TALLINN UNIVERSITY

School of Digital Technologies

Digital Learning Games

"Designing a propaedeutic game for children with speech and communication impairments"

Keelelise erivajadusega lastele mõeldud propedeutilise mängu disainimine

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Declaration

I hereby declare that I have written this thesis by myself and without support from any other person or source, and that I have only used the materials and sources indicated in the list of work cited. Neither I myself nor any other person has submitted this to any other institution for a degree or for publication.

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Abstract

The thesis describes the designing process of an educational video game for children with speech and communication impairments that are approaching the augmented and alternative communication methodology. The research involved the participation of several teachers and therapists. In the first stage of the designing phase, they pointed out that there are not many video games that help the children become familiar with the Picture Communication Symbols (PCS) symbols or that can be used with low functioning autism students. After this first feedback, the main goal of the research become to design a propaedeutic game, able to engage the users in a learning path towards the recognition and use of the PCS symbols. After the first prototype, tested at Käo Tugikeskus of Tallinn, a final version of the game was implemented thanks to the playtesting of students and the indications of the teachers.

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Introduction

The social integration of people with disabilities is an important objective recognised and pursued by national and European policies. Regarding digital technologies, since the ‘80s, architectural barriers to the accessibility to information technology have been gradually been eliminated. For a child with disabilities, computers and technological devices can be indispensable tools for communication or for carrying out the normal school work. However, computers, software, and especially video games cannot always be used by people with special needs, as they are designed for the majority of the population.

A person who has a hearing impairment may not be able to hear the sounds of the game. For people with visual disabilities, the situation is even worse, the player will not be able to perceive shapes and colours (Archambault, Ossmann, Gaudy, Miesenberger, 2007) and often like in the case of physical disabilities they will not be able to play as the ability to interact actively with the game is almost entirely compromised (González, Cabrera, Gutiérrez, 2007). As Caprino (2010) shows, the absence of appropriate aid and facilities (simplification of the level of play, suggestions, and so on) and the lack of clarity of the rules then make the use of these applications difficult or impossible for those with cognitive disorders. Most of the time this category really needs tailored games with the possibility of set specific options (Saridaki, Gouscos, Meimaris, 2009).

As a teacher with kids that have special needs, I was particularly interested in investigating this sector, and in designing an useful game with the help of the team

of teachers. Unfortunately in the schools where I worked, special teachers avoided to use new devices, mostly because the customisation options were not adequate and make a potentially good product very limited regarding usability. Starting from this problem, I would like to design a game for users with speech and language impairments, like some cases of autism, because I think that the use of educational video games with these children could have an even more decisive role than other diseases. Fundamentally because the interaction with a "machine" is characterised by predictability. The player will not deal with possible unexpected reactions, and this eliminates the "wall" that stands in front of the subjects affected by autism (Fassino, Abbate Daga, Leombruni, 2010). The computer (or another technological device) does not become impatient or upset, it reacts in entirely affectless way, without any possibility to give origin to a misunderstanding. For an autistic person, it may be less difficult to understand the voice reproduced through a vocal synthesis because it does not present particular inflexions and turns out to be a stable auditory stimulus (Parsons, La Sorte, 1993).

I decided to select a specific target, children, with severe communication deficits, because I want to create a very tailored games for their special needs. This requires a complete research study on the needs of the players, the needs of people that work with them, including educators, teachers, and therapists, as well as which are the obstacles children face in the existing games and how to effectively use the alternative and augmentative communication (AAC) methodology. As Beukelman and Mirenda (2005) explain, this term is used to describe a wide range of methods that can help people who have difficulty using the most common communication channels, especially language and writing, to interact with other people. It is called alternative because it is used alternatively to the traditional methods of communication and augmentative because it does not substitute but increases the

natural communication possibilities of the person.

The first phase will be conducted through direct observations and interviews. Afterwards, there is going to be a codesign phase in cooperation with the personnel mentioned above. The prototype will be tested with some children and teachers, and the feedback will be used for the implementation of a final version of the game.

As Spinuzzi (2012) states in projects that involve design as well as research, the object of the research tends to be expressed in a *purpose statement* rather than a *research question and here there* are the goals that I intend to pursue with the thesis:

1. Determine which are the needs of users and teachers
2. Study different types of approaches to improve communications skills
3. Determine which strategies are preferable to be used
4. Design a prototype of educational game
5. Test the prototype on a group of participants
6. Verify if the game is engaging and effective
7. Implement the game prototype

Theoretical Overview

Using video games in special education is a topic that has been studied by several researchers already (González, Cabrera, Gutiérrez) and it is well documented that video games have a great attractive power, especially for children with autism spectrum disorder (ASD) (Mazurek, Shattuck, Wagner, & Cooper, 2012). As it is explained by Hiniker, Daniels and Williamson (2013), an American national survey, in fact, shows that 41% of U.S. kids with ASD are "heavy gamers". This means that they spend most of their free time playing video games. This data is referring to commercial games that are not necessarily considered therapeutically or educationally relevant for this population, but the attention required during the game sessions can be considered a prerequisite for learning. The selected target group of users will not be able to use commercial video games as they are going to be children at early stages of their education with impairments in verbal and written communication. However, still is an important data that shows how many children with ASD find digital devices and games engaging.

1. 1 Users and Approaches

The choice for this project to focus on kids with impairment in speech and communication is dictated by the fact that this period is particularly important in developing of effective strategies to relate with the people around and to learn a way to interact with them (Hwang, Hughes, 2000). To give an overview of the characteristics of these children and in particular with the ones with ASD I would like to give a short explanation of the disease.

This disorder manifests itself in a wide range of severity levels (Happé, Ronald, Plomin, 2006) however all those who are affected have typical difficulties in three areas, the so-called autistic triad:

1. Alteration and compromise of social interactions
2. Impairments in communication
3. Restricted interests and repetitive behaviour

From the first moments of their lives, autistic children find difficult to relate to the outside world. Autistic children live in isolation that leads them to ignore some external stimuli. A problematic relationship with other human beings is accompanied, on the contrary by an excellent ability to relate to objects. In fact, an autistic child can play for hours with a simple object. Direct cause and consequence of this ability is the desire for repetitiveness present in autistic individuals, who have an insufficient variety of spontaneous activities (Bodfish, Symons, Parker, Lewis, 2000). Their isolation leads them to create particular expertise and to obtain a phenomenal memory in certain subjects. As stated in the *Diagnostic and statistical manual of mental disorders (2013),* the specific deficits, therefore, concern the following skills:

• meta-representation
• the perception and expression of emotions
• shared attention
• sensorial orientation
• imitation
• the symbolic game
• communication and language
• emotional attachment
• intentional or finalistic behaviour

At present, the DSM-V (2013) has three severity levels:

Severity level	**Social communication**	**Restricted, repetitive behaviors**
Level 3 "Requiring very substantial support"	Severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others. For example, a person with few words of intelligible speech who rarely initiates interaction and, when he or she does, makes unusual approaches to meet needs only and responds to only very direct social approaches	Inflexibility of behavior, extreme difficulty coping with change, or other restricted/repetitive behaviors markedly interfere with functioning in all spheres. Great distress/difficulty changing focus or action.
Level 2 "Requiring substantial support"	Marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place; limited initiation of social interactions; and reduced or abnormal responses to social overtures from others. For example, a person who speaks simple sentences, whose interaction is limited to narrow special interests, and how has markedly odd nonverbal communication.	Inflexibility of behavior, difficulty coping with change, or other restricted/repetitive behaviors appear frequently enough to be obvious to the casual observer and interfere with functioning in a variety of contexts. Distress and/or difficulty changing focus or action.
Level 1 "Requiring support"	Without supports in place, deficits in social communication cause noticeable impairments. Difficulty initiating social interactions, and clear examples of atypical or unsuccessful response to social overtures of others. May appear to have decreased interest in social interactions. For example, a person who is able to speak in full sentences and engages in communication but whose to- and-fro conversation with others fails, and whose attempts to make friends are odd and typically unsuccessful.	Inflexibility of behavior causes significant interference with functioning in one or more contexts. Difficulty switching between activities. Problems of organization and planning hamper independence.

Autistic children, in general, do not have sensory deficits. However many people on the autism spectrum have difficulty processing everyday sensory information, as they experienced an overload of stimuli that are not able to handle altogether. Too much information can cause stress, anxiety, and possibly physical pain (Gillingham, 1995). Thus, a common strategy is to focus on a detail rather than the whole object. During the design phase, it is important to remember that attention in autistics is an important aspect, and it is still confusing in some ways, so it is necessary to design interfaces that are simple and do not distract the child with additional elements that are not very useful for the game. Elements that the child would notice when he was distracted. It is important to also take the desire for repetition into account: even in the graphics, is best to not create too many different visual situations because they would end up diverting the child's attention, which would not understand being in the same game environment.

