Front page

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Hand-in information

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The potential of point of view video modeling with the use of Virtual Reality exposure for teaching adaptive skills to adolescents with Autism Spectrum Disorder

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Abstract. Individuals with autism spectrum disorder face multiple problems, such as a difficulty of having independent adulthood.
Lack of confidence and motivation as well as anxiety interferes with the pursuit of a specific daily living skill. The application and potential of Virtual Reality and Video Modeling for users with autism spectrum disorder for training adaptive skills is recently being investigated more and more. This exploratory pre-experimental single subject design study examine the potential positive impact of combining virtual reality with point of view video modeling for training adaptive skills.
One case with diagnosis of ASD aged 15 years old was purposefully recruited for one week long treatment phase. Participants confidence and motivation, together with the overall usability of the proposed solution were examined through a questionnaire with the user and stakeholder.
The findings concludes that the impact of the proposed design needs to be further examined.

Keywords. Autism Spectrum Disorder, Virtual Reality, Point of View Video Modeling, Observational learning, Pre-experimental single-subject design

Table of Content

1 Introduction

Autism spectrum disorder (ASD) is present from the birth and is well known to have large impact on essential human behavior skills, such as social interactions, relationship establishment, ability to communicate thoughts and emotions, as well as learning, adaptability, self – determinism and generalization. The manifestation of autism varies from “high functioning” to very fewer cognitive impairments, depending on specific cases and characterization of disorder (Lord, C. 2002).
Individuals with ASD are usually not capable of having an independent adulthood due to their diagnoses, therefore it is important to educate and train their adaptive skills, in order to develop personal responsibilities and independence in daily life (Lord, C. 2002). There are many different approaches to deal with this, such as traditional learning method with the aid of teacher, parents or therapist, known as live modeling, applying behavior analysis, facilitated communication systems such as sign language or picture exchange based communication (Ergenekon, Y., 2014). Yet, according to other researches, one of the most effective training methods is video modeling (VM), a form of observational learning, used successfully to teach individuals a variety of adaptive skills (Darden-Brunson, F., 2008).
In this research, the focus is on one of the strains of VM, which is known as point of view modeling. Point of view video modeling (PVM) introduces a first-person perspective of desired behavior in a form of video recorded material.
In addition to human -computer mediated learning interactions, virtual reality (VR) (i.e. virtual world) gets more and more attention amongst ASD community as a promising and emerging platform for learning various behavior skills (Ke, F., 2015). Hence, it is assumed that displaying video modeling training through virtual reality head-mounted displays are likely to be even more effective than exposing it through standard displays, such as computer screen (Newbutt, N., 2016).
Therefore, the purpose behind this research is to continue investigating upon already existing studies and also take traditional video modeling to another level, such as 360-degree point of view video training in combination with virtual reality head-mounted display, and evaluate the effectiveness of its stimulation for observational learning in adolescents with ASD and possible anxiety reduction for a pursuit of a specific daily living skill.

2 Background on Autism and adaptive skills

ASD, a neurobiological disorder, can be further characterized as an impairment of social behavioural, cognitive, and communication skills, and imagination. (Church, Alisanski, &

Amanullah, 2000; Macintosh & Dissanayake, 2006; Orsmond, Krauss, & Seltzer, 2004; Wing & Gould; Rao, Biedel, Murray, 2008). Also, many individuals have furthermore limited ranges of interests, and are often preoccupied with nonfunctional routines and patterns of behaviours (Neisworth & Wolfe, 2005). Young individuals with these disorders have problems with keeping the attention and with repetitive tasks. They can be easily distracted and bored, often looking for more stimulation, and can be very demanding and self-centered. Although the problem is chronic, it is not evident in all circumstances, but may appear spontaneously.
These limits seems to be connected with the functions attributed to the human Mirror Neuron System (hMNS) (Southgate et al., 2008; Raymaekers et al., 2009). It is automatically activated when a person performs an action but also when the person observes the identical action performed by another individual(di Pellegrino G, 1992). By directly mapping observed actions of others to the observer's inner representation of the same action, the hMNS facilitates the observer to understand the goals and intentions behind actions with a first-person point view.
While the individuality and uniqueness of each children with the same diagnosis can vary, a fundamental difficulty and coexisting anxiety within the range of adaptive skills is common to all people with ASD (Rizzolatti G, 2004). By early adulthood, most of the individuals with autism have not developed the adaptive skills necessary to function independently in society and many continue to display significant challenging behaviors which makes them dependent on others and does not allow full incorporation in the community (Volmer, S. S., 2001).
More specifically, adaptive behavioural skills include daily living activities necessary for the one's own independency, that are needed to function and interact with others and the environment. This range from the skills such as tightening the shoes, cooking, going to shop, etc. (Billstedt et al., 2005, Eaves and Ho, 2008, Howlin et al., 2004.)
For most people, the development of those skills happens through basic instructions from acquaintances and naturally occurring social interactions (Mallon, 1998). However, for young people with cognitive impairments the learning of adaptive behavioural skills becomes significantly more challenging.

The next section summarize and describes some of the existing methodologies, and their main strengths, that have been used in order to teach specific skills to young people with autism.

3 Observational learning methodologies

The importance of facilitating the long-term functioning of individuals with any cognitive impairments can be seen clearly due to the previous findings of educational and behavioural research addressing their needs. There is distinct evidence that adaptive behaviour deficits are significantly correlated with dependency and more difficult adulthood of the individuals (Volmer, S.S., 2001).

Multiple approaches, to facilitate the everyday functioning of individuals, had been used in the field of cognitive impairments. Although a complete review of cognitive

specificity literature is beyond the scope of this research, the aim of the following section will be to introduce the concepts from psychotherapy and their connection with observational learning of adaptive skills through Video and Live Modeling.

