Emerald Zoo: A Game Based Application Targeting the Development of Executive Function Skills in Children with Autism Spectrum Conditions

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Abstract

In this research, a game based application for teaching executive function skills to children with Autism Spectrum Conditions is developed. The area is researched in a literature review, then the application is developed through participatory design. The application is evaluated formatively by experts in the field and by the participatory design participants. The application is summatively evaluated by five adults with ASC and three children with ASC. The outcomes of the evaluation are that the application is well received, the participants believe that it is a valid area to design games for and were engaged in suggesting extensions to the basic application implemented.
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Chapter 1

Introduction

A suitable area for this project to explore is the development of an app that allows children with ASCs to develop independent planning and self-monitoring skills. Planning and self-monitoring are two areas of executive function that are consistently found to be impaired in the literature and while effective apps exist that use visual schedules to assist people with ASCs in this area, they require a caregiver to program in the schedule before the person with ASC uses it. This project will be to develop an app that supports people with ASC to develop independent planning and self-monitoring skills, from breaking the task into steps and planning activities through to completion and evaluation.
Chapter 2

Literature Review

This chapter assesses and condenses the current work relating to assistive technology and executive function interventions for children with Autism Spectrum Conditions (ASCs). First, ASCs are defined and the strengths and difficulties of children with ASCs, particularly in areas of executive function, are described. Then, current executive function interventions are investigated and critically assessed. Finally, research the design and use of technology for children with ASCs, focusing on design principles and good practices for developing software for this population.

2.1 Defining Autism Spectrum Conditions

Autism Spectrum Conditions (ASCs) are a group of related neurodevelopmental conditions characterised by a triad of impairments in language and communication, flexibility of thought and social interaction. Approximately 1 in 100 people in the UK have an ASC, each with a unique profile of strengths and weaknesses. In addition to the core triad of impairments, people with ASCs may experience sensory hyper- and hypo-sensitivities, intellectual disability, specific learning difficulties and epilepsy (National Autistic Society, 2016).

An individual with autism will be affected in the following areas, often to different degrees within an individual.

2.1.1 Language and Communication

All people with ASCs have some degree of impairment in language and communication. Those severely affected feel no need and have limited ability to communicate with others, while the moderately affected attempt to communicate basic needs (Beaney & Kershaw, 2006) These people may use some verbal language, some sign/gesture based language and AAC technologies.
People with milder language and communication deficits are able to use verbal language but are unable to grasp subtle aspects of communication. They may talk only about subjects based around their own interests, have difficulty taking turns in conversation and continue to talk when others are not listening (Beaney & Kershaw, 2006).

In school, a child with ASC may have difficulty understanding and following instructions, explaining needs or answering questions due to language and communication difficulties. These difficulties can interact with other aspects of ASC, contributing to social problems. (Perepa 2005)

### 2.1.2 Flexibility of Thought

An individual with inflexibility of thought can lacks understanding of subtle social rules, have difficulty understanding that other people have different views or thoughts, lack spontaneity, and may seek explanation of different or new situations (Beaney & Kershaw, 2006).

In school the child may have difficulty following classroom rules and/or with displaying socially inappropriate behaviour. This can also be due to social interaction difficulties. Limited flexibility of thought can create difficulty dealing with sudden change and lead to anxiety. A child may experience difficulty understanding others and the effect of their own behaviours on other people. They may experience difficulty relating to a story or topic that requires imagination, difficulty using a learnt skill outside a specific situation and they may demonstrate resistance to certain activities and situations. (Perepa 2005)

### 2.1.3 Social Interaction

An individual with mild social interaction difficulties can initiate interaction but may have difficulty coping in group situations and may appear to lack empathy. An individual with moderate social interaction difficulties may tolerate some interaction but not seek social contact, while an individual with severe difficulties may be uninterested in social contact and unaware people have different thoughts to their own (Beaney & Kershaw, 2006). In school, social interaction difficulties may mean that a child has no concept of personal belongings, may experience difficulty following classroom rules, and may display socially inappropriate behaviour (Perepa, 2005).

### 2.2 Autism and Executive Functions

Over the past fifty years, the diagnostic criteria and process for autism has changed, bringing with it a constantly changing population of autistic individuals (Levy et al, 2002). This caused challenges in the review process, particularly when comparing work conducted at different times. As the definition of ASC has changed, the research participant population has changed.
2.2. Autism and Executive Functions

In 1996 Pennington & Ozonoff reported that 75% of children with ASC “function in the mentally handicapped range”. However, a 2010 epidemiological study (Charman et al, 2010) challenged this figure. By identifying and screening at risk individuals in a geographically selected cohort of 56946 children aged 10-14; 156 children with ASC were identified and assessed for IQ. It was found that 55% tested in the intellectual disability range (IQ ¿ 70). The children with ASC were identified as having an ICD-10 diagnosis of either childhood autism (n=81) or “other ASD”, comprising individuals with atypical autism (late onset) (n=6), atypical autism (subthreshold symptomatology) (n=61), pervasive developmental disorder unspecified (n=6) and overactive disorder associated with mental retardation and stereotyped movements (n=3). This study did not include children with Asperger Syndrome, who by definition display no cognitive delay (World Health Organisation, 1992). However in 2013 the DSM-5, the diagnostic manual commonly used in the United States, removed Asperger syndrome as a distinct diagnosis, instead creating a collective autism spectrum disorder incorporating conditions including autism, Asperger syndrome and pervasive developmental disorder (National Autistic Society, 2016). As a result, the population IQ distribution and the autistic population group available to researches as has again changed.

It is known that intellectual disability is associated with executive function skill deficits in inhibition, planning and working memory compared to mental-age matched peers (Danielsson et al, 2012). This is a critical issue when reviewing research into executive function and autism, as many studies did not separate participants on the basis of IQ (Pennington & Ozonoff, 1996; Robinson et al 2009).

Executive Functions (EF) are the set of higher level cognitive processes that allow a person to retain, process and use information to achieve a goal. Executive functions include working memory, planning, response inhibition, mental flexibility and self-monitoring (Hill 2004). Impairment in EF is characteristic of individuals with ASC (Robinson et al, 2009; Pennington & Ozonoff, 1996), though there is uncertainty about causality and the effects of interaction between different executive functions and conditions commonly co-morbid to ASC. Pennington & Ozonoff (1996) note that because EF tasks are complex, assessment of a single task will include many interacting processes, and so one outcome has many possible influences.

Pennington & Ozonoff (1996) describe a history of investigation into EF and ASC dating from 1985. They briefly review work in the area, finding that “perseveration and inflexible rule use” are present throughout past literature. Early studies (Boucher, 1977; Hermelin & O’Connor, 1970) found that subjects with ASC tended to be rigid and rule based in their approaches to experimental tasks. Hermelin and O’Connor (1970) found that autistic subjects “had a tendency to persist in a once-given response rather than select an alternative one”, Boucher (1977) found that when presented with two correct problem solving strategies children with ASC were likely to stick with one strategy, while the typically developing controls would alternate between the two. Pennington & Ozonoff characterise these patterns as “very similar to what EF theorists would call perseveration”.

However, Pennington & Ozonoff were critical of studies of EF in children with ASC because for the most part children with co-morbidities to ASC were not consistently
screened and excluded. These conditions, which they believe also affect EF, include Tourette syndrome, schizophrenia, obsessive-compulsive disorder, ADHD and Intellectual Disability (ID). Notably in 1996 an estimated 75% of children diagnosed with ASC “functioned in the mentally handicapped range”, so the potential impact of intellectual disability related EF impairments on the results is substantial. The inclusion of children with co-morbid conditions “clouds somewhat the interpretation of executive function studies of autism”. Nevertheless, Pennington & Ozonoff conclude that there is strong evidence that children with ASCs have EF impairments - in 13 of 14 studies reviewed (comprising 32 EF measures in total) there are significant differences between subjects with ASC and the control groups, this is found in individuals across a “wide variety of measures with subjects of all ages and functioning levels”.

Robinson et al (2009) also noted that in many studies of EF in children with ASCs, children with intellectual disability (IQ ≤ 70) were not separated from children without ID. They claim that therefore the extent to which EF impairments are related to ASC (vs being related to ID) is unclear. To measure the effect of ASC on EF, they conducted tests with 54 children ages 8:0-17:0 with ASD, IQ 70-130 (i.e. without intellectual disability and within two standard deviations of the mean) and with English as a first language. They also tested a control group of 54 typically developing children (with no neurological abnormality, diagnosed learning difficulty or history of special needs), individually matched to the children with ASC by age, IQ, receptive vocabulary and gender. It is not reported if the children with ASC were screened for common co-morbidities affecting EF, for example, dyspraxia and Tourette syndrome.

Robinson et al 2009 tested planning, mental flexibility, response inhibition, generativity and self-monitoring. They found that children with ASC were impaired in planning, response inhibition and self-monitoring compared the control group. Robinson et al found that generativity (the ability to generate novel ideas and behaviours spontaneously (Turner, 1997)) was preserved on the Verbal Fluency test, but the children with ASC made significantly more perseverative responses, indicating impaired self-monitoring. Likewise in the Wisconsin Card Sorting Test (measuring mental flexibility), there was no significant difference in score between the children with ASC and the typically developing controls but the children with ASC made more perseverative responses. This pattern of poor self-monitoring and poor response inhibition is seen in the Stroop and Junior Hayling tests (measuring response inhibition) and is remarked on by the authors as a “specific pattern of performance across a range of executive measures”. For detailed discussion of these measures, see Robinson et al (2009).

ever, there are many variables which could cause this outcome and planning as a whole requires more investigation.

From these studies, we see that although the causes and specific interactions of EF and ASC need further investigation and there are methodical issues in places, there is consistent evidence that children with ASC experience difficulties with self-monitoring and response inhibition, potentially leading to perseveration. There is also evidence to suggest that individuals with ASC experience difficulties in strategy formation and planning. The next section of this literature review will focus on strategies for improving planning and self-monitoring skills in children with ASC.

2.3 Visual Supports for Children with ASC

This section is written on the basis of work conducted by Hayes et al (2010)/

Visual supports are a commonly employed strategy to assist pupils with ASC at all ages and levels of ability. The support needs to be customised to the needs of the individual child and can be used to aid difficulties with transition and change (visual schedules), understanding emotions (simple face symbols, mood “thermometers”), behaviour management (visual representations and reminders of rules) and communication (PECS is a commonly used system).

Traditionally, visual supports are analogue, such as picture communication cards and printed visual timetables. These are created by teachers and caregivers, are flexible, and can be easily customised to the needs of the child. However, their creation, use and organisation can be difficult and time consuming for teachers and caregivers. Practically speaking, pieces can be lost or damaged, the creation of the aids is tedious and if a visual support system uses many small pieces (PECS is a good example), the system can grow large, disorganised and unwieldy, introducing a barrier to their use.

More recently, digital supports have been developed. These applications are often implementations of analogue supports and do have some advantages- they are a more compact way to store large amounts of data (such as a set of communication cards), they afford some level of customisation, frequently allowing the upload of a user’s pictures, and for some children, the coolness’ of using a tablet computer in the classroom increases use. However, these supports do not fully exploit the potential of the technology. They can be fairly inflexible with limited options for customisation and are often standalone applications geared towards one specific task. An additional issue is that these aids can be difficult to program, especially for non-experts (i.e. most teachers and caregivers) and are static, neither developing with the child nor pushing the child to further develop after the mastery of a task (or a finite set of pre-specified tasks).
2.4 Technology for Children with ASC

Hayes et al (2010) believe that in designing technology for children with ASC, the following areas need to be taken into consideration:

- The need for easy, effective communication between teachers and caregivers
- Options for automatic data recording and analysis
- Different user interfaces for different user groups- children, teachers and caregivers and the interaction between those interfaces
- Design- simplicity for both children and adults
- Adaptiveness of the application for children across the spectrum of ability and age
- Ability of the system to use different media types- text, cartoon pictures, photographs, video and audio
- Safety and privacy of data

Fletcher-Watson (2013) conducts a meta-review into technologies for children with ASC and recommends the following:

- Use participatory design with children with ASC
- Include personalisation
- Include rewards
- Consult literature on cognitive skills and sensory preferences to be guided in the design of technologies for children with ASC
- Investigate multi-setting use and the potential of mobile devices
Chapter 3

Concept Development

This section outlines two potential applications for supporting the development of planning and self-monitoring skills in children with ASCs.

3.1 Fading Prompts

Based on the work of (Parker & Kamps, 2011), create an app that has a fading prompt system at its core. The app should have a child-friendly schedule creation tool, as well as an adult caregiver version. The fading prompt system will give social scripts, gradually fading as child gains confidence and competence. Targets EF aspects of social difficulty: planning, initiation, responding to change.

This app would be an aid to real-world activities and encounters, rather than an app that stands alone as a game or educational activity.

A major design consideration would be how the child user is supported in creating social scripts- should the strategy aspect be left to a supervising adult, or should it be a part of the app. One possibility would be to use a social story to illustrate a concept and then have the child create scripts based on this. Another consideration is how to handle content of the fading prompts- it is unlikely that a child would be able to create fading prompts, so should that be required of a caregiver, or is it possible to automate their creation.

3.2 Game Based Visual Schedule Creation

Based on the idea of extending current visual scheduling apps (e.g. ChoiceWorks), this app is be a game that has visual schedule creation at its core. A primary motivation for this is the comment made at the Autism Games Symposium that often, games designed for children with ASC have an educational goal, rather than being just for fun. The aim of this app is educational, but by extending the core idea of making a plan into a virtual
world with narrative, games and rewards, this app should also be fun and engaging to play.

3.3 Deciding between concepts

The concept that will be designed, implemented and evaluated in this research is the game based visual schedule creation. This is because it is an application that will be suitable for independent use and the use of a game environment should be engaging for the child user. Within a game, the child user can be given control over the environment and can be introduced gradually to difficult executive function tasks.
Chapter 4

Pre-Design Phase

4.1 Methodology

The game is aimed at young children with Autism Spectrum Conditions. When designing for individuals with ASC, it is best practice to use participatory design combined with consultation with parents and professionals (Fletcher-Watson, 2013). Additionally, within the Autism community it is believed that adults with ASC should be consulted during the planning of interventions for children with ASC. Participatory design is an approach that involves the target user group at all stages of development and evaluation. This ensures that the end product meets the users’ needs and the user feels ownership and control over the product, with the intended result of increasing satisfaction and use. (Spinuzzi, 2005).

However, it is not possible to undertake full participatory design with young children with ASC as a part of this research. One constraint is time; individuals with ASC may require multiple meetings with the researcher to feel confident interacting, the researcher may also require multiple meetings, assistance and training to appropriately run an evaluation session and understand the communication style of the participant. Such challenges do not necessarily prevent participatory design with individuals who have ASC and communication difficulties (Benton et al, 2012) but this cannot be achieved with the time and resources allotted to the undergraduate research project.

Instead, the game will be developed and formatively evaluated using participatory design with typically developing children and adult experts in the area as proxies for children with ASC. The final game will then be evaluated by adults and children with ASC, selected for participation on the basis that they are able and willing to participate in an evaluation session without meeting the researcher in advance and communicating either verbally or through writing. The formative evaluation participants and results are discussed in Chapter .

Within the standard participatory design methodology (Spinuzzi 2005), the literature review (Chapter 2) serves as an initial exploration and discovery (stages 1 and 2). The design and evaluation workshops (Chapters 4 and 5) are used to iteratively design the
application through lo- and hi- fi prototyping (stage 3). The first stage of prototyping, design workshops with typically developing children, follows.

4.2 Workshop Design

For detailed workshop plans, see appendices A and B.