After a game session, it is common practise to receive feedback about one's performance on depending on the choices made in the game. This reward systems can be interpreted as incentive to play again or as compromise to ease the displeasure in the case of loss. There are many ways to give it, such as scoring systems, experience points, virtual objects, new resources available, honorary titles, feedback messages, unlocking objects and changes in the game's plot.

Widespread feedback, especially in video games for children, is a graphic smiley, neutral or sad face. The problem is that autistic individuals find it difficult to decode facial expressions, as well as mental states (Balconi, Carrera, 2007). Without the ability to attribute mental states to others, the use of these type of feedback is meaningless. If an autistic child can not automatically decode the meaning of glances, then he or she will perceive a silent message that will be easily ignored. It

is, therefore, necessary to make these feedback messages very clear and understandable during the designing phase, maybe associating them with a sound effect. In this way they will be able to understand the meaning and learn to recognise them in the future.

Another factor to consider is that typically, children with autism can process visual information more efficiently than auditory ones. Different types of visual systems, such as objects, photographs, realistic drawings, symbols, and words, should be used with various technological supports, to better promote the child in the understanding of different visual representation. Each child can process better particular types of visual representation in different contexts. This depends on numerous factors: the abilities of the child his or her level of attention, organisation, distractibility, and so on. It is a common practice to start with a symbol-based representation system and decide only later if integrate it with photographs or real objects (Mizuko, 1987).

Therapeutic Approaches

Once a child is diagnosed with an ASD, a net of support of territorial services, schools, and specialised therapists that will collaborate with the family should be established to give the best opportunities to the child. All together they will provide support interventions, counselling, individual psychotherapy, group and parent-child psychotherapy, and so on.

The proper psychotherapeutic treatment must start from attentive analysis of the history of the disorder, the diagnosis and therapeutic process that preceded the consultation, topics related to environmental and family responses to disturbance and parental representations (Ennis-Cole, Durodoye, Harris, 2013). Several approaches

are generally used with autistic children, here there is a list of the most recognised methods:

• **ABA** (Applied Behavior Analysis) is a scientifically validated approach to understanding behaviour and how it is affected by the environment. It is based on different strategies that are going to be shown below. They all help the correction or reduction of some problematic behaviours and incentivise positive ones. The effectiveness of the practice is highly recognisable from several studies (Birnbrauer & Leach, 1993; Perry, Cohen, & DeCarlo, 1995). Skinner is considered the grandfather of the methodology thanks to his research of "operant conditioning" and his book *The Behavior of Organisms* published in 1938. Results suggested that long-term, comprehensive ABA intervention leads to a medium to large improvement regarding intellectual functioning, language development, acquisition of daily living skills and social functioning in children with autism (Virués-Ortega, 2010).

- **Pivotal Response Treatment** (PRT) is a treatment based on the principles of ABA, first published in the 1980s by Robert and Lynn Koegel (Koegel & Williams, 1980; Koegel, O'Dell, Hoegel, 1987; Koegel, Koegel, 1988) and is considered one of the best-supported interventions for autism and has extensive scientific literature documenting its effectiveness (Ingersoll, Schreibman, 2006; Schreibman, Koegel, 2005). They noticed that kids during a behavioural treatment were performing better in a more natural and interactive setting, instead of in a format for structured tests led by adults. The PRT, in fact, differs widely from structured learning sessions even though both are based on the ABA teaching principles.

Compared to structured learning sessions, PRT techniques motivates children more,

increases the amount of spontaneous responses, and reduces problematic behaviours. The PRT is based on the assumption that because many children with autism need to train many behaviours, it is essential to identify target behaviours that will produce simultaneous changes in many other behaviours (not directly treated) instead of having to treat each behaviour individually one at a time. In the book *How to Teach Pivotal Behaviors to Children with Autism: A Training Manual*, Koegel and collaborators are using the term "pivotal behaviour" to refer to those behaviours that appear to be central in large areas of functioning. Therefore, positive changes in pivotal behaviours should have positive effects on other adaptive behaviours (not directly treated) and constitute an efficient way of producing generalised improvements in the behaviour of children with autism. Examples of pivotal behaviours are the motivation and response to multiple stimuli.

• **DTT** (Discrete trial training), in which the activities are deconstructed into steps to be addressed one at a time and by attempts, which can be foreseen reinforcements (both verbal or tangible). Currently is one of the most important instructional methods for children with autism (Smith, 2001). Children with autism have few opportunities to learn from the environments around them because they do not observe as they usually have particular and stereotyped interests, and because of that, they cannot imitate the behaviour of others. Observation and imitation are essential prerequisites for learning all behaviours, and they do not seem to be gratified by intrinsic reinforcers. A child with ASD has difficulty in learning some "spontaneous" behaviour, so a special way to teach them is promote tailored learning opportunities. This way, DTT enables the teacher to decide on what and how start working, everything is directed by the adult.

Some "artificial reinforcers" replace the natural ones that are not perceived by

children with ASD. For example, if normally a child learns to do a puzzle because it is intrinsically reinforcing for him and especially because his mother says “good” and he likes to be praised, on the contrary, a child with autism, probably needs an artificial enhancer that will variate on depends case by case. In this methodology, a great importance is given to the reinforcement procedure that follows the child’s action.

The teacher must organise a working environment without distractions, that could become an obstruction for the learner. Then he or she must decompose a skill into simple, small parts and teach a single competence at a time, giving the child maximum help and avoiding the errors. This is why DTT is also called “errorless learning” (Weiss, 2001). Typically, the child and the teacher sit one in front of the other with a table between them, and they work on a specific behaviour with a stimulus and a clear instruction. A weak point, however, according to the scientific literature, is the problematic generalisation of artificially constructed learning in real life situations as the reinforcements used in the DTT are hardly traceable in the child's natural environment (Cowan, Allen, 2007).

• **NET** (Natural environment teaching) With this methodology the environment plays a fundamental role: the child and the therapist work in the usual places but enriched with intrinsically motivating materials. In this teaching mode, much attention is given to the motivation and the variables before the behaviour . The teacher's work follows the child's initiative creating learning opportunities starting from the child's interests (Weiss, 2001).

• **Incidental teaching**, relies on the child's natural interests, through reinforcements that allow us to develop a certain propensity of the child. It promotes a significant

development of the language through a greater generalisation and more spontaneous use of prepositions (McGee, Krantz, McClannahan, 1985). Also, in this case the environment is natural, the inputs come from the daily routine, and often the initiative is taken by the child. The reinforcers are natural, and connected to the answer in a functional way. For example: in the kitchen, the teacher will wait before delivering the biscuit that the child will make the request.

• **PBS** (positive behaviour support), which aims to encourage behaviour positively. It emphasises prevention, continuous progress monitoring, data-based decision making, evidence-based practices to sustain positive and adult behaviours (Sugai, Horner, 2006). Certain individual and social behaviours are reinforced while other actions are systematically decreased. Ideally, desired outcomes and corresponding incentives and reinforcements for demonstrating these outcomes are co-generated and thus valued by students, families, educators, and others.

• **VB** (verbal behaviour) the application of ABA procedures to the language that Skinner (1958) considers a behaviour and therefore modifiable through the modification of environmental contingencies. Therefore, it is a set of behavioural procedures, that has been increasingly perfected over the years. It is effective to teach the verbal behaviour that the same Skinner in his famous book from 1957 Verbal Behavior classifies in: mand (requests) tact (labelling) echoic (repetition) and intraverbal.

• **AAC** (Augmented and alternative communication) is an umbrella term that encompasses the communication methods to support and encourage different types of communication. It can take place through signs and gestures granted or with physical supports (paper or technological). It uses all the communicative skills of the

person, including vocalisations or existing verbal language, gestures, signs, communication with aids and advanced technology. It is not merely a matter of applying a rehabilitative technique, but of building a flexible system tailored to each person. It should be promoted in all the moments and places of the patient life because communication is necessary and indispensable for each of us at every moment, and not only in the therapy room (Light, 1989).

• **PECS** (picture exchange communication system), is a technique to teach children and adults with autism and other communication and speech impairments to communicate with the use of images, always in the context of Alternative Augmentative Communication. During the years were developed several symbol collection, and the most famous one is called **Picture Communication Symbols** (PCS) created by Mayer-Johnson (1990) that are graphic symbols used for communication. They also created a software, "Broadmaker", that is suitable for children and adults. It offers around 3,000 black and white symbols that can represent objects and actions to form complete sentences. Symbols can be adjusted in any size and are universally understood. It is a very clear system, which avoids ambiguities and that can often be encountered with photos, especially those made by themselves. Some children with ASD prefer or particularly hate specific colours, and for that they could focus on colour instead of on the whole symbol (Speaks, 2011). PCS solve this potential problem easily as the neutral colour help the kids to concentrate on the whole image, removing the colour obstacle.