Observational learning (OL), is characterized as a teaching method where the students learn through observing the situation and the behaviour of others, what serves as a model for determining their own behaviour, or changing their current memory structure, and for development of their own adaptive skills (Taylor, B. A., 2012). Four components needs to be present: attention, retention, production, and motivation. The observed actions can then be imitated (Bandura 1977).
Short description of four components:

1. **Attention**: Observer needs to pay attention to what is happening around them. This is influenced by characteristics of the situation and the elements, and the level of the observer's emotional arousal.
2. **Retention/Memory:** After recognizing the observed action, observer needs to remember it.
3. **Initiation/Motor**: Observer needs to be physically and intellectually able of replicate the action himself.
4. **Motivation**: The observer needs to have enough motivation to produce the new learned behaviour. (B., 2016)

This components therefore needs to be taken into an account, and considered as a requirements for the learning to happen.

The foundation of OL is based on another closely related approach for improving daily living skills called cognitive behaviour therapy (CBT), (Drahota, A., Wood, J. J., Sze, K. M., & Van Dyke, M. 2011).
The major focus and the core of CBT is on identifying the negative patterns of thoughts in order to alter or challenge the individual's perception and behavioural patterns by modifying the structure of the fear or other emotion (Foa & Kozak, 1986; Foa, Steketee, & Rothbaum, 1989 ; Beck, A. T., & Haigh, E. A., 2014).

The concept of CBT supports the theory that dysfunctional thinking is directly related to increases in emotional distress or anxiety and maladaptive behaviors. Various cognitive disorders share common underlying processes, such as malfunction of the earlier mentioned hMNS. There is an evidence that those inner processes can be reliably distinguished by specific stimuli and the content of beliefs (one's thoughts about specific context) (Murray, K., Jassi, A., Mataix-Cols, D., Barrow, F., & Krebs, G., 2015; Ames, M., & Weiss, J. 2013; Drahota, A., Wood, J. J., Sze, K. M., & Van Dyke, M. 2011). CBT had been used in multiple studies that have used CBT as a tool for both; as a therapy for addressing daily living skills, and reducing the anxiety a common and impairing problem connected with ASD (White, Oswald, Ollendick, & Scahill, 2009; Sukhodolsky, D. G., Bloch, M. H., Panza, K. E., & Reichow, B. 2013; Drahota, A., Wood, J. J., Sze, K. M., & Van Dyke, M. 2011; Butler, A. C., Chapman, J. E., Forman, E. M., & Beck, A. T. 2006).

The following section explains and describe the process of CBT, for the purpose of further taking and applying it into another context.

CBT uses the principles based on a theoretical framework called generic cognitive model (GCM) (Figure 1) used for understanding and conceptualization of the common cognitive processes (or thoughts) of an individual, while specifying the features of everyday psychological problems and finding the problematic content of belief as a target for treatment (Beck, A., T., 2014).

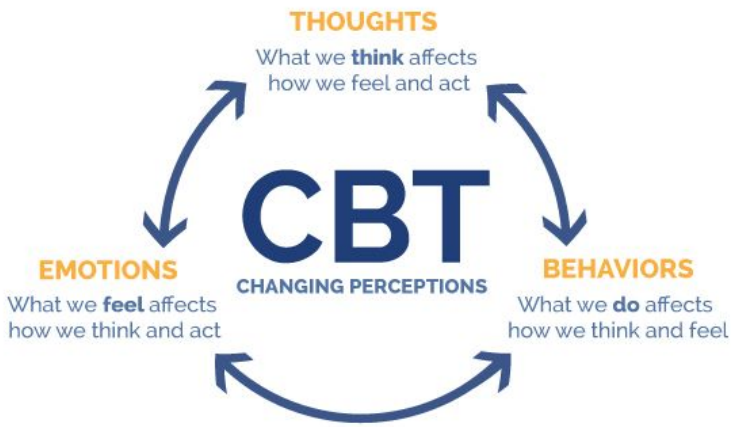


Figure 1: Generic cognitive model.
(Introduction to Cognitive Behavioural Therapy (CBT). (n.d.))

Cognitive schemas, defined as one individual's internally stored representations of stimuli, ideas, or experiences (Beck 1967), control information-processing systems. When a schema is activated, a corresponding meaning is made from the existing stored belief and interacts with other cognitive, affective, motivational, and behavioral systems. Stored biased beliefs, or thoughts exists, and when the bias exceeds the certain 'built-in adaptive level', it increases the probability of an individual to experience a form of anxiety, as it directly affects the person's behaviour (Beck, A., T, 2014).
To access and modify those structures and systems, Foa and Kozak (1986) suggested that there are two conditions that are required. Firstly, the specific emotion memory (such as fear memory) must be activated to be available for modification. This can be done apart of experiencing the situation itself also by thinking or visualising. Secondly, "the information must be provided that includes elements not compatible with some of those that exist" in the stored structure, so that a new memory structure can be formed. This new information, has to be then integrated into the structure for an emotional change to happen (Foa, E. B., & Kozak, M. J. 1986; Anderson, P. L., Rothbaum, B. O., & Hodges, L. 2001).

The two above explained conditions can be therefore considered as requirement for any kind of treatment, so that the change within the individual's behaviour can happen. Even while the most common technique or strategy of CBT include talking with mental health counselor or therapist that is quite time consuming, this concept is widely used

within the field of exposure therapy and other evidence-based practice (EBP) therapies consisting of rather non verbal observational learning method for modifying the memory structure (Parsons, T. D., & Rizzo, A. A., 2008, Bandura, A. 1977).

By following the requirements of modifying a memory structure, together with the four components of OL for changing the current memory structure, this approach for dealing with autism for the purpose of adaptive skill learning can be taken and applied into another context.