4.2.1 Initial Workshop Design

The initial workshop design aimed to gather children’s ideas about zoo activities, animal personalities and games to play with animals. This data was then used to design mini games. However, the participants were not able to effectively participate. The game was abstractly reference and the participants did not understand the connection between talking about “games an animal might play” and animal based mini games. During the workshops, the researcher followed the children’s lead after realising their struggles with the planned activities. Discussion was guided around games that the participants enjoy playing and participants designed mini games verbally and by drawing.

Analysis of the audio recordings revealed that through talking about games, the participants were making clear the features that they consider important. The participants were far more engaged when taking a lead in the workshop and designing their own games than when they were being asked to answer question after question by the researcher. In response to the difficulties and outcomes of workshops 1 and 2, the workshop was redesigned for the later sessions.

4.2.2 Revised Workshop Design

The revised workshop design aimed to gather games that the participants enjoy playing and the game features that they find most enjoyable. This introductory activity put the children at ease with the researcher and the data gathered was used to inform game features and design. The participants were then explicitly asked to design a mini game with a zoo animal as a character. During these workshops, the participants were focused and engaged, were able to talk more coherently about game design and were observed to feel ownership over their designs, in line with the aims of participatory design. In fact, when the researcher returned to the Brownie participants to conduct an evaluation session three months after the design workshop, the participants were excited to see the games implemented using their games and were comfortable sharing both positive and negative reactions. This is a positive outcome, as children can be reluctant to give negative feedback (Hall et al, 2016).
4.3 Outcomes

4.3.1 Participants

Participants were selected on the basis of being typically developing primary school aged (4-12 years) children. Participants in the Informatics Forum workshops (-IF) were predominantly the children of Informatics staff, participants in the Brownies workshop (-BS, -BR) were all members of a local Brownie Unit.

Table 1: Design Workshop Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Sex</th>
<th>Workshop Session</th>
</tr>
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<tbody>
<tr>
<td>AA-IF</td>
<td>7 M</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>AB-IF</td>
<td>7 M</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>NC-IF</td>
<td>5 F</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>LC-IF</td>
<td>5 F</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>TD-IF</td>
<td>7 M</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>FD-IF</td>
<td>9 M</td>
<td>2</td>
<td></td>
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<tr>
<td>TE-IF</td>
<td>7 M</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>EE-IF</td>
<td>7 M</td>
<td>2</td>
<td></td>
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<tr>
<td>DF-BS</td>
<td>9 F</td>
<td>3</td>
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<td>HG-BS</td>
<td>8 F</td>
<td>3</td>
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<td>PH-BS</td>
<td>8 F</td>
<td>3</td>
<td></td>
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<tr>
<td>LI-BS</td>
<td>8 F</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>HJ-BS</td>
<td>7 F</td>
<td>3</td>
<td></td>
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<tr>
<td>EK-BS</td>
<td>8 F</td>
<td>3</td>
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<tr>
<td>HL-BR</td>
<td>9 F</td>
<td>4</td>
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<tr>
<td>NM-BR</td>
<td>9 F</td>
<td>4</td>
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<tr>
<td>SO-BR</td>
<td>7 F</td>
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<tr>
<td>AP-BR</td>
<td>7 F</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MQ-IF</td>
<td>11 F</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>ZR-IF</td>
<td>9 F</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

-IF participant in workshops held in the Informatics Forum
-BS participant in the Brownies workshops, member of the Squirrel six
-BR participant in Brownies workshop, member of the Rabbit six

4.3.2 Workshops 1 and 2

Workshops 1 and 2 were conducted with groups of five-to-nine year old children. Workshop 1 comprised two unrelated 7 year old boys (AA-IF and AB-IF) and 5 year old twin girls (NC-IF and LC-IF). Workshop 2 comprised two sets of siblings: brothers
TD-IF (7yrs) and FD-IF (9yrs), and brother and sister TE-IF (male, 7yrs) and EE-IF (female, 9yrs). The participants were enthusiastic and active, talking at length about animals that they like, the types of games that they like to play and acting out animal-based games.

During workshops 1 and 2, the researcher found that the planned activities were not appropriate for the participants. The participants struggled to describe possible personalities of zoo animals, they preferred to talk about games to play with the animals. The question “what sorts of games might the animals play” was too ambiguous- the participants thought that they were supposed to talk about games that actual zoo animals would play. The researcher followed the lead of the children and guided their discussion about animals and games, with the result that AA-IF, AB-IF, EE-IF and TD-IF produced full mini game designs. The other participants enthusiastically contributed ideas about game features, the games they enjoy playing, expressed their animal likes and dislikes, spent time drawing pictures of animals and participated in the sharing and evaluation of game ideas at the end of the session.

The workshop discussion and game designs were analysed to uncover the features that make games attractive to the workshop groups. Preferred game types were both platform style games and immersive, open world games. The participants were positive towards both goal-based and open ended games. A constant feature of design was missions and quests to fulfil, often with the aim of helping a character in need. In terms of game mechanics, earning points, collecting tokens, power-ups giving special abilities and multiple game levels featured heavily in designs and discussion. Some participants (AA-IF and TD-IF) favoured games with battles, health points and clear winners and losers. Other participants joined in with discussion about these games but did not design games of this type.

The following games were designed during workshops 1 and 2.

D1: Feed the Giraffe
D2: Cheeky Monkeys
D3: Animal Transformation
  Adventure, human becomes snake

**D1: Feed the Giraffe**, designed by AA-IF. The objective of the game is to feed the hungry giraffe.
4.3. Outcomes

1. The player feeds carrots to the giraffe by throwing them into its mouth using a sweeping gesture
2. Player gains points for feeding the giraffe
3. As the player gains or loses points, the giraffe speeds up and slows down- adaptive difficulty levels
4. At a higher level, the player is given a selection of foods for the giraffe. There are high-point items, regular-point items and point-loss items.

D2: Cheeky Monkeys, designed by AA-IF with contribution and discussion from AB-IF. The objective of the game is to retrieve a camera stolen by the cheeky monkey.

1. Platform style game
2. Player progresses through multiple levels
3. For difficult or non-Intuitive moves, e.g. swinging on vines, the player will be shown an animated tutorial
4. At the end of the final level, there is a boss battle with the monkey king to retrieve the camera
5. The player and monkey king have health levels, the first to reach zero loses

D3: Animal Transformation Adventure, designed by AB-IF.

1. Immersive, explorable game world
2. Player transforms into different animals to complete different quests. For example, transforming into a snake to slither under a locked gate, transforming into a penguin to swim across the sea
3. Player can collect power-ups to go faster or have special abilities

D4: Swimming Penguins, designed by AB-IF. The player has to make a penguin swim and collect food for baby penguins that have lost their mother.
D5: **Polar Bear Jump**, designed by AA-IF.

1. Platform style game
2. Player must control the polar bear jumping across ice bricks and collecting coins
3. Player progresses through five progressively more difficult levels
4. If the polar bear falls into the water, the player returns to the beginning of the level

D6: **Penguinator**, designed by EE-IF with contribution from TE-IF. The objective of the game is to raise penguins.

1. Collect fish, put fish into the Penguinator machine to receive a penguin egg
2. Look after the penguin egg, raise the penguin
3. Fish are also food for penguins

### 4.3.3 Workshops 3 and 4

Workshops 3 and 4 were conducted with groups of unrelated seven-to-nine year old girls who were part of a local Brownie unit. The participants were grouped by their Sixes (small groups who participate in activities together at the weekly Brownie meetings). Workshop 3 comprised members of the Squirrel six: one seven year old girl HJ-BS, four eight year old girls HG-BS, PH-BS, LI-BS, EK-BS and one nine year old girl, DF-BS. Workshop 4 comprised members of the Rabbit six: two seven year old girls SO-BR and AP-BR, and two nine year old girls HL-BR and NM-BR.

The participants coped well with the workshop, which was revised after workshops 1 and 2 to focus more on discussion about preferred games and practical, concrete game design activities. During the workshops, the participants were asked to share their favourite game and a reason that they like it. They were then asked to design games in pairs and finally shared their designs with the other participants.

When asked about their favourite games, the participants had a range of interests. Some named creative or open ended games, such as a nail painting game, a babysitter game, Township (a city and farm simulator) and a music creation app. One participant liked Minecraft because she can build anything she likes and play with her faraway cousins. Others preferred goal oriented games including Angry Birds, Disney Crossy Road and Temple Run.

Reasons given for enjoying these games were high scores, excitement, game world exploration, playing with favourite characters (as in Disney Crossy Road), creativity and social play.

After discussing favourite games, the participants were asked to work in pairs and design a game featuring a zoo animal. The results were varied and reflected the games enjoyed by the participants, with a mixture of chasing/level games and creative open-ended games. The following games were designed during workshops 3 and 4.
4.3. Outcomes

**D7: Escape the Zoo**, designed by HG-BS and DF-BS. The player is an animal character and the objective is to escape the zoo.

1. Manoeuvre around the obstacles
2. Collect the coins
3. Collect the mystery boxes
4. The game will have multiple levels with different animals
5. At the successful end of the level, the player gets an animal fact

**D8: Bath the Giraffe**, designed by LI-BS and EK-BS. The objective is to chase, catch, and bath a giraffe.

1. Chase the giraffe, collecting bath items
2. Tripping up will send the player back to the start
3. Collect six stars to go faster and be able to catch the giraffe
4. Catch the giraffe and bath it in the golden bath (top right corner of figure D8)

**D9: Animal Creative**, designed by HJ-BS and PH-BS. This is an open-ended creative game.
1. Immersive, explorable zoo world

2. The zookeeper needs the player’s help- the zoo was boring and no one came, so the zookeeper asks the player to build exciting new animals

3. Player moves around the zoo and collects animal body parts

**D10: Penguin Race**, designed by SO-BR and AP-BR. This is a game for one or two players.

1. 1 player + 3 computer penguins, or 2 players + 2 computer penguins
2. Each player has a button and a smile icon
3. When the icon lights up, the player presses the button to move forwards. If the player presses the button when the icon is dark, they get a freeze penalty

**D11: Zoo and Mini Games**, designed by HL-BR and NM-BR. The game is based around a zoo map with pictures of animal faces linked to mini games. The games are briefly described and are required to have three difficulty levels.

1. Penguin: race the penguins
2. Koalas: hide and seek, koalas pop out from behind trees and player must click to catch
3. Panda: dress up
4. Dolphin: teach the dolphin skills
5. Squirrel Monkey: race up a tree, correctly answering questions to progress
6. Reptiles: click the correct reptile (e.g. select the chameleon)
7. Butterfly: select all the butterflies of a given colour

### 4.3.4 Workshop 5

Workshop 5 was conducted with two unrelated girls, MQ-IF (11yrs) and ZR-IF (9rs). The participants were keen to talk about the zoo game as a whole, as well as designing
4.3. Outcomes

mini games and discussing some aspects of game play. Prior to the workshop, the researcher was informed that MQ-IF is not a confident writer, so writing should be kept to a minimum. With this in mind, the workshop was designed to be entirely verbal if preferred. With only two participants and a quiet environment, it was possible to rely on voice recording. The discussion session was conducted verbally instead of incorporating drawing and writing on sticky notes. During the game design session the participants were invited to draw, talk, or use a mixture of the two methods.

When asked about their favourite games, the participants were quick to share that for them, a very important aspect of a game is that it has variety. MQ-IF criticised games that are “the same over and over again” and was clear that she prefers to play games with plenty of variety. ZR-IF agreed, saying that if you have multiple mini games, they should all be different types of game.

The participants then moved discussion to the zoo game. During discussion of the general structure of the game, MQ-IF suggested that the player should be shown ten animals but only be allowed to choose five. She felt this was a realistic situation and that would be good for children to learn.

MQ-IF suggested that within the game you should be able to visit different habitats and their native animals. ZR-IF referred to an educational game that she enjoys playing, in which the player visits a habitat and is required to answer questions. When enough questions are answered, the player can choose a new animal to add to the habitat. Although she was unable to remember the name of this game, she felt that it was a very enjoyable game because of the animal rewards and the inclusion of mini games.

The final part of discussion centered on game features. Both participants enjoyed having missions and quests in games, this was more important to MQ-IF than it was to ZR-IF. Both enjoyed having reasons to play games and felt positive about achieving goals. ZR-IF reported that she does like to play Minecraft in an open-ended, goal-free way. In contrast, MQ-IF reported that when she plays Minecraft she sets herself quests so that she has “a reason to bother playing”. The participants designed animal-based games individually. ZR-IF made a detailed drawing for her game, MQ-IF chose to draw a little then describe her games verbally.

![D12: Monkey Nut Crack](image)
**Monkey Nut Crack**, designed by ZR-IF.

1. Player has to tap the nuts to crack them for the monkeys to eat
2. The game is timed; the timer (top right in figure D12) counts down in a circle from day to night
3. There is a nut-crack counter
4. The objective is to crack as many nuts as possible by nightfall

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**D13: Orang-utan Helper**, designed by MQ-IF. The objective of the game is to return the baby orang-utans to their mothers.

1. Player is an orang-utan and can swing between areas shown in figure D13
2. Player must pick up baby orang-utans and find their mothers
3. Success will be indicated by the mother and baby’s faces going from sad to happy, a “ping” sound and the baby orang-utan saying “I’m with my mummy!”

**D14: Penguin Rocks**, designed by MQ-IF. This is a story-based game: a penguin comes to the player for help, saying that he has an egg about to hatch but is unable to climb to get any rocks for a nest. The player’s goal is to collect rocks for the penguin’s nest.

1. The player has a customisable human avatar
2. The game is set in an explorable world based on the real-life Edinburgh Zoo penguin enclosure
3. Player moves around the world, speaking to penguins to get clues about the rock locations
4. After collecting enough rocks, the player returns to the parent penguin and is rewarded
5. In figure D14, the penguins are represented by circles, the rocks by dots and the open space is water
4.4 Discussion

During the workshops, the participants discussed games they play, games they like and the designs of new games. Analysis of these discussions revealed themes and features that the participants find desirable and enjoyable in games.

Game Style

- Mission/challenge, often centered around taking care of animals/vulnerable characters.
- Possibility of losing
- Both goal-oriented and open-ended play
- Adaptive difficulty levels
- Opportunity for creative play
- Variety of game styles included
- Enemies to overcome
- Platform games
- Games with an open-ended world to explore

Game Mechanics

- Picking up collectibles
- Earning and losing points, high scores
- Progressing difficulty levels
- Time-limited play
- Surprises
- Power-ups
- Health levels (of player and enemies)
- Rewards

4.5 Design Requirements Arising

4.5.0.1 Clear Requirements

Requirements from Design Workshops

- The mini games will include a variety of game styles, including both goal-based and open-ended games
• The application overall and each mini game will have a story and a mission for the player
• Goal-based games will incorporate point scoring and item collection
• The mini games will have variable difficulty levels
• The games will be designed using ideas generated during the design workshops

**ASC-Specific Requirements Gathered from the Literature Review (Chapter 2)**

• The design will be simple and clear (Hayes et al, 2010)
• The application and mini games will be adaptive to children across the spectrum of ability and age (Hayes et al, 2010)
• The application will give personalised responses (Fletcher-Watson, 2014)
• The application and games will include rewards (Fletcher-Watson, 2014)
• From literature on cognitive skills and sensory preferences
  – The player will be able to control the volume
  – The screen will not be overly bright or crowded
  – There will not be unnecessary items on screen
  – One piece of information will be presented at a time

**4.5.0.2 Features Requiring Consideration**

**Suggested Requirements from Design Workshops**

• It will be possible for the player to lose the game

Experts and parents should be consulted to determine whether the young player with ASC should lose the game or if all feedback should be positive (i.e. “Well done, you tried hard”). Within existing games for young players, many ensure that all interaction is positively rewarded and do not incorporate point or game loss.

