Faculty of health sciences

Technology as a tool in autism spectrum disorder (ASD): an overview

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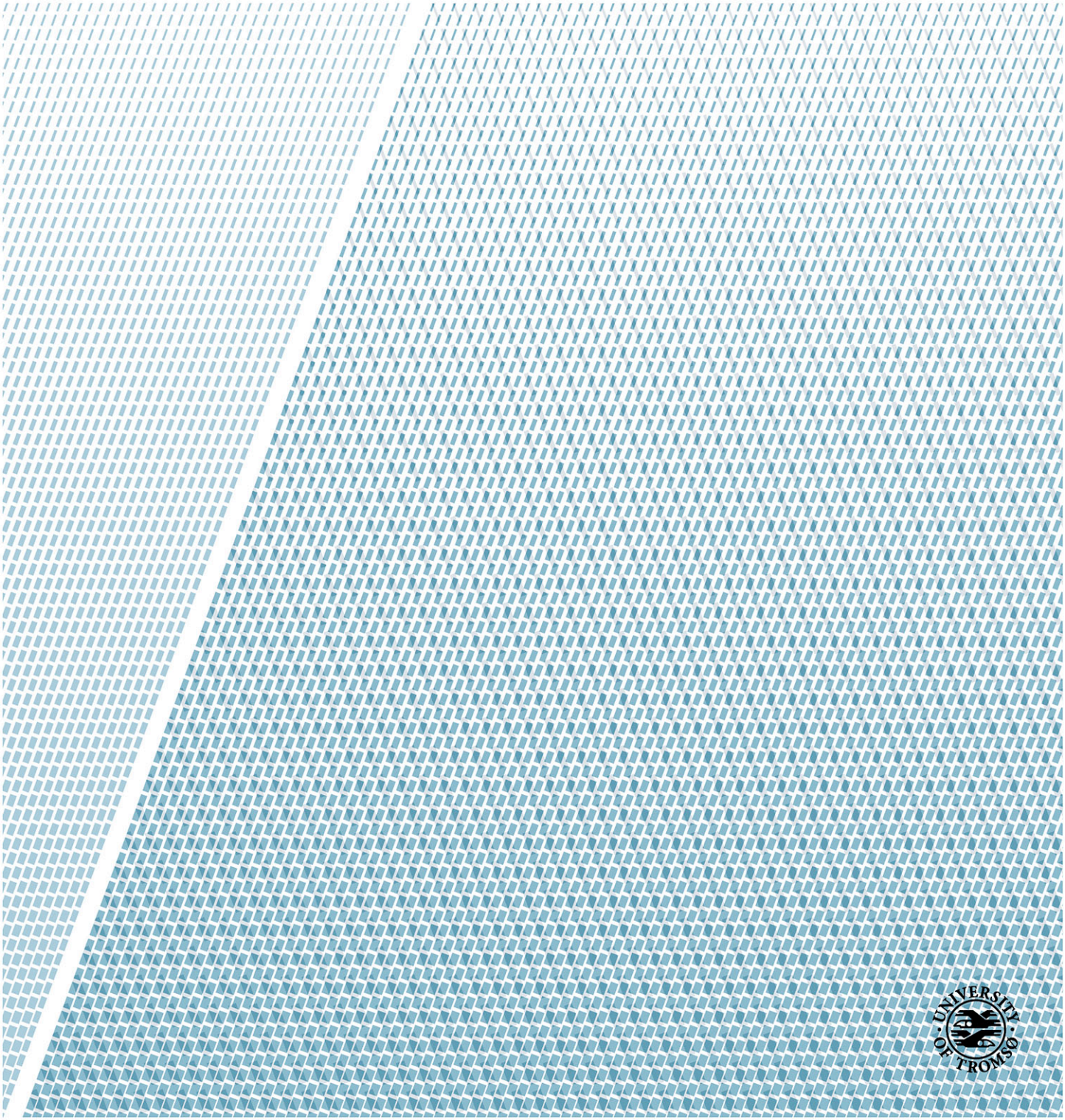

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Preface

When we were assigned to write a fifth year assignment, I decided that I wanted to write about the use of technology in a medical field. I came in touch with Martin Eisemann, who is leader of the research group “mental ehealth” at the University where I take my degree, University of Tromsø – The Arctic University of Norway.