4 Moving beyond traditional methods of learning/skill training

By questioning the traditional use of the methodologies presented above, the idea is to investigate connecting them with current innovative technologies, in order to enhance their effectiveness.
The chapter below presents tools as video modeling and virtual reality, together with an explanation of their use, and other state of the art.

4. 1 Video modeling as a learning tool for ASD

An alternative adapted form of observational learning that has been found to be effective for teaching adaptive skills exists within the field of video modeling (VM) (Keen, Brannigan., & Cuskelly, 2007; Norman, Collins, & Schuster, 2001; Shipley-Benamou, Lutzker, & Taubman, 2002; Bellini an Akullian 2007; Alacantara 1994; Haring et al. 1995; Mechling et al. 2005). It seems that individuals with autism frequently use visual support systems for understanding their environment (Van Laarhowen, 2010), plus visual processing, interest in technology, and response to modeling can be argued as their relative strengths (Kuder & Lord, 2010). Video modeling is defined as the modeling of a target behavior with the needed appropriate actions, as in the case of live modeling, but in a recorded format via an electronic medium (Bellini and Akullian 2007). A study comparing both systems shows that children acquire skills faster in the VM condition (Charlop-Christy et al. 2000). Additionally, video modeling is argued to have several advantages over the live modeling in general, such as the models are more controllable when recorder, it is reusable and cost efficient, but in case of both visual support systems a great number of studies have shown the effectiveness of teaching a variety of skills to children with autism (Ergenekon, Yasemin, et al., 2014).

Point of view type of VM is defined as filming from the point of view of the model, allowing the observer to see the actions as would be seen from his perspective. A number of reviews and meta-analyses have been conducted to determine which type of VM used (i.e., classic vs. self versus point of view) is more effective. To date, there are no differences that have been found between the types, and all of them met the criteria for observational learning (Horner et al. 2005).

Video modeling was demonstrated to be an effective adaptive skills teaching tool in community, both in school and home settings, allowing the observer's attention to focus on relevant stimuli as the screen offers restricted field of vision (Bellini and Akullian 2007; Charlop-Christy et al. 2000; Corbett 2003). From the point of view of psychotherapy, it allows an individualized approach to each individual according to his problematic area by considering the specific targeted behaviour.

4. 2 Features of virtual reality as a learning tool for ASD

The role of virtual reality in observational learning for individuals with ASD is vividly developing over the last few decades. (Newbutt, N., 2016) In comparison with face-to-face and other computerized training methods, VR has ideal features for mastering a desired behavior and problematic interactions. Such features are- (a) *controllable input stimuli*: VR can be manipulated easily and adjusted to specific case, for example the level of input stimuli adopted to the level of individuals skills, expectations and abilities, (b) *modifications for generalization:* slight modifications to the scenes of virtual environment allow faster and significant context connections for individuals with ASD, for example a person is taught to cross a virtual street only in particular scenario, and he/she might not connect it to every single street crossing action, therefore VR allows slight changes to visual aspects of the street and its surroundings. This allows individuals with ASD generalize the crossing street action. (c) *Safer learning situations*: virtual learning provides safe and less calamitous environment for practicing skills. (d) A *primarily visual/ auditory world:* primarily emphasized senses in VR are sight and sound. Which have been effective in teaching abstract concepts. As it is known that autistic thinking is usually visual. (e) *Individualized treatment:* virtual environments are flexible and can be dynamic according to special user needs. (f) *Preferred computer interactions*: studies have showed that establishing influence through the human interaction on the individuals with social disorders is not always an easy task. These people respond well to structure and consistency, which can be provided by human-computer interaction. (Strickland, D., 1997)
Therefore, it is known that individuals with ASD have highly positive response to virtual reality technology itself (head- mounted displays) and only fewer are to respond negatively (Newbutt, N., 2016). This sheds light and establish affirmation on observational learning interventions in this research.

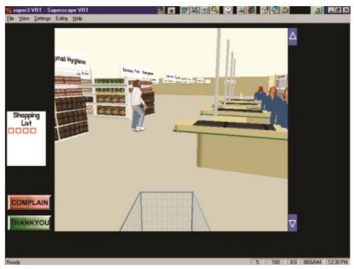
4. 3 State of the art on VR as a training tool for ASD

There were numerous researches conducted in the past decades, concerning VR as a training/ teaching tool for various behavioral skills concerning individuals with ASD. Already in 1999, researchers from Nottingham Trent University, UK, designed a virtual environment (standard display,aka. computer screen) called Virtual City, which intended to provide a safe practice arena for children with learning disabilities (Figure 2, 3 and 4). Virtual City contained four storyboards: a house, a supermarket, a cafe and a transport system. Each of the storyboard had its own learning objectives and goals to

achieve, for example in a virtual transport user had to do following actions to complete the training:

- Select the correct coins for the bus
- Leave the house with enough time to catch the bus
- Cross the road safely
- Catch the correct bus
- Pay the bus driver and collect your ticket
- Get off the bus at the correct stop

Evaluation of the product was focused on the design, usability and monitoring skill learning, as well as transition to the real world scenarios. Results showed a positive attitudes towards the use of virtual reality as a learning tool. However usability testing revealed a number of usability issues concerning users' difficulty level of using/understanding the application, most of the error were related to on-screen text being too small. Moreover it was noted that the system did not provide enough cues as in the real world scenarios. Due to the Human centred design, reserches kept iterating Virtual City development, according to the needs of individuals with learning disabilities. Results regarding skill learning and transfer to the real world were significant improvements, although longer training periods were needed to achieve better results (Brown, D., 1999).