• Games will include be enemies to defeat

This was a popular feature, but there is concern that the young player may be unable to overcome the enemy or unable to comprehend that they should overcome the enemy, potentially leading to frustration over ill-understood point loss.
Chapter 5

Design and Implementation

This chapter describes the initial design, formative evaluation, revised design, and implementation of the application. The application has three main components: the visual schedule-based planning activities, an interactive virtual agent and a set of mini games. Following the initial design, the prototype application was evaluated by experts in the area and child participants who contributed to the pre-design phase. Finally, the application was refined and implemented.

5.1 Initial Design

During the concept development phase (Chapter 3), a zoo theme was initially chosen as a neutral, child-friendly option. Zoo animals appeal to both genders equally, are suitable for all ages and for child participants living in Edinburgh, are likely familiar from real life zoo visits. During the pre-design phase, all participants responded positively to the theme and were engaged when thinking about zoo-animal based games. When asked if they would choose to change the theme of the game, the majority of the participants opted to keep the zoo theme with two, FD-IF and TD-IF suggesting a space zoo theme. Based on the participant responses, the zoo theme was confirmed as an appropriate theme for the game.

8 of the 14 games designed during the pre-design phase (D1, D4, D6, D7, D9, D12, D13, and D14) had the explicit goal of helping or looking after the animals. In addition, a number of the participants’ favourite games had a helping or caring theme, for example, a babysitting game and the Nintendogs franchise. This was true among both male and female participants. Therefore, the mini games will centre on helping the animals. During all design workshops, participants spoke favourably of having storyline, quests, and reasons to play. Therefore, the premise of the game as a whole will be that the player has to become an assistant zookeeper and spend a day in the zoo looking after the animals.

In the literature review (chapter 2), the use of visual schedules with children with ASC was explored. As visual schedules are a commonly used and effective aid to planning
and self-monitoring, this application aims to help the user develop independent skills in their use.

The design of elements of the application is now discussed in detail.

5.1.1 Virtual Agent

In the zoo world, the player will progress though the planning activities and animal care mini-games under the guidance of the zookeeper virtual agent. The overall application is designed to be an intelligent tutoring system: it will give basic direct instruction but focus more on feedback and explanation to the user. Most importantly, it will provide a context to apply the skills being developed (Pain, 2015).

The use of virtual agents in intelligent tutoring systems is supported in the literature. Betty’s Brain (Biswas et al., 2005), and the AutoTutor family (D’Mello & Graesser, 2012) are two intelligent tutor systems with virtual agents as core components. The agents have different roles in the applications- in Betty’s Brain, the task of the student is to teach the virtual agent, Betty, by adding knowledge to the agent’s brain. The agent in AutoTutor is a tutoring agent, taking on the role of a traditional human tutor. Both approaches to virtual agents produced positive educational effects.

The virtual agent will be embodied in the application and will provide scaffolded prompts and affective feedback to the user, as in AutoTutor and Affective AutoTutor (D’Mello & Graesser, 2012). The application will not emulate the full dialogue and feedback of the AutoTutor agent; such interaction would not be accessible to four to eight year old children. Instead, the zookeeper will encourage interaction with the game and give feedback to the user’s actions. This is more appropriate for the target audience. Affect detection and affective loop as implemented in Affective Autotutor is well outwith the scope of this research. The affect implementation will be simpler, using the state of the application and the user’s input to predict their affective state.

Although the application will not explicitly use a Betty’s Brain-style virtual agent, the application is designed to promote feelings of responsibility in the user. This is done through the storyline- the zookeeper needs help- and the animal care themes of the mini games.

The ECHOES project (Bernardini et al., 2014) found that children with ASC can benefit from software incorporating virtual agents. The project used a virtual agent as a social partner for children with ASC and found that the children enjoyed interacting with the agent, appearing relaxed and showing abilities that their teachers had not previously observed. The ECHOES project and this research have different goals and are different types of game, but the findings of the ECHOES project suggest that children with ASC will at worst find the incorporation of a virtual agent neutral, and at best, will find it beneficial.

In summary, this is the role of the zookeeper agent is to:

• Tell the game story
5.1. Initial Design

- Provide scaffolded prompts
- Assist the user to apply new skills in context
- Provide affective feedback

5.1.2 Planning Activities

A difficulty of designing software to improve executive function is that the domain is ill defined and real world applications of skills can be open ended with no clear completion or success criteria. However, the use of a visual schedule is an assessable, clearly defined task. As discussed in the literature review, visual schedules are an effective intervention for children with ASC. This application, therefore, aims to support use of visual schedules and provide an environment where the child can experiment with making choices and creating and following their own plans.

In the game, the player must make a plan of animals to visit and visit the animals in the order that they planned, playing a mini game with each one. This task is broken down into the following steps:

![Flowchart of Game Structure](image)

Figure: Flowchart of Game Structure

In order to minimise cognitive load and visual stress on the user, these tasks will be presented on individual screens. This is beneficial for the child with ASC in that they will be presented with one piece of information or task at a time, an approach recommended by experts (cite). However, it does raise the challenge of ensuring that the flow of the game makes it clear that the individual activities relate to each other and form a story arc. Children with ASC can tend to see situations as a collection of discrete, unrelated parts, so care will need to be taken.

During the planning activities, the Zookeeper agent will provide storyline, guidance and scaffolded support. The Zookeeper agent is intended to be a constant feature in the game, indicating through its presence and story telling that the individual tasks build towards an outcome. This should address the above issue.

In order to minimise cognitive load on the user and to ensure that the child with ASC is being given one task at a time (as recommended by), each of these tasks will have its own screen. The design of the screens will be minimalist to avoid visual distractions.

During the planning activities the zookeeper agent will provide basic guidance and scaffolded support. The feedback will be personalised with the player’s name.
5.1.2.1 Choosing Animals

In the Choosing Animals scene, the player is asked to select three of five animals to visit. This is a design decision taken from pre-design workshop 5 (Section 4.3.4). Children with ASC can experience difficulty making choices, so the game’s gentle choice making is intended to explore choice making, including making “wrong” choices.

There are two prototype designs for this scene. Scene A is a more natural scene with animal layout identical to the Game Selection scene that the child will encounter later in game. Scene A was favoured by NT and described verbally by participants during the workshop, as well as featuring in design D10. However, it is a bright, busy scene, contravening the design requirements for children with ASC (Section 4.3.6.1).

Scene B is calmer visually, which is in keeping with the design requirements for children with ASC. However, as children with ASC experience rigidity of thought, there may be difficulty understanding that scene B connects to the later selection scene.

When the player is choosing animals, there are two potential scenarios. Scenario 1 is that the player has free choice. Scenario 2 is that the player is given a prompt, e.g. “Today the monkeys are hungry”. The player should then infer that they need to visit the monkeys. However, there will not be a strict “right” answer. The intention is to allow children to explore different choices, including suboptimal choices.

During this scene, the zookeeper provides affective feedback and verbal prompts. The affective feedback is given in response to the animal choices, with a happy face in response to choices (scenario 1) or in response to selecting the prompt animal (scenario 2). In scenario 2, the zookeeper gives concerned affective feedback if the prompt animal is not chosen.

5.1.2.2 Ordering Animals

The player will drag and drop the selected animals onto the empty visual schedule. Scene A provides an animated tutorial, as suggested by AA-I in game design D2 (Section 4.3.2). The player would be shown the animated tutorial and then progress to
Scene B, where they make their own choices. While including Scene A design takes a participatory approach, the inclusion of a tutorial prevents the user from experimenting and achieving success independently. It is questionable whether the tutorial is necessary at all— the only interactions available to the player are the drag and drop scheduling actions. In addition, there is concern that the player would simply repeat the zookeeper’s actions rather than making their own choices. If the player had not selected the same animals as in the tutorial, there is potential for confusion related to rigidity of thought (i.e. the player cannot understand why the sets of animals change).

During this scene, every interaction will be narrated. For example, tapping an unscheduled butterfly icon will prompt “When shall we visit the butterfly”, tapping an empty schedule space will prompt “What animal shall we visit first/second etc.”, tapping a filled schedule space will prompt “We’re going to visit the butterfly second”.

The schedule creation will have two levels of scaffolding. At the first level, the player is instructed to drag and drop the icons into the schedule and given time to experiment. If they do not progress (i.e. they have not placed icons within some interval of time”, the assistance level will increase, becoming “Click on the animal you would like to visit first”, on click the icon moves to the schedule space as if it was being dragged and dropped.

5.1.2.3 Using the Schedule: Game Selection

The game selection scene is visually busy, which may pose a challenge to some users. To select the next game, the user must look to the schedule, identify the next unvisited animal, and find that animal within the scene. This scene has three scaffolding levels after the player is unsuccessful in choosing the next animal.

1. Highlight the schedule, prompt “which animal is first”

2. Prompt “The giraffe is first, tap it in the picture”

3. Highlight the giraffe in the picture and repeat prompt “The giraffe is first, tap it in the picture”
5.1.2.4 Monitoring Progress

After playing the mini game, the player progresses to the monitoring scene. In this scene, the player taps the visited animal. The zookeeper provides a scaffold in response to incorrect taps.

5.1.3 Mini Games

5.1.3.1 Dress the Pandas

Dress the pandas is a creative mini-game in which the player dresses the pandas in variety of clothes. The clothes are stored by type in the pull-out drawers to the left of the figure and are dragged and dropped onto the pandas. Fulfils design requirements by being a creative game and a unique type of game within the mini games set.
5.1. Initial Design

This game is based on designs D8, D10 (Section 4.3.3); the creative games that children play and the fact that children specifically wanted games that were not points/challenge based. The design takes inspiration from the Toca Boca family of games (see figures below). Toca Boca games are open-ended, language free games for young children, anecdotally they are also popular with older children with ASC and are accessible to those with intellectual disability due to their intuitive, responsive design.

The left hand figure shows the character’s gaze following the player’s actions. The right hand figure shows the character’s affective response to a questionable move by the player: putting salt on a pear. The game characters respond to all player interaction and if there is no interaction, the players move to attract attention and the food cabinet is pulled out, prompting the child to explore, touch and select a foodstuff.

The panda game will have a free play mode and a panda prompted mode. In the panda prompted mode, the pandas will make statements like “I want to wear green” and will give feedback on the player’s choices through affect, in the style of the Toca Boca apps.

In this game, the zookeeper will narrates choices, e.g. “the panda is wearing blue shirt” and detect inactivity, then drawing attention to the next step in the dressing process, again in the style of Toca Boca apps.

A low stress option is not necessary for this game.
5.1.3.2 Catching Butterflies

This game is based on game designs D4 and D10 (section 4.3). Coloured butterflies fly around the screen, the objective is to earn points by catching the butterflies as directed within a time limit. The player will be given randomly generated tasks to complete, i.e. “catch three red butterflies”. The player is given points for each butterfly caught, when the task is completed, the player is rewarded with bonus points and a new task is given. This is repeated until time runs out and the endgame sequence is played. An AI implementation works to prompt and encourage the player, vary the difficulty within a level and indicate when the difficulty setting should be increased. The game has 4 different difficulty levels and a low-stress setting.

![Butterfly Game](image)

**Figure: Butterfly Game**

**Game components**

*Score counter:* displays the score to the player. 1 point rewarded for correctly catching a butterfly, 1 point lost for incorrectly catching a butterfly, 5 points rewarded for completing a task.

*Timer bar:* displays remaining game time to the player (not visible in low stress version).

*Butterflies:* animated (wing flapping) butterflies fly on random paths, avoiding collision by Unity’s collision engine. A butterfly is caught by tapping it. If a butterfly is correctly caught it will disappear with a reward sound, 1 point will be added to the score counter, the player will be told “well done”, and a replacement butterfly will join from the side. If the player incorrectly catches a butterfly they will lose 1 point (in level 2 and above) and will be prompted to try again. After the successful completion of a task the speed of the butterflies increases.

*Instruction box:* each task is randomly generated (within parameters) and displayed to the player with narration.
Progress bar: at the beginning of the task the progress bar shows \( x \) blacked out butterflies, where \( x \) is the number of butterflies to be caught in the task. The bar fills in with butterflies as they are caught (the colour in the bar matches the colour of the caught butterfly).

Prompting: if the player is inactive for \( x \) seconds, the narrator repeats the prompt and the prompt box flashes to draw attention. When the player correctly catches a butterfly, the narrator says “well done, you caught a red/blue/etc. butterfly”. When the player catches an incorrectly coloured butterfly the narrator says “try again”, if the player then makes another mistake the original prompt is repeated.

Game Levels

Level 1: This is the simplest level of the game. Players will be instructed to catch a number of butterflies with no colour or sequencing requirement. The player cannot lose points. The timer is active and displayed to the player.

Level 2: Instructions have number and colour requirements, e.g. “catch three green butterflies”. The player loses points for incorrect selections.

Level 3: As level 2, instructions now have more complex number and colour requirements, e.g. “catch one green and two red butterflies”.

Level 4: As level 3, instructions have sequencing requirements, e.g. “catch one blue butterfly then two purple butterflies”.

5.1.3.3 Feed the Penguin

This game is based on design D4 (section 4.3.2), which was enthusiastically received by the participants in the group.

The player controls a penguin and must catch fish while avoiding the rocks. The fish move around the screen and the player is given the goal of catching five. If the player
hits a rock, a fish is lost. The game ends when five fish have been collected. The game meets the design objectives by having item collection and variable levels.

This game has three levels: at the easiest level the fish move little from their original place and are not lost when a rock is hit, at the medium level the fish move on random paths, at the hardest level the fish move on paths and are lost when a rock is hit.

### 5.1.3.4 Bath the Giraffe

This game is based on designs D2, D3 and D9 (section 4.3). It combines the popular platform game design of D2 and D3 with the storyline and objectives of D9. During the game, the player moves through the platform level and collects bath items. When these items have been collected, the end scene is an interactive bath picture, with features like clicking bubbles to make them pop.

![Image: Bath the Giraffe](image)

The giraffe moves forwards at a constant rate, the player must interact by tapping on the screen to make the giraffe jump and progress over obstacles. This ensures that the game is accessible to children with low computer game skills. As well as the collectable bath items, there will be pick-up stars along the route providing reinforcement, as in design D3.

Variable levels of difficulty are implemented by having multiple platform levels- i.e. levels set in different scenes, as seen in Mario and other popular platform games. At the easiest level, the giraffe will progress and the game will be completed as long as the player taps on the screen. At the medium level, the game will have enemies that will bounce the player backwards, impeding progress. At the hardest level, the game will have gaps in the ground that if hit, will cause the giraffe to fall and return to the beginning of the level.

### 5.1.3.5 Feed the Animals

This game is based on designs D1 and D12 (section 4.3), and the idea of feeding animals in the zoo which was popular in discussion and design across all workshops (see designs D4 and D6).

The player is shown three animals, each animal has a thought bubble with a picture of the food that it would like to eat. The player’s task is to choose the correct food from the bowl and feed it to the animal by dropping it to their mouth. When the animal is fed, it provides feedback (smile, happy sound for correct food, frown, sad sound for
incorrect food) and a new food prompt is generated in its thought bubble. This part of the game is from design D1.