The teacher usually starts to use the PECS in accord with parents in individual context because tangible outcomes initially are more motivating to children with autism than are social outcomes. The overall protocol is divided into six phases that progress from teaching children how to communicate using the pictures in a manner

that is important to the child, to the use of multipicture sentences, and then to the use of a variety of communicative functions. The protocol combines the theory and practices of both behavioural and developmental, or interactional, perspectives (Bondy, Frost, 1994).

The first phase the teacher must identify the most effective element of motivation for the child, for example food, drinks, toys or special activities and each of them prepares a symbol card to represent them. This first stage of learning is facilitated through the physical guidance of the child and once he/she has delivered the card is widely praised verbally, and the reinforcement is given. After, in the second stage the child will learn to actively search for the symbols and will interact with the interlocutor by leaving the symbol card in his hand. In the third phase there will be a discrimination of the symbol. The child learns to discriminate between visual stimuli and to express a choice between limited options. In the fourth phase will learn to construct of simple sentences, then to answer the questions in the fifth. In the last phase, the student will be able to start and conduct a conversation spontaneously (Howlin, Gordon, Pasco, Wade, Charman, 2007).

In conclusion, there is not an ideal methodology to be used, but on depending by each child, it is going to be useful to structure a combination of different strategies including some in the natural environment to facilitate the generalisation of learning. Some of these approaches that are relevant in the game design are going to be examined later in the thesis.

1. 2 Overview of educational games designed for kids with ASD

Design a quality digital learning games require lot of time, and when is the case of

developing one for children with special needs it is even more difficult. Psychological techniques must be used to help to overcome the users' limitations. I am going now to expose some of examples and different approaches used by game designer and researchers to create games for children with communication disorders.

A) Go Go Games

The pivotal approach was used by the team of designers (Hiniker, Daniels, Williamson, 2013) in the creation of the suite of games called **Go Go Games**. The games were made to train the skill of multiple-cue responding in a nonverbal setting. This skill, notice and respond to simultaneous cues can be very challenging for kids with ASD that tend to hyper-attend to a particular one. Moreover they did it through a core element of PRT know as conditional discrimination, by presenting activities where the kid has to notice multiple cues simultaneously.

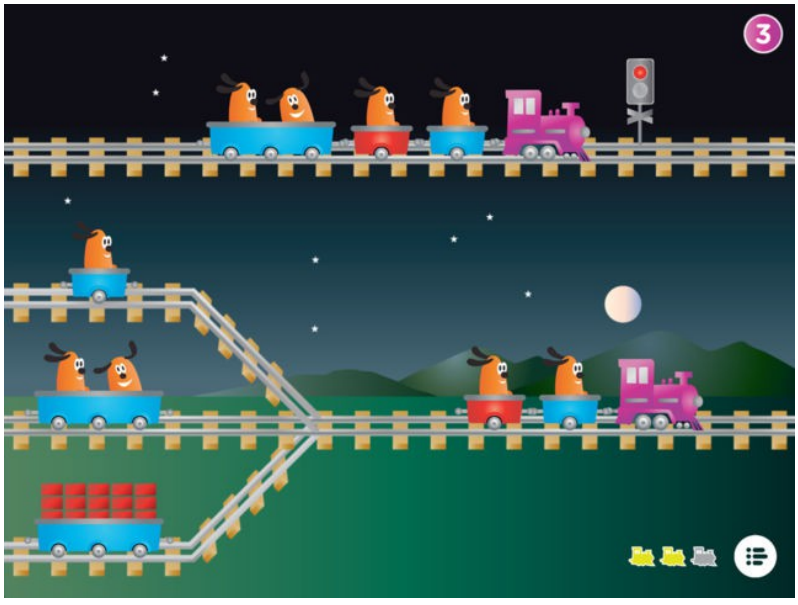

Figure 1. Screenshot of Go Go Games

B) Sc@ut

Another team of researcher of the University of Granada (González, Cabrera, Gutiérrez, 2007) designed a didactic game called **Sc@ut** to enhance reading and writing skills by training kids to associate letters, words or sentences to concepts by using the alternative and augmentative communication. To achieve this goal, they decide to focus on working on oral, visual, auditory stimuli and the relationship that exists between them to obtain implicit links, which help to assimilate new concepts. This theory is known as Stimulus Equivalence Theory of Sidman (1971) and said that if relationships between stimuli are trained clearly, then new relations that have been hidden can be obtained implicitly. However, another critical factor in the creation of a video game for children with special needs is a user-friendly interface.

The Nintendo DS device was chosen by the research team because of its usability. Thanks to the two screens it is possible to use videos and animations without losing the action's context, showing the cause and effect at the same time. In this way, the child will have an immediate reinforcement of the action that he performed. When the user selects in the lower screen the image of the object or action he desires, that image or a video, corresponding to it, appears on the upper screen. Videos and animations are shown in a specific context of action, evidencing the cause and effect of it, and helping in the understanding of it (Rodríguez-Fórtiz, González, Fernández, Entrena, Hornos, Pérez, 2009). Later testes, in fact, showed that children were improving in interaction, social communication and learning how to make sentences to express feelings and desires.

C) PAR

Because social interaction is one of the most significant problems for kids with ASD, a team of researchers in Brazil (Greis, Silva, Raposo, Suplino, 2014) designed a collaborative game to help these children improve their social skills. The game is called **PAR** and was tested on a group of five teenagers with autism with high level of impairment in social interaction. The researchers decided to intervene in two of the possible collaboration patterns: "constraints on objects" that pushes player to collaborate in finding the right object, and "different roles" so that every person has their tasks and role during the game session.

D) Paro

Speaking now about technologies that can be used, there are several of them that can contribute to the difficulties encountered by individuals with autism. Among them, we can mention the use of Robotics technologies. An example is the team lead by Shibata (2001) designed a robot called **Paro** a pet of arctic seal. The weight of the robot is about 2.8 kg and is covered with a soft and white coat. The choice fell on a baby seal to reproduce an unknown animal enough not to create too many expectations in the user during the interaction. In designing Paro, they paid close attention to creating a rich tactile experience, a fundamental source of stimuli for the user that should take the pet as a powerful social mediator. In fact, it is not designed to help the user in performing tasks, but to be involved in personal experiences thanks to the specific physical, emotional behaviour. In addition to the particularly soft fur, the robot was equipped with tactile sensors, light (recognition of light sources), auditory (determination of the direction of a sound source and speech recognition) and balance. The seal can to show three types of behaviour: reactive,

proactive and physiological. The first is the one related to the basic patterns in responding to external stimuli, such as, for example, turning the head towards a particularly strong sound source. A proactive behaviour is generated by a neural system that stores internal data, stimuli and an internal circadian cycle that determines, with the continuation of the interactions, the need to sleep or to be stimulated.

Figure 2. Paro Robot

The physiological behaviour is based on the sleep-wake rhythm, on a long-term memory able to keep track of the previous interaction modes and on the state of the internal batteries, so when these are almost exhausted, Paro will seem more tired and his movements will be slowed down. The fact that the number of basic behaviours that the robot can exhibit is finished, however, allows the generation of a potentially infinite number of behaviours, thanks to the variation of the parameters of the neural network. This makes Paro's behaviour difficult to predict. The research aimed to combine the use of the robot to the normal non-pharmacological therapy and to

verify if this has had positive effects on children with autistic syndrome or with problems in the relational sphere (Palma, Marti). This alternating game session to different tests: CARS-T (Childhood Autism Rating Scale), ABC (Autism Behaviour Checklist), LAP (Learning Accomplishment Profile) and VABS (Vineland Adaptive Behaviour Scales).

E) Robota

Another example is the **Aurora** project lead by Dautenhahn (1999), which focuses on the use of robots as tools that might serve an educational or therapeutic role for children with autism. This project, started in 1998 has develop during time few prototypes that are used to develop communication and social interaction skills, like the **Robota** doll. Robota serves as a robotic platform to provide a safe, simplified, and predictable environment to familiarise these children with the socialisation skills. Depending on the children's abilities, the complexity of interaction can be varied. The Robota doll was specifically designed for engaging children in imitative interaction games and turn-taking games with the robots (Dautenhahn, Billard, 2002). Imitation and mirroring play already an important role in many existing therapies for autistic children. Usually, mirroring/imitation methods are highly time and labour consuming and require the teacher to undergo specific training. A robotic therapy aid could provide an economically-efficient means of taking some strains off teachers or parents.

F) Baldi

Bosseler and Massaro (2003) instead designed a Computer-Animated Tutor called **Baldi**, a three-dimensional talking head that provides realistic visible speech that is

almost as accurate as a natural speaker. Through Baldi, kids are going to develop and strengthen vocabulary that is an essential element of intervention programmes in ASD cases. Computer-based apps are emerging as a prevalent method to train and develop vocabulary knowledge because of the possibility to present new words and images, helping in the processes of association and leaving instant feedback.