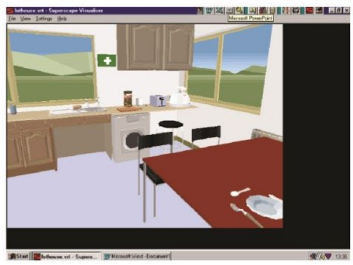



Figure 2, 3, 4: Screenshot of virtual shopping center, virtual home, virtual restaurant.

Another research, similar to the previous one, was conducted in 2008 by Noami Josman and fellow researches. It have focused on providing desktop street-crossing virtual environment where children with ASD could safely practice street crossing skills and develop contextual independence (Figure 5.). Desktop street-crossing virtual environment exposed many possible, potentially dangerous scenarios. Researchers were evaluating whether learned skills can be transferred to real life scenarios. Study results have showed individuals' improvements in the pedestrian behaviour within the real life situations, however some of the participants reported slight difficulties generalising between real life situations and practiced scenarios in virtual environment. Moreover, evaluation showed that street crossing system could be improved, while increasing the difficulty level and introducing varied pedestrian settings. The advantage of such system is the portability and low- cost desktop technology that can easily be

used in any preferable setting, yet the question is whether standard displays, such as desktop is the best way to train individuals with ASD, knowing how distracted they get by the surroundings they are in. In summary, the results of this particular study demonstrates potential of VR interventions for training adaptive skills. (Josman, N., 2008).

Figure 5: Screenshot of street crossing

Yet following research, conducted in 2013 by Michelle R. Kandalaft and others, investigated feasibility of Virtual reality social cognition training interventions enhancing social skills for adolescents with high-functioning autism. VR sessions had various scenarios, such as meeting with new people, dealing with conflicts, negotiating financial and social decisions, as well as interviewing for a job were presented on the computer screen (Figure 6 and 7). Those were designed to represent most likely scenarios in real life. Participants were tested two times per week, 1 hour each, 10 session in total. Before starting VR training interventions participants were introduced how to navigate in VR environment. Professional clinicians trained in ASD were involved in this study to help gathering data.
Findings showed significant increment in social interaction and face emotion recognition in post-training. Once again VR have been proven to have a great potential as a training tool (Kandalaft, M. R., 2013).

Figure 6 and 7: Screenshot of job interview and avatar which suppose to represent users.

In 2014 research team from the university of Newcastle, England, have designed a cave-automatic virtual environment - "the Blue Room", which combined with cognitive behaviour therapy (CBT) was aiming to treat specific fears and phobias, as well as reduce anxiety for individuals with ASD. Nine individuals were recruited and exposed to each of their phobias (Figure 8), after 4 sessions of treatment each individual were able to tackle their fears and gradually overcome them (Maskey, M., 2014).

Figure 8: Phobia exposure in the Blue Room

Recently, Fengfeng Ke and Sungwoong Lee conducted a case study, which was meant to explore the process and impact of a collaborative architectural design and construction in VR on social skill development in children with high functioning autism (Figure 9 and 10). In the "OpenSim" based virtual environment children were able to operate 3D architectural models and various objects, manage them from virtual storages to virtual landscapes and customize them. Thus, children were given the opportunity to alleviate the collaboration skills among each other while agreeing on designing plans, alike a

design team in a real world. Findings demonstrated abilities of children with high functioning autism to sustain engagement and fulfil the aimed design goals. Moreover, lasting personal and social identity expressions were noticed (Ke, F., & Lee, S. 2016). Once again, VR was proved to be a functional tool for training desired behavioural changes.

Figure 9, 10: Collaborative architectural design environment.

Aforementioned researches gave a clear grasp of explicit application of virtual reality use for individual with ASD, however they have not dealt with virtual reality technology head mounted displays. Another yet significantly important research was conducted in 7th of June, 2016th by Nigel Newbutt and colleagues, to obtain knowledge whether individuals with ASD are accepting and willing to wear VRT head-mounted displays. For testing they have used several VR scenarios (Figure 11, 12). Study's results suggested that users with ASD generally accepted and were willing to use such human computer interaction (Newbutt, N., 2016).
These findings lays acute foundation for the future researches that will try to establish observational learning interventions through VRT- HMD, as well as greatly supports our exploratory study.

Figure 11: Left virtual cafe ´ (retrieved from Tore Knabe, www.tore-knabe.com), right virtual safari (retrieved from Gert-Jan Verburg, www.vergevr.com)

Figure 12: Top Tuscany Village outside and inside locations, bottom Apollo 11 mission outside rocket and inside (retrieved from David Whelan, www.immersivevreducation.com)

4. 4 Taking standard video modeling training to another level

Knowing that both Video Modeling and Virtual Reality are successful instruments (see more in State of the art on VR as a training tool for ASD subchapter) used in various contexts while training and educating individuals with autism spectrum disorders, it would be even greater deal to give a try and combine those two mediators, to assumably produce even more powerful tool.

Individuals with autistic syndrome are characterized as visual thinkers, therefore they are highly attracted to visual triggers, and this is exactly why video modeling is capitalized, thereupon the screen puts forward a restricted field of vision and directs attention towards necessary stimuli (Cardon, T. A., 2016). As already mentioned before VR head-mounted displays are well accepted and enjoyable amongst users with ASD (Newbutt, N., 2016). Accordingly, VR head mounted display could direct attention even better in comparison to standard screen display and also preserve from unwanted/ irrelevant triggers.
Moreover, in contrary to traditional video modeling, 360 degree perspective is introduced, which additionally aids with impliedly higher levels of engagement and fosters learning process even more, as well as cultivates generalism, because of the possibility to look around which gives direct associations to real world scenarios. Besides, depending on the content of the training, higher amount of exposure is possible.
As follows, 360 degree point of view video modeling displayed through VR head mounted display is expected to be tested and evaluated in this project as an adaptive skill training tool for individuals with autism spectrum disorder.