Aspects of design D12 will be used to control the timing, points and gameplay. This is a timed game, the timer will be a day-to-night transition picture with countdown as in D12. Points are gained by feeding the animals, in more difficult levels points can also be lost. The objective is to earn as many points as possible in the time period. The game has three levels:

1. Points and positive animal feedback given for feeding any food to the animal
2. Points and positive animal feedback only given for feeding the correct food to the animal
3. Points and positive animal feedback given for feeding the correct food to the animal, points lost and negative animal feedback given for feeding the incorrect food to the animal

Losing points can be hard for children, as can being given negative feedback. The animals’ responses will be designed to be amusing (i.e., looks of shock, sounds like “eugh!”, screwed up face) in an attempt to prevent overly negative responses to the feedback. This feedback is inspired by the Toca Boca app referenced in the Dress Panda game, where the negative feedback is amusing rather than punitive.

5.2 Expert Evaluations

JH-E, HT-E and MW-E formatively evaluated the initial application design during semi structured interviews. Mock ups of the design of the game (figures P1-6 and G1-5 in Section 5.1) were used to guide the evaluation. As the expert with most experience working directly with young children playing digital games, JH-E was asked to evaluate the mini game designs. HT-E and MW-E have more experience in the area of design
for individuals with ASC, they were asked to evaluate the premise, virtual agent and planning aspects of the game.

Table 2: Expert Evaluators

<table>
<thead>
<tr>
<th>Expert</th>
<th>Background</th>
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<tbody>
<tr>
<td>JH-E</td>
<td>Preschool assistant with 16 years’ experience working with children aged 2.5 to 5 years. The setting frequently uses a SMART board, the children actively interact with games and stories. JH-E is the IT specialist. The children are predominantly native English speaking and typically developing.</td>
</tr>
<tr>
<td>HT-E</td>
<td>Academic in the area of supportive tool development for individuals with specialised communication and learning needs. In particular, HT-E has recently been involved in research supporting children with ASC using serious game environments.</td>
</tr>
<tr>
<td>MW-E</td>
<td>PhD student with research experience at Masters and PhD level in technology development for children with ASC. MW-E has spent time in schools observing children with ASC, has undertaken placements with diverse groups of children with ASC and has worked with 5-8 year olds with ASC in a local special school setting.</td>
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5.2.1 Zookeeper Agent

The Zookeeper agent was well received by evaluators HT-E and MW-E, with HT-E saying that positive affective feedback from the zookeeper is an appropriate reward during the planning activities. Discussion focussed on the affective feedback and scaffolded prompts offered. The Zookeeper design has three faces- happy, neutral and negative. HP-E felt that the emotion faces should be kept clear and simple, agreeing with the initial design choice.

Both HT-E and MW-E suggested that the Zookeeper’s affective feedback be extended from the three static faces. MW-E noted that in real life, affective state is inferred from dynamic facial expression, tone of voice and context. HP-E suggested that the Zookeeper’s feedback uses the whole body’s language, for example, having the Zookeeper jump up and down as well as smiling.

Both HT-E and MW-E were positive about the use of scaffolded prompts, with MW-E feeling that scaffolded prompts were an appropriate way to make the game accessible to players with a variety of ability levels. MW-E was clear that among children with ASC, there can be a disparity between chronological and developmental age and as such, the game needs to ensure that it has the capacity to provide enough support.

MW-E advised that the game provides visual structure as well as verbal support, as many children with autism prefer visual prompts. This advice is supported by the
findings in the literature review (Section 1.3). MW-E suggested visual scaffold structures including highlighting the borders of items to select during the planning scenes and having items move to attract attention if the child is struggling to find the correct choice. This was advised in particular for the game selection (P4) scene. However, MW-E cautioned against avoiding verbal prompts entirely in favour of visual prompts as language development is important for children with ASC. MW-E felt that the short and simple prompts were suitable for the target audience.

5.2.2 Planning Activities

Evaluation of the planning activities involved discussion of different design choices such as the inclusion of a prompt to choose a specific animal to visit, the visual design of scenes, and the level of support provided by the Zookeeper’s prompts. The evaluators also raised questions about design decisions that had not been previously considered, including allowing the player to change the plans and having the game make interruptions to the player’s plans. These questions were discussed in detail during the summative evaluation sessions conducted with individuals with ASC (Chapter 6).

MW-E felt that the planning activities were appropriate to the group and should be within their ability. She believed that it could potentially help with planning, as plan creation is enforced in the first steps (the planning activities) and reinforced during the game as the player consults the schedule to find the next activity and engages in self-monitoring activities after mini-game play.

MW-E was very positive about the planning aspect of the game, feeling that it’s important for children to be able to make and follow their own choices, and experience the consequences of doing so (e.g. sadness at not being able to visit all animals, or regret at not choosing an animal during the planning stage that they later want to visit).

Choosing animals to visit: There were two initial designs for this activity. The first was for the player to have freedom to choose any three of the five animals, the second was for the Zookeeper to give a prompt that the child would have to infer to choose the animal based on the perception of need, e.g. “The monkeys are hungry”. Questions to be explored during the evaluation were whether the inference activity was suitable for the target audience, whether the use of a prompt animal is appropriate and if so, should it be mandatory to visit the animal and what consequence should there be for not visiting.

HT-E thought it likely that the older children in the target group would be able to make the inference. She suggested implementing both designs, as prioritising an activity based on need is an important skill to learn within planning, but for some children it would be more suitable to allow free choice. MW-E shared the opinion that it is important to learn to make priority-based choices. HP-T noted that the requirement to make choices may be difficult for children with ASC, so this should be the basic level of the game. HT-E strongly suggested that the Zookeeper gives positive reinforcement to all choice making, e.g. “Good choice, the monkeys need feeding today”, in both the
prompt and non-prompt versions of the scene.

The graphic design of the scene was also discussed. The researcher explained that the more realistic scene P1 was favoured by the typically developing design participants (see figure D10, section 4.3.3), but that scene P2 was designed to adhere to the design requirements for children with ASC outlined in section 4.5. HT-E felt that while scene P1 gives more context, scene P2 is more appropriate for children with ASC and that scene P2 would connect more smoothly to the schedule creation scene that follows. Discussion of the broader game structure followed, HT-E liked the idea of having a set of planning activities (choosing animals, making a schedule) and then moving into the realistic game world.

**Creating a schedule** A design decision to be made in the schedule creation scene is whether or not to preface the schedule creation activity with an animated tutorial. Animated tutorials were suggested by the design workshop participants, e.g. in design D2 (section 4.3). However, there was concern about the inclusion of a tutorial (see section 5.1.2.2) so the question was brought to the evaluators. HT-E felt that the concerns raised by the researcher were valid and the animated tutorial should not be included. HP-E believed that appropriate scaffolding in this scene would negate the need for an explicit tutorial.

**Using the schedule, choosing the game:** HT-E felt that this scene was appropriate for its purpose but that as it was more visually complex and requires the player to correctly refer to the schedule and find the matching animal, scaffolded support is important.

**Extensions to the planning activities:** During discussion of the planning activities, both HT-E and MW-E suggested extensions to the planning task. It was suggested that the player be able to go back and change their choices and that at an advanced level the game would interrupt the player’s plan, requiring them to re-plan in response.

Both HT-E and MW-E suggested that the player should be able to go back and change their decisions about animals to visit and the order of the schedule. MW-E felt that as in the real world, plans often can be changed and children with ASC can experience difficulties in this area, it would be beneficial to allow the child to change their plans if they desire, reinforcing that plans can be changed. MD-E believed that allowing the child to change their plans gives the child more flexibility and agency, it supports exploration and playful activity rather than having to follow a certain series of events.

HT-E suggested that at a more advanced level the game should interrupt the player’s plans. For example, if the player has chosen to visit the giraffe second, at the point where the player correctly selects the giraffe as the next animal to visit the Zookeeper would say “Sorry, the giraffe is sick, we need to change the plan”. HT-E felt that this more sophisticated planning activity could be beneficial, but also upsetting to a child who experiences rigidity around their plans or is looking forward to playing a specific mini game.

MW-E was asked her opinion on the idea of interrupting plans. She believed that it would be a good challenge to include at an advanced level of the game as in the real world plans do change unexpectedly and this is something that can be distressing to children with ASC. MW-E believed that it would be beneficial to allow the child to
observe and experience appropriate reactions to interrupted plans within a game environment. MW-E suggested a scaffolded approach to interrupting plans, with the intention of minimising distress and teaching the player an appropriate way to manage these interruptions. First, at the planning stage when the giraffe (for example) is selected, the Zookeeper would give warning, saying “The giraffe doesn’t need to have a bath today. We will go and feed her instead”. That way, the child still visits the expected animal and participates in an enjoyable activity. The interruption could then progress to “The giraffe needs to rest today, let’s visit a different animal instead”. Finally, there would be the possibility of including interruptions with no warning during gameplay. MW-E advised that the key to minimising negative reactions here is to give interaction around the interruption (i.e. asking the player to choose an alternate activity rather than simply saying “You can’t do that, let’s move on) and introducing the interruption gradually with modelling, teaching the child a good way to react to change.

5.2.3 Mini Games

HT-E and MW-E gave general feedback on the game designs, JH-E gave in depth feedback. HT-E and MW-E approved of the game designs, with HT-E especially approving of the inclusion of a low stress option for games that involve timing and potential loss. HT-E explained that for some children, timing and loss are difficult to cope with. The researcher agreed that as the mini games are intended as rewards for successfully following the schedule and the intention is to have the child follow the entire schedule; the games should be fun and should not cause distress that may cause the child to abandon the game (and planning and self-monitoring activities) part way through.

However, HT-E noted that many children do want to know their scores and progress, do enjoy the excitement of having a timed game and do enjoy the challenge of having to avoid losing points. HT-E advised that the key here was flexibility- the game with challenging levels and point loss should be implemented, but it should be possible to ensure that a child does not encounter certain situations. This could be done by allowing the parent to enforce the low stress setting or restrict the game levels that the child can access.

MD-E felt that the games should be short with a defined end point, as there is a risk with all children that if there is a pleasant activity as a reward for work, they will not want to give up that activity and return to the work.

JH-E evaluated the games from the perspective of a professional working with 2.5 to 5 year olds. Although these children are younger than the target age range, if the easiest levels of the mini games are suitable for typically developing pre-school children, then it is likely that they will be accessible to children with ASC that are developmentally younger than their chronological age. However, the more advanced levels of the game should be too difficult for the pre-school children, making the game appropriate for a variety of children and ensuring that the player can progress in difficulty if desired.

JH-E responded positively to the game concepts, feeling that they would be attractive to the children within the preschool setting and that the easier levels of the games
would be suitable for preschool children. JH-E felt that there was a good variety of games and interaction types within the designs. Note that in this evaluation, the games were presented as touch screen games. JH-E noted that some children have difficulty using touch screens because they touch other parts of the screen unintentionally, affecting gameplay. She advised that tapping is a much easier action than dragging and dropping, with few preschool children requiring help with tap-based games but many requiring help with drag and drop based games.

When asked about countdown timers in games, as included in the penguin, butterfly and feeding games, JH-E responded that the preschool setting plays very few timed computer games, but that it could increase excitement and appeal to older children.

JH-E also noted that sound is very important to include in games, she has observe that the children within the preschool setting enjoy when games have sound. However this can backfire- in a frequently played animal matching game, several children make deliberate mistakes because they enjoy the “incorrect” sound much more than the positive reinforcement that the game gives for a correct response.

JH-E suggested that animations and responses to touch in the zoo background could amuse and engage children. On the other hand, she felt that it could have the potential to distract from the sequencing work.

JH-E gave evaluations of the individual mini game designs.

### 5.2.3.1 Dress the Pandas

JH-E liked that there would be a variety of clothes available to the children. A similar game is played in the preschool, the player has to drag and drop the bears’ clothes to the correct bear. The children enjoy this game and are particularly delighted when the bears give feedback in funny bear-voices. However, the game is unchanging and some children are uninterested after playing once or twice. In terms of controls, JH-E noted that some of the children have difficulty coordinating the drag and drop motion, in particular with keeping their finger on the board throughout. Some children find it frustrating to “drop” an object and not understand why, some require hand-over-hand assistance from staff to play the game. JH-E notes that this difficulty isn’t necessarily a bad thing, as practice helps children’s motor skills to develop.
JH-E felt that if the prompt was read aloud, the majority of the older children in the setting would be able to complete the prompted level of the game (example prompt “I want to wear red”). JH-E suggested that the prompts be extended to include two pieces of information, e.g. “I want to wear a red jumper”, or “I want to wear blue and green”, and that at an advanced level the prompt could be more abstract and life-skill focused, e.g. “It is sunny outside, what should I wear?”.

5.2.3.2 Butterfly Catching

JH-E felt that the easiest level of the game would be accessible to young children as it only requires a tapping action. JH-E liked the idea of having butterflies’ speed change in response to player success and noted that the game could have a wider application as a game played by multiple children in a free-play preschool or school setting. As the game would adapt to each child’s skill, children could come and go freely from the SMART board or tablet and play the game independently, rather than needing an adult to reset the game and select a difficulty level for them.

JH-E believed that the two part instructions (e.g. “catch a green butterfly then two blue butterflies”) would be difficult for the majority of children in the preschool setting.

JH-E suggested that at a higher level, the game could include two types of animal for the player to distinguish between, for example, butterflies and birds. However, she felt that if the child was being required to distinguish between animal type, their prompt should be simple, e.g. “catch two birds”, rather than “catch two red birds” or “catch a blue bird then a butterfly”.

5.2.3.3 Penguin Swimming

JH-E felt that preschool children could definitely do the easiest level but that the hardest level sounds very challenging compared to the other games in the mini game set. She suggests brining it more in line with the other games.

JH-E was concerned that unpredictable fish movements could be frustrating to the child, especially in the hardest level where the child could experience the double frustration of struggling to catch the fish and losing the fish that they do catch by colliding with the rocks.

5.2.3.4 Monkey Feeding

JH-E really liked the concept of this game and felt that it would be engaging for children. Educationally, she approved of the matching aspect for preschool children. As with the panda game, she suggested having the hardest level require two pieces of fruit to be fed to the animal. As with the panda game, JH-E noted that some children would lack the motor ability to drag and drop the food to the animals.
5.2.3.5 Bath the Giraffe

JH-E found the concept of this game amusing and liked the idea of collecting the items necessary for a bath and then showing the giraffe having a bath as the end-activity reward. She believed that preschool children would enjoy the interactive bath scene as a game within itself. JH-E approved of the simplest level only requiring the child to tap on the screen to succeed, but she thought that all but the oldest/most computer experienced children would struggle to complete the hardest level.

JH-E suggested extending the bath scene into a game where the child has to bath the giraffe in the right order, e.g. touch the tap to run the bath, shake bubble bath into the water, drag and drop a shower cap onto the giraffe’s head, rub soap on the giraffe and touch the shower head to rinse the giraffe.

5.3 Children’s Evaluations

Following the expert evaluations, implementations of the penguin and giraffe mini games were tested in children’s evaluation workshops. The participants were asked to play the game, and then discuss the things they enjoyed most about the game, things they enjoyed least about the game and things that they would do to improve the game. A Likert questionnaire was used to prompt the children to think about different aspects of the game. Although Likert scales are the best rating-type to use with children (Laerhoven et al, 2004), there are methodical weaknesses to using Likert scales as the sole form of feedback. Children can be hesitant to give negative feedback, giving an untrue picture of their experiences in game testing (Hall et al, 2016). For this reason, the questionnaires are a tool to encourage the participants to consider different parts of the game, rather than a tool for data collection.

During the evaluation sessions, it was clear that this decision was appropriate, as participant AC-IF refused to give feedback, quickly selecting “neutral” for every question and participants in workshops 3 and 4 were uninterested in filling out the questionnaire, preferring to play the game and talk. Some who selected a positive option in the questionnaire shared during discussion shared that they didn’t really like the aspect of the game.

