concept of the game.

Figure 3.1: Photos of the designs the children came up with in the workshop
<table>
<thead>
<tr>
<th>Participant</th>
<th>Character</th>
<th>Game Location</th>
<th>Game Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Elephant</td>
<td>Forest</td>
<td>Collect fruit for the character you have chosen. Each time you give them some fruit you build a closer bond</td>
</tr>
<tr>
<td>P2</td>
<td>Children</td>
<td>Playground</td>
<td>Help others in the playground to overcome obstacles</td>
</tr>
<tr>
<td>P3</td>
<td>Lion</td>
<td>Outdoors</td>
<td>Game has two pathways to it where the outcomes depend on the choices the user takes with a lion friend</td>
</tr>
<tr>
<td>P4</td>
<td>Owl</td>
<td>Outdoors</td>
<td>The owl acts as a &quot;side-kick&quot; and helps the user through different situations.</td>
</tr>
</tbody>
</table>

Table 3.3: Summary of the results from the workshop with TD children

Recoverability is being able to recover from an accidental mistake such as pressing the wrong button on the screen. The toolkit ensures recoverability by, if the user accidentally moves to a page they did not intend to, they can easily go back to the page they were on using the "Next" and "Back" navigation buttons.

Observability is being able to understand when the user has achieved their goal or not. The application ensures the user understands when they have achieved their goal, for example when they click on the correct answer they receive positive feedback and a reward which indicates that they have chosen the correct answer. If the user chooses the wrong answer they will be informed and asked to try again.

Responsiveness is the ability of the system to provide the user with feedback in response to an action taken, and for this to be performed at an acceptable speed. The application meets this principle in that it has a quick response time, in that the user will not be left waiting for something to happen, which may result in them abandoning the application. It also responds with feedback such as a reward or a "Try Again" message in response to the users action.

- **Flexibility** refers to the different ways in which the application can be adapted to different users. Therefore the principle of flexibility considered in this design is customisability. This is especially important for the users of the application being built as they are children with ASD who require different types of rewards, or methods of inputting answers. Currently the application only has one
set of rewards, but the future work is to implement the option for the practitioner to choose from a set of different rewards which are applicable to the children. There would also be the option for the text on the screens to be read out by a text-to-speech functionality allowing for the user to be presented with information in different methods. The implemented method of customisability in the application prototype, is that the user can choose from different characters in the game comprehension check method.

- **Learnability** is defined by how easily a new user can learn how the system works to achieve their goals. Two important principles of learnability which are considered in this design are **predictability** and **consistency**.

Predictability is defined by the user being able to predict what will happen when they perform a certain action. Therefore by using buttons which clearly state their use will help the user predict what will happen. For example when the user presses the button that says "Answer", they will understand that they will be given an array of answers to choose from.

Consistency refers to the system having a consistent way of moving through pages, how the information is provided to the user and how similar buttons or features react when they are pressed. In the application, all the pages have a similar structure and the ways in which you move through the pages are similar. The ways in which the questions, partial sentences and game comprehension check methods and are presented are also set out in a consistent manner.

Furthermore, there are some more specific design principles which must be followed when designing technology for children, and especially for children with ASD.

- **Visual Design** - it is important that designs for children contain some animations and sounds as children are very attracted to this (Nielson, 2010). In the case of designing for children with ASD it is important to have the option for these animations and/or sounds to be turned off as some children with ASD may suffer from auditory sensitivities (Davis et al., 2010). If there are icons in the design, they should represent actions or objects in a simple way so that the children understand how they need to interact with them (ETSI, 2005). In the case of children with ASD being the audience then it is key that these objects are clear representations of what they do as children with ASD struggle with abstract concepts (Mesibov et al., 2007; Leach, 2010). It is also important to represent instructions in an age appropriate format, and they should be easy to understand and remember (Druin, 1999).

- **Feedback and Guidance** - tasks should be intuitive to use and help the user through them and build the knowledge for remembering the tasks later (Chiasson & Gutwin, 2005). This is important when designing interfaces for children with ASD as they prefer environments that are predictable, well structured and controlled with tasks that have a clear beginning and ending (Davis et al., 2010). Any actions the user takes should have a direct effect and should provide the user with feedback quickly, otherwise they can become frustrated (Chiasson & Gutwin, 2005). Giving direct feedback is very important for children with ASD,
and it is important that the feedback is positive and provides the opportunity for
the child to carry out a task correctly (Davis et al., 2010). An option should
also be available for the user to recover from an error they make, for example if
they accidentally press a button as this encourages the user to explore the applica-
tion further (Chiasson & Gutwin, 2005). For children with ASD the application
should be highly structured, as children with ASD explore in a very systematic
way (Baron-Cohen, 2009).

• *Motivation and Engagement* Children can have short attention spans (Nielson,
2010) and therefore it is important to keep the application engaging, and inter-
esting so that the child does not stop paying attention. The use of rewards is a
way of helping keep children motivated (Chiasson & Gutwin, 2005). Rewards
are important with children with ASD as they can be very motivating, as long as
they focus on their areas of interest. The rewards must be appropriate though, in
that they are not too complex and end up distracting the child from the task at
hand (Zepke & Leach, 2010).

These design principles are not extensive, as throughout the development process, var-
ious other design principles come into play. The design principles discussed are the
key areas which must be looked into when designing technology for children.

### 3.3 Implications

The workshop with the TD children provided valuable information for informing the
design, and providing further insight on how children think. It aided in developing
a clearer idea of what types of stories children think about and how they perceive
different situations.

Based on this workshop, the literature review and methods of comprehension check,
an initial set of requirements have been developed. These requirements can be di-
vided into five categories. These categories are as follows: user requirements, task
requirements, user interface requirements, educational requirements and language re-
quirements.

**User Requirements**

The target users are children with ASD between the ages of 7-11 years old. The users
must be familiar in using a tablet with a touch screen, since the only interaction with
the game is touching various objects. The application should be easy to use for the
target users, with the use of simple language and straightforward tasks.

It is important that if any animations and/or sound is present in the game, the user
should have the option to turn this sound off. It is also important for the user to have
the opportunity to have a break between different tasks they need to complete. The user
should also be able to use the application independently, and therefore it must be easy
to recover from mistakes (based on robustness principle) and have a simple structure.
3.4 Summary

Task Requirements

The user will be tasked with selecting the story they want to read from what is available, followed by carrying out one of the three comprehension check methods. During the comprehension check methods, the tasks which the user will be required to complete are selecting the correct answer from a pool of answers which will be provided on each page linked to the question asked, and also selecting objects which will be on the screen.

User Interface Requirements

The application will open on a main page which will present the stories the user has available to read depending on the ones selected by the practitioner (part of future work). The user will have the opportunity to read through the story and once they complete the story they will be provided with a three comprehension check methods. The user will be able to select one of three methods and complete it. For each correct answer and completion of a comprehension check method, the user shall receive a star as a reward. A star was chosen as the reward, due to this being the most popular reward suggested by the children during the design workshop. During the game comprehension check method, the user will be able to select a character from a pool of four different characters. This was inspired by the interest the children showed in the design workshop of having animals as the characters in the game.

Educational Requirements

The application must allow the child to read through a Social Story™, and then test whether they have understood the Social Story™ through a series of comprehension check methods. The Social Stories™ used must be taken from Gray (2010).

Language Requirements

The language used in the application must be kept simple and should avoid the use of any jargon, otherwise it can lead to the child giving up on using the application. The pages which contain text should have as minimal text as possible, as otherwise the child may lose focus. When the child gets an answer wrong, the language used must be positive, which will aid in encouraging the child to try again, increasing their motivation. The partial sentences should follow the structure discussed by Gray (2010), and the questions asked in the application should follow the “5W+H” (Aking & MacKinney, 2004; Gray, 2010) format.

3.4 Summary

This chapter first described a workshop conducted with TD children during the pre-design stage, which was carried out to gain deeper insight into what children like as characters, rewards and game story-lines. The workshop informed the design of the application in terms of the characters, rewards and story-line implemented. A set of general design principles (Robustness, Flexibility, Learnability, Visual Design, Feedback and Guidance, and Motivation and Engagement) for children with ASD were
introduced to guide the design of the tool. Bases on the results in the workshop
with children and on the literature review (including the design principles presented
in this section) a list of requirements were devised which were grouped into five cate-
gories (user requirements, task requirements, user interface requirements, educational
requirements and language requirements).

The next chapter describes the the design of a low-fidelity prototype based on these
requirements and the evaluation of the prototype with four experts in HCI and ASD.
Chapter 4

Low-Fidelity Prototyping

This chapter presents the design and evaluation of the low-fidelity prototype of the application. The chapter begins by presenting a low-fidelity prototype developed in Balsamiq based on the requirements and design principles presented in the previous chapter. Section 4.2 discusses the justification of the design decisions made whilst building the prototypes, and is followed by an evaluation of the prototypes with experts in HCI and ASD. Section 4.3 discusses the low-fidelity evaluation carried out with four experts in the field of HCI and ASD.

4.1 Prototype Description

The development of the application was iterative. Thus, an initial low-fidelity prototype was designed and then evaluated with four experts in HCI and ASD. The low-fidelity prototype was designed first as it is a commonly used method in iterative design due to them being quick and inexpensive to create. They also emphasize the big picture with minimal detail and foster design thinking (Beaudoin-Lafon and Mackey, 2003).

The feedback from the experts was used to improve the design and set of requirements. The low-fidelity prototype was based on the set of requirements discussed in the previous section.

Figure 4.1 (see next page) shows the prototype of the Home Page for the application in Balsamiq (http://www.balsamiq.com). Balsamiq is an online tool which can be used to create graphical user interfaces. Balsamiq has several advantages: It has a drag and drop feature which allows for easy customisability and re-building, it is less time consuming than drawing everything by hand, the mockups look similar to a software implementation which allow for easier use by the users, and it is easily accessible with a free license as a university student.

This home page is only accessible by the practitioner, and this would be where the practitioner would adapt the application to the needs of the child. This page is will not be fully implemented as it will be part of the practitioner’s side of the application which is part of future work (see Chapter 7). There is a help page with guidance on
Chapter 4. Low-Fidelity Prototyping

Figure 4.1: Home Page for the Social Story™ Comprehension application

using the application and a settings page for adjusting the settings to the children’s needs. As mentioned earlier, the part of the application aimed for the practitioner is part of the further work, as there would not be enough time to implement this.

Figure 4.2 presents the prototype for the pages where the child chooses the story they will read (shown in Figure 4.2a). These stories are set by the practitioner based on the requirements of the child. Figure 4.2b shows a page from the story "Sharing". The stories used are taken from Gray (2010) and each paragraph is separated into

(a) Page where the child selects the stories which have been made available by the practitioner. Here only a story about Sharing is active.
(b) A page from the story "Sharing". The stories are taken from Carol Gray’s book. The pages describing sharing are in this format.

Figure 4.2: Screenshots of the stories in Balsamiq.

different pages so that the pages do not contain too much text. Once the child has finished reading the story they are taken to the page shown in Figure 4.3 where the
child selects the comprehension check method they will complete. This will be set by the practitioner depending on the child’s requirements, as each child will have unique requirements. This part of the application will not be implemented due to the time constraints of the project and is part of future work, where the practitioner’s side of the application will be implemented.

Figure 4.4 presents the “Questions and Answers” comprehension check method. ”5W+H” style questions are given to the child, who is given multiple answers to choose from where just one of them is correct.

If they get the correct answer then the correct answer turns green. The child is then taken to the reward page shown in Figure 4.5.
Chapter 4. Low-Fidelity Prototyping

Figure 4.5: Small reward when the child gets the correct answer which allows for encouragement and increased motivation.

This reward acts as a motivational factor for the child to keep answering the questions (Constantin, 2017). If the child does not get the correct answer, then they are taken to Figure 4.6 where they are provided with a positive message such as "Try Again".

Figure 4.6: A hint page for when the child gets the question wrong. This would include a message such as "Try Again" and "Would you like to re-read the story".

Figure 4.7 shows the partial sentence comprehension check in the application which has a sentence based on the story they read with a missing word which is key to the
sentence as shown in Figure 4.7a. Similar to the "Questions and Answers" section, the child chooses the option they believe is the correct one. If it is correct, the answer they picked turns green as shown in Figure 4.7b, fills in the gap, and they are then taken to the rewards page in Figure 4.8d. If they get the wrong answer then they are taken to the page in Figure 4.6 which provides them with a positive message to try again.

Figure 4.7: Screen-shots of the Partial Sentences comprehension check in Balsamiq

Figure 4.8 shows the "Game" comprehension check method pages. They begin by choosing a character, which ends up being taken away to a castle which is in a forest. The child chooses if they want to help the character and if they do they go through the forest finding obstacles on the way. These obstacles aim to ask the child questions about what they learned and help animals in the forest. Each correct question they get a piece of fruit as a reward which they will end up giving to the character they chose at the beginning, as an answer to the last question (see Figure 4.8e).
Chapter 4. Low-Fidelity Prototyping

(a) The user chooses which character they want to become friends with.

(b) The character introduces themselves and introduces the story line of the game.

(c) Example of an animal needing help in the forest.

(d) Reward given for helping the animal in the forest. Given a fruit which is used later for their character friend.

(e) Character friend reached and the fruit collected in the forest are given to it to form a strong friendship bond.

Figure 4.8: Screen-shots of the Game comprehension check in Balsamiq
4.2 Justification of Design Decisions

This section explains how the design principles discussed in the previous chapter (Section 3.1.4) have been reflected in the low-fidelity prototype.

Robustness

Robustness refers to the support in which a user gets in achieving their goals, and is comprised of recoverability, observability, and responsiveness. Responsiveness is met in the low-fidelity prototype through the messages the user gets when they get the wrong answer to a question encouraging them to try again and try the route which will lead to the achieving their goal and through the rewards which the user receives once they achieve their goal, such as getting the correct answer. The rewards and wrong answer message also cover observability as this allows the user to understand whether or not their goal has been achieved. Recoverability is obtained through the "next" and "back" buttons which are implemented in the toolkit.

Flexibility

Flexibility refers to the number of methods the user has to complete a certain task. As discussed in Chapter 3, the part of flexibility which is considered is customisability. In the current low-fidelity prototype, this principle is met through the "Game" comprehension check method where the user can choose different characters, and therefore customise the game to their needs.