5 Design

The previous research serves as a brief overview and dives into the existing methodologies and theories for approaching the chosen problem area and as a transition towards contemporary alternative design. In this section, the design requirements for the solution together with specific points to be implemented will be presented.

5. 1 Design requirements

Every system or a product must have its functional and nonfunctional guidelines in order not to be compromised halfway through the project and guarantee smooth production by the team or other researchers and users, who might want to reproduce it.
Since this study focuses on aiding individuals with adaptive skills through point of view 360 degree video modeling displayed through VR-HMD, the aim of this chapter is to provide steps for producing adaptive skills training. The proposed training tool requires certain both technical and empirical knowledge. The basic system design requirements are as follows:

Functional requirements:

- *The system should include virtual reality head- mounted display*;
- *The system should provide 360 degree video training*;

- *The system should address representation of the targeted behaviour/skills/situation*- meaning that every desired training objective, either it is shopping, taking bus, crossing street, etc., has to be introduced in a clear manner from the first perspective view ;
- *The system should give an exact representation of location/surroundings, that target is used to (same as target's location)*;
- *The system should represent first person perspective*;
- *The system should have multiple scenarios of the same situation*- meaning that video training suppose to represent most often and likely to occur real world scenarios ;
- *The system should be easily adoptable to any VR setup*- meaning that any kind of VR reality head- mounted display should support it;
- *The system should be easily adaptable to any kind of content*- meaning that training supposed to be created to each individual adaptive skill level; needs;
- *Visual and auditory representation should match and be visually and audibly clear*- meaning that quality of video as well as audio suppose to be high-fi, understandable and unambiguous; (Cardon, T. A., 2016)

Non- functional requirements :

- *Repetition of the target situation to trigger a specific emotion related to particular situation* ;
- *Foster learning of set social behaviour rules*;
- *Depending on the individual case, training sessions should be conducted 2-4 days per week,time limited sessions takes (12- 16 sessions) 3-4 week, 4 times per week for CBT.*; (Macpherson, K. H., 2012; Cognitive Behavioral Therapy and Autism Spectrum Disorders., 2012, August 16), *other researches states 3-7 sessions in total*;(Meister, C., 2015) *3-9 sessions*; (NADD Bulletin Volume XII Number 1 Article 2. (n.d.))
- *Showing informations that includes elements incompatible with some of those that exist in the fear structure of users, as triggered previously* (Bandura, A. 1977);
- *The representation of target behaviour should match individuals age and developmental level* - the training should be customized and adapted to the level of cognitive learning disability and the functioning of autism of each individual;(Cardon, T. A., 2016)
- *If individual does not respond to the training, live behavioral modeling prompts might be needed, such as, completing targeted behaviour tasks together with a teacher, parents or therapeut*;
- *Potential future performance of completing task in realistic settings*;

The above proposed requirements were based on the previous research on other state of the art using virtual reality when working with autistic individuals, and the requirements originating from the CBT.

5. 2 Design parts

The aim of this chapter is to provide a clear understanding of the chosen design, and the procedure and methods used, while meeting the design requirements.
Design choices and considerations are divided into smaller parts, according to MoSCow analysis tool (Benyon, D., 2010). This is used to specify and list the design features together with the order in which they should be implemented. More specifically, this includes parts as follows: must have in order for the solution to work, should have if there is additional time, could have but the solution can work without it, and want to have but will not have time and resources. This classification of the specific requirement can be read below.

Must have

The most important aspect of this project which must be implemented is a ***360 point of view video recording*** of a bus trip.

According to National School Transportation Specifications and Procedures, the skill of taking a bus includes, but is not limited to, the following necessary points (National School Transportation Specifications and Procedures, Fourteenth National Conference on School Transportation, 2005):

Loading and unloading procedures. Getting in and out of the right bus (checking the time and the bus number), paying the fare or checking in with a card and possibly communicating with the operator of the bus, finding a seat or place to stand, identifying the desired bus stop, and signaling the passenger's exit station.
Traveling with the bus. Sitting on a chosen seat while the bus moves to the desired bus stop.
This sequence have to be applicable to virtual reality.

Should have

An original source sound of the above mentioned video sequences.
Travel to and from bus stops. This includes finding the stop or station, waiting at the station possibly with other passengers, and identifying the correct vehicle.

Could have

Additionally, depending from the case to case, such as obtaining assistance, navigating in crowded conditions, communicating with passenger, bus driver, or the public transport conductor, etc.
Different scenarios. While it is beyond the possibilities to make a training with all the possible scenarios of taking a bus as they change every day, three scenarios can be

considered as the most probable conditions that the ones encounter when taking the bus.

1. Crowded bus
2. Uncrowded bus
3. Communication with the inspector as he checks the student's card

Want to have

To make the whole experience interactive and improve the immersion of the participant, interactive video system with a multiple scenario choices (meaning more than 3 choices) could be implemented. This could include choices for the participant such as: choosing the correct bus stop and bus, choosing any preferred seat, pressing the stop sign, etc.
However this would be way beyond the scope of this project, and is considered only as possible future perspective.

6 Methods

6. 1 Design method

As the research is within the field of behaviour science and the experiment is focused on only one individual, the chosen design method was single subject design. This section serves as a description of the general characteristics and the procedure of this experimental research design.

Unlike experiments with higher external validity where the researcher randomly assigns big number of participants to a control and treatment group, in single subject research only one participant (subject) serves as both the control and treatment group. A single individual is being treated, observed, and measured, with the goal to identify cause and effect relationship between variables. Pre-experimental AB design type of single subject design, allows a detailed description of the subject and the experiences and might serve as a building block for true experimental designs (Gravetter, F. J., & Forzano, L. A. B., 2015). The This design type serves to demonstrate the correlation between the independent and dependent variables, and it is made up of two phases: the A (baseline) phase and the B (treatment) phase (Byiers, B. J., Reichle, J., & Symons, F. J., 2012).