G) ABC Autism

Similarly, another Brazilian team of researchers work in a game to enrich kids vocabulary: **ABC Autism** is a suite of games whose primary function is to assist in the literacy process of children with ASD and, consequently, to serve as a support tool in the treatment and education of these individuals (Magaton, Bim, 2017). The game ComFim besides of working on communication skills also provide a multiplayer environment, and in it, two players can play the game and work together to achieve the game goals (Ribeiro, de Araujo, Raposo, 2014). The game was designed with the help of the **MDA framework**, a model that aims to provide the tools to divide a game into three different layers, each linked to the others: Mechanics, Dynamics, Aesthetics (Hunicke, LeBlanc, Zubek, 2004).

Every game is composed by these different layers that are very connected to each to create a unique combinations. In the design phase, these three levels can be seen as steps that stand between the work of the developer, and the use of the game by the player.

Figure 3. Scheme of MDA framework

By organising the game system in this way, it is clear how easy it is for the designer to work on the mechanics rather than on the rest. The designer has no direct control over the dynamics but can only plan them by creating mechanics suitable for the purpose. The only way he/she can see if his plan is successful is to test the game with the target of users. In fact, in this case children, parents and therapists participated in the validation phase of the digital game.

Tartaro and Cassell (2008) from Northwestern University designed a robot that imitates a peer that tell a story. It is known that learning from peers is motivating and effective but in the case of children with ASD the social and communicative deficits make difficult for them to learn through peer social interactions.

Methodology

In this section I focus on the explanation of the methodology used in the game development, passing from the prototypal research of the product through the educational path realised. I refer to not only the development operations per se but also to the aspects that precede these operations, selecting the guidelines and criteria shared with the actors involved in the design. I was in constant relationship with the representatives of the educational sector or recipients.

In the developing phase of apps and games, different design methods can be used, mostly on depends on the level of involvement of different partners as children, relatives and therapists. Developers most often involve parents and teachers about what they think their children or students may need, rather than ask children (Druin, 1999).

From all typology of children with special needs, kids with high functioning autism (officially called level one) are the target group most often involved in the design process (Börjesson, Barendregt., Eriksson, Torgersson, 2015) because of their ability to communicate and accomplish more complicated tasks. For these children there is a range of adapted methods, especially in the requirements and design phase. For both groups of high and low functioning autistic children, field studies or observations often contain the implicit goal of establishing rapport with the children.

2.1 Design-based research

The main methodological reference is represented by **design-based research** in the educational sector (Brown, 1992) from which numerous studies and projects are originated. Wang and Hannafin (2005) define the approach:

"[...] a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories."

And they proposed five characteristics for DBR: *"Pragmatic, Grounded, Interactive, iterative and flexible, Integrative, and Contextual"*

Design-based research has represented a reference element in the creation of cross-media learning environments, intercultural educational resources, and digital platforms capable of bringing schools and other partners into dialogue. The key of the success is probably because its goal is to solve current real-world problems by using a practical and flexible approach, with its attention to the authenticity of contexts, matches very well with the educational environments. These products can effectively respond to the needs of users as they are tailor-made tools and materials. The introduction of teaching technologies and the use of digital materials and tools in the learning processes has revealed the need to plan together with user resources, environments and educational paths, accepting their needs, expectations and possibilities for innovation. Many theoretical solutions are still used but the elaboration of solutions on the theoretical level and the observation of contexts, also if punctual, is no longer sufficient for formulating an effective output. In traditional

educational research, existing theories are usually tested through artificial treatments in controlled contexts, and the goal is to verify that the design instruction based on the principles works. As is written in the article "What is Design-based Research?" (2018) on http://dbr.coe.uga.edu/explain01.htm#first, the purpose is not testing whether the theory works, rather, both design and theory are mutually developed through the research process.

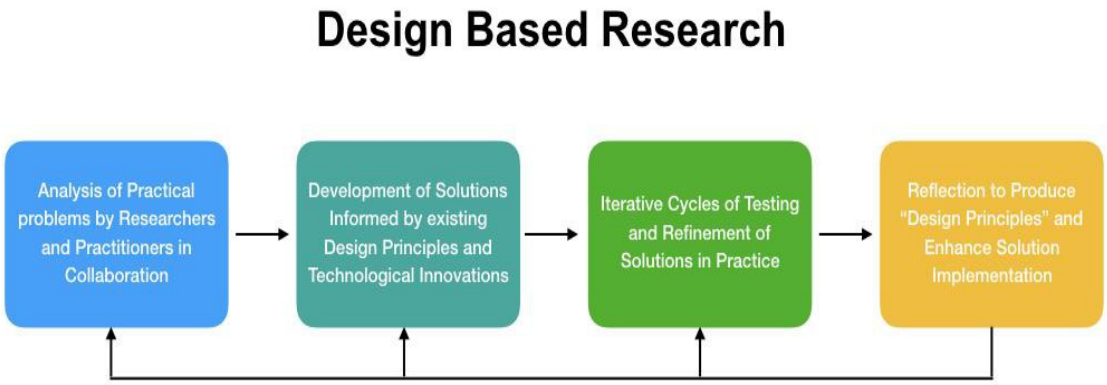

Figure 4. Scheme of Design-Based Research

2.2 Principles of the DBR

Here are going to be stated more clearly the principles behind the chosen approach, written in the "The Design-Based Research Collective" (2003) and after in which way they were applied in the current project:

a) First of all, it must be emphasised that the fundamental objectives of designing learning environments and developing theories of learning are closely connected.

b) The development of the project both in its practical and theoretical sides should pass through continuous cycles of planning, implementation, analysis, and redesign.

c) Design research must lead to shared theories that will help in communications between the designers and the operators to work all with a clear understanding of the educational actions.

d) The research must reflect how the project works in authentic contexts, documenting successes and failures, focusing on the interactions that define our understanding of the learning problems involved.

e) The achievement of these feedbacks and reports is based on reliable methods that document the processes and will help in the future implementation of the product.

2.3 Workflow

The current research on the design of a tool for ASD children involved the participation of a therapist who daily uses ACC and teachers and users from two different schools: the special school Käo Tugikeskus of Tallinn (Estonia) and I.C. Ungaretti of Piossasco (Italy). The first approach was with a ABA therapist, who also studies at Tallinn University. She, in first interview, suggested me to visit the Käo Tugikeskus, to talk with teachers and start to understand better the needs of the students and teachers. Käo Tugikeskus is a centre that supports 40 children with cognitive/developmental and multiple disabilities between the ages of 7 and 18. A key focus of the centre is to develop skills and knowledge in alternative communication (simplified signs, technical communication equipment, communication books, computer programs and other AAC methods) and for this reason it was really an interesting partner to work with.

From the first interview that was conducted with three teachers and the Head of Special Education at the institute, I discovered that there are several apps that can be used with children that already use AAC or those with a high-functioning levels of autism, but there are none for younger ones or with severe deficits that start to approach the techniques. From this feedback I start to elaborate the idea of using elements of AAC in the new game prototype.

The PCS are going to be used functionally to interact with the story, and the player will start to understand the connection between choices and consequences. After the creation of the first prototype, the game was presented first to the therapist and after tested in a School of the Metropolitan Area of Torino.

Figure 5. Ungaretti School

The reference point was a special teacher that works with two students with speech impairments that attend lessons in normal classes. In fact, in 1971, the Italian Law number 118 (Canevaro, 2007) granted all children with disabilities the right to be educated in ordinary classes with the support of special trained personnel. After that date all special schools were closed and all pupils with disabilities were included in

ordinary schools. This influenced a bit the tests as the users collaborate with the help of peers, and this is a great motivational push, as they really want to learn how to communicate with the classmates. The fact that the game does not require the use of lot of text allows it to be adapted to different language very easily. After the feedbacks of the students the game was implemented again and tested in the Käo Tugikeskus and in Italy.

2. 4 Design Guidelines

In the designing phase of the game it is essential to take into account the specificity of ASD, particularly in relationship to medium-low functioning children, that is the selected target (Bartoli, Garzotto, Gelsomini, Oliveto, Valoriani, 2014). Therefore, it is important to define general and specific guidelines. General guidelines consider high-level design principles and concern general interface and usability features. Instead specific guidelines focus on design features related to specific learning goals. In particular this category is composed by three sub-categories, respectively associated with learning skills in the motor, cognitive, and social dimension.

When designing a product, including games like in this case, it is wise to keep the usability principles in mind. Usability is defined by the ISO as the effectiveness (accuracy and completeness of users achieving set goals), efficiency (the resources expended to complete goals), and satisfaction (the users' attitude) (Federoff, 2002). These three measures are going to determine the involvement in the game. If the game has a high usability level, then it reduces the need of training the user, who can concentrate totally in the game rather than in understand its functioning. Before to

start with designing the game mechanics, interfaces and graphics, with the help of teachers and of the book "*Level Up! The guide to great video game design*" of Rogers (2014) I devise some Guidelines.