Together we discussed possible topics for the thesis, and I thought it could be interesting to make an overview over different uses of modern technology that could prove to be helpful for children and adolescents on the autism spectrum.

The process of writing a thesis was at times challenging, and I’ve learned a lot in the process, especially about autism spectrum Disorder (ASD), and hopefully this will help me when encountering children with ASD and their families when I have obtained my medical degree.

I would like to thank my both supervisors on this thesis, Martin Eisemann and Roald Øien, for their help throughout this project.

1 Abstract

1.1 Aim

The aim of this thesis is to provide an overview of modern technology as a tool in diagnostics and treatment for children and adolescents with ASD.

1.2 Method

A literature review was performed during early 2016, based on results from PubMed searches with MESH-tags “Autism” or “Autism Spectrum Disorder” and one of the following: “Technology”, “Robotics”, “Video Games”, “Video”, “Video Modeling”, “Diagnostics”, “Radiology” and “Virtual Reality”.

1.3 Results

Both studies about the use of technology in diagnosis and in treatment are presented in the literature overview.

Studies showed that researchers were able to differentiate children with ASD from typically developing children using different types of technology: video tapes, eye-tracking, movement patterns and fMRI.

Studies revealed that many types of technology could prove useful in teaching children with ASD new skills or encourage social activity. Among these were social robots, robotics classes, video games, virtual reality, mobile applications, animated series and video modeling.

1.4 Conclusion

Some studies show that certain uses of technology give good results when used correctly in treatment or diagnostics. Most of the studies about technological intervention available today are based on relatively small samples, which compromises the generalizability of the results. Nevertheless, with the vast diversity of new technologies and research, there is reason to believe that use of technological intervention in children or adolescents with ASD will be increasing.

2 Introduction

The aim of this paper is to provide an overview over technology that may function as a helpful tool in treatment, teaching and diagnosing children and adolescents with ASD.

2.1 Technology

During the last decades there have been a rapid development in technology. In 1969, man landed on the moon using state of the art technology. Today, everyday objects such as smart phones are many times more powerful than the computer technology NASA used to put man on the moon.

There are huge amounts of technological devices designed to function as tools in diagnosis and treatment of disabilities, but there are also technologies that may work efficiently as a tool in the medical field, even though they were not initially designed to do so. Technological, powerful devices such as smart phones, video cameras and computers have become everyday objects and are widely available at a reasonable cost.

The untapped potential in everyday technological devices as helpful tools could be huge for children and adolescents with ASD.

2.2 Autism spectrum disorder

Autism spectrum disorders (ASD) is a group of complex neurodevelopmental disabilities characterized by typical repetitive patterns of behaviour, social deficits and communication difficulties.

2.2.1 Characteristics

ASD are characterized by three major characteristics:

- Social-interaction difficulties
- Communication challenges
- Tendency to engage in repetitive behaviours

Children on the autism spectrum may differ greatly from each other. The spectrum consists of severe disabilities to minor struggles. A patient on the high functioning end of

the autism spectrum may not be very affected by the disability, while for others, the disabilities may greatly affect their day-to-day life.

2.2.2 Incidence

According to CDC's (Center for Disease Control and Prevention) Autism and Developmental Disabilities Monitoring (ADDM) Network, one in 68 (147/10000) children has been identified with ASD in America in 2012 (1). A study by Fombonne estimated in 2005 an incidence of children with ASD to 60-70/10000 (2). While the studies differ in rates, they both show that ASD is no longer a very rare disease.

2.2.3 Diagnostic criteria

With the release of DSM-V in 2013, autism spectrum disorder was introduced as a new term which included the four previous DSM-IV diagnoses Autistic disorder, Asperger disorder, Childhood disintegrative disorder and Pervasive developmental disorder (3).

In ICD-10 the same diagnoses are gathered under "F.84 Pervasive developmental disorders". In this group of diagnoses there are subgroups, such as "F84.0 Autistic disorder" and "F84.5 Asperger's syndrome" (4).

In DSM-V, the subgroups are removed, and instead they are all a part of the autism spectrum. Whether there will be changes to this group of diagnoses with the release of ICD-11 in 2018 or not, is unknown.