- Baseline phase- a series of baseline observations made by the student's teacher, with the aid of a custom comfortability and motivation data sheet, which measures levels of comfortability to take the bus. Investigation of his reasons he does not want to take a bus.
- Treatment phase- a series of treatment observations also made by teacher after introducing a treatment. Evaluation method with the same comfortability data sheet.

These phases provide preliminary objective data for further evaluating the effects of the proposed intervention (Beeson, P. M., 2006).
Before further continuing the procedure with those phases, the participant background needs to be known.

6. 2 Ethical considerations

In order to ensure the maximal safety and follow the moral principles of the individual, multiple consideration were taken into the account.
As mentioned previously, according to Newbutt, N., 2016, kids with autism respond well to virtual reality and technology, however the team needs to be conscious of possible side effects. According to current Healthy and Safety guidelines for the Oculus Rift this might include short-term side effects that are known, such as motion sickness, loss of awareness, and seizures.(Yao, 2014) As already included in the design requirements, multiple points were considered to minimize those effects, however a special attention is still necessary. Even that only some people (one in 4000) experience those severe reactions, the user needs to be monitored closely by an adult for the symptoms while using it and also after the use.
Before the virtual reality exposure, the participant will get an information about using the technology and the procedure of the experiment.
The research team will not come to direct contact with the participant, as the team does not have any previous knowledge on working with such individuals. Instead, the evaluation will be concluded in a close contact with his teacher. (Indiana University Bloomington) The teacher working with the participant have previous experiences and knowledge about working with autism and other cognitive disorder children, and therefore knows how to communicate and what to consider.

6. 3 Case description

Name: Mervan Kesmez
Age: 15 years
Location: Valhøj school, Rødovre, Copenhagen.
Position: Student
Diagnosis: February 2010 - diagnosed DF84.1, atypical autism, Child and Adolescent Center Glostrup.
Available informations about the case's bio:
Mervan is a high school student, studying at a specialized school for children with autism. His specific issue is, that he is not able to take the bus alone and travel to and from the school on his own. His reasoning is that he is getting motion sickness in the bus, however when he takes the bus with his father or teacher, he has no issues. Those informations are according to his teacher, collected from the first interview, and can be concluded into the fact that Mervan does not feel comfortable or motivated enough to take the bus alone.

6. 4 Procedure

Below, an ideal procedure and the key elements for the treatments are suggested. The reasoning for the proposed procedure comes from the conducted background research or inspired from other state of the arts.

1. For the therapy to have any visible effects it is suggested that VR video training treatment will be 2 times per week, with a minimum amount of 3 weeks to 6 months. As such a long period of time is outside of the scope of this project, the evaluation will be conducted already after 2 treatments.
2. Participant will be introduced to the technology and explained how it works, how to use it, and what's the procedure of the experiment.
3. Participant will be exposed to VR treatment and meanwhile his reactions will be observed by teacher. The teacher was beforehand informed about what reactions to focus on, note them down, and in case if necessary interrupt the treatment.
4. Approximately estimated time of the session is around 3 minutes, as that's the length of the video.
5. Afterwards, participant will be handed in a confidence and motivation rating scales, to identify his confidence about taking the bus together with his motivation to take the bus.
6. Teacher will answer the questionnaire for himself with noted down observations.

The questionnaire and more in depth explanation of the exact procedure can be found in the Appendix B.

6. 5 Measures

The chosen objectives of measures for evaluating the final solution will be presented together with the more detailed description of the approach.

Measurement objectives

Efficiency of the product. In order to evaluate whether or not the solution can be effective as a treatment intervention for teaching adaptive skills to adolescents with autism spectrum disorder, it's efficiency will be questioned by comparing the participant's ability, confidence, and motivation towards the specific skill. This will provide an approximate idea of his current state of mind towards the action, and whether or not it has changed after the treatment phase. However, to support this self-assessed evaluation, teacher's opinion needs to be collected simultaneously. This approach will be discussed more in depth below, in the pre-treatment and post-treatment measurements.

Usability of the product. The usability of the product will be evaluated, and the teachers opinion on the product will serve as a foundation, collected from a questionnaire and semi-structured interviews. The specific questions can be found in Appendix B.

Pre- treatment and post-treatment evaluation

Semi- structured interviews with a stakeholder:
Due to special conditions and our limited access to the participant, stakeholder such as participant's teacher was the principal observer and assisted us with establishing baseline (the collection of data on the dependent variable before any intervention) of the subject's behaviour. It was conducted after the solution (product) for the research was designed, but before finishing the final implementation. First interview was done at the beginning of the project research phase, and the second one after the baseline establishment phase. During all phases, the team communicated with the teacher through mails whenever necessary. Questionnaire together with observation guidelines were provided for the teacher (see more in Appendix B) in order to confer us with requisite information. After the baseline establishment as well as after treatment period, results and observations made during baseline establishment phase and treatment phase were discussed, compared and noted.

Confidence rating scales:
Both times, pre-treatment and post-treatment phase, participant was asked to rate his confidence concerning targeted behaviour. In Post-treatment phase it was done after the VR sessions. Confidence rating scales are typical scales used also in other similar researches oriented at reducing phobias, aimed to rate the person's own confidence at tackling their targeted situation (Maskey, M., 2014). Scale were from 0 (not at all) to 6 (very comfortable)(Figure 13.)