Table 3: Evaluation Workshop Participants who Participated in Design Workshops
5.3. Children's Evaluations

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Sex</th>
<th>Workshop Session</th>
<th>Design Workshop Session</th>
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<tbody>
<tr>
<td>TD-IF</td>
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<td>2</td>
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<tr>
<td>FD-IF</td>
<td>9</td>
<td>M</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>MQ-IF</td>
<td>12</td>
<td>F</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>TE-IF</td>
<td>7</td>
<td>M</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>EE-IF</td>
<td>7</td>
<td>M</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>PH-BS</td>
<td>8</td>
<td>F</td>
<td>4</td>
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<tr>
<td>SO-BR</td>
<td>7</td>
<td>F</td>
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<td>4</td>
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<td>AP-BR</td>
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<td>4</td>
</tr>
<tr>
<td>LI-BS</td>
<td>8</td>
<td>F</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>EK-BS</td>
<td>8</td>
<td>F</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

-IF participant in workshops held in the Informatics Forum
-BS participant in the Brownies workshop, member of the Squirrel six
-BR participant in Brownies workshop, member of the Rabbit six

Table 4: Evaluation Workshop Participants who did not Participate in Design Workshops

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Sex</th>
<th>Workshop Session</th>
</tr>
</thead>
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<tr>
<td>AC-IF</td>
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<td>M</td>
<td>1</td>
</tr>
<tr>
<td>RC-IF</td>
<td>11</td>
<td>F</td>
<td>2</td>
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<tr>
<td>SD-BM</td>
<td>8</td>
<td>F</td>
<td>4</td>
</tr>
<tr>
<td>VE-BS</td>
<td>8</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>IG-BH</td>
<td>7</td>
<td>F</td>
<td>5</td>
</tr>
</tbody>
</table>

-IF participant in workshops held in the Informatics Forum
-BS participant in the Brownies workshop, member of the Squirrel six
-BM participant in Brownies workshop, member of the Mole six
-BM participant in Brownies workshop, member of the Hedgehog six

5.3.1 Outcomes

Participants across sessions were excited to see their game designs implemented, especially the Brownies who had designed the giraffe concept and the several participants who had designed games incorporating penguins. The researcher observed participants giving feedback on games that they had had a role in designing gave a greater amount of critical feedback than participants introduced to the game for the first time in evaluation.
5.3.1.1 Penguin Game

The penguin game was very well received by all participants. The participants chose to play the game together and were able to play the game with the instruction “use the arrow keys to move” and no other prompting from the researcher. The participants were very engaged in the game, with the game, encouraging each other in play, lots of laughing and positive vocalisations.

Participants in workshop 1 were engaged in the game but did not achieve high scores because as well as catching the fish, they enjoyed bouncing the penguin off the rocks. AC-IF rated the penguin’s bouncing and sound effect as his favourite aspect of the games but did not like that his enjoyment affected his score. FD-IF suggested that the player not lose points for hitting the rock, because hitting the rocks are a very fun part of the game.

Participants had varied responses to the controls in the penguin game. FD-IF, and MQ-IF commented that the penguin moves suddenly and quickly, with MQ-IF thinking that this could be frustrating to younger players. In general the fact that the penguin’s movements are a little unpredictable caused amusement and was a well-liked feature. TD-IF was very positive about the penguin’s movements, commenting that “the game is very funny because the penguin was a bad swimmer and it kept hitting the rocks and spinning away”.

The participants in workshops 1 and 2 were critical of the fact that no matter the player’s performance, at the end of the game they are congratulated and told that
they’ve helped to feed the penguin. The participants believed that if the player performs poorly, there should be a consequence. RC-IF suggested having different messages at the end depending on the number of fish caught.

5.3.1.2 Giraffe Game

The participants were also very engaged in this game, during workshop 4 the participants spent a lot of time exploring the whole platform world, discovering that implementation glitches in some areas allowed the giraffe to jump out of the top of the screen and playing the game together multiple times. The participants were specific in saying that the high jumping glitch is so much fun and rewarding to find that it should not be removed from the game.

Figure: Participants play the giraffe game together

Criticisms of the giraffe game were that the shampoo item is hard to find (the player must jump onto a platform to get it) and for some, the controls were difficult. However, all participants quickly overcame any initial control difficulties and were able successfully play the game.

MQ-IF and RC-IF disliked the premise of the game and suggested that the zookeeper figure should be the character that collects the bath items, then the giraffe can appear and be bathed in the reward scene. The rest of the participants, however, enjoyed controlling the giraffe.

5.4 Implementation

The application was implemented as a laptop game with keyboard and mouse controls. A touchscreen game would have been more appropriate to the target audience, how-
ever, limitations were encountered in hardware available to the researcher. As a proof of concept, the laptop implementation is adequate.

The application was implemented on the basis of the initial designs and expert feedback.

### 5.4.1 Zookeeper

The Zookeeper was implemented with three affective states and used text to give scaffolded prompts and feedback to the user.

![Figure: Negative Affect](image)
![Figure: Neutral Affect](image)
![Figure: Positive Affect](image)

### 5.4.2 Choices Scene

The choices scene has a prompt to choose an animal in need and has a minimally scaffolded response encouraging the player to reconsider their choices if they have not chosen the prompt animal.

![Figure: Prompt and choices](image)
![Figure: Questioning Feedback](image)

### 5.4.3 Schedule Creation

The schedule creation scene uses a Unity library, Simple Script Drag and Drop (https://www.assetstore.unity3d.com/en/#!/content/66449) to implement the behaviour. This scene is also minimally scripted.
5.4. Implementation

5.4.4 Using the Schedule

The schedule use scene provides scaffolded support if the user clicks on the incorrect animal in the zoo. The supports are:

1. Not quite, try again
2. Check the schedule
3. Check the schedule, the next animal is the...

Although the design specifies that the scaffold will incorporate visual prompts involving the zoo animals, the implementation does not include visual prompts. During the summative evaluation, their necessity will be assessed. The implementation does incorporate the visual schedule which displays game progress.
5.4.5 Monitoring Progress

The monitoring progress scene requires the user to click on the completed animal to mark progress.
5.4.6 End Game Scene

The end game scene is a static scene which shows happy animals and congratulates the player.

![End Game Scene](image)

5.4.7 Mini Game: Bath the Giraffe

Bath the giraffe is fully implemented, note the visual progress monitor showing that the player has failed to collect a necessary item.

![Giraffe game, showing visual progress monitor](image)

5.4.8 Mini Game: Feed the Penguin

The feed the penguin game is implemented with a level that has static rotating fish (owing to technical limitations) and the rule that the player loses a point if they hit a rock.
5.4.9 Mini Game: Catch the Butterflies

The butterfly mini game was a simple implementation of the full design, included in the focus group evaluation session to ensure that the participants could play a full game with three animals. The gameplay is simple: click on a butterfly to catch it, catch as many as possible in 60 seconds.
5.4. Implementation

Figure: Penguin introduction scene

Polly the Penguin wants to have a party with her friends, but she hasn't got any food! Can you help her to get some?

Use the arrow keys to make Polly swim.

Catch the fish. 🐟

Don't hit the rocks! 🐟

Figure: Penguin success scene

Well done Jacob, you’ve helped Polly catch 27 fish.
Her friends will have lots to eat!

Figure: Butterfly game, showing visual countdown bar
Oh no, the butterflies are escaping!

Click on the butterflies to catch them. Catch as many as you can!

Figure: Butterfly introduction scene

Well done Jacob, you've helped rescue 19 butterflies. I'm glad they're safe!

Figure: Butterfly success scene
Chapter 6

Summative Evaluation

Following the formative evaluation and design iterations, the game was evaluated by a group of adults and children with Autism Spectrum Conditions. The group comprised three unrelated adults and one family group of a mother and four children aged 8, 11, 13 and 20. Individual observation and interview sessions were conducted with four adults, the sibling group participated in an observation followed by a focus group evaluation. In response to hypotheses formed during the individual evaluation sessions, a small informal study was conducted with typically developing adults to test particular aspects of the game (see section 6.1.3). Part of the focus group session was used to test variations of the game suggested during the individual evaluation sessions, this testing was in A/B form (see section 6.3.6).

The aim of the evaluation sessions is to conduct a deep exploration into how the game is received by individuals with ASCs. To achieve this, the evaluation sessions will use interviewing as the primary means of feedback, with prompts from gameplay observations, screenshots and Likert-scale ratings for aspects of gameplay. In order to ensure participants’ comfort, a criteria for selection was that they were willing and able to give feedback verbally, though the sessions were designed in a way that the participant would be able to give feedback via writing or drawing if required.

6.1 Methodology

6.1.1 Individual Adult Evaluations

In the evaluation session, the participant is observed playing the game. Aspects of think aloud are used - the participants are asked to say their thoughts aloud, the researcher makes notes of things to revisit in the interview. It is not appropriate to do a full think aloud study, as the game has limited options to explore and it is not possible to set tasks for the participants to complete.

The observation is followed by a semi structured interview. Participants are asked to verbally rate aspects of the game on a Likert scale and are then prompted to discuss
and explain their rating. The researcher also revisits any points raised by the participant during gameplay and discusses any behaviour or responses noted during gameplay.

Finally, the participant is asked about their personal experiences of ASC and executive function. This session is designed to be conducted verbally with the game screens and functions as prompts. However, recognising that unfamiliar situations can put stress on individuals with ASC, participants are invited to respond via writing if they prefer, particularly during the game play stage. The interviewer is prepared for this eventuality. During the evaluation sessions, all participants gave verbal responses throughout.

### 6.1.2 Young People’s Focus Group

The focus group session has been designed with input from the participants’ mother to ensure that it is pitched at an appropriate level and that the children will be comfortable with the activities and topics covered in the session. The participants are a sibling group ages 8, 11, 13 and 20, they are the children of participant MD.

The participants’ mother reported to the researcher that they were very excited to be “beta game testers in a focus group”, so the session has been designed around this idea. The session has three sections: observed play, A/B testing of game variants and a focus-group.

Similarly to the individual adult sessions, the participants will be asked to play the game and say any thoughts or difficulties aloud, this will be observed by the researcher and addressed in the focus group session. Two computers will be used during this session, with the children participating in pairs.

The participants will then be asked to test alternative designs for parts of the game, implemented from suggestions during the individual feedback sessions. The game sections tested will be planning scenes that allow the player to go backwards and change choices, the giraffe game with modified controls and the penguin game with modified controls.

Finally, the participants will take part in a focus group-style interview. The participants’ mother has asked that the children are only asked about the gameplay experience, no questions about experiences of ASC or executive function. The topics covered in the focus group will be the same as the topics covered in the individual feedback sessions, with the children asked to rate the sections and then discuss. Screenshots of the game will be used as prompts. This will form a smaller part of the session than in the adult evaluation sessions. The participants will then be asked about their choices in the A/B tests, they will be asked to give reasons for their choices and to give suggestions about how to further improve the design.

This session is designed to be conducted verbally as the participants’ mother reports that it is the preferred method- FD is not yet able to write, KD is recovering from a broken wrist and SD struggles with fine motor control as a result of his dyspraxia. However, each child will be given a Likert-response sheet and an A/B testing sheet to
record their thoughts for later. These are designed to require minimal mark making, felt-pens and stickers will be available for participants to use. It will be made clear that the participants are free to respond entirely verbally, if preferred.

### 6.1.3 Micro Evaluations with Typically Developing Adults

During the individual evaluation sessions, only one participant (RS-A) noticed that the zookeeper’s expression changes during the game, while three of the four noticed that the zookeeper gave text based feedback. It had been expected that the players would notice the zookeeper’s feedback, there were three hypotheses for this:

1. As a result of ASC, the participants were less aware of faces and emotions
2. As a result of being confident adult readers, the participants focused on text rather than images
3. The Zookeeper’s implementation is poorly designed, the result being that changes in expression are not noticed

To test these hypotheses, participants from three groups were asked about the perception of the zookeeper’s emotions: adults with ASC, typically developing adults and young people with ASC and dyslexia affecting their reading ability.

During the typically developing adult micro evaluations, the adults were asked to play the game and were then asked if they had liked the zookeeper in the game, prompts following this question were “Did you think that the Zookeeper gave enough feedback?” and “Did you notice that the Zookeeper’s expression changed”. All the participants were given the game with the expression change. While inaccurate reporting could be an issue, this is simply an informal study to investigate typically developing adults’ perceptions.

Some participants also offered comments about the design and play of other parts of the game.

### 6.2 Participants

Participants for the ASC groups were selected with the requirement that they have an Autism Spectrum Condition and they are willing and able to express their views and experiences verbally. Participants for the typically developing group were selected on the basis that they are adults without ASC, ADHD or any other neurological condition affecting their perception of faces and emotions. In order to prevent priming the TD participants to look at faces and emotions, they were told “You cannot have autism, Asperger’s, ADHD or any similar condition”. In a more rigorous study, the participants would be asked to confirm the absence of any condition affecting face and emotion perception at the end of the test session. The typically developing adults were selected to be approximate age, ability and gender peers to the adults with ASC.
Table 5: Evaluation Participants

<table>
<thead>
<tr>
<th>ID</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnoses</th>
<th>Profile</th>
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<tbody>
<tr>
<td>RS-A</td>
<td>&gt;21</td>
<td>M</td>
<td>Asperger Syndrome, informally diagnosed by GP in childhood</td>
<td>Undergraduate sciences student</td>
</tr>
<tr>
<td>JT-A</td>
<td>&gt;21</td>
<td>M</td>
<td>Asperger Syndrome, formally diagnosed</td>
<td>Postgraduate sciences student</td>
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<tr>
<td>VU-A</td>
<td>&gt;21</td>
<td>F</td>
<td>Asperger Syndrome, formally diagnosed January 2016</td>
<td>Postgraduate humanities student</td>
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<tr>
<td>RR-FG</td>
<td>20</td>
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<td>Dyslexia; ASC formally diagnosed</td>
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<td>SR-FG</td>
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<td>Home-educated</td>
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<td>KR-FG</td>
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<td>Dyslexia; currently undergoing diagnostic process for ASC</td>
<td>Home-educated</td>
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<td>FR-FG</td>
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<td>Dyslexia; currently undergoing diagnostic process for ASC</td>
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<td>JV-TD</td>
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<td>&gt;21</td>
<td>M</td>
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</table>

-A participant in individual adult evaluations
-FG participant in young people’s focus group
-TD participant in the typically developing adult micro evaluations

The individual adult evaluations lasted between 30 and 75 minutes. Participants experienced no difficulty in the activities that they were asked to complete.

The focus group workshop lasted 70 minutes. The participants were engaged throughout and responded to different degrees to the researcher’s activities and questions. FR-FG was a very active, chatty participant who was eager to share her ideas. SR-FG and
KR-FG were also actively engaged in testing though at times were more reluctant to share ideas and preferred to play the game. RR-FG was reluctant to interact with the researcher and so participated in the workshop by observing FR-FG play the games and assisting her at times during gameplay. During the discussion, RR-FG listened and contributed his opinions and ideas with the assistance of his mother.

6.3 Outcomes

Overall, all participants enjoyed playing the game, were visibly engaged and gave predominantly positive reviews of all aspects of the game.

6.3.1 Suitability

In general, the adult participants believed that the game and its goals were important and suitable for the target audience. All the adults reported struggling with executive function and planning activities in their day to day lives, the participants who had the strongest planning techniques reported the least impact and stress on a day to day basis. All adult participants reported difficulty in the transition to independent adult life and with the loss of the parent as an “executive function manager”. It was felt that encouraging the child to learn planning strategies from an early age could help to reduce this difficulty.