The diagnostic criteria for autism spectrum disorders in DSM-V are the following: "

A. *Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history (examples are illustrative, not exhaustive; see text):*
    a. *Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.*
    b. *Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal*

communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures: to a total lack of facial expressions and nonverbal communication.

c. *Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.*

B. *Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive; see text):*

a. *Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases).*

b. *Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat same food every day).*

c. *Highly restricted, fixated interests that are abnormal in intensity or focus (e.g., strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interests).*

d. *Hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).*

C. *Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learned strategies in later life).*

D. *Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.*

E. *These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism*

spectrum disorder and intellectual disability, social communication should be below that expected for general developmental level." (5)

3 Methods

The thesis was written based on the authors interests in psychiatry and technology. Contact was made with the research group "mental ehealth", at UiT – The Arctic University of Norway, which strives to explore and research new and innovative methods and tools that can be preventive, and strengthen diagnosing and treatment for a variety of mental illnesses and conditions.

Based on discussions with the supervisors on this thesis, a decision was made to write a literature overview about the potential in the use of technology as a tool in treatment, learning and diagnosing children and adolescents with ASD.

The first couple of weeks were used to search and read relevant literature. Searches were made in PubMed database, using searches with MESH-tags such as "Video Games", "Video", "Virtual Reality", "Mobile Phone", "Radiology" + "Autism Spectrum Disorder" or "Autism". The findings were put in a digital library of references using EndNote X7. Articles were read and the most relevant for this thesis was saved and used in this overview.

Regular searches in Google were also conducted to search for projects concerning children and adolescents with ASD and the use of video games. If interesting non-scientific relevant articles were found, searches in PubMed were conducted to see if there were scientific articles regarding the same or similar projects.

After a content digital library was created, the last 10 weeks were used to write the thesis.

4 Results

Below are studies looking into the use of technology as a tool in either diagnosis or treatment of children and adolescents with ASD.

4.1 Technology as a tool in diagnosis

Video, eye-tracking, logging movement patterns with the use of tablets, and fMRI are some of the technologies that can be helpful in diagnosing an infant or a child with autism spectrum disorder. There are, at the moment, no biological tests that can easily diagnose autism spectrum disorders. Consequently, an infant or children must be diagnosed by specially trained medical personnel based on behavioural patterns. Behavioural symptoms are most often not visible before the age of two. Therefore, many clinicians and researchers find it interesting to look into the possibility of using technology to help diagnose ASD at an earlier age.

4.1.1 Video recording

Today, when mobile smart phones are widely available at a reasonable cost in most of the Western world, it has become much easier to make home videos. This can be a huge asset for a physician as a tool when diagnosing a child or adolescent with ASD. Children who is at a doctor's office might not behave as they typically do at home, and it might be difficult for the physician to see the child or adolescent's behavioural patterns during the limited time of the consultation.

A study was done in 2007 by Clifford et al. (6) to see if one could use home videos of infants between 1-2 years of age to diagnose autism. They looked at home videos from 3 groups: 15 infants who had later been diagnosed with autism, 15 infants who had a developmental or language delay and 15 typically developing infants. The result showed that the children who later were diagnosed with autism were clinically distinct from their peers before the age of 2 yeas, and that there are clearly observable behaviours that are important predictors of autistic disorder in pre-verbal children.

4.1.2 Eye-tracking

As children with autism spectrum disorders tend to have different gaze patterns, also in early age, eye-tracking is thought to possibly be a powerful tool in early diagnostics as a behavioural biomarker.

A study by Shic et al. (7) used eye-tracking to examine the gaze patterns of 6-month-old infants both at high risk and low risk for developing ASD. 122 participants enrolled in the prospective study, but 23 were excluded due to movement or inattention during calibration procedures. The high-risk group of children was younger siblings of children with ASD, and the low-risk group was infants who had no family history of ASD in any first- or second-degree relatives.

At 6 months of age the children were seated in a car seat in front of a 24-inch widescreen monitor. They were then presented stimuli in three conditions: a static condition, an affective condition and a speech condition. In the static condition they were presented with a neutral female face. In the affective condition a video of a smiling female face was shown. In the speech condition a video of a female reciting a nursery rhyme was presented.

Gaze patterns were analysed with standard area-of-interest analysis techniques using custom software. Using this technology, they were able to record data of where the infants focused at specific times, on the screen.