2.4.1 General Guidelines

Customisation

Every child is different, and in the case of users with disabilities, this is even more accurate. Each child manifests unique strengths and skill deficits. Things that are reinforcing or rewarding to one individual may be unpleasant for another person. Any play activity must, therefore, be oriented to addressing the unique capability and needs of each child, which implies that a game must support a high degree of customizability. It must be able for caregivers to adapt a gaming experience to the individual skills and preferences of each child, customising the feedback system, rewards, some elements of the interface and difficulty level.

Instructions

The game is going to have an intuitive, clear, and user-friendly interface that will lead the user along a semi-structured path. However, there will be a system of simple instruction that will give graphically hints and/or vocal messages, in this way kids will benefit from a combination of different channel of communication and will start to practice with PCSs. Understanding the goal and tasks should be facilitated before playing and should be reinforced during the whole game session.

Rewarding

The choices made in the game will bring the player to different scenarios, there will not be victories or defeats but only different ending situations. Nevertheless, a mechanics of rewarding is going to be introduced once that a certain action is going to be selected, in fact is always a powerful stimulus that may increase the child's motivation, enhances player engagement and implicitly improve player skills (Sylva, Jolly, Bruner, 1976). In addition, researchers have shown that for medium-low functioning autistic children a positive reinforcement like a funny video or audio effect is more motivating than a reward based on quantitative performance results (Bartoli, Garzotto, Gelsomini, Oliveto, Valoriani, 2014).

Repeatability

As mentioned before, children with ASD are quite comfortable with repetitions, so using the same structure could help the players to do not feel frustration when they play. Also, repetitive actions play an important role to achieve proficiency and provide control of the rate of learning. In another direction the choices of the player will change the course of the story, bringing the player to discover new scenarios but inside his/her comfort zone.

Longevity

The game should be played many times, and to avoid repetitive or boring match it is important to offer many stories and incentivise the users to experiment different choices. Eventually, the child will be able to unlock difficult scenarios after complete the easiest ones. It should be a smooth and fast process for the caregiver and the child to repeat a game, as well as to move to the "next level". The time of restarting a session or switching from one level to the next one must be minimised,

to reduce the risk of a child's loss of concentration during the transition.

Graphics and Animation

The graphic should be cheerful and aesthetically nice, but always strictly functional to the goal. Kids should not be distracted by visual elements that are not strictly relevant to the current task or they may lose attention. In addition, too much visual stimuli may induce anxiety as children may not be able to discriminate and interpret individual elements within a group. It is always important to find the right balance between a lack and an excess of stimulations. At the same way if the visual elements remain static and nothing else happens, the child may lose concentration and move his or her attention to something outside the game. A prolonged static situation may trigger abnormal behaviours, such as motor rigidity or stereotyped movements. The final element is the choice of the colour: it should be customisable, in fact some users can become very nervous when dealing with certain colours.

Clear Audio

Along with the colours, audio settings are going to be customisable. Sounds elements will follow the user's interactions and significant moments during the progress of the story that keep the children's attention. Music can be played during moments when nothing happens on the screen or there is a transition from one game configuration to another, or at the end of the game to complement visual rewards effects. It is important to remember that kids with ASD easily perceive as annoying too many audio stimuli, like a mass of noise that they cannot interpret, which creates extra stress.

2.4.2 Cognitive Skills Guidelines

Promoting Symbol Recognition

The main goal of the game is to bring the kid to familiarise with the symbol of PCS methodology in a ludic context. The game is especially designed for kids who do not know how to use them or have attempted to do so without success. The game will help the users to enter in contact with the new methodology in a different way, without the pressure of the performance.

Improving Attention Skills

Learning is widely seen as tightly coupled with the ability of focus on a certain activity for a determinate period. In particular, the game aims to improve the sustained attention: the ability to direct and focus cognitive activity on specific stimuli.

Causality

One of the main goals of the game is to facilitate an understanding of cause-and-effect relationships. It is a fundamental skill for kids with speech and communication impairments that are approaching alternative methods as AAC. They have to learn that choosing a determinate symbol will lead to specific actions, in the reality this can scare the kid but in the app the user will experiment in a safe environment without direct or bad consequences. In addition, they will start to train with simple but abstract ideas. While cause and effect may seem like a concrete concept to understand, it may be difficult for the target.

2.4.3 Motor Skills Guidelines

Increasing fine motor skills

Fine motor skills can be defined as the ability to complete coordinated hand and finger movements with precision and awareness (Iverson, Braddock, 2011). This ability begins to develop in the child, when, growing up, he focuses the attention on external objects and elements. In particular, the development of fine motor skills is a consequence of the development of oculo-manual, space-time and right-left coordination (Hourcade, Bullock-Rest, Hansen, 2012).

The required level of fine motor skill is not very high, but it can still be challenging for some kids with ASD who cannot manipulate objects well.

2.5 First Interviews

The initial phase of the research consisted of interviews. I conducted a group interviews at Käo Center with the teachers and the specialist of special education. Other interviews were made with Italian teachers of the metropolitan area of Torino.

From these interviews I discovered the following things:

- Teachers are willing to use digital devices, but they are not familiar with many apps. The market offers a lot of choices, but the process of selecting good apps is highly time consuming. Some solutions are also quite expensive and most of the schools cannot afford to pay several subscriptions.

- The more popular ones are for children who can already use an AAC methodology. For children who have comorbidity or are approaching the use

of PECs there are few, if any, usable apps.

- They would like to have some customisable app that will allow them to offer to their kids a personalised path.

Figure 6. Käo Tugikeskuse

To facilitate a fruitful discussion I decided to propose already some ideas to the teachers, in order to understand which direction to follow:

1. Game of symbol-object recognition, in which kids has to recognise, find and take photos of tools in the real environment.

2. An augmented reality game that helps kids to familiarise with the symbols and its functioning, this by combine symbols and markers that will show with

animation the purpose of objects.

3. A storytelling game where kids can start practising the recognition and the choices.

In the discussion the teachers pointed out that games that needs the player to move and to take pictures are too much complicated for the majority of students of the center, that have a low level of fine motor skills. The last option was the one most appreciated and I decided to develop the prototype starting from that idea.

2.6 The Prototype

Prototyping is essential to evaluate the usability of what is being designed, especially in order to check the interactive dynamics, weak points and find possible improvements. The realisation of the prototype was mainly useful to explore some aspects of the game's interaction and graphics. The game was created in three different phases, following the guidelines above mentioned. The protagonist of the story is a little animal that was modified during the process and is called Millo. The character does not have a gender connotation. The player can follow the explorative adventure of Millo slide by slide and sometimes interact with the story by choosing between some options. When the story starts Millo is at home, a hole in a bark in a green forest, but because is bored, decide to start a journey and discover the world. The user will be responsible for some choices of Millo. In fact the player will be asked how to proceed in the story, by selecting one symbol out of two.

The first prototype was built with Apple Keynote in order to prepare a story and with

hypertext writing tool Twine (http://twinery.org) for visualise the different branches of it. It does not have the symbols yet.

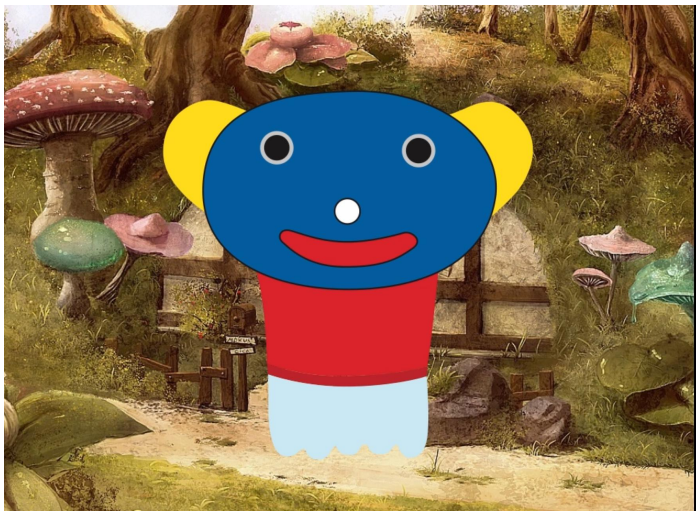

Figure 7. First Prototype

Once that the storytelling was ready I started to develop a working prototype on Google Presentation, as I needed the game to be tested in different devices easily and this was the best option. I would like to have already a captivating graphics and characters and I decided to design a new one and find nice background landscapes on Creative Commons image websites. At this point, the app is divided in two parts:

Setting Options

This very important section allows adults to set differents variables to make the game accessible and engaging. It is possible to change the colours, level of difficulty, sounds and rewards.