Learnability

Learnability refers to how easily a new user can learn to use the system. Learnability consists of predictability and consistency. Consistency is currently met in the low-fidelity prototype in that the buttons throughout the application follow the same design which allows the user to relate that specific shape with a button which will perform an action. The pages are also consistent throughout the prototype in terms of the colours used, the layout of the pages and how the information is delivered. Predictability is met in the prototype, as the buttons throughout the prototype provide enough information to the user indicating what their action will be. For example the "next" buttons clearly describe what their action is.

Visual Design

As discussed in the previous chapter, it is important to have an attractive visual design for children but must also be careful that they do not cause the user any frustration or anxiety. Therefore, the images chosen and the rewards are very simple, static images to prevent from becoming overwhelming. In further work there will be the option for selecting sound and also animations but will be able to be turned on and off.

Feedback and Guidance

Feedback and guidance helps the user achieve their goal, and therefore it is important that this is implemented. In the current prototype of the application, this is implemented through the "Try Again" messages when the user gets the answer wrong and
the rewards when they achieve their goal. The language used is simple and has followed the language style used in the CLICK-EAST project (Fletcher-Watson, 2013) where she discusses how wrong answers must not be given in a negative way and the ECHOES project (Farrow & Lemon, 2011). For example, rather than using "That was wrong", a positive message such as "Try Again" should be used.

**Motivation and engagement**

The rewards is a key factor in the motivation of the child to keep using the application (Ames, 1992; Humphry, 2011), and hence the reason as to why there are rewards given to the child after each correct question. The rewards are also simple to avoid overwhelming the child. It is also key to keep the child motivated even if they get the wrong answer and therefore when they do they are given a positive message of "Try Again" (Fletcher-Watson, 2013).

### 4.3 Low-Fidelity Evaluation

This section covers the evaluation of the low-fidelity prototype with four experts from the University of Edinburgh. This section begins by presenting the aims of the study and the method use, and then then moves on to the results of the study.

#### 4.3.1 Aim

The main aims of this study were to:

- evaluate the suitability of the activities in the toolkit
- evaluate the appropriateness of the activities for the target users
- identify potential usability problems in the design
- get suggestions on how to improve the design of the application

#### 4.3.2 Method

**4.3.2.1 Participants**

The participants were four experts in the fields of Human Computer Interaction (HCI) and ASD. Table 4.1 summarises the experts who participated in the evaluation. In the next sections I shall refer to them by E1, E2, E3 and E4. The participants used in the workshop were recruited via email. Thus an email was sent (including details about the study to the staff in the Informatics department) to ask if they would be interested in participating in the evaluation. Ethical approval had been obtained for all the studies following the guidelines of the ethics procedure of the School of Informatics 2017 (see Appendix A).
4.3. Low-Fidelity Evaluation

<table>
<thead>
<tr>
<th>Participant</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Human-Computer Interaction and Cognitive Science</td>
</tr>
<tr>
<td>E2</td>
<td>Human-Computer Interaction and ASD</td>
</tr>
<tr>
<td>E3</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>E4</td>
<td>Human-Computer Interaction</td>
</tr>
</tbody>
</table>

Table 4.1: Experts used in the low-fidelity prototype evaluation

4.3.2.2 Location

The evaluation was carried out in the University of Edinburgh Informatics Forum.

4.3.2.3 Materials

The materials needed for the expert evaluation of the low-fidelity prototype include:

1. Laptop with the Low-Fidelity prototype on Balsamiq
2. Printed out version of the Low-Fidelity Prototype
3. Post-it notes
4. Tablet for my notes
5. Two voice recording devices
6. Information sheet

4.3.2.4 Procedure

Before the evaluation took place, the researcher had a plan which they would use to make sure all the tasks required were completed. The researcher planned to use the "Think Aloud" method, where the expert would carry out a free exploration of the prototype and verbalise their thought process whilst the researcher took field notes and audio recordings. At points where they found things difficult or had some feedback, a small discussion would take place. Each expert evaluation was carried out separately so that there was just one expert evaluating each time, and the procedure used was repeated for each expert.

The overall evaluation took between 40-45 minutes depending on the length of the discussion taking place. To begin with, the experts were informed about the dissertation project, the second research sub-question which would be answered through this evaluation ("How can technology be designed to support Social Story\textsuperscript{TM} comprehension checking in children with ASD?"), and the requirements to which the low-fidelity prototype was designed with. The experts were asked whether or not they would be okay in using a recording device, providing spoken consent. Once the experts asked any questions they had, the low-fidelity prototype was presented in front of them on
A4 pieces of paper. Once this was setup, the expert began the think aloud process as they moved through the prototype. Once the expert had completed the exploration of the prototype, the researcher asked them a series of questions:

1. What did you like and dislike?
2. Are the activities in the application suitable for the target users?
3. Do the methods of checking comprehension fulfill their purpose?
4. Do you think the reward system is appropriate?
5. What changes would you suggest?

### 4.3.3 Data Analysis

Once the evaluation sessions were completed with the experts, the researcher transcribed the recordings and combined these with the field notes taken. Following on from this, the researcher used open coding as in the pre-design stage in Chapter 3 to extract the key information from the data. The researcher looked for a set of themes within the data including comments made on:

1. the expert’s likes and dislikes
2. the activities in the application
3. the appropriateness of the comprehension check methods
4. the rewards used
5. suggestion on changes

The information the researcher looked for was based on the questions presented at the end of the previous section, and any other information which involve the usability and suitability of the prototype.

The researcher worked through the transcribed data and whenever a relevant piece of information appeared in the text, this would be noted. This method of transcribing the data allowed for specific information the researcher was after to be extracted from the data. Table 4.2 shows an example of how the data was coded using open coding.

<table>
<thead>
<tr>
<th>Expert’s Statement</th>
<th>Open Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The back button needs to be bigger”</td>
<td>Usability - Button</td>
</tr>
<tr>
<td>“The rewards should be on the same page”</td>
<td>Rewards</td>
</tr>
<tr>
<td>“The questions are well structured”</td>
<td>Likes</td>
</tr>
</tbody>
</table>

Table 4.2: Open Coding of the transcribed workshop data

Once all the data collected had been transcribed and analysed, the researcher drew their results together. These are discussed in the next section.
4.3.4 Results

Based on the data analysis discussed in the previous section, the following results were noted.

Likes and Dislikes

All the experts had a positive outlook on the prototype and like the overall idea. The experts had the same comment in regards to the amount of text presented where the child reads the story and that this could be an issue. E1 remarked:

"It would be good if the text could be introduced slowly, for example a couple lines each time rather than a whole paragraph".

After some discussion new potential ideas of how to represent the story were discussed but would not be implemented due to the application being about checking the comprehension rather than presenting the Social Story™. The experts liked how the pages were structured and how the navigation through the pages is straightforward. Expert 2 remarked:

"I like the questions who have chosen in the questions and answers and the game, they seem to extract the important information".

E4 stated:

"It would be good if you introduced the story-line of the game a bit better as I found it a bit confusing”.

Suitability of activities for the target users

Commenting on the suitability of the activities, E2 stated:

"I think the activities would be simple for the target users because of the simple language that is used. The tasks are also quite easy to complete which will be beneficial”.

Expert 3 remarked:

"The language used in the activities and the way they are set out improve their overall suitability for the target users”.

All the experts commented on how it is very easy learning how to use and navigate through the various activities.

Appropriateness of the comprehension check methods

All the experts found that the comprehension check methods ("partial sentences", "questions and answers" and the "game") fulfilled their purpose of checking comprehension. They all commented on how the questions extract the main information from the story and seem to be asked in a very straightforward manner. Expert 4 commented on how the questions could potentially have a method of escalation, such that the first question is a very broad question, followed by more specific questions.
Rewards

Expert 3 said that they believe the reward system is appropriate in how they provide feedback to the child whether or not they have achieved their goal, but had some comments regarding how they are displayed. E3 remarked:

"You should make sure the comments remain on the same page rather than being navigated to another page as this will confuse the child."

The other experts made comments similar to this, in that it would be good to keep the rewards the child obtains on the pages at all times until the task is completed. E4 remarked

"It would be nice if the rewards could be gradual, for example collecting medals and then at the end receiving a trophy as this lets the child work towards something"

Suggestions

The experts came up with several suggestions which could improve the application. All the experts commented on how there was quite a lot of text on the story pages and how this could potentially become overwhelming. The experts suggested that it would be good to find a way to minimise the amount of text. The researcher noted this and would be a part of the further work since the main goal of the prototype was not to display the Social Story™, but to test the comprehension. The other suggestion the experts mentioned was how the rewards were given on separate pages and then vanished. The experts noted how this could become confusing for the child as it seems that their rewards are taken away. Therefore they suggested that the rewards should be kept on the pages when they are obtained. Expert 1 made a suggestion that there should be the option for the child to either have the opportunity to complete any of the three comprehension check methods, or have to complete one comprehension check before having access to the next. Expert 4 had also noticed that some of the pages were "Dead-ends" and suggested that these must either be taken away or implemented, and that there should be a distinct home page in the application. Expert 4 remarked

"It would be nice if you could add a progress bar, or something similar to the story pages as this would let the child know how many pages they have left to read."

A summary of the changes the experts suggested are shown in Table 4.3.

4.3.5 Discussion

The results discussed in the previous section have been beneficial in further informing the design. Based on the feedback from the experts, there have been several implications on the design. These include:

- ensure that the rewards are displayed on the same page as the task which results in the reward
- add an indicator on the story pages which shows the child how many pages of reading are left
4.4. Summary

<table>
<thead>
<tr>
<th>Suggestion</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep the rewards on the same page</td>
<td>All</td>
</tr>
<tr>
<td>Reduce the amount of text on the story pages</td>
<td>All</td>
</tr>
<tr>
<td>Add the option of the child having to complete one comprehension check before moving onto the next</td>
<td>Expert 1</td>
</tr>
<tr>
<td>Try and introduce the story of the game better</td>
<td>Expert 2</td>
</tr>
<tr>
<td>Add a page where the user is given a hint if they require one</td>
<td>Expert 3</td>
</tr>
<tr>
<td>Add a progress bar on the stories pages</td>
<td>Expert 3</td>
</tr>
<tr>
<td>Make sure there are no dead-end pages</td>
<td>Expert 4</td>
</tr>
<tr>
<td>Define a &quot;Home Page&quot;</td>
<td>Expert 4</td>
</tr>
</tbody>
</table>

Table 4.3: Suggestions made by the experts for changes on the application.

- ensure that there are no dead-end pages within the prototype
- improve the story-line of the “game” comprehension check method
- present the character chosen in the game more often
- ensure that feedback is given to the child on the actions they take during the game

These suggestions which have been collected through the evaluation study with the experts will be implemented in the high-fidelity prototype, discussed in the next chapter.

4.4 Summary

This chapter described the design and evaluation process of the low-fidelity prototype. The prototypes discussed in this chapter were based on the requirements and guidelines discussed in Chapter 3, HCI principles, the information collected in the design workshop with TD children and the background literature.

The evaluation carried out was with four experts in HCI and ASD which resulted in suggested changes to the application as well as encouragement on the methods chosen for checking comprehension. The feedback from the experts revealed that the methods have potential for checking comprehension and the design is suitable for the target users. There were some changes suggested which would help improve the design. These changes were made in the implementation of the high-fidelity prototype. The evaluation with the experts also answered part of the second research sub-question. This questions was "How can technology be designed to support Social Story™ comprehension checking in children with ASD?". Based on the prototype implemented and the evaluation with experts, the basis for the technology-based tool have been determined.

Having drawn the implications for the design based on the feedback from experts, the next step was to implement the high-fidelity prototype.
Chapter 5

High-Fidelity Prototype Implementation

This chapter describes how the low-fidelity prototype introduced in the previous chapter has been adapted and implemented, based on the results from the evaluations with experts in the previous chapter. This chapter begins with the implementation section which discusses the technical decisions taken. Section 5.2 is a walk-through of the prototype. Based on the results obtained in the expert evaluation, a high-fidelity prototype has been implemented in Android Studio. This chapter aims to answer the remaining part of the second research sub-question "How can technology be designed to support Social Story™ comprehension checking in children with ASD?".

5.1 Implementation

5.1.1 Development Process

The development process of the high-fidelity prototype followed a highly agile approach, where the researcher met with an expert each week and received feedback on new implementation. The feedback was then taken away and changes to the prototype and further implementations were carried out. This agile process was carried out up until the final version of the prototype was developed and was ready to be evaluated by typically developing children and experts.

5.1.2 Development Platform

The decision as to which development platform should be used to develop was taken by evaluating the various platforms available and weighing their pros and cons and deciding on which one the researcher felt the most comfortable using for development.
5.1.2.1 Android Studio

Android studio is the platform used to develop Android application and is the official integrated development environment (IDE) for Google’s Android operating system. The advantages of using Android Studio as a development platform is that it will be supported by a large range of Android devices. Android Studio uses Java and XML as the development languages for building application. Android Studio has an extensive range of online documentation and supports which supports new users who are looking to develop applications with Android Studio. The researcher has previously used Android Studio in previous projects, and therefore has a good understanding of the platform and also has numerous years of experience in using Java. The combination of the online documentation and help available, and the previous knowledge of Android Studio lead the researcher in deciding to use Android Studio as their chosen development platform.

5.1.2.2 iOS

iOS is the operating system used for Apple products, and the iOS Software Development Kit (SDK) is the platform provided by Apple for developing iOS applications. The iOS SDK is similar to Android Studio in that it has a vast range of online documentation and help, but the researcher has no prior knowledge of using iOS SDK and therefore did not choose to follow this development platform.

5.1.2.3 Unity

Unity is a cross-platform game development platform which is used to develop two and three dimensional video games and simulations and includes drag-and-drop functionality and scripting in C. An advantage of Unity is that it supports 27 different platforms, including iOS, Android Studio, Windows and others, which would be advantageous in that it would target more platforms making the application more accessible. The researcher considered using this platform, but decided on not using it for a variety of reasons. One of the reasons was that the researcher did not have previous knowledge surrounding Unity which would mean having to learn how to use a new system from scratch. This was not a preferred route to take, due to the limited time available to develop the application, the researcher preferred to spend time in developing the application than learning the new system. Another reason is that the researcher was aiming for a application which would be a combination of having a game but also more simple methods like the Questions and Answers and the Partial Sentences comprehension checks. Therefore it was not required to have a very complex game integration as this was only a proof of concept prototype to see if this method would work as a comprehension check. Taking these into account, the researcher decided that they would have more control and confidence developing the application in Android Studio.
5.1.3 Resource Requirements

5.1.3.1 Hardware

To run the application, an Android Tablet is required. The approximate memory space required is around 25MB and should have a Quad Core 1.2 GHz CPU or higher. The application was tested and run on a Huawei MediaPad T1 8.0 Pro, and therefore any tablet which has similar specifications or better should be substantial.