They found that children who later developed ASD focused less on what was presented in general compared to other infants. The children who later developed ASD also focused less on inner features of the face, but only when the presented face was speaking (the speech condition).

4.1.3 Tablet application

Abnormalities in development of motor patterns early in life is thought to be a possible early marker of ASD. Differences in motor development can possibly be observed very early and can therefore become a valuable early marker of ASD, since more typical early

markers, such as poor social function skills and problem reading emotions are hard to detect at such an early age.

Anzulewicz et al. (8) conducted a study where they used tablet-based gameplays to identify autism-related movement patterns. In their study, 436 children participated, of which 46 of them were diagnosed with ASD and 20 of them with other developmental disorders (i.e., Down's Syndrome, intellectual impairment, aphasia).

Two mobile game-like applications for children aged 2-5 were used. During the gameplay, touch data and data from tablet's sensors (gyroscope and accelerometer) were recorded. The data were analysed by means of computer learning algorithms. The algorithms performed with 72% sensitivity and 88% specificity for differentiation of ASD from typically developing children.

The authors concluded that they were able to identify a prominent motor component specific for patients with ASD, by using touch data and data from the tablet's sensors.

4.1.4 fMRI

Functional Magnetic Resonance Imaging (fMRI) is used for the depiction of changes of local blood supply in the brain activated by specific stimuli. This is made possible because oxygenated haemoglobin and deoxygenated haemoglobin have different magnetic properties. Since blood oxygenation varies according to the levels of neural activity, these differences can be used to detect brain activity (9).

A study by Just et al. (10) used fMRI to determine how the neural representations and meanings of social concepts are altered in autism. In this study they included 34 participants, where half of them were control. They were asked to think about the nature of specific verbs, such as insult, adore, hate, hug, kick, encourage and humiliate, while in fMRI machine. Machine learning algorithms classified individuals as autistic or control with 97% accuracy from their neurocognitive markers.

4.2 Technology as a tool in treatment

A meta based study by Grynszpan et al. (11) showed that technology based intervention have proven successful in teaching children with autism spectrum disorders new skills. There are so many forms of technology, both high-tech and low-tech, that can possibly work as a tool in teaching, so not all are described here. Robotics, video games, virtual reality, smart phone and tablet applications and video are topics that are included under this heading.

4.2.1 Robotics

Children and adolescents with ASD often struggle with communication, and in some cases, they would not communicate at all in a social environment. There have been a few projects where robotics is used to help patients with ASD to socially interact and communicate with others.

4.2.1.1 Robotic animals as an aid in social development

A study was conducted in Washington in 2008 where children with autism played with a robotic dog, and a mechanical toy dog, to see which one they preferred (12). The robotic dog used in this study is called AIBO, has dog-like form, moveable parts and sensors that can detect distance, acceleration, vibration, sound and pressure. It can walk, shake it self, sit down, lie down and rest. It can locate a pink ball, walk towards it, kick it or head butt it. It could also initiate interaction with humans, such as offer its paw, and respond with either a positive (green) light or negative (red) light.

In the control condition, the same children were set to play with a mechanical toy dog who also could walk, wag its tail and make noise. This dog though had no ability to detect or respond to its physical or social environment.

The study showed that the children preferred the robotic dog over the mechanical toy dog. They spoke more with the robotic dog, and also interacted more with the third peer (the experimenter). They coded for 16 different behaviours typical of children with autism. When combined, the mean number of autistic behaviours per minute with AIBO was 0.75, and the mean number of autistic behaviours per minute with the mechanical

dog was 1.1. While this is highly suggestive, it showed no significant differences in numbers of occurrences per minute of any of the individual behaviours.

4.2.1.2 Robotics class for adolescents with high-functioning ASD

A study by Wainer (13) was conducted to see if children on the higher-functioning end of the autism spectrum disorder would collaborate more with each other in a after-school robotics class involving programmable Lego robots. The class took place once a week over several months. Seven children with ASD attended in more than 60% of the classes and were included in the results of the study.

In each class, during the first 15 minutes the experimenter would teach a new robotics lesson, and groups of 2-3 children would program and play with the robots to demonstrate what they had learned in the remaining 45 minutes.