RS-A and JT-A felt that this game would have been appropriate and engaging to them as children. MR-A reported that even as an adult, she was very engaged in the game and genuinely enjoyed playing. From a parent’s perspective, MR-A felt that the game was pitched at an appropriate level and that it would be enjoyable to her children, even the 11 and 13 year old boys.

6.3.2 Affective Zookeeper

During the individual adult evaluations, only one participant, RS-A noticed that the zookeeper’s expression changes at all during the game. Although he noticed that the Zookeeper smiles at the end of mini games, he did not notice that the Zookeeper gives affective feedback during the planning stages. MR-A, JT-A and RS-A commented that they were more focused on reading the text and completing the planning activities than looking at the Zookeeper’s face.

The hypotheses formed in section were tested by conducting a micro study of typically developing adults and including questions about the affective zookeeper in the children’s focus group.

None of the typically developing adults noticed the Zookeeper’s expression change, with KX-TD and JV-TD commenting that they were more focused on the text than the pictures.
Three of the focus group participants, all of whom were dyslexic and spent much more time on the planning screens than the adult participants, responded to questions about the affective Zookeeper. Two of the three participants noticed the Zookeeper’s expression change and rated it positively. FR-FG, who noticed the change, commented that although she didn’t understand that she was expected to choose a prompted animal, when she was making choices she made lots of different choices until the Zookeeper smiled.

These results show that hypothesis 1, that the faces were not noticed as a result of ASC, is invalid because neither the typically developing nor autistic adults noticed the change, while two of the three autistic children did. The results suggest that hypothesis 2, that the faces were not noticed as a result of the individual adult participants, is valid, as only one of eight confident readers noticed the change, while two of three poor readers noticed the change. This is a small sample size, so the results cannot be taken as conclusive. Critically, the game should be tested with adults who are poor readers and children who are confident readers.

There is also evidence for hypothesis 3. The confident adult readers reported being too focused on the text to realise that there was a changing picture. RS-A suggested that if the zookeeper was bigger or more animated, it would have perhaps been more obvious. This is supported by the advice of HT-E and MW-E during formative feedback (section 5.2), who suggested that the Zookeeper be animated and use whole body language and tone of voice.

When shown the Zookeeper’s changing expression, the individual adult participants were positive and felt that it was a good part of the game. MR-A felt that the feedback level was right for 4 to 8 year olds and RS-A commented that as a child, he would have liked getting the affective feedback.

Although they did not notice the affective Zookeeper picture, the adult participants were positive about the affective Zookeeper agent as a whole. MR-A strongly liked the feedback and guidance provided by the Zookeeper and reported that it helped her to feel more engaged with the game.

RS-A and VU-A suggested that voice acting would further improve the affective feedback of the Zookeeper. Narration is discussed further in section 6.3.7.

The results of the micro experiment and the feedback from the users shows that the Zookeeper has potential but its design and implementation needs to be further developed. Important further work would be to animate the Zookeeper and add narration with variable tone of voice. The game should then be retested with a new group of individuals with ASC to determine whether ensuring that confident readers are not only focused on the text changes their ability to notice the Zookeeper’s face.

6.3.3 Music and Sound Effects

The music and sound effects were well received by the individual adult evaluators, however, the young people’s focus group participants strongly disliked the music. In
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discussing design decisions, all participants felt that the game requires controls for music and sound effects which can be easily accessed during game play.

All four individual adult evaluators felt that the music was either good or very good and had a positive effect on the gameplay experience. MR-A, RS-A and JT-A reported that the made the game more engaging and that the music was appropriate to the mini games, planning activities and cut scenes. VU-A commented that “the music is repetitive enough not to be distracting, but not repetitive enough to be irritating”.

The sound effects were also well rated, though the evaluators were less conscious of them than they were of the music. MR-A liked that she got both positive and negative feedback from the sound effects. One potential issue with the sound effects is that they are an additional distraction to the player. During the penguin mini game, all game testers noticed the “boing” sound effect and bouncing penguin when the rocks were hit, but few noticed that points were lost. See section 6.3.6 for further discussion.

The adult evaluators had few negative responses to the music. MR-A reported that when she was struggling with the penguin game, the music raised her stress levels. However, she felt that the overall level of stress during the game was appropriate and that it made the game enjoyable. Three participants (MR-A, RS-A, VU-A) felt that the music had the potential to become irritating over time, though they did not experience this irritation during the evaluation sessions. From a parent’s perspective, MR-A thought that the music would be irritating to a parent who was in the same room as a child repeatedly playing the game. Only one participant, JT-A, had a negative reaction to the music during the evaluation session. JT-A disliked the game completion music, feeling that it was too sudden and “in your face”. He had no issue with the rest of the music in the game.

The focus group had very different reactions. The sound effects were generally well received, in particular, the penguin’s “boing” sound effect caused much amusement. The music was a negative part of the game for the participants. One participant, RR-FG, disliked the music, found it overwhelming, and opted to spend some time sitting outside the evaluation room in quiet. The other participants did not have such strong negative reactions, but when asked to name the thing that they thought was worst about the game, KR-FG and SR-FG immediately named the music. FR-FG rated the music as “OK” and gave no direct comment about it. The participants chose to mute the computers after playing the game through once.

In discussion of design decisions, all participants (adult evaluators and focus group) were asked about volume control options- would they rather have sound at a fixed level controlled only by the computer volume, or would they choose to be able to control the music, sound effects and (hypothetical) voiceover separately (see section 6.3.7 for discussion of narration). All participants opted to have more control. MR-A felt that it would be important to have the volume controls easily accessible to the children-while it may be irritating to the parent, she believes that it is more important for the child to have control over their playing environment. The need for separate volume controls was highlighted by the focus group participants’ reaction to the music. With better controls, they would have been able to mute the music and still enjoy the sound effects.
These evaluation sessions show that the sound effects are positively received, add enjoyment to the game experience and do not need any major revisions. The very varied responses to the music prompts further design work. On the one hand, it is clear that music appropriate to the game and individual can greatly enhance gameplay. This was the experience of the adult participants. On the other hand, music inappropriate to the individual can have a negative effect on game enjoyment (as in the reviews of KR-FG and SR-FG) or in more extreme cases, be distressing to the individual (as in the case of RR-FG). Additionally, user interface work should be done to design an age-appropriate volume control interface.

6.3.4 Graphics

The adult evaluators made little comment about the game graphics, only RS-A commented that the mini games would be better with animated animal movements.

The focus group participants found the graphics satisfactory, but suggested that improvements be made. All felt that animated movements for the animals and zookeeper should be added. FR-FG and RR-FG suggested that as the player progresses through the game, the sky background in the zoo animal scene could change to reflect the time of day.

These suggestions would improve the look of the game, but are low priority for future work.

6.3.5 Planning Activities

The planning scenes were completed by all participants with only minor difficulties related to user interface rather than inherent difficulty in the planning tasks. All four individual adult evaluators rated the planning activities as like, two focus group participants rated them as OK, one as good. The planning scenes cover choosing animals, ordering the animals in the schedule, selecting games according to the schedule and tracking progress (see sections 5.1 and 5.4 for details). Discussion of the planning activities gave rise to multiple design decisions, some of which had been explored during the design phase (see sections 5.2 and 5.3).

Observations of the planning activities were that generally the participants completed the activities quickly and with little hesitation, though not necessarily with full reading and comprehension of the game’s plot. VU-A reported that she read little of the text and didn’t realise that she was being prompted to choose a specific animal. She worked quickly and entirely from the images, commenting that “You can do these without having to read”. Typically developing participant JV-TD did not select the prompt animal and didn’t realise this until the researcher questioned her at the end of the test session. With the focus group participants the planning scenes were completed fairly easily, but the level of comprehension was questionable.

This finding is both positive and negative. The fact that multiple participants (VU-A,
FR-FG, KD-FD, SR-FG, JV-TD) were able to progress through the game without complete comprehension of the instructions suggests that the user interface is effectively and intuitively designed. However, the Zookeeper is intended to help the user develop planning skills through scaffolded responses. If the user does not understand these responses, they may not be learning the skill as effectively or completely as a user who does understand the responses. At present, the skill gains of this app, regardless of text comprehension, are untested (see Chapter 7 for discussion of further work).

In the case of VU-A, the issue was a decision not to read. She explained explicitly that she chooses not to read “irrelevant information”, and as a result did not read the text when she could progress through the planning tasks on the basis of images. VU-A did not disclose any specific learning difficulty related to literacy and appeared, to the untrained researcher, to have no difficulty reading. The issue for JV-TD also seems to be one of attention, she reported trying to progress through the planning scenes quickly. For FR-FG, KD-FD and SD-FD, who are diagnosed with dyslexia, the issue was in reading ability. Observation suggested that all three participants struggled to read and comprehend the text. FR-FG was assisted by RR-FG. The four focus group participants were strongly in favour of a voiceover feature. For discussion of reading and voiceover, see section 6.3.7.

Responses to individual scenes will now be discussed in more detail.

### 6.3.5.1 Choosing Animals

The Choosing Animals scene gave the participants a prompt animal— an animal described as needing attention— and a selection five animals, of which three should be chosen. In this scene the Zookeeper gives affective feedback, varied on whether or not the player has chosen to visit the prompt animal.

Among the participants that read and understood the prompt animal text (RS-A, MR-A, JT-A), this task was completed easily, with RS-A and MR-A reasoning aloud that they should be visiting the prompt animal. JT-A commented that he had to go back and reread the prompt text because there were other things happening on the screen, which confused him momentarily.

KR-FG understood and followed the prompt, but due to difficulties reading FR-FG did not. She chose the “correct” animal by making different choices until the zookeeper smiled.

Among the typically developing group, every participant attempted to click continue after only choosing one animal. VU-A and FR-FG were observed making the same error. FR-FG realised quickly with the assistance of RR-FG that she needed to choose more animals, but two typically developing participants (JW-TD, KX-TD) believed that there was an error in the game, rather than in their actions. These difficulties show a need for a scaffold prompt to be added to this scene specifically addressing the need to choose three animals to visit.

There was only one negative response to this scene. VU-A did not like the idea of
being asked to play a butterfly game. She reported a fear of butterflies and said that she would choose to stop playing a game altogether rather than play a butterfly mini game.

During interviews, some participants commented without prompting that choosing the prompt animal should be mandatory. In consideration of suggestions made by experts in section 5.2, all participants were asked “Should visiting the prompt animal be mandatory, and if not, what should the consequence of not visiting be?” For discussion of this design decision, see section 6.3.12.

6.3.5.2 Ordering Animals

In the Ordering Animals scene, the player places their chosen animals into a schedule of morning, afternoon and evening. There were no difficulties in this scene, the only negative aspect was that the animal icons disappear as they are being dragged. VU-A and KR-FG gave negative opinions about this.

An issue that arose was that all the individual adult evaluators expected the game to require the prompt animal to be put first in the schedule, with scaffolded responses to encourage the player to do this. The game does not act this way, it puts no constraint on the ordering of the animals. MR-A commented that she was confused that the monkeys were hungry but the zookeeper didn’t care if they weren’t fed until the evening. RS-A and JT-A made similar comments. When asked, FR-FG, KR-FG and SR-FG all immediately answered that the prompt animal should be ordered first.

This scene gave rise to the question “Should it be mandatory to put the prompt animal first in the schedule, and if not, what should the consequence of not putting it first be?” For discussion of this design decision, see section 6.3.12

6.3.5.3 Using the Schedule, Selecting the Game

The Selecting Game scene posed the most difficulties to participants with terms of user interface difficulties, minimal scaffolding and for one participant, issues with rigid thinking related to ASC. In this scene, the user is shown their schedule, complete with progress marks, and must select the next animal to visit in the zoo. The Zookeeper provides scaffolded support if the user selects the wrong animal.

No participants were observed selecting the incorrect animal, they were all able to look at the schedule and correctly identify the next animal to visit. JT-A reported that after playing the first game, he couldn’t remember the next and had to check the schedule to see. He felt that this is a valuable skill to teach people, as he has observed that a lot of people with ASC have poor executive function skills but are unaware that their difficulties are a result of this and could be helped with better planning. (Note, this is JT-A’s observation and analysis).

The majority of the participants (VU-A, JV-TD, JW-TD, KX-TD, OY-TD, FR-FG) were observed clicking on the correct animal in the schedule, expecting it to take them to the game. JT-A did not make this mistake, MR-A and RS-A tested an earlier version
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of the game which did not have a functioning selecting game scene. There was no scaffold response for this error, but it is obvious that it needs to be added. There was some frustration when clicking the schedule didn’t work as expected, this was observed by the researcher and explicitly reported by VU-A.

Another usability issue was that some participants (VU-A, KX-TD) reported being unsure if the zoo scene was clickable or if it was background. VU-A suggested that the animals be outlined or highlighted to make the interaction obvious.

The only non-usability issue was encountered by VU-A, but it is one that is recognised in the literature as a potential problem with the use of visual schedules and more generally as an aspect of ASC (National Autistic Society, 2016). VU-A demonstrated significant rigid thought with the use of the visual schedule. When the schedule showed a panda facing left and the zoo had two pandas, one facing left and one right, VU-A was adamant that only the identical, left-facing panda should take the user to the game. Similarly, when the schedule showed a blue butterfly, VU-A could only accept the blue butterfly in the zoo as the correct choice. VU-A seemed frustrated and upset at this and returned to the topic several times during the interview, repeatedly expressing frustration.

In order to test this issue further and explore its prevalence, the focus group participants were presented with printed screenshots of the scene and asked to circle the things they could click if the schedule had a single panda and if the schedule had a blue butterfly. KR-FG and SR-FG both circled all the butterflies and both pandas with no issue, FR-FG indicated the same choice on the sheet. It seems that among the small participant group VU-A is the only person to experience these issues, but this should not be discounted. For further discussion, see section ASC specific issues.

![Figure: KR-FG's response](image1)
![Figure: SR-FD's response](image2)

The evaluation of this part of the game shows that scaffolded support and clear indications of incorrect actions are essential. With high priority, further development of the application should focus on adding appropriate scaffolding and prompts to this activity.

6.3.5.4 Progress Checking

The final scene in the planning activities is the Progress Checking scene. After the completion of a mini game, the player is prompted to mark the animal completed by
clicking on it. There was a technical difficulty with this scene which caused some frustration, as only part of the button was clickable. Aside from that, there was no usability issue in the design and every participant successfully used this scene.

6.3.6 Mini Games

6.3.6.1 Giraffe Game

The giraffe game popular with participants of all ages, who were visibly engaged and entertained during play. However, it was clear that the game controls were a significant weakness. The researcher observed participants struggling to control the giraffe and when asked for feedback, all the ASC participants responded that the controls needed to be better.

All the participants were engaged in the game with MR-A taking the time to collect all the stars, VU-A choosing to play the game twice and commenting “I’m going to get better at this, I can do this”, and several participants (MR-A, VU-A, focus group participants) making positive vocalisations at success during the game. During the focus group, FR-TD was clear that she particularly enjoyed the story of collecting the items and bathing the giraffe. On game completion, FR-FG was observed jumping in her seat, smiling, and engaging with brother RR-FG to show him her success. Similarly, MR-A was visibly happy and later commented that she was “really chuffed” with herself when she had collected all the items and been rewarded with a picture of the giraffe bathing. Although SR-FG and KD-FG gave less affective response, they chose to play the game multiple times and were engaged during play.

A movable, roll-able Polly the Penguin was included in the scene as a surprise feature, her presence was positively received by several participants. VU-A spent time moving the penguin around and laughing, later commenting that she was “a great fan of being able to kick the penguin around”. Likewise, MR-A verbally greeted Polly and engaged in moving her around. Participants JT-A and RS-A noted Polly’s presence but did not engage with her, instead continuing to work towards the game’s goal.