5.1.3.2 Software

The software required is an Android run tablet. The application was run and tested on an Android Tablet with a 4.4.4 version of Android, and therefore any tablets with the same or a newer version of Android would be sufficient. The application may work on older versions of Android but it has not been tested on such devices.

5.1.4 XML

XML is the language used to design the layout of the pages in the application being built in Android Studio. The XML contains all the buttons, text and images which may be present in the application.

5.1.5 Java

The application is built with a number of Java files which are used to provide the functionality within the application. A number of the Java files are present as placeholders for future work when the practitioner’s side of the application is implemented. The java files are linked to the XML files which control the layouts of the pages which change depending on the options the child chooses. Having different java files for the various layouts throughout the application have the advantage of being able to add a new layout between the current layouts very easily by managing how the pages are interlinked.

5.1.6 VCS

A private GitHub repository was used to control the various versions of the application as it was being implemented. Having a version control system added to the steady implementation of the application, as the researcher had the advantage of being able to work on the development of the application from various locations. Having a VCS also made sure that the application was backed up at all times and therefore if there were any malfunctions in the researcher’s hardware then the work carried out would not be lost.
5.2 User-Interface

The development of the user-interface followed on from the feedback which was given for the low-fidelity prototype by experts. The same structure as the low-fidelity prototype was followed. The general format is:

- The child chooses a story to read
- Once the child completes the story they choose one of three comprehension check methods.
- The comprehension check methods are related to the story the child has just read

5.2.1 Selecting a Story Page

The first page that the child see is the story page shown in Figure 5.1 (see next page). This page contains the stories which the practitioner has selected for the child to use. In a future fully developed application, there would be a practitioner’s side of the application where they would be able to edit the stories based on the child’s needs. The stories are all taken from Gray (2010). This page was designed in this way to provide the user with an idea of what they must do on this page. The buttons where chosen to be this shape and style as they fulfill the requirement of looking like buttons, making it obvious that they must click the button. The other two buttons are grayed out as there are currently no stories, as this is a prototype of the application. In future work there will be stories behind all three buttons, but there will be an option for the practitioner to choose whether they must complete one story before moving on to the next, or if they can pick whichever one they want. Three stories were chosen to be presented on the page, so that the child is not overwhelmed by the amount of stories they must read.

5.2.2 Story Pages

The pages which follow on when the child selects which story to read are shown in Figure 5.2 (see page 54). The Social Stories are taken from Carol Gray’s book and therefore ensures that the language is at a standard which children with autism would not have difficulty reading. It also ensures that the stories take the required format of Social Stories which was discussed in the literature review. Each page in Figure 5.2 is a paragraph from the Social Story™ about sharing, ensuring that each page talks about a similar aspect of sharing. The pictures chosen also relate to the story being read. For example, the story about sharing chocolate cake with eight slices, the cake in the picture has eight slices so that the story matches the picture. If the picture had 11 pieces rather than eight, then a child with autism could get frustrated at this as it does not match the story, as children with ASD take information literally.

The children can navigate through the story using the "Next" and "Back" buttons where the "Next” button has a slight time-delay which helps in not letting the child skip
5.2. User-Interface

Figure 5.1: Page in the application with the stories the child has to read.

through the pages without reading them. The same style of buttons are used as the previous section where the child selects the story they want to read. This helps with the learnability of the application as the user will associate that feature as a button throughout the use of the application.
Chapter 5. High-Fidelity Prototype Implementation

Figure 5.2: Story about Sharing which the user reads through

What is Sharing? 
I am learning about sharing. There are times when someone asks me to share. My mum may ask me to share. My dad may ask me to share. A classmate may ask me to share. Knowing what sharing is, and why people do it, may make it easier to share.

What is Sharing? 
Sometimes, a share is part of something. If someone has a great big chocolate cake, and there are eight people who want chocolate cake, each person gets their share. Their piece of the cake is their share. And if each size is the same size, it's fair too!

What is Sharing? 
People also share by taking turns. The people in my family share one computer. Each person uses the computer differently. Mum sometimes uses our computer to get recipes. My sister uses it for her homework. We can't all use it at the same time. So, each person has a turn using the computer.

What is Sharing? 
As children grow they learn to share. Many children discover that sharing is often a nice thing to do. Sharing helps make friends, too. My mum and dad were children once. As they grew, they learned how to share. They can answer my questions about sharing.

As I grow, I will try to learn more about sharing.
5.2.3 Reward for Story Completion

A key motivating factor is having rewards when the user completes a certain task. When the user finishes reading the story they are given the message and reward shown in Figure 5.3. This helps provide some motivation for the user to keep going and complete the next steps in the application.

![Reward for Story Completion Image](image)

Figure 5.3: Reward given to the child for completing the story

5.2.4 Comprehension Check Page

The next step from reading the Social Story™ is to check if the user has taken in the story and understood the concept. Therefore this requires methods of comprehension check. As discussed earlier the three methods are through partial sentences, questions and answers and a game. Once the user has read through the Social Story™ they are taken to the page shown in Figure 5.4. Here there is a selection of three comprehension check methods, where the user can select which method to carry out. As discussed earlier, in future work the practitioner will be able to decide if the user can select any of the three methods or if they must complete them in a certain order. The user also has the option to return to the page with the stories if they decide they want to read another story.

5.2.5 Questions and Answers Comprehension Check

If the student chooses the Questions and Answers comprehension check they are taken to the page shown in Figure 5.5. The user is given a “W+h” type question as based on the literature these types of questions are easily understood by children with ASD and also extract the necessary information. The answers are all buttons which are
Chapter 5. High-Fidelity Prototype Implementation

Figure 5.4: Page where the child chooses the method of comprehension check

Well done on finishing the story! Now let’s see what you have learned! Choose one of the options below!

- Questions and Answers
- Fill in the gaps
- Game

Figure 5.5: Questions and Answers comprehension check page

What was the story you just read about?

- The story was about playing in the playground
- The story was about how I should never share my things with anyone
- The story I read was about how giving some of my things to others is a nice thing to do
made obvious as to that they can be pressed. They follow a similar pattern as the other questions throughout the application which aids in the learnability of the application. If the user selects an answer which is incorrect, they are directed to the page shown in Figure 5.6.

![Figure 5.6: Questions and Answers try again message](image)

This page gives them feedback on their incorrect answer by asking them to ”Try Again”. In this way, the user is not confronted with a negative comment which may lead to frustration and disappointment. If the user chooses to ”Try Again” they are re-directed to the page with the question they got wrong, but this time the incorrect answer they chose earlier is gone as shown in Figure 5.7.

![Figure 5.7: Questions and Answers removed possible answer](image)

This is done to help enhance the learning of the child by erroneous learning. The one disadvantage of this is that the child may choose the correct questions by eliminating
the incorrect answer. To combat this, in a future version of the application, the practitioner will be able to see the number of attempts taken to get the correct answer by the child. When the child gets the correct answer they are taken to the page shown in Figure 5.8.

![Image of Figure 5.8: Questions and Answers correct answer chosen with a small reward]

This indicates that they have chosen the correct answer and also given a reward. The reward they receive, remains on the page for the next question so that they do not become worried that they’re reward has been taken away. Once the user completes the questions and answers they are taken to the page shown in Figure 5.9 which shows the three stars they have collected during the questions and also a larger star for completing this comprehension check method.

![Image of Figure 5.9: Questions and Answers completed successfully]
5.2.6 Partial Sentences

The partial sentences comprehension check has a similar structure to the questions and answers. The user is given a sentence which is related to the story they have just read, but with a missing key word from the sentence. Figure 5.10 shows an example of the partial sentence page. As with the questions and answers, if the user gets the answer wrong then they are taken to Figure 5.6 and asked to try again, and the wrong answer they chose is removed. The partial sentences also has the same reward system in which they receive a star for each question they get correct, and finally are taken to the page shown in Figure 5.9.

![Partial Sentences example](image)

**Figure 5.10: Partial Sentences comprehension check method**

5.2.7 Game Comprehension Check Method

The third and final comprehension check method is through a game structured method. The game sets a scene for the user at the beginning, which then sets the user off on a quest to find their friend which they choose at the beginning of the game. Through their quest they have to answer certain questions, and it is these questions which help them to collect rewards and move one step further to finding their friend. Figure 5.11 shows the first page of the game where the child selects a character out of the four available.

From that point on the story begins with the character they chose setting the scene as shown in Figure 5.12.

There are options to both help or answer questions but also to not help and not answer questions. If they child decides they do not want to help or answer the question they are taken to a page as shown in Figure 5.13. This page asks them if they are sure as the user may have clicked the button accidentally. This method of asking them if they are sure enhances the usability of the overall system. As seen in the figures the buttons are consistent throughout the application which helps ensure that the user associates those shapes with buttons.
Chapter 5. High-Fidelity Prototype Implementation

Figure 5.11: Characters which the user can choose to be friends with.

Select a character from below to be friends with.

Figure 5.12: Page after the user chooses the character they want. User being asked if they want to help.

Hello there! Are you ready for an adventure? I have been taken away to a secret castle in the forest. Do you want to help save me?

NO I DON'T WANT TO. YES I WANT TO HELP! 
5.2. User-Interface

Once the user decides that they want to help their character, they are taken on an adventure shown through a forest. To progress through the stages in the forest they must answer some questions which are based around the story they have read. They also have to help some animals which does not test comprehension but adds a fun activity in the game. Figure 5.14 shows screen shots from the game of how the user answers questions and also helps some animals in the forest. The same way of showing that the user has chosen the correct answer is used as in the Question and Answers and the Partial Sentences section. The user also receives a reward each time they answer a question correctly which remains on the page as in the other sections. The final stage of the game is when they reach the castle where their friend is being held.

Once the user reaches the castle, and passes the last obstacle successfully they are granted access to the castle where their friend is being kept. At this stage, the character at the beginning asks the user if they have any food to share, and if the user wants they can share the fruit rewards they collected. This part of the game is also another method of comprehension check as it see whether the story the child has read about sharing has been integrated. If the child has understood the concept of sharing, they should share some of the fruit they have collected in the forest. Once they share the fruit they have collected, the character gives them a positive message and the game finishes. This stage of the game is shown in Figure 5.15.

Throughout the application, the navigation through the pages, and the way that the user chose the answers were designed to satisfy the design requirements. The text style and font were kept consistent, and the buttons where the same colour and shape which helps users learn and understand that they are buttons.
Figure 5.14: Stages in the game where the user helps animals and answers questions based on the story they read.
5.3 Summary

This chapter described the overall procedure for carrying out the design and implementation of the high-fidelity prototype in an iterative method. A series of events were required to reach the high-fidelity prototype implementation, beginning from workshops with children to get ideas, then designing a low-fidelity prototype and evaluating it before finally implementing the high-fidelity prototype.

Currently the high-fidelity prototype is not at a level of being distributed to the public due to some of the features not being implemented. These features include being able to change the brightness of the display, change the display to gray-scale, have a speech-to-text feature and also the practitioner’s side of the application. The reasons these have not been implemented are due to time constraints. Further investigation into these features are discussed in the "Further Work" section in the discussion.

The high-fidelity prototype implemented will be evaluated in the next chapter, to determine whether or not it fulfills its objective of aiding in checking Social Story™ comprehension.

Figure 5.15: The final stages of the game where the user can share the fruit they have collected with their friend.
Chapter 6

High-fidelity Evaluation

This chapter presents the final evaluation of the high-fidelity prototype introduced in Chapter 5. The evaluation was conducted in two stages. The first stage involved 16 TD children and was focused on determining whether the application provides appropriate activities for children. The second stage was conducted with five experts in HCI and ASD and was aimed at determining whether the application fulfills its purpose of checking comprehension. Section 6.1 describes the evaluation with the TD children, followed by the evaluation with the experts in section 6.2. This chapter answers the third research sub-questions introduced in Chapter 1, RQ3: "To what extent does the new technology support children with ASD and practitioners in checking Social Story™ comprehension?”. This question was split into two sub-question. RQ3.1: "Does the app provide appropriate activities for children?” which is answered in Section 6.1 and RQ3.2: "Does the app fulfill its purpose of checking comprehension?” which is answered in Section 6.2.

6.1 Evaluation with TD Children

This section reports on the evaluation study completed with 16 TD children. This section begins by presenting the aims of the study, followed by the materials and procedure used. It then describes how the data was analysed, followed by a discussion of the results obtained. The TD children are used as proxies for children with ASD due to the difficulties of carrying out studies with children with ASD (Frauenberger et al., 2012). For instance, Hirano et al (2010) along with the teacher and other school staff consider that involving children with ASD in the design is too burdensome for these children.

6.1.1 Aim

The main aim of this study was to answer sub-question RQ3.1: "Does the app provide appropriate activities for children?”. For that reason, the study was focused to:
• determine the general experience with the application.
• determine the ease of use of the application.
• determine the learnability of the application.
• determine the likeability of the application.
• identify any usability problems of the application.
• collect recommendations from the children to improve the game.

6.1.2 Method

6.1.2.1 Participants

For this evaluation study, 16 TD children were used. Table 6.1 shows the participants details. The participants in the workshop were recruited via email. Thus an email was sent (including details about the study to the staff in the Informatics department, and to the Brownies\(^1\) in Stockbridge) to ask if their children would be interested in participating in the evaluation workshop. The email contained the information sheet (see Appendix H) and consent forms (see Appendix F) for the parent. Ethical approval had been obtained for all the studies following the guidelines of the ethics procedure of the School of Informatics 2017 (see Appendix A).

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>6</td>
<td>Female</td>
</tr>
<tr>
<td>P2</td>
<td>7</td>
<td>Female</td>
</tr>
<tr>
<td>P3</td>
<td>7</td>
<td>Female</td>
</tr>
<tr>
<td>P4</td>
<td>8</td>
<td>Female</td>
</tr>
<tr>
<td>P5</td>
<td>8</td>
<td>Female</td>
</tr>
<tr>
<td>P6</td>
<td>8</td>
<td>Male</td>
</tr>
<tr>
<td>P7</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P8</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P9</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P10</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P11</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P12</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P13</td>
<td>9</td>
<td>Female</td>
</tr>
<tr>
<td>P14</td>
<td>10</td>
<td>Male</td>
</tr>
<tr>
<td>P15</td>
<td>12</td>
<td>Male</td>
</tr>
<tr>
<td>P16</td>
<td>12</td>
<td>Female</td>
</tr>
</tbody>
</table>

Table 6.1: Participants in evaluation of the High-Fidelity Prototype

\(^1\)Brownies are the section in the Girl Guides organization for girls aged seven years old to ten years old.
6.1. Evaluation with TD Children

6.1.2.2 Location

The evaluations took place in two separate locations. The first took place with the Brownies in Stockbridge at the Brownie’s weekly meeting, and the second evaluation took place in the University of Edinburgh Informatics Forum.