During the first class, the experimenters observed that the children had difficulties taking turns with their group mates while playing with their robot. The experimenters designed a turn-taking wheel for the children to use to decide who could play with the robot at any given time. The last two classes the observers removed the turn-taking wheel to see that the children still continued to take turns playing with the robots like they did when they had the wheel.

The children talked more about robot-related subjects with each other on the last classes than during the first classes, and also more on what they considered the most enjoyable days than their least enjoyable days. They also exhibited significantly more pointing behaviour, as well as shared displays of positive affect with their group mates during their most enjoyable classes than during the least enjoyable ones.

In interviews that were held after the study, four of the parents felt that their child could use experience and knowledge from the class in social situations for their benefit. One of the parents told that their child learned about how to take turns and talk with others about programming problems.

4.2.2 Video games

Video games are often found fun, entertaining and are designed to be rewarding. If these qualities can be combined with being educative, video games could prove to be a very a helpful teaching tool for children and adolescents with ASD.

4.2.2.1 MindLight

MindLight is a video game aimed at children of 8-12 of age and is based on the principles of cognitive-behavioural therapy (CBT). The child playing the game must wear a brainwave reading EEG-headset, which records information that will be used as an element in the game technique.

In the game, Arthur, the main character, is left at the doorstep of an old, dark mansion. He finds a glowing magical headset which introduces himself as Teru the Magical Hat. Teru teaches him to control his inner strength, because only when Arthur focuses his inner strength, Teru can shine light on the environment.

Throughout the game, Arthur is presented with (at first) simple puzzles and relaxation techniques, and later on increasingly difficult puzzles and "fear events". The player learns that he can conquer his fear and anxiety by tapping into the power of his own mind. While staying calm, Teru can bring light upon the situation, and the player can see that what he thought was scary, actually was something completely else, something banal.

The game uses exposure techniques to teach children to overcome their fears by not giving attention to threatening cues and shifting attention to positive aspects of the environment. The more relaxed/meditative the player become, the brighter Teru shines (14-16).

These is an ongoing study that looks into whether using the game MindLight as video game intervention is effective in decreasing clinical anxiety symptoms in children who are diagnosed with ASD, but the results are not published yet.

4.2.3 Virtual Reality

Virtual reality is one of the most exciting technologies that could prove useful in treatment of ASD, because of its countless possibilities. Since the technology is brand new, there are not many published studies available, yet.

4.2.3.1 The VR technology

Virtual Reality is a technology that makes it possible to emulate three-dimensional, real time virtual environments that can be used to simulate real or imaginary situations.

A Virtual Reality set up can either consist of a desktop computer and regular input devices such as mouse and keyboard, or a VR head mounted display with ear phones that could be used to visually immerse the user within the environment. These "immersive" VR head mounted set ups also often contain an accelerometer and a gyroscope, so that the image on the screen can interact with the user's head movements.

Until recently, immersive VR technology was not available for commercial use. In 2012 a Kickstarter campaign was presented by Oculus Rift, a company who wanted to create an immersive VR system for the use of commercial video gaming. The campaign was one of the largest, most successful Kickstarter campaign ever. After the huge media interest in VR technology, several companies which specialise in making electronics have presented their versions of immersive VR set ups.

4.2.3.2 Virtual reality in social cognition training

A study from Center for BrainHealth at The University of Texas at Dallas in 2012 (17) looked into whether virtual reality could be a useful tool in social cognition intervention focusing on social skills, social cognition and social functioning in young adults with high-functioning ASD.

Using a computer with preinstalled non-immersive VR-software, 10 young adults completed a 10 sessions program over 5 weeks. The VR technology was developed using Second Life, a three-dimensional virtual world software available to the public.

The participants modelled an avatar that represented them in the game. In the virtual

reality, the participants of the study were put in 10 different training scenarios. The scenarios were the following: “Social instructions and interaction with a friend, initiating conversation with a roommate, meeting strangers/friends, negotiating with a salesman, job interview, working with co-workers and managing a conflict, celebrating with a friend, a blind date and interacting with someone of a different background (with no common interests)”

A battery of social cognition measures was used to assess performance before and after the virtual reality intervention in three areas: verbal and non-verbal emotion recognition, theory of mind and conversation skills.

The result showed that after 10 sessions, scores significantly increased on some of measures of verbal and non-verbal recognition and theory of mind. Social performance scores increased, although not significantly after the intervention (17).