Although the majority of reaction to the premise and play of the game was positive, there were some negative reactions. RS-A expressed slight confusion at the instruction “collect the stars and the bath things”, he wanted to know which was more important to collect. Once starting the game, his confusion was resolved. VU-A did not like the “silliness” of the game and made similar comments to MQ-IF and RC-IF (section).

All participants gave negative feedback about the controls of the game. Feedback was that the movement was tricky or unpredictable (MR-A, VU-A, JT-A, ), the jumping was difficult to control (MR-A, RY-A, MR-A, JW-TD) and that the double-jump feature was inconsistent and needed to be explicitly addressed in the instructions (RS-A, VU-A, JW-TD). Observations of gameplay found frustration consistent with these reports. However, while JT-A reported frustration with the game’s controls, he also reported a sense of achievement at learning to control the giraffe effectively and felt that having
“interesting” physics in a game is a good thing, as it adds challenge and creates player engagement through concentration.

The focus group followed the adult interviews. As the game controls had received universal negative responses, a modified version of the giraffe game was created and presented to the participants in an A/B test alongside the original giraffe game. The modifications made were that the giraffe continues to move for as long as the arrow keys are held down (suggested by VU-A and by FD-IF and RC-IF during formative evaluation) and that the physics engine puts greater drag on the giraffe, with the result that the giraffe’s movement stalls quickly after key up.

All four focus group participants preferred the modified version of the game, with SR-FG and KR-FG specifying the giraffe’s continuous movement as the reason for their preference.

Participants gave suggestion for further development of the game. The major suggestion was for refined controls. VU-A felt that while the stars are necessary for engagement during the game, they should have some impact on the result. She suggested that in the reward scene, the amount of bubbles in the bath should be proportional to the number of stars collected. For further discussion of reward structures, see section ...

FR-FG suggested that after collecting the bath items in the platform game, the player should move to an interactive bath scene and have to run the bath, add bubbles, put the giraffe in, wash him with a scrubber, shower the soap off and towel him dry. This echoed JH-E, MQ-IF and RC-IF’s suggestions for improvement to the game. MR-A commented that this sounds similar to games that FR-FG enjoys playing at home, Nintendogs and Cats.

The summative evaluation of the giraffe game has shown that its basic premise is solid and popular with participants, and that with modified controls it is a game appropriate for inclusion in the application. An interactive bath scene has been suggested by an expert and by child participants during both formative and summative evaluation. Therefore, future development of the application should include an interactive bath scene.

A question to consider is whether this scene should be an interactive picture (i.e. click the bubbles to burst them, click on the duck to make it quack), or if it should be a
full bath sequence as described by FR-FG above. A concern is that adding a full bath sequence to the end of the game is too large a task for a reward and may require prompting from the Zookeeper for successful interaction. For this reason, the reward scene should be an interactive picture and future development of the application could include a stand-alone animal bathing game, where the player can choose an animal and go through the bathing sequence. This would fulfil the design requirement of having open-ended play in the mini game set.

6.3.6.2 Penguin Game

All participants were very engaged with this game. All, including the adult participants, made positive vocalisations. VU-A liked that the penguin doesn’t lose health or die when it hits the rocks, an opinion shared with the first formative evaluation workshop (section ). RS-A and RR-FG rated the penguin game as their favourite game.

RS-A believed that as a child he would have played the game repeatedly and would have been obsessed with earning high scores. KR-FG and SR-FG compared their scores and engaged in casual competition during the focus group. RS-A suggested that a high score board be implemented in the game so that the player could track their performance against themselves and other players, KR-FG and SR-FG approved of this suggestion.

Although all participants were aware when the penguin hit the rocks, few (JO-TD, JT-A) were aware that they lost points when this happened. When the penguin collides with the rocks, there is an amusing sound effect, and the penguin spins away. In contrast, the point number in the top corner simply decreases by 1. Although MR-A did not notice point loss, she strongly felt that it was appropriate to include in the game. She advised that it is necessary for children to learn to cope with negative consequences, even if it is challenging, as it has been for some of her children.

Both VU-A and MR-A were engaged with the game but visibly anxious and frustrated, with vocalisations including “oh no”, “ahh”, “damn”, “ah rocks!” and hard, frequent pressing of keys. The penguin’s is more controllable with long key presses than with repeated tapping. MR-A was visibly happy at the completion scene. During the interview, MR-A reported that during the game she was both frustrated and enjoying the game. She was able to learn how to make the game work before it became too frustrating and felt invested in getting fish for the penguin, feeling achievement at the end of the game.

As with the giraffe, the controls were the main topic of negative feedback. While the “floatiness” of the penguin was intended to be an aspect of the game and was enjoyed or neutral by child participants in the formative evaluation, the controls were disliked by the majority of the participants with ASC. For MR-A, this was the reason that the penguin game could only be rated as “neutral”, despite the fact that she felt strongly positive about the game’s premise and play. MR-A suggested that controlling the penguin with the mouse would be more intuitive than with the keyboard. During the game, VU-A became increasingly frustrated with hitting the rocks, later complaining
that the penguin bounces off the rocks too quickly and was difficult to control when this happened.

However, the difficult controls were positive for JT-A who also liked the challenge of the controls in the giraffe game. He reported that he found the game tricky at the start, but that it was enjoyable and engaging rather than frustrating. JT-A did not feel motivation from the penguin’s story, but found the challenge of the game to be motivating.

In response to the negative feedback on the controls during the adult evaluations, a modified version of the penguin game was created and presented to the focus group participants in an A/B test alongside the original game. The modification was to add drag to the penguin, making it respond much more closely to the key presses (i.e. reducing the “floatiness”). All four focus group participants preferred the modified version, with SR-FG reporting that he strongly preferred the modified version to the original because he was able to better control the penguin and achieve higher scores.

VU-A felt that the feedback (“Well done, you’ve helped Polly catch x fish, her friends will have a lot to eat”) was inappropriate for a child who performed poorly in the game. She suggested that instead, the child be prompted to play the game again and that they would be given a subtly easier version were they do not lose points if they hit a rock and there are more fish on the screen, seven instead of five. VU-A felt that the player should not be told that they’re being given an easier version and that the easiness should not be obvious to the player.

RS-A had several suggestions for the extension of this game. He felt that as a child he would have played this game repeatedly to get high scores but that in its current implementation would have quickly hit an upper limit. He felt that he would have been most motivated to play if he thought it was possible to progress further and further. He suggested that with each fish caught time is added to the timer in order extend the game length and potential score. He would have also liked to be able to choose the penguin game directly from the menu, as if he had been presented with the full Zookeeper version as a child he would have simply chosen the penguin and two other random animals, ordered them with the penguin first, played the penguin game then restarted the application to be able to play the penguin game again. RS-A suggested that after playing the complete game a number of times, or reaching a specific score, the player unlocks the option to play the individual games directly from the menu.

Evaluation of the penguin game found that it was popular and engaging with all participants, but that for some the controls were frustrating, adding negativity to the gameplay experience. Future development of this game should implement variable “floatiness” control, allowing players to control the difficulty level. This would mean that players who found the unpredictability stressful would be able to have a very controllable penguin, while players who enjoyed the challenge would be able to have a more difficult game. A high score board should be implemented, and the extensions suggested by RS-A should be considered. Another possible extension suggested during formative evaluation with children is the use of power ups and special fish, giving special abilities and more points respectively.
6.3.6.3 Butterfly Game

Despite being a quick and simple implementation, this game was the most popular among the focus group due to its intuitive simple controls, bright butterflies and the possibility to earn very high (>70) scores. The very positive reaction to this game raises the question of whether simplicity is better than complexity within the mini games. Enjoyment is the intention in these games, so considerations around difficulty vs. enjoyment should be taken.

The focus group participants suggested extensions to the game, including moths which the player must avoid catching (moths cause point loss) and rare golden butterflies that give the player ten points.

6.3.7 Story

Evaluation of the storyline was complicated by the fact that one adult participant chose not to read any of the text during the game and all four focus group participants struggled to read the text.

Among the participants that did engage with the storyline, reception was positive. MR-A was particularly positive about the personalisation in the story, noting that it is especially engaging for younger children. MR-A, RS-A and JT-A felt that the story linked the planning activities and the mini games together and was therefore a positive aspect of the game.

RS-A felt that there could have been more detail in the story, for example, more background information about the animals. JS-A would have enjoyed playing the mini games without any backstory, but did like that the story gave the application overall structure.

The focus group participants were generally ambivalent about the story, with KR-FG rating it “OK” and SR-FG rating it between “not very good” and “OK”. FR-FG said that she believed the story but thought that there should be more to it, “like more words”. She would have preferred a more difficult story with more challenges. For discussion of extension of the application through more complex stories and planning activities see section.

All four focus group participants struggled to engage with the text based story as a result of dyslexia. In the initial design, a voiceover is specified as important to include. However, its implementation was outwith the technical scope of the project. During the interview section of the session, the participants were asked if they would prefer to have voiceover function or if they would prefer the game to use images as an aid to text (see figure below). All would prefer to have a voiceover feature. While FR-FG would be pleased if the game simply read out all the text on screen, SD-FG suggested that the player should be able to hover over an unknown word and have it spoken aloud, he also felt it important that the player is able to turn off the voiceover. KR-FG and FR-FG suggested a “helpful parrot” that would sit in the corner of the screen and “help you read” by speaking words aloud. The other participants strongly approved of the idea of
having the narration within an animal character. None were particularly interested in
the suggestion of having the Zookeeper himself speak the text, though the researcher
posed this question after the parrot suggestion, which was novel and the participants
were very excited by.

Evaluation of the storyline shows that the story itself is appropriate to the game and
helps the player understand that the planning activities and mini games fit together
within the application, rather than being random discrete parts. However, accessibility
issues were severe and resulted in the focus group being unable to engage with the story
at all, this could also have an effect on the player’s ability to learn how to effectively
plan, especially in more complex versions of the game. Future development must treat
implementation of a voiceover function as a critical addition.

In terms of design and implementation of the voiceover, the idea of having individual
words read aloud on hover is the most educationally appropriate as it encourages in-
teraction and scanning of text. However, the parrot idea should also be incorporated as
it was very positively suggested and received by the participants. A potential design
would be that when the parrot is clicked, it moves with the player’s cursor and reads
the words on hover. The player would need to return the parrot to its perch in the cor-
ner in order to progress with the game, encouraging the use of short term memory and
recognition of important words.

6.3.8 Usability

Good usability was defined to the participants as an application that feels intuitive to
use, where you can quickly determine the action to take to achieve a goal and where
the application behaves in ways that you expect. Poor usability was defined as the
opposite: difficult to use with unexpected responses to interaction. Note that partici-
pants tested slightly different versions of the game. At the time of MR-A, JT-A and
RS-As’ evaluation sessions, the using schedule scene was not functional. They were
not observed attempting to use the scene.

When observed and asked about usability, MR-A responded that she found the intro-
ductive tasks easy, understood what she was doing and felt that they flowed well. She
felt that an older or more able child in the 4-8 age range would be able to complete
these tasks easily, but a younger or less able one may need parental assistance. She felt
that this was acceptable as she believes that parents should interact with young chil-
dren while playing computer games, rather than leaving them alone. JS-A and RT-A
were similarly positive, except from in review of the progress check screen which was
noted to have a bug affecting usability.

The majority of participants encountered critical difficulty in the using the schedule
scene. Virtually all participants, including the typically developing group, clicked re-
peatedly on the schedule when asked to select the next animal to visit. Frustration was
clear and the Zookeeper provided no support. The Zookeeper did provide support if
the player clicked on the wrong animal in the zoo, but no participant did this. VU-A
reported that she was not aware that the zoo scene was clickable, she believed that it
was background. Critically, when the user clicked on the schedule, the game did not provide any indication that this was an incorrect choice and that the player should be clicking in the zoo picture. This lead some participants (KX-NT, OP-NT and VU-A) to believe that the game was broken.

Observation of gameplay revealed that with the exception of the schedule using scene in which the player must select the next animal to visit, the game was usable to all participants. Despite not reading the text, VU-A and the focus group participants were able to progress through the planning activities and mini games. During interview, VU-A said that it was unnecessary to read the text as the images were “self-explanatory” and she was able to progress. The critical difficulty encountered by these participants during the using the schedule scene was also encountered by reading participants.

It should be noted that VU-A did not realise that she was being prompted to visit a specific animal and did not realise that she was being given negative feedback as a result of not choosing the animal. FR-FG, who had limited reading ability, did not understand that she was being prompted to visit a specific animal but was aware of the Zookeeper’s affective feedback. During interview, she reported that during the animal selection scene she made different choices until the Zookeeper smiled. The fact that the non-reading participants were able to progress through the game as successfully as reading participants suggests that the usability of the planning activities and mini games is good.

The use of text with no voiceover was an issue for the non-reading participants, implementation of a voiceover is discussed in section . The issue of background colour was not directly raised in the focus group, but while completing consent forms RR-FG could not read the form as he did not have his overlay, a piece of translucent coloured plastic that aids dyslexic readers by altering the background colour. Some software designed for individuals with dyslexia allows the user to alter the background and text colours to optimise reading ability. Implementation of such a feature should be considered, as it would assist users with dyslexia and would also provide customisability for users with visual sensitivity or aversion to certain colour combinations relating to ASC.

The usability issue of poor controls in the penguin and giraffe mini games is discussed in section. The participants found usability issues throughout the game which were frustrating but in general did not prevent successful use. The animal icons disappear while being dragged and dropped, VU-A found that the cursor was too small and she could not keep track of it and a bug existed in the progress tracking screen which meant that only a small portion of the animal icon was clickable.

VU-A made suggestions for improvement of the using schedule scene. This suggestions are similar to the designs made (but not fully implemented) for the scene. She suggested that if the user clicked the schedule, the game would make it visually clear that they should be clicking in the zoo picture by having the animals flash or highlighted in the zoo. She suggested that the zoo picture be more obviously clickable. This suggestion is supported by observation of KX-TD’s gameplay. She did not make the mistake of clicking in the schedule and when asked about this, explained that as she moved the cursor to click on the schedule, she moved over an animal and saw it
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darken slightly (the default highlight) and realised that she should click on the animals in the zoo picture.

RS-A and VU-A also suggested the implementation of a back button so that the player could change their choices. Further discussion of choice changing can be found in section.

Evaluation of the usability section shows clear direction for future work. The cursor graphic should be enlarged, as is common in games for young children, the bugs causing disappearing icons while dragging and icon problems in the progress tracking screen. The full design of the using schedule scene must be implemented with appropriate visual and verbal scaffolding. With these issues resolved, the application would have very good usability. Additionally, a voiceover should be implemented.

6.3.9 ASC-Specific Issues

Some difficulties encountered during the game appeared to be directly related to aspects of ASC, specifically due to rigidity of thought. All these difficulties were encountered by the adult participants, the focus group participants did not report difficulties of this type though were not asked about the idea of interrupting plans.

VU-A had difficulties with rigid thought around the use of the visual schedule, this is discussed in section.

To a lesser extent, VU-A was also confused by a pink bottle of shampoo during the giraffe game- to her, a tall pink bottle can only be Johnson’s Baby Lotion. Similarly, MR-A was confused by having a penguin called Polly, as to her the name Polly is very strongly associated with parrots.

When asked about interrupting schedules, RS-A, JT-A and VU-A were all opposed to the idea and their reasons for the opinion were rigid beliefs around plans and changing plans. For further discussion see Auditory sensitivity issues relating to the music affected many participants, this is discussed in section.