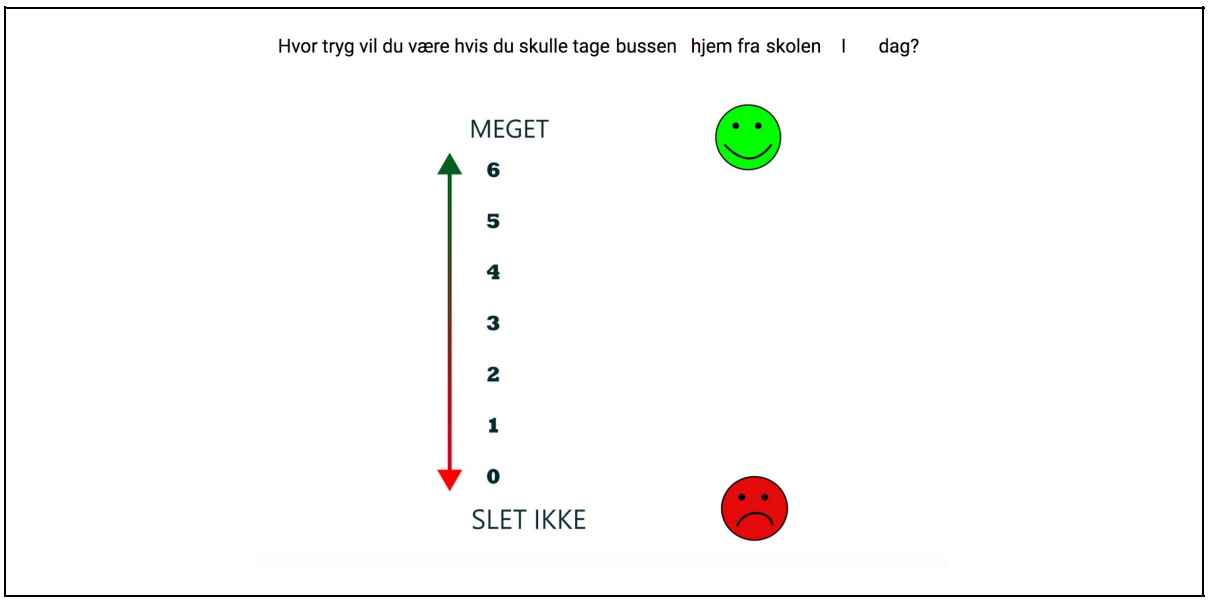


Figure 13: Self assessed confidence rating scale

Confidence rating scale served as a primary tool for data collection, to observe any effect within the participant behavior towards the targeted situation of taking the bus. Also, the teachers opinion on the answers, and what the answers would be according to him, will be collected simultaneously as part of both phases. This was decided to obtain both views, as the presented participant's idea about himself might be biased.

Motivation rating scale:
Additionally to confidence rating scale (Figure 13), participant was asked to rate his motivation concerning the targeted behaviour. He was asked both times, in pre-treatment and post-treatment phase, where he was questioned after the VR session.
Motivation rating scale is used as a tool in behavioral sciences to observe and learn more about possibly occurring behaviour problems. To create this scale (Figure 14), we have drawn inspiration from The Motivation Assessment Scale, which was originally designed to "..assess the influence of social attention, tangible, escape and sensory consequences on the self injury." (Matson, J. L., 2011)

Figure 14: Self assessed motivation rating scale

Motivation rating scale served for data collection, to observe any additional effect within the participant behavior towards the targeted situation of taking the bus. Also, the teachers opinion on the answers, and what the answers would be according to him, will be collected simultaneously to confidence rating scale, as part of both phases. This was decided to obtain both views, as the presented participant's idea about himself might be biased.

Likert Item scales:
For the treatment phase few Likert Item scales were used to evaluate usability of the product. Those scales included questions like: *How effective it was as a tool for training daily life skills?* (*Not effective- Effective*) and *How comfortable was the child with the learning tool?* (*Not comfortable- Comfortable*).

7 Implementation

The following chapter will examine the implementation of the system, with a focus upon the technical choices taken during the process of implementation, as well as the more practical considerations. Throughout this chapter the system will be peeled apart to see what it contains, both in hardware and software considerations.

7. 1 Software and hardware

The main software tools used to create (cutting, editing and post production) the product were Adobe Premier Pro - video editing program and Adobe After Effects - advanced post production/video editing software as well as Adobe Photoshop CS6 - photo editing software. Those were considered the most efficient software tools in terms of the video production needs. The use and application will be explained in the next subchapter.
For the filming "360fly" camera was used (Figure 15). Accordingly to our technical research more options were considered, such as Kodak PixPro SP360 4K, Nikon Key Mission 360 and Kodak PixPro Orbit 360, last two examples have two lenses. However, the most accessible solution was camera 360fly, which has only one lens, yet specifications were appropriate to fulfil production needs.

Figure 15: 360fly camera

For usability testing Oculus rift VR head mounted display was used, whereas the final version of video exposure was displayed through the VIVE HTC VR head mounted display.
In the following subchapters implemented scenarios and decisions behind filming and editing are going to be explained.

7. 2 Implemented Scenarios

The initial ideas for the content and length of the video were followed. This included specific scenarios of walking from school to bus stop, taking the bus, finding the seat in the bus, getting out, walking to the next bus stop and taking second bus, and walking from final bus stop to home. However at the end multiple changes were introduced. Throughout the process several internal usability tests were conducted and some of the shots had to be eliminated because of the tottering/shaky view while walking action was executed, which were potential threats to cause motion sickness. This was necessary especially for the long walking sequences. Since the walking sequences were not considered as important as the sequences involving bus, they were deleted from the final video sequence.
Another change that was decided upon, was including only first bus sequence, and delete the footage of going to the second bus stop, waiting there and taking the second bus. The reason for this decision was the restricted field of view of that footage, as the chair in front took the most space in the view. This footage could have been replaced and recorded again sitting in a chair with a better position, however this was found in the latest part of the project and not considered as priority, and additionally there was a need to shorten the length of whole experiment.
That way the final footage could be much shorter, exactly 10 minutes shorter than the original sequence with all the above mentioned scenarios. This shortened the whole time necessary for the experiment, and made it less demanding to be conducted, while still meeting the necessary design requirements.