4.2.4 Smart phone and tablet applications

Mobile smart phones and tablets are now widely available. Mobile phones and tablets have great potential as a technological tool to help and support children and adolescents with autism spectrum disorder if used correctly.

4.2.4.1 Application marked

The last 15 years there have been a tremendous growth in applications on smart phones and tablets. After Apple and Google joined Blackberry and Windows Mobile Phone in 2007 and 2008, the amount of apps has exploded in numbers. When released in 2007, Apples App Store hosted 500 apps. In June 2015, Apple revealed that their App Store hosted over 1.4 million apps, and Google play approximately the same (18).

While there are literally millions of smart phone applications, not all are made with the purpose to function as a tool specifically for children and adolescents with ASD. Because of the huge marked for smart phone applications, there are also a great amount of application developers. This makes it possible to hire application developers to make specific apps at a recent cost.

4.2.4.2 Mobile application for early literacy and language intervention

Children with ASD often exhibit deficits in both expressive and receptive language development. This leads to delayed literacy skills and comprehension abilities.

One possible intervention approach is to give a visual representation of an object with the orthography, while teaching expressive communication. With this in mind, two researchers from Purdue University, Rasche and Wendt, created a mobile application designed to "target the delay in literacy skills, specifically comprehension, by teaching expressive and receptive language together" (19).

With their application written in iOS platform, the participants can scan labels with QR-codes that are placed on actual objects. The scanning screen shows an image of the object, the orthography and the user have the possibility to listen to the spoken word. Within the application there are game modes with reward systems that provide repetition of skills learned during the scanning of the physical objects.

Preliminary results suggest that the application has positive effect on receptive and expressive language development. They report that "initial feedback from parents and clinicians has been favourable praising the ease of customization to learner needs and the engaging and motivating nature of the game-play mode".

4.2.4.3 Mobile application for augmentative and alternative communication

Tobii Dynavox is a company who specializes in making both touch based and eye controlled computers and software for special education that help individuals with motor and speech impairments (20).

While their software is specifically designed for their own hardware, the Tobii Dynavox Tablet, it is also available as an app for your iPad or Windows tablet. Their app provides several tools to help users communicate, both directly using letters or words, or through symbols or pictures.

Tobii Dynavox believes that their tool can help children and adolescents with ASD to communicate their needs and have an easier time interacting socially. They believe that this can lead to less challenging behaviour.

4.2.5 Video

While video is not state of the art technology, its availability and ease of use makes it a helpful tool for use in teaching and treatment in children with ASD.

4.2.5.1 Animated series

A study was done at Autism Research Centre at Cambridge University (21), where they looked into whether they could make an animated series that focused on teaching children emotion recognition. They based their series on the premise that children with autism are especially fond of film about vehicles. The idea behind the premise is that they are drawn to predictable, rule based systems.

They made an animated series consisting of linear moving vehicles with real faces from actors. They wanted to explore whether children would teach more about emotion recognition if taught by actors in a film series which take place in an autistic friendly context.

It turned out that children with autism spectrum disorders who viewed the films, named "The Transporters", over a 4-week period showed considerable improvement in emotion comprehension compared to the control group.

4.2.5.2 Video modeling

Video modeling is based on learning desired behaviours through watching video of certain behaviour, then imitating the behaviour of the model.

Video self-modeling (VSM) is a specific form of video modeling that allows the individual to imitate desired behaviour by observing him or herself successfully performing said behaviour. The video can be made by filming a specific task done by a child. Then the video can be edited to only show the desired behaviour.

A meta study from 2007 by Bellini and Akullian concluded that video modeling and video self-modeling show great promise as intervention methods for teaching behavioural functioning, functional and social skills, and communicational skills for children and adolescents with ASD (22). They also mention that the method applies well for a broad age range of children and adolescents, and that the skills acquired are maintained over time and transferred across different settings and conditions.

4.2.5.2.1 Video modeling and oral hygiene

Mademtzi et al. conducted a pilot study where the objective was to ”investigate whether video-modeling can be an effective method for children with autism to learn how to brush their teeth” (23). 8 children with autism participated in the study, where as 4 were assigned to an experimental group and the last 4 were assigned to a control group.