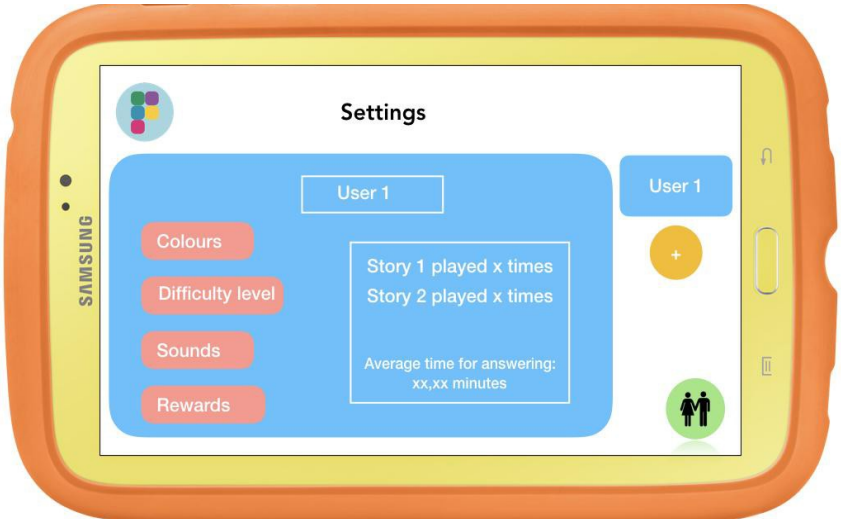

Figure 8. Settings Screenshot

From the initial page is possible to have access to several subpages. Clicking on the button "colours", the adult can choose between some palettes of colours, including black and white. This because as mentioned before, colours can be a strong element of distractions and is important to give the opportunity to remove some, if the case required it.

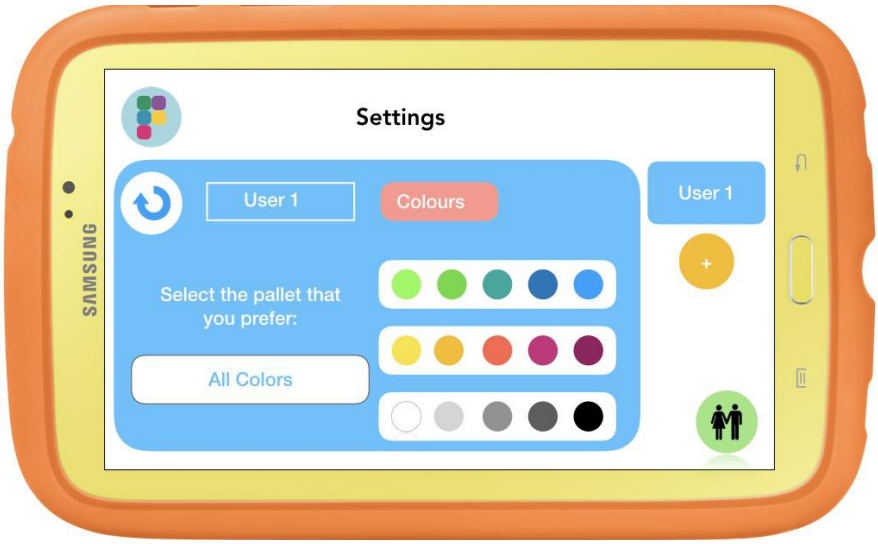

Figure 9. Colours Setting Screenshot

It is possible to decide to play at easy, medium or difficult levels. The variables that are going to change are the number of possible choices and the length of the all story. With a similar interface also sounds and rewards are going to be selected, always in order to make the game more effective and specific for each user. There are two types of rewards, visual and auditive ones, and both are customisable.

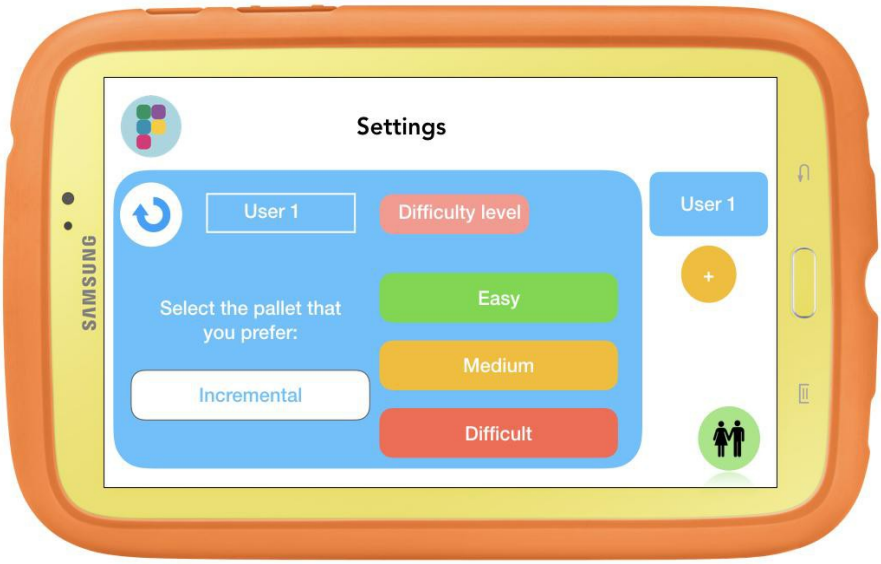

Figure 10. Difficulty Setting Screenshot

Play Mode

The second prototype is made with Google Presentation, in order to be easily played in different devices. Above is possible to see a sample of the game interface:

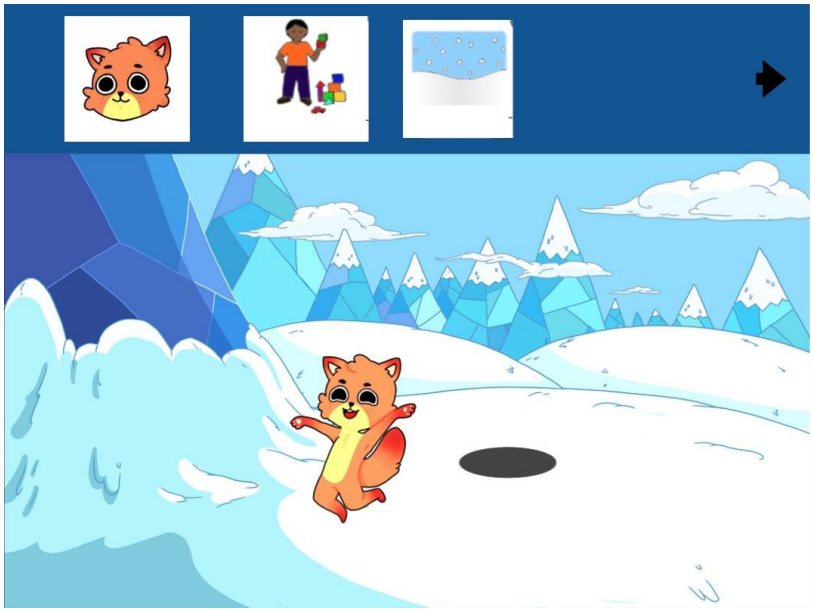

Figure 11. Game Screenshot

The game is structured in different interconnected slides that enable the player to actively take part in the story and modify the course of actions. Every slide has voice over that with a clear and inflexion-less voice leads the child in the story. It is possible to repeat the sentences by clicking on the icon of the megaphone. To progress the player has to click on the display and the slide will change. On the top of the slide there is a banner with the symbols in order of the sentence. For example in the images below the voice will say: “Where Millo has to go? To the Mountains or return at home?” In this way the user can enjoy the story by watching the animations but if he/she wants to understand fully the story they have to pay attention also to the

symbols or the voice.

Sometimes, during the story, the user will be asked to choose between two options or more on depends by the selected option of the settings.

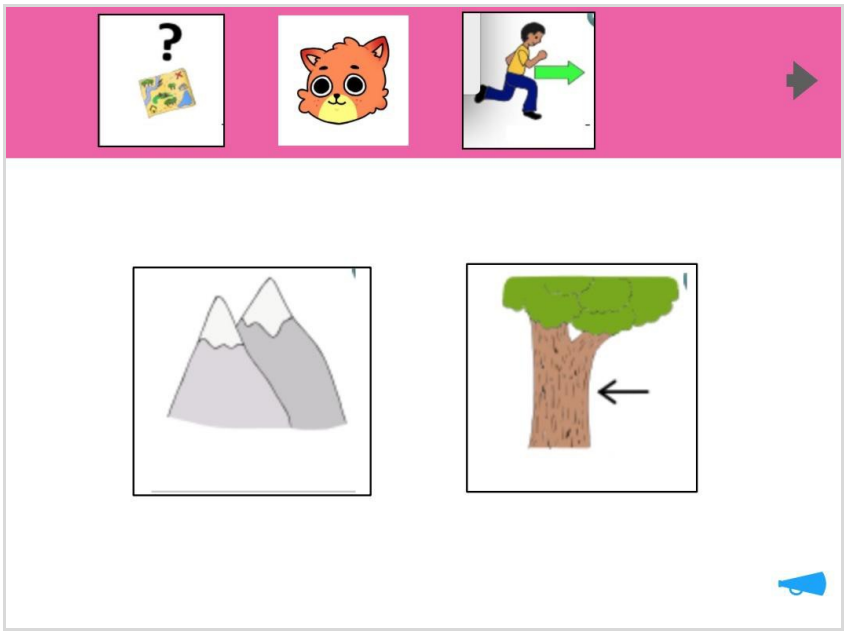

Figure 12 Choice Screenshot

In these special slides, the user has to click on one of the two objects in order to proceed. The choices can be related to different aspects, but I intentionally added some daily situation that the users have to deal with it. In fact, therapists, teachers and parents usually start to use symbols when they want the child to choose between two food items and two toys.