6.1.2.3 Materials

The materials needed for the expert evaluation of the low-fidelity prototype included:

1. Huawei MediaPad T3 8 with the latest application version installed.
2. Workshop plan
3. Pen and pad for note-taking
4. Mobile phone for recording
5. Information sheets
6. Consent forms
7. Certificates

The tablet was used to present the application prototype to the children and allowed for interaction with the application. The tablet was also used to record audio at the same time as the children used the application. The mobile phone was used as a back up for the audio recording in case the tablet did not capture everything that had been said. The workshop plan was used by the researcher to keep track of the activities they wanted to complete, and also to make sure that all the necessary questions had been asked for evaluating the application. The researcher also used the pen and pad to take down field notes. The information sheet and consent form for children can be found in Appendix G, the information sheet for the parents is in Appendix H and the parent consent form is in Appendix F.

6.1.2.4 Procedure

The children arrived with their parents with both the parent and child signed consent forms. Once all the information sheets and consent forms had been collected the evaluation session could commence. The researcher began the evaluation study by first introducing themselves and then provided the children with a brief introduction of the plan and aim of the workshop. The researcher asked the children if they had any questions before beginning the workshop. The researcher opened up the application on the tablet to the first page and gave this to the participants with no previous training. The children were given the tasks of reading the story and then moving onto complete the three comprehension check methods available. The researcher let the children use the application and took field notes and voice recordings as they worked through the application. The field notes were on any usability issues the children were having, and any comments the children made as they used the application.
• What did you like the most about the application?
• What did you like the least about the application?
• What would you change about the application?
• Did you find the application easy or hard to use?
• Did you find the story hard or easy to read?
• Which was your favourite comprehension check method?
• Did you enjoy the rewards?
• What would you change about the rewards?
• What did you think about the characters in the Game?
• Would have liked to be able to customise the characters?
• Would it be nice to have an audio option for having the story read out to you?
• What did you think of the questions asked in the Questions and Answers and Partial Sentences?
• What did you think about the storyline of the game?
• What would you add to the game?
• Was the font throughout the application easy to read and understand?

Figure 6.1: Questions asked by the researcher once the children finished using the application

Once the children had completed the tasks, they were asked a series of questions which are listed in figure 6.1. The researcher use these questions to try and extract as much information as possible from the children about their experience with the application. Once all the information required had been collected, the children were thanked for participating and a certificate (see Appendix I) with their name was presented to them in a small ceremony with all the children involved.

6.1.3 Data Analysis

Once the workshops had finished, the researcher transcribed the recordings collected from the workshop and combined them with the field notes taken during the workshop. The transcription of the recordings combined with the field notes taken resulted in a large amount of text. Therefore, to be able to collect data from it a method of qualitative data analysis was needed. The researcher chose a method similar to open coding (Saldana, 2013), a method in which concepts are attached to the data which is being analysed. The reason for this were because the researcher was looking for specific information from the data, such as likes and dislikes, opinions on the rewards, comprehension check methods and story-lines.

This method of transcribing the data allowed for specific information the researcher was after to be extracted from the data. Figure 6.2 shows an example of some of results from this method.

Once all the data collected had been transcribed and analysed, the researcher drew their results together. These are discussed in the next section.
6.1 Evaluation with TD Children

6.1.4 Results

This section discusses the results obtained based on the data analysis discussed in the previous section.

Whilst analysing the results the researcher recognised a pattern in the answers of the children to the list of questions in Figure 6.1. Therefore the decision was made to summarise the results obtained for each question. The results will be discussed below based on the research questions employed in this study.

What did you like the most about the application?

All sixteen participants said that they enjoyed using the application and found it very easy and fun to use. P16 stated:

"I really liked how I had to first read the story before moving onto the comprehension check methods as it helps me understand what I need to do”.

Six of the participants said that they liked the pictures on the pages which had the stories as they were associated with the stories they were reading. P5 states:

"I like the picture with the children on the sofa as that’s what we do at home with my brothers and sisters”.

Eleven participants said they liked how they could pick a different character and all sixteen said they enjoyed the story-line of the game where they were collecting fruit for their friend and also helping others on the way. P14 stated:

"I really like the comprehension check methods as they are really easy to understand. My favourite was the game as I really like elephants”.

All the participants also liked how when you got a wrong answer it just asks you to "Try Again” in a positive way which keeps you motivated to play, rather than losing the work you have done or being told in a "mean" way that you are wrong. Participant 15 stated:

"I really like how the pages are quite plain and do not have an overwhelming amount
of information on them. It really helps me concentrate on the answers and get the correct answers”.

Five out of the 16 participants were very enthusiastic about the application and enquired if they could download it. Specifically participant 3 stated:

"Is this app on the app store as I would want to download it and play it at home”.

Table 6.2 shows the features which were mentioned by the children as something they like, and the number of children that liked it.

<table>
<thead>
<tr>
<th>Feature Liked</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall application</td>
<td>16</td>
</tr>
<tr>
<td>Structure of Reading Story followed by the Comprehension Checks</td>
<td>1</td>
</tr>
<tr>
<td>Pictures on the story pages</td>
<td>6</td>
</tr>
<tr>
<td>Ability to pick different characters</td>
<td>11</td>
</tr>
<tr>
<td>Story-line of the game</td>
<td>16</td>
</tr>
<tr>
<td>Comprehension check methods</td>
<td>16</td>
</tr>
<tr>
<td>Feedback messages on wrong answers</td>
<td>16</td>
</tr>
<tr>
<td>Rewards</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 6.2: The features of the application which the participants liked

What did you like the least about the application?

Fifteen of the participants noted that there was nothing in particular that they did not like. Participant 12 stated:

"I didn’t like how there was only just one story as I wanted to use the application more, so I would like it if there was more stories”.

However adding multiple stories was not a goal in this prototype, but rather to prove that the tool has potential in supporting children and practitioners in checking Social Story comprehension. However the research considered that as future work.

What would you change about the application?

Thirteen participants could not think of anything they would change about the application. Participants one, two and fourteen noted that they would change the page where you select characters to be able to create your own customised character. Participant 12 stated:

"I would have liked it if I could add my own character or edit a character. It would be funny to put my friend’s face on the owl”.

Participant fourteen also noted that they would change the rewards to medals than stars. These suggestions were included in the future work.

Did you find the application easy or hard to use?

All sixteen participants stated that the application was very easy to use and that they did not get confused at any point on how they have to use certain buttons or what they have to do next. Participant four stated:
"The questions were really easy to answer, and it was really easy to move around in it".

Did you find the story hard or easy to read?
All sixteen participants found reading the story at the beginning of the application easy to read and did not have any difficulty with understanding what was being said.

Which was your favourite comprehension check method?
Fifteen participants said that their favourite comprehension check method was game as they enjoyed helping the animals along the way and collecting fruit to share with the character they chose at the beginning. Participant 13 stated:

"My favourite method was the Questions and Answers and Partial Sentences as they it was really fun answering the questions and collecting the stars as rewards".

Did you enjoy the rewards?
All the participants liked the rewards and they all said that it gave them some motivation for completing more tasks, questions or partial sentences to collect more rewards. The participants particularly liked the rewards (fruit) collected in the forest, as participant five stated:

"I really liked how the fruit I collected in the game were then used to feed my character at the end".

What would you change about the rewards?
All the participants said that they would not change anything in the rewards as they liked the stars as rewards. Participant 16 stated:

"I would like it if there was a big reward when all the comprehension check methods were completed".

Participant 13 and 14 said that it would be nice if each time they completed the game with a different character, that they could get a list of the friends they have made.

What did you think about the characters in the Game?
All the participants liked the characters in the game and particularly liked that they could choose the character they wanted to help at the beginning. They all liked that there were different animals in the forest and that they were helping these animals.

Would you have liked to be able to build your own characters?
All the participants said that they would have liked it if they could make their own character or choose to customise some of the characters. Participant 16 stated:

It would be really cool if each time you complete a comprehension check method, you unlock another modification you can make to your character".

These comments were taken into consideration in the future work.
Would you prefer to have an audio option for having the story read out to you?

All the participants said that it would be good to have an audio option for the story being read out to them in parallel with the text being on the screen. Five of the participants also added that they would like to be able to turn it off if this feature was implemented. Participant 8 stated:

"I think this would be quite nice, especially for younger children, but I think the text should still stay on the page".

What did you think of the questions asked in the Questions and Answers and Partial Sentences?

All the participants found the questions easy to follow and understand. All participants managed to answer the questions without any help.

What did you think about the story-line of the game?

All the participants liked the story-line of the game. All the participants liked the idea of answering some questions to help others in the forest to eventually reach their character friend at the castle. Participant 10 stated:

"I liked how I had to collect the fruit and help all the animals as its a nice thing to do. It was really nice sharing the fruit at the end of the game as well”.

What would you add to the application?

Of all the participants only three came up with some suggestions for additions to the application. Participant 14 said that it would be nice, if in the game, once they had found their character friend in the castle, to be able to go on more adventures after that point with their friend. Participants 13 and 9 also added a suggestion for the game that it would be a nice addition if they could follow a route where they choose all the "bad" options and see what the outcome would be for taking this route where you do not want to help. Specifically, participant 13 states:

"It would be cool to see what happens if I refused to answer the questions and help the animals. What would happen to the character?".

Was the font throughout the application easy to read and understand?

All the participants said that they did not have any trouble in reading the font and could understand all the text very easily.

6.1.5 Discussion on the evaluation with children

This section aimed at answering the first part of the last research question which was RQ3.1: "Does the app provide appropriate activities for children?". This would be determined by a number of different factors, including the general experience, the ease of use, its learnability, its likeability, its robustness, its flexibility and its consistency.
6.1. Evaluation with TD Children

General Experience
All the participants had a positive general experience when using the application and were enthusiastic during the exploration of the application. None of the participants had any issues with navigating through the application, or understanding what the steps to accomplish their goals were. The participants were kept engaged throughout the use of the application and did not show any signs of boredom or being uninterested. Out of the sixteen participants, five participants made the inquiry on whether the application was available for download on the app stores, and that if it was they would want to download it.

Ease of Use
The application was given to all the children with no prior training or explanation, and all the participants managed to use the application successfully. This is good evidence on how the application’s simplicity makes it easy for the children to use without much explanation or training. When asked about if they found the application hard or easy to use all the participants said it was very easy to use, and that none of them were confused at any point. They commented that all the buttons were clear for they action they were built to do, and they also understood what they have to do.

Learnability
The learnability of the application was determined on how easily the children managed to learn how to use the application and whether or not they had any points of confusion whilst using it. Based on the results and the observations made when the children used the application, it was determined that it had a high learnability as all the children managed to learn how to use the application quickly and did not have to ask how to complete a task. Considering the children had no prior training to use the application it shows that the application is highly learnable.

Likeability
The likeability of the application was based on the observations made and also the comments received from the children. All the children when asked whether or not they liked the application were very positive and enthusiastic about it. Five participants were eager to find out whether it would be available for them to download and use which displays that they liked the application significantly. Overall based on the observations (such as smiling during the game, and cheering when getting the correct answers and receiving a reward) and comments made by the children the application was determined to be very likeable by its target audience.

Robustness
During the evaluations there were no cases where the participants ended up on a page they did not want to, or selecting a button they did not want to. This was judged by participants using the "Back" buttons which were not used throughout the study. This is mainly due to the limited number of buttons on each page and also the instructions given on each page which indicate clearly what must be done.
Flexibility

The main way in which the participants could interact differently with the application is through selecting different characters at the beginning of the game. Some of the participants tried to take a different route or as they stated, the "mean" route by choosing not to help the characters but this just lead them to a page where they were asked to try again.

Consistency

All the participants seemed to understand how the navigation of the pages was done, and how they must answer the questions in each of the different sections. This was due to the consistent way in which the questions, navigation buttons and answer buttons were set up throughout the application. The way the information such as the story and the questions were conveyed remained the same in each section so that the participants linked a certain type of text and background as a question or text they must read.

The results revealed that the application was very positively received by the children, and provides appropriate activities for the children. There have been some suggestions by the children which could enhance the children’s experience and these will be discussed in further work.

6.2 Evaluation with Experts

This section describes the evaluation session which was conducted with experts in the field of Human-Computer Interaction, ASD and Language, Cognition and Computation. It begins by setting out the aims of the study, then follows onto the method used and finally discusses the results obtained.

6.2.1 Aims

The primary aim of the evaluation with experts was to answer the sub-question RQ 3.2: "Does the app fulfill its purpose of checking comprehension?" for that this study aimed to:

- Determine the appropriateness of the comprehension check methods.
- Check the appropriateness of the game to check SS comprehension
- To evaluate the overall ability of the application for checking Social Story™ comprehension.
- Evaluate whether the application is easy to use
- Evaluate if the application is easy to learn
- Identify any needs for change in the application, such as improvements or other suggestions.
• Identify any usability problems

6.2.2 Method

6.2.2.1 Participants

The participants were chosen based on their fields of expertise. There were five participants in total, with two experts being the same as the ones in the low-fidelity evaluation. The experts which were used again are E3 and E4. The remaining three experts are new experts and are referred to as E5, E6 and E7. The reason for this is to avoid confusion with E1 and E2 in the previous evaluation. Table 6.3 summarises the experts used in the evaluation. In the next sections they shall be referred as E1, E2, E3, E4 and E5. An email was sent to experts in the field of Human-Computer Interaction, Language, Cognition and Computation and ASD in the department of Informatics and School of Health in Social Science. The email included the aim of the study and what the evaluation session would consist of. Ethical approval had been obtained for all the studies following the guidelines of the ethics procedure of the School of Informatics 2017 (see Appendix A).

<table>
<thead>
<tr>
<th>Participant</th>
<th>Role</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>E3</td>
<td>PHD student</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>E4</td>
<td>Researcher</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>E5</td>
<td>Researcher</td>
<td>Language, Cognition and Computation</td>
</tr>
<tr>
<td>E6</td>
<td>Researcher</td>
<td>Language, Cognition and Computation</td>
</tr>
<tr>
<td>E7</td>
<td>PHD student</td>
<td>Clinical Psychology</td>
</tr>
</tbody>
</table>

Table 6.3: Experts used in the application evaluation

6.2.2.2 Location

The studies took place in the School of Informatics forum at the University of Edinburgh.