Parents of the children in the experimental group received a link twice a day for three weeks prompting them to watch a video with their child before tooth brushing. The video showed a girl brushing her teeth with spoken instructions and the control groups video consisted of moving fractal shapes and symbolic background music.

Before the intervention, dental hygiene did not differ between the groups. After the intervention, the experimental group showed greater improvements in the same measure compared to the control group.

While this study was conducted with a small number of participants, its results show a promising potential.

5 Discussion

The articles and their findings presented in this literature review show only some of the many potential uses for technology as a tool in diagnosing, learning and treatment of ASD.

Hopefully use of technology could help with diagnosing children with ASD earlier, and when diagnosed, be used in teaching and as a valuable tool in everyday life.

5.1 Early identification and treatment

Early genetic and environmental risk factors affect the development of the brain in infants with ASD. It is thought to contribute to an atypical trajectory of brain and behavioural development. This again affects how the children interact with their environments (24).

The atypical development of brain and behaviour might negatively affect how children engage in early social interaction. Assumingly, early social interaction promotes development of social and linguistic brain circuitry during these sensitive periods of early age. Because of the lack of interest in social interaction, the children might not go through a typical development of social and linguistic brain circuitry.

If atypically developing children were to be diagnosed early, intervention could begin at an early age. If this intervention could affect positively how the child engage in early social interactions, it is possible that these changes can contribute to alter the pathway of brain and behavioural development towards a normal, typical development. This could lead to better language and social skills, which again has many benefits for children and adolescents with ASD.

Intensive behavioural treatment has shown to have good effect on children with ASD. Research by Howard et. al. showed that intensive behavioural treatment got higher scores in cognitive, language and adaptive skills than a control group who received traditional treatment through school or educational programs (25). With earlier identification of ASD comes possibility of earlier intervention. Its reasonable to believe

that with earlier intervention, when the brain has a more developed neural plasticity, the outcome could be even better.

With the advance of technology and diagnostic methods, its reasonable to assume that identification of autism at an early age could be more easily achieved in the future.

5.2 Social function and communication skills

If children with ASD can be diagnosed at an earlier stage in life, treatment can begin earlier compared to those diagnosed at a later stage in life. This can be very helpful in the terms of starting specialized learning and treatment earlier when the brain is developing. Hopefully this could lead to better social function and better communication skills, making it easier to live satisfying and fulfilling lives.

Well developed social function and communication skills are very helpful in many respects. The ability to express your thoughts is extremely important for almost all actions throughout the day. In addition – it will be much easier to be able to get education and eventually a fulfilling job.

With better communication skills it is reasonable to assume that children, adolescents and adults with ASD can easier get help with their problems, and by getting help when needed, lower the chances to develop depression and anxiety disorders.

5.3 The potential of technology as a tool

Many uses of modern technology as a tool in either diagnosing or treatment are not yet researched well enough. It is likely that the development of technology will continue, and there will obviously be great potential applicability of technology for medical personnel or patients with ASD and their families.

5.3.1 Robotics

The idea of using robots in intervention and diagnosing is quite new – and the research on the subject is at an early stage. Children and adolescents on the autism spectrum seem to have an intrinsic appeal of technology. In the studies mentioned in this overview, the participants often found the robots more interesting than their typically

developing peers. Because of this, using robots as a tool in treatment and diagnosing could be a valuable tool.

Robots are programmable and deterministic, which is suitable for intervention with predictability and repetition that a child on the autism spectrum needs. Because of their programmable nature, they are easily adjusted to give each child individualized treatment. This is particularly important in ASD, because the children on the spectrum are so different from each other.

Social robots can be programmed to deliver simple functions, one at the time. I would be possible to make a robot interact socially with a child with ASD and only focus on one aspect of communication at once, making it far less intimidating than communication with another person.

5.3.2 Video games

Video games could have a huge potential, if used correctly. Specialized video games, such as MindLight, is believed to have positive effect in helping children and adolescents dealing with anxiety. Online gaming could be helpful in social training, where they can engage in social interactions with other children over a shared interest, in controlled environments. There is an example where a father of a child with ASD has started a server in the game Minecraft for children with ASD. The server is administrated by adults, and its purpose is to make a friendly, positive and helpful online community where children with ASD can meet, and interact if they want to.