In the early stages of the prototype I decide to use creative commons symbols that should be replaced by the official ones PECS in the final version of the game. It is, in fact, important to be coherent, especially in the first period in order not to confuse the children with many different symbols.

2.7 Playtesting and Feedback

The second version of the prototype was first showed to the teachers and after tested with three children in an informal environment to not put pressure on the children. One playtest was conducted at the Käo center and other two with two students of Ungaretti school. The game was played in the presence of the teachers, who were verbalising the story and helping them to understand how to use it, if needed.

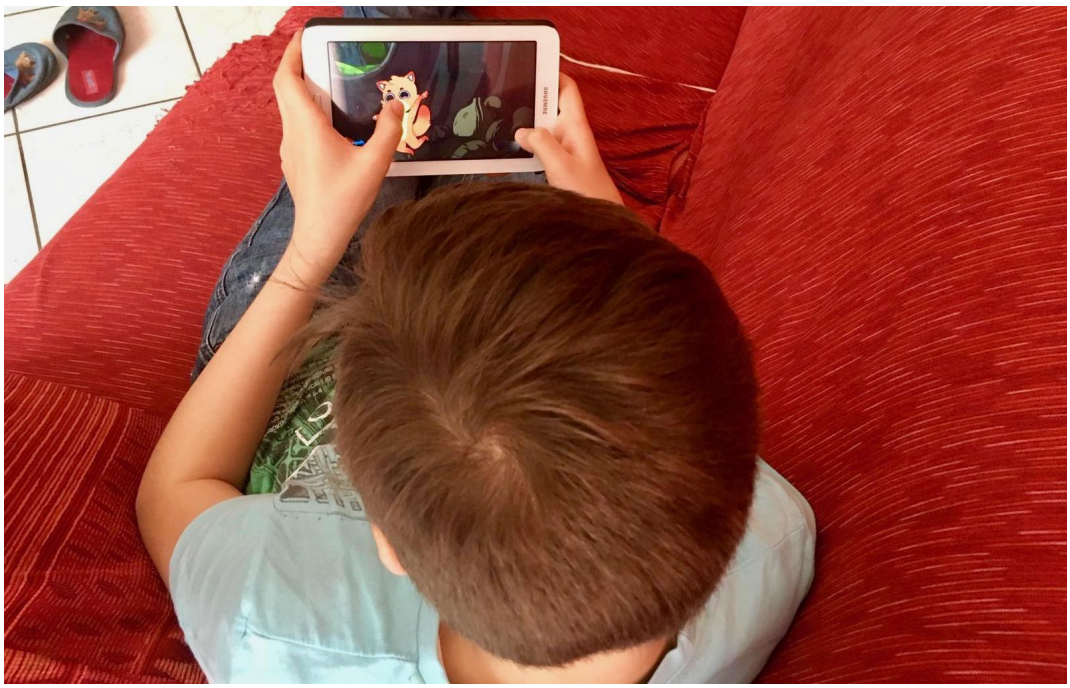

Figure 13. Playtesting

From the talk with the teachers I obtained valuable feedbacks that were going to be used for implementing the final version of the game:

- In the first version of the game a recorded voice leads the user through the story. It was suggested to add the possibility to record a customisable voice (parents or teachers) in order to make the game more familiar.

- A feature that can be added would be the personalisation of the main character. This would give a sense of involvement in the game.

- Combine to every symbol the voice of it, this would work only after that all the sentence is heard. This would help the user to practise with the single symbol.

- Make the symbols appear one by one to give the sense of progress and of the structure of the sentence.
- It was also suggested to add some minigames inside the story in order to make it more engaging and train more skills. In particular sorting games would be suitable and matching with some part of the game.

- Between two options of design it was indicate to prefer the use of symbols and not photos and the 3D effect, that remember and hopefully connected the user to the PECS cards that are going to be used in the real life:

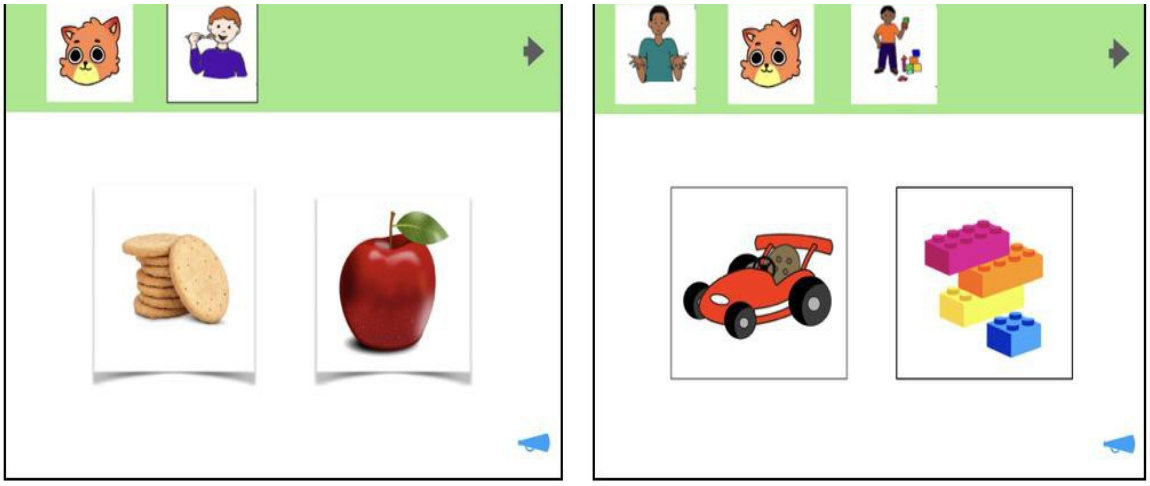

Figure 14. Comparison Different Layout

Although with a small number of users, this playtesting has been very important. In fact, it allowed me to collect a series of information that could be useful for possible implementations. From the user's point of view the test showed:

- All players showed interest towards the app and the digital device. A good starting point, that will help to increase involvement and motivation.

- The children were actually familiar with the device and eager to play.

- One player used the app by doing the zoom in action on every slide. This makes it impossible to pass to the next slides.

- Children were not waiting for finishing the sentences that they were already trying to pass to the next slide.

- There is not a verifiable way to understand whether the game is appreciated by children, as they cannot communicate verbally. Therefore, it had to be sufficient to study the general behaviour of the user with the help of a

familiar person that can recognise it.

- To test improvements in symbol recognition and order skills, additional time is needed (several sessions and a pilot group).

The Results

At the end of the research is time to do an analysis and to evaluate if the initial goals were satisfied or not. The first steps of the research were successfully accomplished. In fact, I was able to find the needs of the target users and personnel related and work with them in a productive way. I am satisfied of the prototype and its progresses and of the feedback received. I'm going to expose now the implementation guidelines that I obtained followed by an empirical study for measure the appreciation of the game.

3.1 Implementation Guidelines

From the playtesting I obtained really important data in the form of valuable feedback from teachers and users. These allow me to create a series of indications to guide a final implementation phase:

- An important feature to add is the single word audio, this will permit to distinguish better each symbol.
- The symbols will be displayed one by one in order of appearance to facilitate the narration and consequently the understanding.
- Combine symbols and the 3D effect: this will help the user to transfer this assimilated skill in the daily life with paper cards that are used in AAC.

- Do not allow the player to skip the slide until the voice over will finish to pronounce the sentence and to zoom.

- Change the icon of the audio repetition as that image is more connected with the idea of increase/decrease volume.

I decided not to add additional minigames, despite the fact that I think it could be a good idea, because this will required an additional research. About the customisation of the character I also decide not to add it because this could be a distracting factor that would not generate a significant increase in involvement in the game. The other suggestions are going to be implemented in the final version of the game.

3.2 Empirical Study

To validate the appreciation of the game, it was conduct an empirical controlled study. The main first goal was to evaluate the level of the engagement during the playtesting monitoring the attention and the reactions of the children. The lack of communication skills forced an investigation based on analysis of the behaviour, social respons and motor reactions during the game sessions.