Aside from the music, by far the ASC related issue that negatively affected the most participants was rigid beliefs around changing plans. This was obviously an issue for the participants and is well recognised as being a major difficulty for people with ASC. This suggests that future work on the application could focus on teaching ways to cope and adapt to changes in schedules and plans.

6.3.10 Emotion and Engagement

All participants were observed during gameplay and asked during interview how they felt about the game. There was an interesting gender split in both observation and interview response. All participants were engaged in the game, but while the female participants gave significant positive affect (more extreme positive affect than would
be expected from an typically developing adult or child), the male participants gave little affective response.

In interview, none of the male participants reported feeling particularly emotionally invested in the game, they reported feeling some frustration when controls were difficult and happiness at game completion. The main source of motivation was desire to perform well in the games. On the other hand, female participants FR-FG and MR-FG were heavily emotionally invested in the game, reporting that most motivation came from the task of helping the various animals.

Obviously this is a very small participant group and these observations are anecdotal, but it raises interesting questions about sex differences in ASC. This is an area that is becoming more prominent in research, but it is still the case that much research and information about ASC is based on studies of predominantly male participants and little research could be found about affect display differences in males and females.

In conclusion, although the participants experienced and displayed their engagement in very different ways, the game was appropriate and engaging for all.

6.3.11 ASC-Specific Issues

6.3.12 Design Decisions

6.3.12.1 Selection of Prompt Animal

During the animal selection scene, participants MR-A, RS-A and JT-A reasoned that “the game is telling me that the penguin is hungry, therefore I must have to visit the penguin”. Other participants did not realise that they were being prompted to select an animal (see sections ) and therefore did not have to think about making a choice and planning based on priority. This raised the question “Should it be mandatory to select the prompt animal?” The adult participants were asked this question.

VU-A felt strongly that selection should not be mandatory because the player may dislike some of the animals and games. She noted that she has a fear of butterflies and if forced to select a butterfly mini game would choose to quit the game altogether.

MD-A, JT-A and RS-A felt that this question raised a conflict between autonomy and learning to plan. MD-A strongly believed that children should have autonomy over choices where reasonable, and that would include to not forcing them to play games or interact with animals when they wish not to. Similarly, JT-A and RT-a felt that if you give someone a choice, you should allow them to make bad choices.

However, MD-A, JT-A and RS-A also recognised that the objective of the game was to teach planning and prioritising and that through making the selection mandatory, the need for prioritising in planning is reinforced. All suggested that if the player does not choose the animal, they should face some sort of consequence within the game. JT-A was unsure on how this would be implemented but felt that it should be a gentle correction, “rather than telling the child that the monkeys starved”. RS-A suggested
that at the end of the game the Zookeeper says “We visited the penguin, giraffe and butterflies today, but we didn’t visit the monkeys even though they were hungry. Shall we feed them now?” The player would then be prompted in a small end scene to click fruit to feed it to the monkeys. RS-A felt it important that the consequences are not distressing to the player and that they are given an easy way to “fix” their mistake.

Discussion of this design decision lead to the conclusion that the choice of the prompt animal should not be mandatory. If the animal is not chosen during the selection scene, the zookeeper should question that choice, requiring the player to interact with the questioning prompt before continuing. This will help encourage the player to consider the choice not to visit the prompted animal. A consequences scene should be implemented at the end of the game, reminding the player that they did not visit the prompted animal and offering them a small interactive scene that allows them to remedy the animal’s need. With consideration of players such as VU-A, who are strongly adverse to certain animals, there should be an option to exclude animals from appearing in the game.

6.3.12.2 Ordering of Prompt Animal

When creating the schedule, multiple participants (RS-A, MR-A, JT-A, OY-TD) reasoned aloud that the prompted animal should be put first in the schedule because it has the greatest need. The game does not require the prompted animal to be put first and on creation of any schedule, the player is given smile feedback. This gave rise to the questions “Where should the prompt animal go in the schedule?”, “What do you think would happen if you didn’t put the prompt animal first?”, and “What should happen if you don’t put the prompt animal first?”. This question was asked to the individual adults and the focus group. The researcher made VU-A aware of the existence of the prompt and gave the focus group a verbal and onscreen example of the prompt before asking the question.

All participants (individual adults and focus group) believed that the prompted animal should be put first in the sequence. RS-A felt that this was logical— if the monkeys are hungry, they should be fed first in the morning, not left until the afternoon or evening.

All participants also believe that if the prompt animal was not put first, the game would prompt them to put it first or would not allow them to continue. During gameplay, OY-TD expressed surprise that the Zookeeper allowed him to put the prompt animal last.

Finally, the participants were asked what they thought the Zookeeper should do if the prompt animal was put first. As with the animal choices, no participant believed that the player should be forced to put the animals in a certain order. They did, however, believe that there should be an explicit consequence related to not putting the animal first in the schedule.

JT-A thought that the Zookeeper should prompt the player to consider putting the prompt animal first and should only give the smile affective feedback if the animal was ordered first. He thought that if the animal was not first, the player should be allowed to continue but should be given neutral feedback on their schedule and should
be given a consequence later in the game. During the focus group, SR-FG, KR-FG and FR-FG suggested that if you don’t put the prompt animal first, the consequence should be some extra task in the animal’s game when it is reached. They gave the example of not ordering a prompted giraffe first. They suggested that when the game is reached, the Zookeeper says that the giraffe is “extra smelly” because he’s been waiting a long time to get washed and the giraffe sprite should have some mud or “smell lines” coming from it. During the game, the player should need to collect extra bath items to get the giraffe clean.

Discussion of this design decision has shown that the current ordering scene is inadequate and should be redesigned to provide more support for making schedules based on priority. As with the animal choices, the participant consensus is that the choice should not be forced, but that a consequence explicitly related to the choice should be encountered later in the game. The focus group’s suggestion of adding consequence to the animal’s mini game is an appropriate, as it is a clear consequence without being a punitive.

6.3.12.3 Changing Decisions

During the formative evaluation, both HT-E and MW-E suggested that the player have the option to go back and change their animal choices and schedule, believing that allowing the child agency to change their plans could reinforce the idea that plans can be changed and would support exploration and playful activity. However, it was also recognised that learning to make and follow a set schedule is an important skill. During the individual adult evaluations, participants were asked “After choosing the animals and making the schedule, should the player be allowed to go back and change their choices?”

MR-A and VU-A both felt that players should have the option to change their schedule before they begin to play the games because the player may make a mistake in their choices, but were unsure if the schedule should be changeable after the “zoo day” begins. MR-A noted that she observes her children make impulsive decisions and errors that they then correct, and as such feels that reinforcing that mistakes are fixable is a positive thing.

RS-A believed that if choice is given, it should be available at every point in the game, with the zookeeper saying “This animal is next, do you still want to visit it”, the player would then be able to change their choice if desired. JT-A held the opposite opinion, feeling that a positive aspect of the game is that you have to make choices and keep them throughout. He noted that as he was playing, he did not remember the second animal to visit and had to refer to the schedule, this reminded him that there was an overarching story rather than a set of discrete games. He believes that this is a positive behaviour to reinforce within the context of learning to plan.

Discussion of this design decision with experts and adults with ASC suggests that while it is positive to teach children that plans can be changed and mistakes can be fixed, it is also important that when learning to use planning techniques, the child has
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Therefore, further development of this application should implement reversible choices during the planning and schedule creation scenes. A scene showing the schedule and asking the child if they would like to make any changes should be added before the using the schedule scene. This will ensure that children are able to correct any mistakes or regretted decisions. Once the games are begun, however, the child will have to keep to their plan to reinforce the plan following and self-monitoring aspects of planning skills.

6.3.12.4 Interrupting Plans

Both HT-E and MW-E suggested having a more advanced level of the game where the player’s plan is interrupted by the computer, for example, by an animal being sick and unable to play (section ) MW-E believed that careful, gradual scaffolding of the interruption and scaffolded prompts to help the child make a new decision would minimise distress and enable the child to learn positive ways of coping with unexpected interruptions. However, it was also recognised that for children with ASC interrupted plans can be distressing and within the context of this application, if a child has chosen to visit animals in order to play specific mini games, potentially very frustrating. HT-E and MW-E were clear that because this is a more complex and upsetting task, it should be an advanced level rather than part of the basic game. The adult evaluators were asked if they thought that having a level that incorporated interrupted plans would be useful in the context of learning planning skills, and if they would find it personally upsetting to have their game plans interrupted.

MR-A believed that this would be a very good addition to the game, as she recognises that inflexibility of thought around plans is an aspect of ASC and executive function that negatively impacts both her and her children. She explained that when she encounters interruptions in her plans, she struggles to replan and move forward from the interrupted point. She thought that introducing the idea within a game at a young age would be positive, as difficulties coping with change of routine are apparent in very young children with ASC. She added that as a parent to four children with differing needs, interrupted plans are inevitable and are something that the children find distressing. She reported that helping children with ASC learn to cope with interrupted plans is a difficult and long term task, but that it is something that is important for them to learn, both to be able to adjust to change in everyday life and for their stress levels and mental health.

The other participants were less positive. RS-A thought that depending on the situation, he would have been quite distressed as a child if his planned game had been interrupted. He believed that he wouldn’t have had much difficulty if all he knew was “the penguin is next”, but if he’d been given a prompt about the penguin being ill, he would have been upset to not be able to help. Additionally, if he had chosen animals to play specific games, he would have been angry and frustrated to have the game “taken away” from him.

JT-A and VU-A both felt that interrupting the plan would be negative. VU-A explained that she would have no trouble with an interrupted plan if it was her choice, but if it was
forced by the game she would think “oh, well I can’t do that so I can’t continue and do the rest”. VU-A is the participant who experienced significant rigid thought around the animal icons in the zoo. JT-A copes with difficulty with interrupted plans by spending a significant amount of time planning his activities in order to avoid unpredictability and changed plans. This approach works for him. He felt that the idea of having to stick to an overall plan in the game was a very positive aspect, but that the plan should not change. He reasoned that if a plan is going to be interrupted and changed, there is no point in making a plan and working from it. He believed that interrupting plans in the game would lead children to feel that there is no point planning, which would be negative because stringent planning is, for him, a good way of coping with uncertainty in the world.

Discussion about this design decision did not lead to a conclusive decision. While the experts and MR-A had very good, literature-supported reasons and implementation ideas for including interruptions in the game, the very negative reactions of RS-A, JT-A and VU-A warn that caution should be taken in this area. Further development in this aspect of the evaluation should strongly consider incorporating an advanced level with plan interruption and well designed, gradual scaffolded support both in introducing the idea of interruptions and for coping with interruptions. In order to implement this in a way that teaches children positive planning and coping skills and does not lead them to conclude that planning is worthless (as was the concern of JT-A), this extension to the application should be designed with input from experts in the field. This could include but not be limited to educators who regularly work with children with ASC in this age range, experts in autism and psychology and adults and children with ASC. Learning to cope with changed plans is an important skill, but it must be recognised that the work required to appropriately implement the level is extensive.

6.3.12.5 Multiple Levels and Complex Prompts

During the formative and summative evaluation, there were many suggestions for extensions to the application, including complex planning tasks (see sections above), more complex games and a more complex storyline. Participants were asked “Do you think that there should be more levels in the game, for example, with stories that are more complex”.

MR-A agreed strongly with this idea, saying that while she liked the structuring and planning activities in the game, it currently had a very limited scope. She felt that the game should begin with a planning level that is “played straight”, i.e. without a prompt animal. The child could then progress to the prompt level and from there could tackle more complex ideas like interrupted plans, prioritising prompts from multiple animals and having to strategically visit animals in order. For example, the player could be told that the penguin wants a toy, but it is in the giraffe’s enclosure. They would have to reason that in order to get the toy for the penguin, they would have to first visit the giraffe. JT-A and RS-A were positive about the development of multiple levels and when shown MR-A’s ideas, thought that they were good extensions to the complexity. During the focus group, KR-FG independently suggested that the game should have
more difficult levels, like being told that the animals need to go to the vet and having to plan a way to take them all.

VU-A felt that a good way to add complexity would be to have more animals to choose from. She did not approve of the idea of interrupted plans (see section) or having to strategically visit one animal before the other. She reported that as a child she found games like that frustrating because often she did not correctly interpret the prompt and found herself unable to progress. She believed that if the strategic reasoning was included, it would need to explicitly walk the player through the thought process and ensure that they took the required actions.

Discussion about this design suggestion is strongly supportive of adding more complex levels and story prompts to the game. Future development should focus on adding levels as described by MR-A, but in design children should also be consulted to discover what they would find a compelling story. VU-A’s concerns about difficulty inferring actions are very valid, especially for younger or less able children. Gradual scaffolding should be incorporated into the later levels with explicit explanation of thought processes.

6.3.12.6 Points and Reward Structures

A complaint about the game during formative and summative evaluation is that after completing the mini games, the points “disappear” and are therefore meaningless. Participants in the individual adult evaluations and focus group were asked “What should happen with the points that you collect during the mini games?”

JS-A and VU-A believed that having a cumulative points total with rewards would be motivating to children, especially if they were playing with others.

RS-A suggested that as you play the game and collect points, you are unable to unlock new animals and games. He felt that along with more complex stories and planning challenges, the ability to unlock new animals would have kept him engaged with the game as a child. FR-FG and SR-FG shared this idea, suggesting that you should be able to use the stars to buy animals to add to the zoo and that sometimes the player should earn “surprise prizes” on completing the game. KR-FG and RR-FG suggested that instead of just buying animals, you should be able to buy a plane ticket to a different country and play a mini game to catch new animals for the zoo. MR-A approved of this design from an educational standpoint (animals, countries and habitats) and the focus group were enthusiastic to share information about their favourite animals and their habitats. FR-FG enthusiastically added to this idea, suggesting that the player should be able to go to a workshop and use their points to buy different body parts and construct new animals to add to the zoo. This is a very similar idea to game design D8 created during the Brownies’ design workshop (see section..)

Discussion of points and reward structures strongly suggests that future development incorporate in-game progression related to the accumulation of points. Critically, the progression should not be related to the difficulty of game that the child is playing, so a child who is unable to engage with more complex planning tasks is still able to
have a sense of progression in the game as a whole. The progression should involve getting new animals and games for the zoo. The new animals should be chosen by the player, as suggested by the focus group. This will give agency to the player and also avoid the child being disappointed or upset by the animal that the game unlocks. The suggestion to use points to travel and find animals was unique and engaging and should be strongly considered for inclusion in the game.

6.3.13 Limitations

The summative evaluation was limited in the following ways:

- The researcher was a relatively inexperienced interviewee and encountered difficulty thinking of non-leading questions spontaneously
- The study participants are from a narrow section of the ASC population, particularly the individual evaluation participants
- The participant group is small
- The evaluation does not experimentally or anecdotally explore effects of the application on executive function ability
- Only one participant is part of the target user group (4 to 8 year old children with ASC)
- The adult participants expressed difficulty in imagining how they would have reacted to the game as a child

These limitations mean that the results should be taken as explorative and could be used to inform further work. Within the scope of the UG4 project, these limitations were inescapable.
Chapter 7

Discussion and Further Work

The outcomes of this research are encouraging and show that the design of a game to assist with teaching executive function skills is a valid area of research. The formative and summative evaluation shows that while there are issues with implementation that need to be resolved (i.e. narration, increased scaffolding), the application as a whole works well and is engaging to both adult and child evaluators.

Further work:

- Fix usability and implementation issues discussed in Chapter 6
- Implement more levels, complexity, mini games and features as recommended in chapter 6
- Conduct research into appropriate methods for incorporating plan interruption into a level of the game
- Explore the possibility of conducting experimental work or longer term user studies to explore the impact of the application on planning and self monitoring skills
Chapter 8

Bibliography