6.2.2.3 Materials

The materials used for the evaluation of the application with the experts include:

1. Huawei MediaPad T3 8
2. Evaluation plan with questions to ask practitioners
3. Pen and pad for note-taking
4. Mobile phone for recording
Chapter 6. High-fidelity Evaluation

The tablet was used to present the application prototype to the children and allowed for interaction with the application. The tablet was also used to record audio at the same time as the experts used the application. The mobile phone was used as a back up for the audio recording in case the tablet did not capture everything that had been said. The evaluation plan was used by the researcher to keep track of the activities they wanted to complete, and also to make sure that all the necessary questions had been asked for evaluating the application. The pen and pad was used to take field notes.

6.2.2.4 Procedure

At the beginning of the session, the researcher introduced themselves and their study. The researcher then informed the expert about the data which will be collected through field notes and voice recordings. Once verbal consent was given, the evaluation session began. Each expert worked independently and each session took approximately 40-45 minutes. The session began with the researcher setting up the application on the tablet and gave it to the participant, with no prior training. The researcher asked the participant to carry out a think aloud process, discussing any features they enjoy and any usability issues they detect. As the participant used the application, the researcher took field notes. The session was also audio recorded. The participants spent between 10-15 minutes using the application. Once the participant was finished using the application, the researcher began to ask the participant a series of questions (see Appendix L), which aimed to cover a series of topics shown in in Figure 6.3. The questions were written as a guideline so that the researcher could ensure that all the topics were covered. Time was allowed to go into some topics in more depth as this was required to retrieve as much information as possible.

1. Likes and dislikes of the application
2. Appropriateness for its target users (children with ASD between the ages of 7-11)?
3. Learnability and easiness of use of the application
4. Effectiveness of application in testing Social Story™ comprehension in children with ASD?
5. Suggestions for improvement
6. Are there any usability issues in the application.

Figure 6.3: Topics covered in the evaluation of the application with experts

6.2.3 Data Analysis

Once the evaluation sessions were completed with the experts, the researcher transcribed the recordings and combined these with the field notes taken.

The transcription of the recordings combined with the field notes taken resulted in a large amount of text. Therefore, to be able to collect data from it a method of qualitative data analysis was needed. The researcher chose a method similar to open coding.
6.2. Evaluation with Experts

(Saldana, 2013), a method in which concepts are attached to the data which is being analysed. The reason for this were because the researcher was looking for specific information from the data, based on the topics at the end of the previous section, such as positives of the toolkit, any usability problems and comments on the comprehension check methods.

The researcher worked through the transcribed data when a relevant piece of information appeared in the text, this would be noted. This method of transcribing the data allowed for specific information the researcher was after to be extracted from the data. Table 6.4 shows an example of how the data was transcribed using open coding.

<table>
<thead>
<tr>
<th>Expert’s Statement</th>
<th>Open Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;The questions manage to extract the important information&quot;</td>
<td>Comprehension check - positive</td>
</tr>
<tr>
<td>&quot;It is good that the rewards remain on the page and do not vanish&quot;</td>
<td>Rewards</td>
</tr>
<tr>
<td>&quot;The navigation of the pages is very clear and easy&quot;</td>
<td>Usability - Positive</td>
</tr>
</tbody>
</table>

Table 6.4: Open Coding of the transcribed data from the evaluation with experts.

Once all the data collected had been transcribed and analysed, the researcher drew their results together. These are discussed in the next section.

6.2.4 Results

Based on the analysed data, the researcher recognised a pattern in some of the answers of the experts to the topics discussed in Figure 6.3. Therefore the decision was made to summarise the results obtained for each topic. The results will be discussed below based on the research questions employed in this study.

Likes and dislikes of the application

All of the experts liked the overall application, finding it easy to use and learn. The experts also made comments on how the language used in the application is simple and clear to understand. E5 commented:

"I have young children, they are typically developing but I believe they would be able to use this application very easily"

All the experts made comments of how they liked the comprehension checks, and especially the game. E7 commented:

"I really like the ending of the game comprehension method, as it performs the action described in the story, and through this tests whether the child has understood the concept. Overall I really like the application, and it is well built and has great potential."
All the experts, apart from one said that there was nothing specific they did not like in the application. E4, made a comment on the amount of text presented in the story section, stating:

"I do not like the way the story is presented at the start as there seems to be too much text on one page, which may be daunting for younger children"

**Appropriateness for its target users**

All the experts commented that the application was appropriate for the target users based on the language used and the simplicity of the application. E7 made a comment which could improve the appropriateness of the application. They stated:

"Children with ASD sometimes need prompts such as flashing lights on buttons or some sounds, so it would be useful to add such prompts to the application"

E7 also made a comment stating:

"Apart from the prompts, there are no reasons as to why the application would not be appropriate for the target users, especially for children with high-functioning autism. The language used is simple enough and the questions asked throughout are structured well."

E4 also commented on the simplicity of the toolkit, making it appropriate for its target users, stating:

"Using this application, there is nothing which would cause any issues to the target user, as there are no distracting features and the overall language used is simple enough"

**Learnability and easiness of use of the application**

All the experts had similar views on the learnability of the application, in that it was easy for a new user to learn how to use the system and achieve their goals. This was mainly based on the simplicity of the application and how a similar layout was used throughout. Specifically, E3 stated:

"Due to the application’s simplicity, it is easy to discover what is needed to perform the tasks to complete the story and comprehension checks."

E6 made a similar comment, stating:

"The way in which all the pages follow the same format, and the buttons used throughout are the same makes the application simpler which helps a new user learn how to use it quickly"

**Effectiveness of application in testing Social StoryTM comprehension in children with ASD?**

The comments made by the experts for the comprehension check methods used in the application were very positive and all the experts believed the application fulfilled its purpose for testing comprehension. E3 stated:
6.2. Evaluation with Experts

"The questions and answers, and partial sentences really extract the important information from the social story and I believe it would be a good way for testing Social Story™ comprehension."

E7 made a similar comment on the comprehension check methods:

"The comprehension check methods extract the important information from the social stories and successfully check the child’s comprehension."

E4 stated:

"I really like how the questions asked in the application go from a general concept to more specific situations in regards to the story read [...] I also like how the game comprehension check method ends with the user sharing their fruit with the character they chose, as this tests the concept of the social story I read which was about sharing."

Suggestions for improvement

The suggestions for improvement from the experts were minimal, and mainly based around how the story was presented at the beginning of the application. E3 commented:

"I think there is a lot of text on the pages where the story is presented. It would be good if this text was separated out slightly. Apart from that I don’t have any other suggestions."

E7 made a comment on how adding prompts to the toolkit could improve it. They stated:

"It is important to grab a child with ASD’s attention, and using prompts such as a noise or a flashing button are usually good methods to do this. It would therefore be worth adding prompts to the application, but other than that there is no other improvements I can comment on."

E4 commented on the game comprehension method stating:

"It would be nice if the game could become slightly less static, for example there could be more animations or noises added to it."

E6 also made a contribution for an improvement stating:

"It would be a nice feature on the pages which have rewards, for example the star rewards, to add "greyed" out stars which indicate that you can collect X amount of stars during the comprehension check methods."

Usability issues detected

None of the experts came up with any serious usability issues whilst evaluating the application. All the experts found that the learnability, ease of use and robustness of the application were good. There were only some comments made based around some buttons used and additional features for future work.

E4 commented:
"For a child with ASD who may have limited reading skills it would be valuable to have a text-to-speech feature so that the child can listen to the stories and comprehension checks, and maybe have an alternative method of inputting an answer."

E3 commented on some of the positioning of the buttons and how they could be moved to avoid confusion. They stated:

"On one of the "Try Again" pages you have the positive action button on the left hand side and the negative action button on the right hand side. You should change these over, as positive actions are usually on the right hand side rather than the left, and this could cause confusion."

6.2.5 Discussion

This section contained the methods in which different components of the application were evaluated with experts in HCI and ASD, to determine what parts of it are good and which areas require improvements.

One of the key questions sought to be answered was based on the comprehension check methods in the application, and whether these fulfill their purpose of checking Social StoryTM comprehension.

All the experts who evaluated the application noted that the questions used in all three methods were very good in extracting the important information. The language used in the questions was also simple and easy to follow which helped in making it easier for the children to answer them. The rewards enhanced these comprehension check methods as they helped in increasing the children’s motivation when they would get the correct answer.

One of the areas in which the experts were asked to comment on was the suitability of the application for the target users, which are children with ASD between the ages of 7-11. All the experts commented that they believe it would be suitable as it was very simple to use and not too complicated, which would allow for the children to use this application independently.

In regards to whether the application actually tests the comprehension of Social Stories, all the experts stated that they believe the application does test the comprehension of the Social StoriesTM as the questions extract the important information and are clear for the children to understand. E4 who was currently involved in research with children with ASD believed that the application was very effective in its purpose and was set out in such a way which would be usable by children with ASD. They agreed that it would be useful for practitioners to have at hand to teach children with ASD about social concepts and test if they have understood the concept.

There were no major usability problems, though some minor problems were identified. A number of suggestions for improving the app were collected and they inspired the future work directions. They were grouped around: the location of buttons, the addition
of sound and prompts and the amount of text on the story pages. A summary of these are shown in Figure 6.4

<table>
<thead>
<tr>
<th>Problem</th>
<th>How Many People Spotted It</th>
<th>Solution</th>
<th>Decisions and Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too much text on story pages</td>
<td>5</td>
<td>Reduce the text through animations or by spreading the text over more pages</td>
<td>This is a low priority issue as the main focus is not the story but checking the Social Story™ comprehension</td>
</tr>
<tr>
<td>Location of some buttons</td>
<td>2</td>
<td>Move the location of some buttons</td>
<td>This is a low priority issue which will be changed on the current prototype</td>
</tr>
<tr>
<td>Adding prompts on the buttons</td>
<td>1</td>
<td>Add prompts such as flashing lights or noises on the buttons to get the children's attention</td>
<td>This is a high priority issue which will not be changed on the current prototype due to time constraints, but will be a high priority in future work.</td>
</tr>
<tr>
<td>Adding some background music to the game</td>
<td>1</td>
<td>Add background music to the game to make it more engaging</td>
<td>This is a medium priority issue which will not be changed due to time constraints but will be changed in further work.</td>
</tr>
</tbody>
</table>

Figure 6.4: Usability problems which have been found through the expert evaluations

Based on these results, the research sub-question RQ3.2 "Does the app fulfill its purpose of checking comprehension?" can be answered. The application does fulfill its purpose of checking comprehension, and has shown the potential to be expanded further.

### 6.3 Discussion

This chapter set out to answer the third research sub-questions introduced in Chapter 1, "To what extent does the new technology support children with ASD and practitioners..."
in checking Social Story™ comprehension?”. This question was split into two sub-
question. RQ3.1: "Does the app provide appropriate activities for children?” and
RQ3.2: "Does the app fulfill its purpose of checking comprehension?”.

RQ3.1 was answered in the evaluation with TD children, and RQ3.2 was answered
in the evaluation with experts in HCI and ASD. The results in the evaluation with
TD children showed that the application provided appropriate activities for children,
as the children showed enthusiasm and enjoyment when using the application. They
also asked about having the opportunity to download this for their personal use, which
shows that it was successful with the children. None of the children displayed any
difficulties when using the application which also showed how it was easy to use. The
results in the evaluation with experts provided the necessary information to claim that
the application fulfills its purpose of checking comprehension. All the experts were
very positive in regards to the application and were enthusiastic with the potential it
displayed.

With both RQ3.1 and RQ3.2 answered successfully, the third research sub-question
"To what extent does the new technology support children with ASD and practitioners
in checking Social Story™ comprehension?” can be answered. Based on the results
in the evaluation with TD children and the experts it can be claimed that the appli-
cation can support children with ASD and practitioners in checking Social Story™
comprehension.

6.4 Summary

This chapter presented two evaluation studies of the high-fidelity prototype involving
16TD children and seven experts in HCI and ASD. This chapter focused on answering
RQ3: "To what extent does the new technology support children with ASD and prac-
titioners in checking Social Story™ comprehension?”. This question was broken into
two sub-questions. The first question RQ3.1: "Does the app provide appropriate ac-
tivities for children?” was answered based on the study with the children. The second
question RQ3.2 "Does the app fulfill its purpose of checking comprehension?” was
answered in the study with the experts. Additionally, the studies aimed at identifying
potential usability problems and suggestions to improve the toolkit. The analysis of
the data from the studies revealed that the application has potential in checking Social
Story™ comprehension. The studies with the children revealed that the activities pro-
vided are appropriate for children, as they were easy to use and learn. The studies with
the experts revealed that the application fulfills its purpose of checking comprehen-
sion. The results from both studies support that the application can support children
with ASD and practitioners in checking Social Story™ comprehension.
Chapter 7

Conclusions and Future Work

This thesis was focused on the following general question: *How can practitioners and children with ASD be best supported by technology in checking Social Story™ comprehension?* Three research sub-questions were devised to answer this general question. The first section in this chapter focuses on answering the these sub-questions based on the literature and the results in the studies presented before. The second section presents the future work directions. Finally, section 3 highlights the conclusions of this work.

7.1 Dissertation Questions

**Q1. What methods of checking Social Story™ comprehension in children with ASD are currently used/recommended?**

This question was answered by the background literature discussed in Chapter 2. The background reading revealed what kind of comprehension check methods are currently being used with children with ASD. Thus, Gray (2010) suggested that partial sentence stories are appropriate for comprehension checking. Another method identified from the research literature is through questions and answers (Aking & MacKinney, 2004; Crozier & Sileo, 2005). This method is sometimes used by practitioners (Constantin, 2015). The "5W+H" (where, when, what, why and how) approach has been considered appropriate as it is in line with one of Gray’s (2010) criteria for writing Social Stories™.

There has also been research into using computer-based educational games for teaching children with disabilities skills such as reading skills (Charlton et al., 2005) but also in the field of education in general. Some games included tools for comprehension checking (Habgood and Ainsworth, 2011).

Therefore three methods of checking comprehension were identified and considered suitable for being used during the Social Story™ interventions: "Partial Sentences", "5W+H" questions, and a game-based comprehension check method.
Chapter 7. Conclusions and Future Work

Q2. How can technology be designed to support Social Story™ comprehension checking in children with ASD?