3.2.1 Measure the Appreciation

Before the game session, a preliminary phase took place, the child was invited to seat near the adult of reference in a friendly environment. Once that the game starts, I controlled without interfere with the conduction by taking notes of how many times the user divert the attention, showed altered state of mind or other behaviour noteworthy. However, because of different personalities and the peculiarity of the disease involved, it is very important and useful to conduct a follow-up interview

with the adult that knows the child and can clarify the dynamics.

	Child A	Child B	Child C
Divert the attention (look in other directions, leave the seats)	0	1	0
Aggressive Episode	No	No	No
Display of Happiness	No	Yes	Yes
Display of Sadness	No	No	No
Display of Frustration	Yes	No	No
Display of Confusion	No	No	Yes
Display of Engagement	Yes	Yes	Yes
Teacher's Notes	The child is familiar with the device. He tended to zoom on the screen because of previous games. He touched the screen vigorously because impatient of finish the animations. He showed a satisfied expression in choosing the car.	The child is familiar with the device. The child has motor stereotypies that became more evident in some part of the game. He showed to be happy to play the game.	The child is not familiar with the tablet, but he seems comfortable in use it. He stayed focus all the time. When the game end the child would not leave the tablet.

As said before, autism disorder is characterised by specific impairments in processing social and emotional information. The lack of attention and perception of the face expressions, as well as perception of the specific emotion makes them unable to replicate normal behaviours and they tend to maintain a neutral facial expression (Dawson, Webb, Carver, Panagiotides, McPartland, 2004).

This tendency was clearly visible in the playtesting and makes it difficult to understand the level of engagement of the users. To be as objective as possible some criteria were selected. The main factors to consider were the absence of episodes of distraction and the indications given by adults, who in this case, work as translators of the states of mind of the children.

3.3 Discussion

The playtests showed that the game is user friendly and enjoyable to play for children. In fact, user understand promptly how to use the commands and the maintain the concentration for all the game session. As a result of the interviews with teachers, it was concluded that the children experienced a nice time without episodes of frustration. The teachers agreed that the game seems to be a potentially effective tools to be used combined with others ABA methodologies for training children to use the symbols.

3.3.1 Limitations

Due to the difficulties in communication with children with ASD the process of studying the appreciation of the game was forcibly mediated by the teachers. This made the research founded on a qualitative data. In addition, there was not enough time to verify its effectiveness, by testing the transferability power in the daily context. It is also true that the scope of the study is too limited to draw solid conclusions, but the initial playtesting seems to suggest that the game has potential and can be improved by reliable guidelines.

3.3.2 Further Study

Another of the goal stated at the beginning of the research was to measure the improvement of the abilities of children after play the game. Measure the performance will need a much deeper understanding of the cognitive skills and screening activities before and after the use of the game. Despite the fact that it was not possible to conduct this part of testing I would like to explain the same how I would like to conduct this part.

The variables considered in the evaluation phase can be divided into two different categories: **Performance** and **Clinical** variables. The performance variable measures how much the child can communicate his or her wish. This measure is related to the recognition of the symbols, to the intention to make conscious choices being aware of the consequences and to the ability of transfer this skill outside of the game.

The clinical variables include attention aspects, and the capability of integrating visual and motor skills, and general cognitive aspects. Although the game is designed specifically for children with severe communicative impairments, to be played the users will need to be able to:

- focus on an important stimulus ignoring competing distractions
- hold the attention for the time needed to conclude an activity

To evaluate the capability of children to integrate visual and motor skills in the recognition process of the symbols and after that in the transfer of this skill in the daily life, it should be investigated:

➔ **Visual Perception**, the ability of interpret the elements on the screen and

objectively process visual information

- **Motor Coordination**, the harmonious functioning of body parts that involve hold the tablet and touch limited parts of the screen (fine motor movement)

- **Visuo-Motor Integration**, the ability to control body movement guided by vision.

- **Cognitive Skills**, mental capabilities that are responsible for the translation of the symbol and the adaptation of the context.

Unfortunately, this procedure requires much time because few games sessions are not sufficient and should be combined with testing the performances with paper PECS. In addition the variables to consider are several and would require a complete research, that is not going to be possible for privacy reasons. The teachers are not allowed to declare personal information related to the students without a special permission of the parents.

Conclusion

The project that was explained and shown in the thesis started in last months of 2017 and ended in April of 2018. This research greatly helped me understand what it really means to design for a target. It was very useful and productive to collaborate with professionals, have them on board was a great strength of the project. This field shows potential and it would be nice to continue to work on it. In particular, I would like to conduct further investigation into the effectiveness of the game and maybe integrate new functionalities, because I think that it can become a valid tool to train several skills.

Through the literature study and the design and development of the prototype, it is possible to draw several conclusions regarding the initial plan. The design path of the game has been articulated and complex. I explored the literature study to identify the existing methodologies to support children with speech and communication impairments. From this part of the research I learned several theories, but more important that does not exist a universal effective approach. Every methodology has strengths and weaknesses, and is fundamental to have a clear idea of the context and of the goals to achieve in order to integrate them well in a engaging game mechanic.

Also through literature study, the interviews and from personal experience as special teacher, I was able to identify important guidelines to design the game. In fact they merged behavioural approaches, with usability concept and peculiarities of the target of users. The result of this study is therefore a useful game to training children's

symbols recognition, attention skill, cause-effect relationship and secondly narrative skills. It is a container of stories, which offers the possibility to choose and discover the various options available. The system therefore does not impose itself a solution but rather train different skills during the game session.

Finally, a last version of the game was implemented thanks to the valuable feedbacks of teachers and students. The empirical study, based on three playtests, shows that the game has the potential to become a good tool for training children to use symbols and has an intuitive interface. However besides the more technical aspects, the hope is to have in the future an increasing numbers of projects which aims is to involve people with different disabilities, not only as users but also as codesigner of special games and apps.

Summary

Väitekirjas kirjeldatakse kõne- ja kommunikatsioonihäiretega lastele suunatud hariva videomängu projekteerimisprotsessi, mille käigus kasutatakse alternatiivse ja augmentatiivse suhtluse (AAC) metoodikaid. Rakendatav mudel on disainipõhine uurimistöö. Sissejuhatusele järgneb ülevaade uusimatest arengutest konkreetses valdkonnas ning seejärel uurijate poolt loodud mängude kirjeldused, mis on valminud koostöös sihtrühmaga ehk puuetega lastega. Metoodika selgitab, kuidas viidi läbi terviklik uurimistöö, mis hõlmab nii mängijate endi kui nendega töötavate isikute - näiteks õpetajad, instruktorid ja terapeudid - vajaduste välja selgitamist, takistusi, millega lapsed olemasolevate mängude puhul silmitsi seisavad ning viise AAC metoodika tõhusaks rakendamiseks. Uurimistöö esimeses etapis, ülevaate koostamise käigus, tõid mitmed õpetajad esile asjaolu, et leidub väga vähe videomänge, mis aitavad lastele PCS-sümboleid tutvustada või mida saavad kasutada ka raske autismispektri häirega õpilased. Pärast esmast tagasisidet kujunes uurimistöö peamiseks eesmärgiks propedeutilise mängu loomine, mis aitaks mängijatel leida tee PCS-sümbolite tundma õppimise ja kasutamise poole. Pärast esimest prototüüpi, mida testiti Tallinnas Käo Tugikeskuses ja Torino ühes linnaosas asuvas koolis, nägi ilmavalgust mängu lõppversioon, mille valmimisele aitasid oluliselt kaasa õpilaste katsetused ja õpetajate näpunäited.

Lõppkokkuvõttes leidsid õpetajad, et konkreetne mäng võib olla kasulik tööriist, mis aitab lastel vastavaid sümboleid kasutada. Testid näitasid, et mäng on laste jaoks

nauditav, kuid kahjuks ei olnud efektiivsuse kontrollimiseks piisavalt aega, seega ei ole kindlaks tehtud selle tegevuse mõju igapäevases kontekstis.
Järgnev on kokkuvõte eesmärkidest, mida ma selle väitekirja abil saavutada üritan:

- Kasutajate ja õpetajate vajaduste väljaselgitamine
- Erinevate suhtlusoskuse parendamiseks kasutatavate meetodite uurimine
- Kõige sobivamate strateegiate kindlaksmääramine
- Hariva mängu prototüübi disainimine
- Prototüübi testimine katseisikute rühmas
- Mängu kaasahaaravuse ja efektiivsuse kontrollimine
- Mängu prototüübi rakendamine

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List of Abbreviations

AAC	Alternative and augmentative communication
ABA	Applied behavior analysis
ASD	Autism spectrum disorder
DBR	Design-based research
DTT	Discrete trial training
MDA	Mechanics dynamics aesthetics
NET	Natural environment teaching
PBS	Positive behavior support
PECS	Picture exchange communication system
PRT	Pivotal response treatment
VB	Verbal behavior

Appendix

Link to the prototypes and appendix repository:
https://drive.google.com/open?id=1hKYEv0YRWQtX4d0NruuDt4m3J8fih_bW