5.3.3 Video

Most modern smart phones have integrated high quality video cameras. This have made video recording technology widely available. Video editing software is also easily obtainable, both advanced software for home computers or easy-to-use video editing apps for phones and tablets. Because of this increased availability and ease of use of video cameras, it has become a valuable tool that can be used in diagnosing ASD.

Making videos to be used in video modeling could be done by parents or teachers, and does not require expensive equipment.

5.3.4 Virtual reality

Virtual reality is one of the technologies that has a huge untapped potential. It is a device where you literally can simulate any imaginary situation. It can be used as exposure therapy to help children overcome phobias, such as going to the doctor or the dentist, or get used to social situations. It can be used to train social function, by interacting with other children in safe environments. It can be used to simulate possibly dangerous situations, such as how to behave in traffic, or simulate driving lessons. These are just some examples of situations where it is possible to use a VR-system.

It is possible to create 3D VSM videos using high end video recording equipment. This could be presented to the individual in the videos through immersive VR-setups. This way the child or adolescent could look at himself in an immersive simulation of the situation showing desired behaviour. While, as far as this study has been able to identify, there hasn't been done any documented scientific experiments using the combination of these interventions/technologies, it could be interesting to look into.

5.3.5 Mobile phone and tablet applications

There has been a huge increase in the number of mobile phone and tablet applications for children and adolescents with autism. Hundreds of applications are released every day, there is reason to believe that there are several applications that could be found useful for children and adolescents with ASD. Not all may be created specifically for children and adolescents with ASD, but may prove helpful as a tool in special education or as an everyday helpful tool.

5.3.6 Eye tracking

With modern eye tracking we hope to be able to identify early indicators of ASD in order to diagnose and be able to start early intervention. The method of using eye tracking technology is a promising objective method for characterizing early features of autism. While the method probably will not be neither time nor economically efficient as a screening method, it could be very valuable to help diagnose children at high risk of being on the autism spectrum, such as children with siblings already diagnosed with ASD.

5.3.7 fMRI

Most of the studies about fMRI and autism have small samples, and consist of adolescents or young adults. It will be interesting to see more studies whether the use of fMRI can be helpful in diagnosing young children, even infants with ASD through functional neural imaging. There are some challenges to get young children or infants to lay still in a noisy MR machine for the duration of the scan. There have been studies addressing this problem by getting the child used to the sounds by playing them at their home, when the child is going to sleep. If the child gets used to the noise, he or she might be able to lay still if the scan is done while the child is asleep.

fMRI while sleeping could be a valuable tool in diagnosing young children or infants with ASD. This would be a very expensive form of diagnosing, but could be useful in diagnosing children at high risk of developing autism spectrum disorder.

5.4 The pitfalls of technology as a tool

The use of technology in treatment and diagnosing children and adolescents with ASD could prove very helpful, but it is important to remember that without good guidance and correct use, it might not prove helpful at all. An iPad itself will not help children learn how to communicate, or reduce social anxiety. In the same way that a book with symbols and words might be helpful in teaching, and iPad might as well, but the iPad is also programmable and adjustable for the benefit of the spectrum of disabilities.

A computer, if used correctly, could be very helpful for children with ASD. If used incorrectly, it could possibly be damaging. This goes for the other types of technologies. Care takers, medical personnel and educators must learn specifically how to use modern technology for the benefit of children and adolescents with ASD. The technology itself cannot replace the skill and knowledge educators, medical personnel and care takers have to teach children with special needs.

Children and adolescents with ASD, as typically developing children, could become overly involved with computers and video games. It is important to modify such an obsession into a productive interest that could benefit them instead.

Using technologic utilities such as computers, tablets, smart phones etc. instead of their low-tech alternatives, can also be over-stimulating for children. It should be balance with regular hands on play, free time, interactive time with others and family.

6 Conclusion

This literature review looked into studies dealing with the use of different types of technology for the benefit of children and adolescents with autism spectrum disorder. Because of the great diversity of new technology available today, there exist no with large enough samples to be able to tell whether something definitely has an effect in treatment or diagnosing children and adolescents with ASD. We do have studies with strong suggestions that certain methods and technology, if used correctly, might be of beneficial use for children and adolescents with ASD.

In this overview, only technology available today is described. Considering how much new technology has been developed during the last decades, we can expect that the use of technology in diagnosing and treating patients will further increase.

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