This research question was addressed through developing a prototype using an iterative process (see Chapters 4 and 5). This prototype was informed by the literature and studies with children and experts in HCI and ASD. The approach used to design and implement the prototype was inspired by the Informant Design approach (Scaife Rogers, 2013) and involved experts in HCI and ASD.

An initial workshop with TD children was conducted and an initial list of requirements were derived based on the input from children but also on the research literature.

A low-fidelity prototype was developed based on the requirements developed. The low-fidelity prototype was then explored with 4 experts in the field of HCI and ASD, followed by a refinement of the design requirements (as described in Chapter 4).

A high-fidelity prototype was developed based on the refinements made. A summative evaluation was carried out in two stages. This evaluation involved 5 experts in HCI and ASD, and 16 TD children.

The high-fidelity prototype demonstrates that technology can be developed to support Social Story™ comprehension checking. This prototype followed the HCI principles as well as specific design principles for children with ASD.

The evaluation of the high-fidelity prototype with children and experts in HCI and ASD showed positive results as is discussed next.

Q3. To what extent does the new technology support children with ASD and practitioners in checking Social Story™ comprehension?

In order to answer this question, it was divided into two sub-questions. These are answered below.

Q3.1 Does the app provide appropriate activities for children?

The study with 16 TD children in chapter 6 showed that the children could easily use the application and complete all the comprehension check methods successfully. The language, story lines and activities were all appropriate for the children as all the children found them easy to follow and also fun to complete. Overall the children found it fun and some of them said that they would like to own the application. When the children were using the application they showed signs of excitement and concentration which showed how they enjoyed using it and were engaged in the application. The children also enjoyed all three methods of comprehension check and enjoyed the rewards they received with each correct answer. However the conclusions drawn from the study with children cannot be extrapolated to the target users as the children in the studies did not have ASD. Despite this limitation, the results from the study are very positive and promising for the purpose the application has been developed.

An evaluation with 5 experts in the field of HCI and ASD was conducted to help answer this question, and is described in chapter 6. The evaluation study aimed at determining the appropriateness of the comprehension check methods chosen, identify any usability problems and whether it is appropriate for its target users (children with ASD between
the ages of 7-11). The evaluation session showed that the toolkit provided appropriate activities for the target users and did not display any major usability issues. All the experts found the comprehension check methods effective as they extracted the relevant information from the story, and the language used throughout was simple enough for the children to understand. The experts also found the rewards used in the application good for the children’s motivation. Through these evaluation sessions, there were a few suggestions for improvement which will be detailed in the future work section.

Based on both of these evaluation sessions, the application provides appropriate activities for children.

Q3.2 Does the app fulfill its purpose of checking comprehension?

The study with experts in Chapter 6, concluded that the activities which are in the application are appropriate for checking the Social Story\textsuperscript{TM} comprehension. They also commented that these are easy to use by the target users. The expert’s comments on the comprehension check methods were very positive, and highlighted that they are focused on the important information. They added that the language is simple and appropriate for the target users. The experts also commented on how the pages were not overwhelming or distracting which would be inappropriate for the children with ASD.

The study with 16 TD children in Chapter 6, helped discover whether the application is appropriate for children between the ages of 7-11. The results from the study with the children showed that they completed the tasks correctly and that the comprehension check methods were effective. This result was obtained by observing the children during the evaluation and the questions asked at the end of the evaluation.

Based on the answers provided for the three research sub-questions, it can be argued that the new technology has the potential to support children with ASD and practitioners in checking Social Story\textsuperscript{TM} comprehension.

7.2 Limitations

This section discusses the limitations which the researcher faced in this project. The limitations faced revolved around: time availability and access to practitioners and children with ASD. Therefore there were some limitations on the methods used and the application developed.

Due to the time frame in which this research had to be conducted, the research had to be limited to a very specific area. The application developed in this research focused on the child’s interface which checks Social Story\textsuperscript{TM} comprehension. The application is also limited to one particular story. It would be beneficial if the application could be used for any story and for this reason it is necessary to have a practitioner’s interface.

The limited time available also meant that the suggestions made by the experts in the evaluation discussed in Chapter 6, which required a timely implementation, were not made. These suggestions were therefore discussed in the further work section. With
more time available, the suggested changes would be implemented followed by another evaluation session with experts.

Access to practitioners and children with ASD is generally limited. Limited access to the children is mainly due to the stress which may be caused to the children with ASD (Hirano et al., 2010), and the ethical issues which could be involved. It is also hard to get access to practitioners due to the limited time available.

Despite these limitations, they did not prevent the researcher from coming to the conclusion that the application is appropriate and effective to checking Social Story™ comprehension.

### 7.3 Future Work

This section discusses a number of directions in which the application could take which have been identified during this research project.

#### 7.3.1 Further Development of the Application

To make the application more efficient for its user, a number of further developments could be carried out.

In order to improve the application’s customisability, several features could be added, such as:

- add the option to add more types of rewards
- add an option to customise the characters in the game comprehension check
- extend the application to add more stories
- add the option to have a difficulty level for the questions
- randomise the questions presented to the children to make it harder to memorise answers
- add more animations and sounds to the application

In order to present the story at the beginning of the toolkit with minimal amount of text on each page, experts came up with several ideas on how this could be presented, including:

- animate the story so that it is presented in a more engaging manner and also reducing the amount of text
- split the paragraphs into shorter sentences presented gradually to the child rather than the whole page
- add more prompts to the pages to draw the attention of the child to the text
7.4 Contributions

- add the option of text-to-speech so the story can be read out in combination with the text

7.3.2 Extending the Application

To make this application customisable, it would be useful to provide an interface for practitioners. This could provide the practitioners options for adapting the methods to the child abilities and preferences, but also to the story content, whatever the story is. For example, practitioners could choose different elements of the games, as well as the questions, could record their choice to be used throughout the game, or could change the font characteristics (e.g. size and colour).

7.3.3 Studies with Children with ASD

One of the methods in which the application can be determined if it will be successful with children with ASD (target users), is to evaluate it with children with ASD. Taking into account the time limit for this thesis it was decided to involve TD children as proxies for the target users. This approach called participation via proxy is suggested by the literature (Frauenberger et al., 2012). vSked project researchers argued that participation via proxy is useful, highlighting that: "The burden of involvement was deemed too high for these children by the researchers, teachers and IRB to include them directly" (Hirano et al., 2010)

7.4 Contributions

The contributions of this research to knowledge are as follows:

1. Background research on suitable methods for Social Stories™ comprehension check, and the use of educational-based games.

2. Informing the design of a technology-based tool to support practitioners in checking Social Story™ comprehension based on empirical data and literature review.

3. The implementation, and evaluation of a technology-based tool to support practitioners in checking Social Story™ comprehension.

4. Empirical evidence from the evaluation with TD children and experts in HCI and ASD, that the tool may aid practitioners in checking Social Story™ comprehension in children with ASD.
7.5 Conclusions

This project investigated how technology could aid in checking Social Story™ comprehension. A prototype of this application was built, following an iterative approach which involved experts in HCI and ASD and TD children within the age group of 7-11. Involving the TD children and the experts in the design of the application prototype ensured that the design was fulfilling pre-set requirements and principles. Once the application prototype had been implemented an evaluation was conducted with both TD children and experts in HCI and ASD. Both the results from the children and the experts evaluations revealed that the prototype has potential to support children with ASD and practitioners in checking Social Story™ comprehension.
Bibliography

(2018). Balsamiq mockups @ONLINE. http://www.balsamiq.com/.


Filipek, P.A., Accardo, P.J., Baranek, G.T., Dawson, G., Gordon, B., Gravel, J.S.,


http://www.k12reader.com/what-is-reading-comprehension/ 29/05/2008 Reading Worksheets, Spelling, Grammar, Comprehension, Lesson Plans. Retrieved 01/04/2018


School of Informatics, the University of Edinburgh ethics procedure 2017 https://www.ed.ac.uk/informatics/research/ethics/procedure


Scaife M, Rogers Y, Aldrich F, Davies M. Designing for or designing with? Informant


# Appendix A

## Ethics Forms

### Part C

### Ethical Review Procedures:

#### Level 1

**Project Details & Self-assessment**

This document is closely modelled on documents used in School of Philosophy, Psychology and Language Sciences provided by Ellen Bard and Cedric MacMartin.

<table>
<thead>
<tr>
<th align="left">This form is to be filled in and submitted at the same time as the project proposal or the funding application it applies to. The form should be submitted by the Principal Investigator, except in the following cases:</th>
</tr>
</thead>
<tbody>
<tr>
<td align="left">- Post-doctoral fellowships – the proposed postdoc mentor.</td>
</tr>
<tr>
<td align="left">- UG, MSc, and PhD research projects – the supervisor.</td>
</tr>
<tr>
<td align="left">- Visiting researcher – the staff hosting the visitor.</td>
</tr>
</tbody>
</table>

Please submit the completed form by email to: infkm+ethics@inf.ed.ac.uk

This address, with appropriate RT number once issued, should be used for all correspondence (including forms and attached documents). This is essential to ensure proper record keeping. No signature is required if the form is sent from a valid University email address.

---

**Project Details**

1. **Type Of Project:**
   - [ ] Research grant proposal
   - [ ] Post-doctoral fellowship
   - [ ] Personal research
   - [x] UG final year project
   - [ ] PhD project

2. **Is there a sponsor/ funding body?**
   - [x]Yes/NO

3. **Does the sponsor/funder require formal prior ethical review?**
   - [x]Yes/NO

4. **Is any other institution and/or ethics committee involved?**
   - If YES, give details and indicate the status of the application at each other institution or ethics committee (i.e., submitted, approved, deferred, rejected):

5. **Title of Project**
   - Development of a technology-based tool which will aid in checking Social Story comprehension

6. **Researchers’ names, affiliations, emails**
   - Supervisor: Aurora Constantini, School of Informatics, auroraconstantini@ed.ac.uk
   - Student: Nicholas Georgiou, School of Informatics, s1342226@sms.ed.ac.uk

7. **State which professional organisation guidelines you are using:**
   - [x] School of Informatics research ethics code: http://www.inf.ed.ac.uk/research/ethics/
Other ethics code as required by funding body or professional organization:

Title: ___________________________  URL: ___________________________

68/11/17
Part C

Self-assessment

Refer to Level 2 form for details on any of the following points.

1. Protection of research participants' confidentiality
   Are there any issues of CONFIDENTIALITY which are NOT ADEQUATELY HANDLED by normal tenets of academic confidentiality?  
   YES/NO
   These include well-established sets of procedures that may be agreed more or less explicitly with collaborating individuals/organisations, for example, regarding:
   (a) Non-attribution of individual responses;
   (b) Individuals and organisations anonymised in publications and presentation;
   (c) Specific agreement with respondents regarding feedback to collaborators and publication.

2. Data protection and consent
   Are there any issues of DATA HANDLING AND CONSENT which are NOT ADEQUATELY DEALT WITH, and compliant with established procedures?  
   YES/NO
   These include well-established sets of procedures, for example regarding:
   (a) Compliance with the University of Edinburgh's Data Protection procedures (see http://www.recordsmanagement.ed.ac.uk);
   (b) Respondents giving consent regarding the collection of personal data (via consent form).

3. Significant potential for physical or psychological harm, discomfort or stress
   Are there any risks of:
   (a) psychological harm or stress for the participants?  
   YES/NO
   (b) physical harm or discomfort for the participants?  
   YES/NO
   (c) any kind to the researcher?  
   YES/NO

4. Vulnerable participants
   Are any of the participants in the research vulnerable, e.g., children, patients, disabled participants?  
   YES/NO

5. Moral issues and researcher/institutional conflicts of interest
   Are there any SPECIAL MORAL ISSUES/CONFLICTS OF INTEREST? These include:
   (a) Conflict of interests: potential benefit to the researcher, friends or family of a particular research outcome which might compromise the researcher’s objectivity or independence;
   (b) The need to keep the purposes of research concealed;
   (c) Use of participants who are unable to provide informed consent (e.g., children);
   (d) Situations where research findings would impinge negatively/differentially upon the interests of participants.
   YES/NO

6. Bringing the University into disrepute
   Is there any aspect of the proposed research which might bring the University into disrepute? For example, could any aspect of the research be considered controversial or prejudiced?  
   YES/NO

7. Use of animals
   Does the research involve animals?  
   YES/NO

8. Developing countries
   Does the research involve developing countries?  
   YES/NO

20/11/17
9. Dual use
   Is the research classified or does it have specific adversarial military applications?  **YES/NO**

10. Terrorist or extremist groups
    Does your research concern groups which may be construed as terrorist or extremist?  **YES/NO**

Can you stop now?
You may want to assure yourself that your ‘NO’ answers are correct by checking the detailed form in the next section:
If all the YES / NO answers are NO, the self assessment has been conducted and confirms the ABSENCE OF REASONABLY FORESEEABLE ETHICAL RISKS. This form should be signed by the researchers and submitted. The researchers may retain a copy for their own records.
If any answer is YES, please complete the relevant section in the Level 2 form below.
Ethical Review Procedures:
Level 2
Detailed Assessment

This material should help you answer the questions in the self-assessment form. If any difficulties arise, you should fill in the relevant parts of this form in consultation with a near colleague who is not directly involved with the research. You can also seek advice from members of the School Ethics Panel, or from relevant Ethics Committees of other schools.

You should file a new form if you receive advice on changes from the School or College Ethics Committees. For accountability, the School will view the most recent submission as accurate.

1. Protection of research participants’ confidentiality

Refer to the University Data Protection Policy to ensure that the relevant conditions relating to the processing of personal data under Schedule 2 and Schedule 3 are satisfied. Details are available at: http://www.recordsmanagement.ed.ac.uk.

1. If the research requires the collection of personal information from e.g., universities, schools, employers, or other agencies about individuals without their direct consent, what information will be sought and why will written consent for access to this information not be obtained from the participants themselves?

N/A

2. If any part of the research involving participants will be recorded using any electronic medium, what medium is to be used and how will the recordings be used?

Phones, tablets, laptops and cameras may be used to record audio, provided permission is given by parents and children. These recordings will be used for later reference by the researcher to analyse findings and inform the toolkit design.

3. Who will have access to the raw data?

Nicholas Georgiou, the student conducting the research and his supervisor Aurora Constantin will have access to the raw data.

4. If participants will be identified in your records, how will their consent to quotations/identifications be sought? N/A

5. If they will not be identifiable, how will anonymity be preserved?

Anonymity will be preserved by not keeping their names on record apart from the consent forms. In all other situations, such as write ups and quotations they shall be identified as participant X.
Part C

6. Will the datafiles/audio/video tapes, etc. be disposed of after the study?
   No

7. If not, how long they will be retained and how will they eventually be disposed of?
   The files shall be kept on password protected computers up until at least the project has been marked, evaluated and revised by a certified board of examiners. Consent forms will be kept in locked filing cabinets. Data may be kept until the records of the student involved have been destroyed. Recordings may be used in future for academic purposes including teaching and disseminations

8. How do you intend the results of the research to be used?
   The results of the research shall be used to design a prototype of a technology-based toolkit which will be appealing to children, and also usable. I will use the information the children convey to me about what they like and do not like about the current prototype to make adjustments.

9. If feedback of findings will be given to participants, how and when will this feedback be provided?
   Feedback shall be given to the participants if requested. If they choose to participate in design and testing workshops they will be shown the resulting prototype. Testing workshops will be a few months after the design workshop.

2. Data protection and consent
   Participants have the following rights over observations and records of their own behaviour:
   ● If they are engaging in any activity outside their normal daily routine (for example answering a questionnaire, listening for a particular syllable), they must be given some account of what they will be asked to do before they start, and must formally consent to participation;
   ● In any event, if they will be observed or recorded, they must be informed of and consent to the kinds of record taken;
   ● They must be assured of anonymity in any publication or dissemination;
   ● They must consent to how the data will be used;
   ● They must be free to withdraw from participation at any time.

1. Explain how and when written consent will be obtained from participants or from those responsible for participants unable to consent meaningfully on their own behalf. (If further discussion of this form is needed, please attach a copy of any information sheets and consent forms.)
   Participants are children under the age of 16 which means formal consent must be sought from parents/guardians. This will be done prior to conducting the studies enabling

20/11/17
parents/guardians to have reasonable and sufficient time to give consent. Consent will be given via a consent form to be read and signed by the parent/guardian. Information sheets will accompany the consent form giving detailed descriptions of the project and session. Parents will be asked to agree to allow their child(ren) to participate in said study. Additionally, they will be asked to give permission to have their child audio/video recorded during the session.

The child will also be consulted by being asked to fill in a brief consent form asking if they are willing to be a game designer or tester and if they are happy to be audio/video recorded. Should the child not wish to be recorded, we will respect this regardless of the decision made by their parent/guardian. This form will be given and read to the children on the day of the study, but information sheets designed specifically for them will be sent out alongside the information sheets for the parent/guardian.

2. If participants cannot meaningfully provide formal consent in this way, normally someone who is legally able to act on their behalf, for example a parent or legal guardian, must do so. If any of the following cases apply, explain how you will obtain the necessary consent and if you will not, how you can proceed ethically without doing so.

- administrative consent in lieu of participants’ consent
  (Administrative consent may be deemed sufficient:
   i. where the data collection involves aggregated statistical information and where the collection of data presents no invasion of privacy and no potential social or emotional risks:
   ii. where studies focus on the development and evaluation of curriculum materials, resources, guidelines, test items, or programme evaluations rather than the study, observation, and evaluation of individuals.)

As the children cannot provide consent on their behalf to participate in the study as they are under the age of 16 years old, consent will be received by their parents or guardians. An information sheet and a consent form will be sent home where their parents or guardians will read this and either provide consent or not. Detailed in Question 1

- the consent or assent (at least verbal) of minors,

  Consent will be obtained and information provided as detailed above.

- the consent of participants who do not share a language with the researcher,

- the consent of participants with special educational needs.

3. **Significant potential for physical or psychological harm, discomfort or stress**

If the research could induce any psychological stress or discomfort, state the nature of the risk and what measures will be taken to deal with such problems. [n/a]
Part C

If the research requires any physically invasive or potentially physically harmful procedures, give details and outline procedures to be put in place to deal with potential problems. [n/a]

If the research involves the investigation of any illegal behaviour, give details. [n/a]

If there is a real risk of disclosure of activities which should be reported to the authorities, a warning to this effect must be included in the Informed Consent documents. Please provide the wording of this warning. [n/a]

If there is any purpose to which the research findings could be put that could adversely affect participants, describe the potential risk for participants of this use of the data. Outline any steps that will be taken to protect participants. [n/a]

If the research could adversely affect participants in any other way, give details and outline procedures to be put in place to deal with such problems. [n/a]

If the research could adversely affect particular groups of people, describe these possible adverse effects and the protection to be put in place against them.

If the research is expected to benefit the participants, directly or indirectly, give details.

If the true purpose of the research will be concealed from the participants, explain what information will be concealed and why. [n/a]

If participants will NOT be debriefed at the conclusion of the study, explain why not.

N/A to all above

4. Vulnerable participants

What criteria will be used in deciding on the inclusion and exclusion of participants in the study?

Emails will be sent out to supervisor’s existing connections (including university staff) and participation is voluntary.

If any of the participants are likely to be in any of the following vulnerable categories, indicate the category and describe the measures that will be used to recruit, protect and/or inform participants:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 16 years of age</td>
<td>in the care of a Local Authority</td>
</tr>
<tr>
<td>known to have special educational needs</td>
<td>physically or mentally ill</td>
</tr>
<tr>
<td>vulnerable in other ways</td>
<td>members of a vulnerable or stigmatized minority</td>
</tr>
<tr>
<td>unlikely to share a language with the researchers</td>
<td>in a student-teacher relationship with the researchers</td>
</tr>
<tr>
<td>in any other dependent relationship with the researchers</td>
<td>likely to have difficulty in reading and/or comprehending any printed material distributed as part of the study</td>
</tr>
</tbody>
</table>

Consent forms and information sheets will be given to the participants and their parents/guardians, as detailed above, and read aloud to children if necessary.

If participants will receive any financial or other material benefits because of participation, what benefits will be offered to participants and why?

N/A
5. Moral issues and researcher/institutional conflicts of interest

The University has a draft ‘Policy on the Conflict of Interest’. Regarding research the draft states that a conflict of interest would arise in cases where an employee of the University might be

“...compromising research objectivity or independence in return for financial or non-financial benefit for him/herself or for a relative or friend. ...”

The draft policy also states that the responsibility for avoiding a conflict of interest, in the first instance, lies with the individual, but that potential conflicts of interest should always be disclosed, normally to the line manager or Head of Department. Failure to disclose a conflict of interest or to cease involvement until the conflict has been resolved may result in disciplinary action and in serious cases could result in dismissal.

If your research involves a conflict of interest or any situation which could be construed as a conflict of interest, please give details.

N/A to all above

6. Bringing the University into disrepute

If on the level 1 form you have answered that some aspect of the proposed research “might bring the University into disrepute”, please elaborate alongside how this might arise, and what steps will be taken by the researcher to mitigate and manage this, to minimise adverse consequences to the University.

N/A to all above

7. Use of animals [based on EU FP7 guidelines]

If the proposed research will use animals, please provide the following information:

1. Describe how you have applied the 3Rs: Reduction, Replacement, Refinement.
2. Describe and justify:
   - species and numbers of animals used;
   - humane end points and pain and suffering;
3. Describe how you have explored alternatives to using animals.
4. Answer the following questions:
   - Are those animals transgenic small laboratory animals?
   - Are those animals transgenic farm animals?
   - Are those animals cloning farm animals?
   - Are those animals non-human primates?

N/A to all above

8. Developing countries [based on EU FP7 guidelines]

Questions to consider include:

1. Does the research project provide benefit to the local community (in terms of access to healthcare, education, allocation of property rights, capacity to assess and use modern technologies while respecting the population’s own choices and needs, etc.)?
2. Does the research project use local resources (genetic resources, animals, and plants)?

N/A to all above

How to deal with research involving developing countries

The categories of issues requiring special attention include:

- A disproportionately heavy burden of diseases (particularly infectious diseases); the breadth and depth of poverty; and high levels of illiteracy
Part C

- Wide disparities in health systems and in access to health care; and imbalance between the often ample resources available for research and the meagre resources available for even basic health care
- Inadequate scientific and ethics infrastructures for the required reviewing process
- The extent of disempowerment of the poor in their personal and communal lives
- Knowledge of the ways in which people of other cultures traditionally view themselves as individuals embedded in communities with respect to the changing boundaries between perceptions of the self that differ from the classical Western notion
- The need to understand what it means to be ill in contexts very different from those known to researchers and what can be expected from those ones consults for help under those circumstances

N/A to all above

9. Dual use (based on EU FP7 guidelines)

1) What is considered as potential dual use

Generally speaking, dual use is a term often used in politics and diplomacy to refer to technology which can be used for both peaceful aims and adversarial military aims. Ethical issues of dual use might arise in cases where:

(d) Classified information, materials or techniques are used in research;
(e) Dangerous or restricted materials e.g. explosives are used in research;
(f) The specific results of the research could present a danger to participants, or to society as a whole, if they were improperly disseminated.

2) How to deal with potential dual use

Regarding implications for the use of and misuse of the research and products, the following measures and strategies can be applied:

(c) The researcher should show awareness of potential risks to participants and society as a whole from inappropriate dissemination of their results;
(d) Appropriate measures to deal with dangerous or restricted materials should be detailed, where applicable;
(e) An appropriate strategy to deal with issue of informed consent and risk management for participants and for society where classified information, materials or techniques are concerned should be demonstrated;
(f) An advisory board should be included in the project, which should identify risks to participants from particular research activities and devise a strategy for minimising and dealing with these risks;
(g) The dissemination and communication strategy of the study results to a wider audience should be controlled by the advisory board, which should report to the relevant funding body on a regular basis.

EU FP7 ethical guidelines can be found at http://cordis.europa.eu/fp7/ethics_en.html.

N/A to all above

10. Terrorist or extremist groups

If your research concerns groups which may be construed as terrorist or extremist, please fill in the following form and submit it with your ethics form.

Prevent Duty supplementary form

The Terrorism Act (2006) outlaws the dissemination of records, statements and other documents that can be interpreted as promoting or endorsing terrorist acts.
Part C

1. Does your research involve the storage on a computer of any such records, statements or other documents? Yes / No

2. Might your research involve the electronic transmission (eg as an email attachment) of such records or statements? Yes / No

3. If you answered ‘Yes’ to questions 1 or 2, you are advised to store the relevant records or statements electronically on a secure university file store. The same applies to paper documents with the same sort of content. These should be scanned and uploaded. Access to this file store will be protected by a password unique to you and your School Research Ethics Officer. Please indicate below that you agree to store all documents relevant to questions 1 and 2 on that file store: Yes

3a. Please indicate below that you agree not to transmit electronically to any third party documents in the document store: Yes

4. Will your research involve visits to websites that might be associated with extreme, or terrorist organisations? Yes / No

5. If you answer ‘Yes’ to question 4, you are advised that such sites may be subject to surveillance by the police. Accessing these sites from university IP addresses might lead to police enquiries. Please acknowledge that you understand this risk by putting an ‘X’ in the ‘Yes’ box: Yes

6. By submitting to the ethics process, you accept that your School Research Ethics Officer and the convenor of the University’s Compliance Group will have access to a list of titles of documents (but not the contents of documents) in your document store. Please acknowledge that you accept this by putting an ‘X’ in the ‘Yes’ box: Yes

Countersigned by supervisor/manager

N/A to all above

20/11/17
Appendix B

Child Information Sheet - Design Workshop

Designing and testing 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 you to help design 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.

Who is organising the event? This is Nicholas and Aurora. 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 providing ideas for new computer games, participating in different activities and answering some questions.

Mr. Nicholas Georgiou
Dr. Aurora Constantin

How can I help?

Children with autism may find it difficult sometimes to understand some situations and may be scared or confused because of this situation. For example, some children may not understand why they have to wash their hands and sometimes will find this confusing. Through special stories they can learn why some things are important and how they might behave or respond in a particular situation. Teachers would like to ask children about the story they read to see if they understood it. Some children may find it difficult to answer these questions. Therefore, I would like to create computer games so that children will find it easy and fun to answer teachers’ questions. However, I am not a child, and this is why I ask your help to find out together how to create these games.

What will happen if I help? When you arrive, you will be told more information about the workshop. You will be invited to play with paper prototypes. These are drawings which shows you how the game could look like. You will be asked what you like, what you don’t like in these drawings and what other ideas you have to make them nicer.
This will help me create fun games that can be used when teachers need to ask children questions about stories they read. Later you may be asked to play these games.

You can tell me or Aurora if you want to stop doing any of the activities. You do not have to tell us why. Please tell us 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.

We will ask if it is OK to make an audio or video recording of you helping design the game, and answering questions. This is because it is too hard for us to write down everything that happens. We will listen to or watch the recording later to help us understand what you said, or your ideas for the game.

**What will happen after I am finished helping?** We will learn a lot about children and computers from the things you make, do and say when you take part in the design workshops and do other activities, or later when you play the games. We will write about what we have learned, and use it to design the games. Sometimes we 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 our feelings.

Do you want to ask a question about being a games developer? It is OK to have more questions. You can ask the researchers 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.
Appendix C

Parent Information Sheet - Design Workshop

Development of a technology-based tool which will aid in checking Social Story comprehension

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:

- Mr. Nicholas Georgiou, lead researcher
  - s1342226@sms.ed.ac.uk; 07517214502
- Dr. Aurora Constantin, research advisor
  - aurora.constantin@ed.ac.uk; +44 (0) 131 515 643

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

I am a UG4 from the University Of Edinburgh working on a technology-based toolkit for checking Social Story comprehension for children with autism as a part of our Honours projects.

What is the goal of the project?
Children with ASD find it difficult to develop social and communication skills and therefore practitioners and teachers must find ways in which to teach them these vital skills. One way in which these skills are taught are through Social Stories which were created by Carol Gray in 1990. Though Social Stories prove effective in teaching children with ASD these vital skills, practitioners and teachers find it difficult when it comes to testing the comprehension of these Social Stories by the children. The goal of my project is to develop a technology-based toolkit which will aid practitioners and teachers in testing children's comprehension of Social Stories.

What is the purpose of the workshop?

The workshop is intended to inform the design process of the toolkit. The children’s opinions regarding methods of testing comprehension, rewards/feedback and enjoyability of using the toolkit will be invaluable to the design and implementation of the toolkit. The ways in which the children interact with the prototype of the toolkit, and how they respond to different methods of testing comprehension through filling in blank sentences, answering questions and a small game will be invaluable to making changes to the current design of the toolkit.

How can my child help?

During the workshop, your child will interact with a prototype of the toolkit. They will use the different methods of checking social story comprehension and provide their opinion of what they like and dislike. As this toolkit will be used by children in the same age group, it is important for me to implement features that children enjoy and find intriguing. Therefore this workshop will provide me greater insight on how children think and work with technology based toolkits.

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 20-30 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 either video or audio 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 are not comfortable with your child being (and possibly 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 researcher (listed above). It is indirectly paid for by the University of Edinburgh and the funding is not attached to a specific
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 (and possibly video) 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 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.
Appendix D

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 ▢

Nicholas and Aurora will listen to/watch the recordings later.

They may 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 E

Certificate - Design Workshop

Designer Award

A Name

In recognition of excellent contribution in game design workshops

2017
Nicholas Georgiou
Appendix F

Parent Consent Form

Research permission form (for parents)

Please circle

<table>
<thead>
<tr>
<th>Question</th>
<th>YES / NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you read the information sheets?</td>
<td></td>
</tr>
<tr>
<td>Have you received enough information about the study?</td>
<td></td>
</tr>
<tr>
<td>Do you understand that participation is completely voluntary and your child can leave the study at any time, without having to give a reason?</td>
<td></td>
</tr>
</tbody>
</table>

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 tester.

With reference to further anonymous use of video and audio data, please circle yes or no in response to the following (note: even if you say 'No' to this, your child can still participate in the study, but the video and audio data will only be seen by the research team):

I AGREE that short recordings 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 this. 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: _________________________________________

Signature: __________

Date: _______/_____/_____

Parent design workshop permission form 1/1  March 2018
Appendix G

Child Information Sheet and Consent Form - Evaluation Workshop

Designing and testing games to help children
(to be read aloud to the child)

This page is for children. We will ask you to help design and test new computer games, take part in different activities, and answer a few questions. You can decide if you want to say “yes” or “no” to helping, and can change your mind at any time.

Who is organising the event? This is Helen, Aurora, Mai Anh, Nicole, Orisa, Stasi, Nicholas and Tara. They want to make computer games that can help children. You can help them by providing ideas for new computer games, taking part in different activities, helping test them, and answering some questions.

How can I help?

Mai Anh: Children with autism may find it difficult to understand and describe what they are feeling. By using music, they may get more comfortable with their emotions and
learn to identify them. You will help me to test musical mini-games, to help better understand emotions.

Nicole: Some children with autism find it hard to make friends, because they feel uncomfortable talking to people or do not know what to say. To help them, we have developed a game to teach them how to make friends. We will use your experience of making friends, in different situations, to help test this game.

Orisa has created a game to encourage children with difficulties to take part in 'pretend play', where they might pretend to be someone else - perhaps an animal or a character from a story. This uses something called 'augmented reality', where a tablet or phone can help you to imagine that something looks different from what it really is. You will help test the game.

Stasi: Some children find it hard to understand other people when what they say is different from what they mean. If you said that 'your homework was a piece of cake' you would mean that it is very easy, not that you are having cake as homework. Stasi has made a game to help children understand these phrases. You would help test this.

Tara: Some children struggle with complicated sentences: these can be quite tangled and confusing. But often a few simple questions are very helpful in working out what is actually being said. Tara has made a game to help children untangle these sentences. Your job will be to help test it.

Nicholas: Children with autism may find it difficult sometimes to understand some situations. Through special stories they can learn why some things are important and how they might behave or respond in a particular situation. Teachers would like to see if they understood these stories, by asking them questions about them. Some children may find it difficult to answer these questions. You will help test a computer game that helps children to answer teachers' questions.

What will happen if I help? You will get to take part in game testing 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 want to take a break. You can also say you do not want to be a game tester any more, and that is OK.
The researchers will ask if it is OK to make an audio or video recording of you helping design the game, and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to and look at the recordings later to help them understand what you thought about the game.

**What will happen after I am finished helping?** The things you make, do and say in the game testing workshops will help them. They will write about what they have learned, and use it to evaluate their games.

<table>
<thead>
<tr>
<th>Your mum or dad said it is OK for you to help us.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you want to be a games tester? You can say “yes” or “no”. It is OK to say “no”. It will not hurt the researchers’ feelings.</td>
</tr>
</tbody>
</table>

**Do you want to ask a question about being a games tester?** It is OK to have more questions. You can ask the researchers 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.
I can choose to be a games tester.

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 tester 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 tester? YES NO

Mai Anh, Nicole, Orisa, Stasi, Nicholas, Tara, Aurora and Helen will listen to/watch the recordings later. They may show them to other people who make games for children.

Is it okay to take audio recordings? YES NO

Is it okay to take video recordings? YES NO

Write your name: __________________________________________________________

THANK YOU!
Appendix H

Parent Information Sheet - Evaluation Workshop

Testing 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:

- Mai Anh Nguyen, lead researcher, s1456537@sms.ed.ac.uk; 07405868454
- Nicole Meng, lead researcher, s1513402@sms.ed.ac.uk; 07857074813
- Orisa Ngampakdeepanich, lead researcher, s1309783@sms.ed.ac.uk; 07895863725
- Stanislava Borisova, lead researcher, s1432790@sms.ed.ac.uk; 07478298595
- Tara Wudhiphan, lead researcher, s1427786@sms.ed.ac.uk; 07467789073
- Nicholas Georgiou, lead researcher, s1342226@sms.ed.ac.uk; 07517214502
- Dr. Aurora Constantin, research advisor, aurora.constantin@ed.ac.uk; 131 515 643
- Prof. Helen Pain, research advisor, helen@inf.ed.ac.uk, 07974 971 475

University of Edinburgh, School of Informatics

Please return the parent consent form to one of the researchers if you give permission for your child to participate in the project. Note that if you completed the consent for game design in November, you do not also need to return this consent form.

Overview of the project

We are five 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?

Mai Anh: 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.
Nicole: Social interactions might come easy to many people, but for children with ASC it represents a major difficulty in life. For autistic children approaching new people, asking for help or making friends is a struggle, especially, in a new environment. To improve the ability to enter social interactions more freely, we are designing an educational game to encourage autistic children to start communication and interaction with other people.

Orisa: We are investigating how to design an effective social game to teach children with ASC how to pretend play. Pretend play is a significant diagnostic indicator of childhood autism and is closely related to critical developments such as symbolic thinking, language and social interaction. To encourage more spontaneous pretend play in children with ASC, we will be incorporating augmented reality and social support into a tablet game to expand their imagination and improve their cooperative play skills.

Stanislava: We are investigating how to design an educational game for children with ASC which aims to promote the better understanding and casual use of non-literal language forms such as metaphors and idioms. People with ASC often interpret language literally, rather than with the intended meaning, which may lead to communication problems. The game will present a narrative story, aiming to introduce non-literal expressions in common situations and a number of minigames focusing on specific phrases to promote learning through repetition.

Tara: Research shows that ASC and Specific Language Impairment (SLI) co-occur within individuals at above chance level. For this reason, it is unsurprising that many children with ASC struggle to understand complex language structures such as wh-questions (who/what/when/where/why/how), as well as embedded and subordinate clauses. They also often cannot focus on details or parts of a whole, something known as Gestalt perception. This can be seen in the fact that they often attend only to keywords instead of the actual meaning conveyed by a narrative. We aim to develop a game that can help children tackle such difficulties by applying them within a narrative context.

Nicholas: Children with ASD find it difficult to develop social and communication skills and therefore practitioners and teachers must find ways in which to teach them these vital skills. One way in which these skills are taught are through Social Stories which were created by Carol Gray in 1990. Though Social Stories prove effective in teaching children with ASD these vital skills, practitioners and teachers find it difficult when it comes to testing the comprehension of these Social Stories by the children. The goal of my project is to develop a technology-based toolkit which will aid practitioners and teachers in testing children’s comprehension of Social Stories.
What is the purpose of the workshop?

- **Mai Anh:** The workshop will help in testing the mini games developed, to help children with autism in exploring the relationship between music and emotions.
- **Nicole:** Children will test the game we have developed to teach children with autism how to make friends. We will use your child's experience of making friends, in different situations, to help test this game.
- **Orisa:** The workshop will test how children respond to the game mechanics, i.e. the 'charades' component (guessing game) and the augmented reality, and other aspects of the game.
- **Stanislava:** The children will evaluate how the game developed might encourage children to use more non-literal language and to explore the children's comprehension of non-literal expressions and their interpretation of their meaning.
- **Tara:** The workshop will explore whether the game developed can potentially help children understand and 'untangle' complicated sentences.
- **Nicholas:** The workshop is intended to test a tool to evaluate children's comprehension of social stories.

How can my child help?

The game testing workshops will comprise a variety of activities, including testing versions of the games developed, giving feedback on them, and making suggestions for improvements.

**Workshop Information**

What happens during the workshop?

Workshops will take place in the Brownies' meeting hall. Your child will get to play with the game prototype and provide feedback through related activities for c. 30 minutes. If your child is willing to talk to us about the activities, we will ask them a few questions. They will each participate in two workshops, if they are happy to do so.

Video and audio recordings

We would like to either video or audio 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 are not comfortable with your child being audio (and possibly video) recorded 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).

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 some of 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 tester role to your child, and ask them if they want 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 (and possibly video) 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 ask your child to be a games tester.

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.
Appendix I

Certificate - Evaluation Workshop

In recognition of excellent contribution to game testing workshops 2018

Professor Helen Pain

Jacob Ng
Appendix J

Social Stories™ Criteria

These ten criteria are taken from Gray (2010).

**Criterion 1: The Goal**

"The goal of a Social Story™ is to share accurate information using a process, format, voice and content that is descriptive, meaningful, and physically, socially and emotionally safe for the Audience. Every Social Story™ has an overall patient and reassuring tone" (Gray, 2010).

**Criterion 2: Two-Step Discovery**

Authors of Social Stories™ need to complete two steps before writing them. Step 1 is to gather accurate information, and step 2 is to identify the topic and type of information that will be added to the Story (Gray, 2010).

**Criterion 3: Three Parts and a Title**

A Social Story™ has a title, an introduction which clearly states the main idea, a main part which goes into more detail and a conclusion which summarises the information in the story (Gray, 2010).

**Criterion 4: FOURmat**

"A Social Story™ has a format that clarifies the content and also enhances the meaning for the audience” (Gray, 2010). Each story will be formatted depending on the audience which will be reading it. This means the reading abilities and any other factors which may impact must be taken into consideration. For example the age and ability of the audience, if the audience would benefit from illustration and if having repetition, rhythm and rhyme would also benefit the audience (Gray, 2010).

**Criterion 5: Five Factors Define Voice and Vocabulary**

A Social Story™ must have a vocabulary defined by five factors (Gray, 2010):

1. First or Third-Person Perspective
2. Positive and Patient Tone
3. Past, Present, and/or Future Tense
4. Literal Accuracy
5. Accurate Vocabulary

**Criterion 6: Six Questions Guide Story Development**

Social Story™ answers relevant "w+h" questions, which are important in describing information about a specific topic. The 5W+H questions (who, what, when, where, why and how) outline the information about specific topics.

- Where - describing the context
- When - time-related information
- Who - relevant people
- What - important queues
- How - basic activities, behaviours or statements
- Why - Reasons and/or rationale behind them

**Criterion 7: Seven Types of Social Story™ Sentences**

Social Stories™ contain seven types of sentences (Gray,2010):

- Descriptive present factual, objective statements, free of opinions or assumptions. For example "There are many stars in the sky at night".

- Perspective sentences which describe a person’s internal state or their opinions, motivation and their physical condition or health. For example "Adults may think it is polite to ask before taking a cookie from the jar".

- Sentences that coach are used to guide the behaviour of an audience or of a team. These sentences are comprised of three types of sentences: sentences that coach the audience (for example, "I will try and write between the lines"); sentences that coach the team (for example, "My mum will help me with the washing" and self-coaching sentences (for example, "I can use a paper chain to help me keep track of the number of days until my birthday").

- Affirmative sentences enhance the meaning of statements and express an opinion within a specific culture. They are usually used to enhance an important point. For example "To stay safe, children take turns going down the slide. This is very important".

- Partial Sentences follow a fill-in-the-blank format which are used to check comprehension or encourage the audience to make a guess as to what the next part of the story is. Partial sentences provide an opportunity for the child to participate in the review of a Story.

**A GR-EIGHT Formula**

To create a Social Stories™ a ratio of the types of sentences used introduced earlier must be followed. This is known as the Basic Social Story™ Ratio (Gray, 1998).
This ratio states that for every 0-1 directive and control sentences there should be 2-5 descriptive, perspective, affirmative and coaching sentences when writing Social Stories (Gray, 2010).

**Nine Makes it Mine**

In the cases where it is possible, the Social Stories™ should be tailored to the individual’s needs. These needs may include preferences, talents and specific interests the target audience may have (Gray, 2010).

**Ten Guides to Editing and Implementation**

There are ten guides to editing and implementation (Gray, 2010):

1. Edit
2. Plan for Comprehension
3. Plan Story Support
4. Plan Story Review
5. Plan a Positive Introduction
6. Monitor
7. Organise Stories
8. Mix and Match Stories to Build Concepts
9. Story Re-Runs and Sequels
10. Recycle Instruction into Applause
Appendix K

Social Story™ Example

Safety Wherever I Go

Wherever I go, there is something – or someone – to help keep children safe.

Wherever I go, there are places with fences, ramps, rails, walkways, doors, or locks that help to keep children safe.
Wherever I go, there is safety equipment that helps to keep children safe. Things like helmets, life jackets, or seat belts.
Wherever I go, there are signs to help keep children safe.
Wherever I go, there are laws to keep children safe. That’s one reason why children wear seatbelts in a car.

Wherever I go, there are rules to help keep children safe. When I am at school, my class forms a line to walk safely from one place to another.
Wherever I go, there are people that help to keep children safe. Parents and grandparents, crossing guards, teachers, police officers and firefighters all work to keep me safe.

Wherever I go, there are signs, equipment, laws, rules, and people working to keep children safe.
Wherever I go, there’s one more person who may help to keep me safe. He will always be with me, every second of my whole life. That person is me!
Appendix L

High-fidelity expert evaluation questions

1. What are your initial thoughts on the application?
2. Do you believe the application is appropriate for its target users (children with ASD between the ages of 7-11)?
3. Was the application intuitive to use, and do you believe it would be for the target users?
4. Is there anything in the application target users would find hard to use?
5. Do you think the application would be effective in testing Social Story™ comprehension in children with ASD?
6. Do you think it would be easy for the target user to use this with no assistance?
7. Would you suggest any improvements to the application?
8. Have you detected any usability issues?
9. Do you think the language used is at a comprehensive level?
10. Do you think the pictures used throughout the application are good?
11. Do you think the buttons are easy and intuitive to use?