7. 3 Filming and editing

First of all, the way of filming is going to be described, whereas it is one of the most important aspect of point of view video modeling. Since the video has to be represented through the first person perspective, we had to film it accordingly. Hereby a special method of attaching 360fly camera to one of our team members chest (figure 16,17) was designed.

Figure 16, 17: Camera attachment

The reason for this kind of attachment was to shoot necessary body parts such as arms and legs inside the field of view, to fulfill the requirement of point of view video modeling. Any other placement of the camera would not have represented this property, showing only persons torso otherwise.
Settings for the camera were set in the 360fly application from the phone. The application served as a screen to see the view from the camera. (Figure 18,19.)

Figure 18,19: The adjustment of settings and the field of view from the 360fly application.

The chosen resolution was 2880 x 2880, with 24 fps. Focal length was preset by default to 0.88 mm.

When video material was obtained as a fisheye video view (Figure 20), the adequate shots were selected, exported in equirectangular format through 360Fly Director (Figure 21), cut in Adobe After Effects (AAE) and sequenced accordingly to the design requirements.

Figure 20: Fisheye video view

Figure 21: Equirectangular video format

After exporting raw material, shots were edited to obtain logical sequences. Long and monotonous shots were shortened and merged together, to produce the same logical sequence in the shorter time and make it less boring for the user.
While filming we could not avoid getting the camera mans' head inside the field of view since camera was mounted to the chest. Therefore it had to be eliminated digitally. Several considerations were made concerning "head elimination process", notwithstanding "blurring" appeared to be most optimal one. Gaussian blurring and "feathering" were used to achieve this effect (Figure 22, 23). Moreover, sharpening effect was applied to the whole sequence, to enhance the appearance of the video (Figure 24). Additionally, in some of the shots there were more unwanted artifacts, such as hair or scarf, taking that into account "masking" was needed to be applied. It was achieved by saving frame (with a clear, unpolluted view) in Adobe After Effects (AAE) and exporting that frame into Photoshop CS6, where unobtrusive part of the sky was cut out imported back to the AAE and used as a mask to cover unwanted artifacts within the same settings.

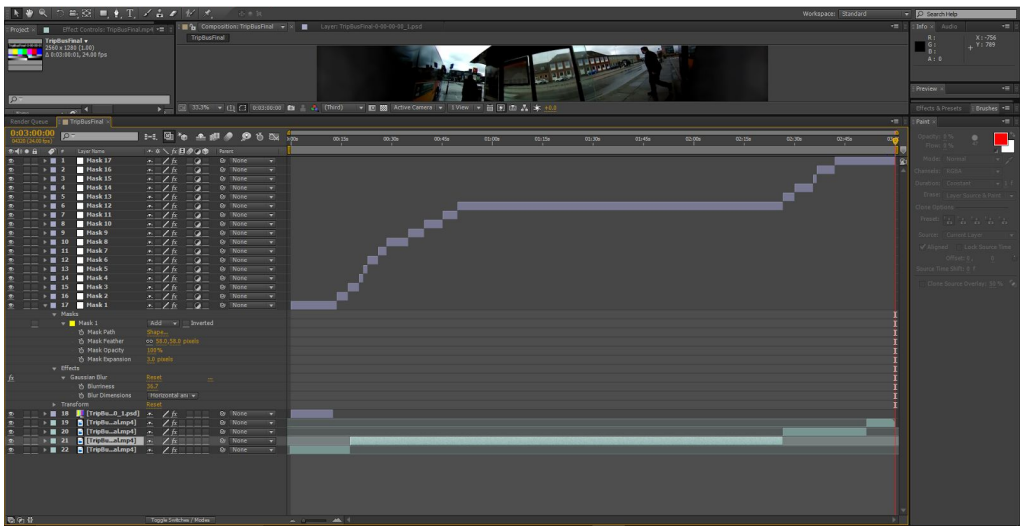


Figure 22: Sequence, with 17 masks applied

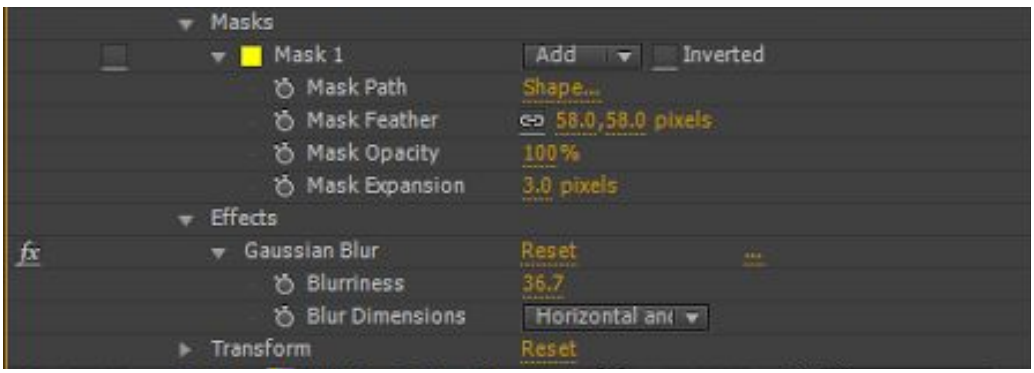


Figure 22: Settings of one of the mask. Feather and blurriness settings

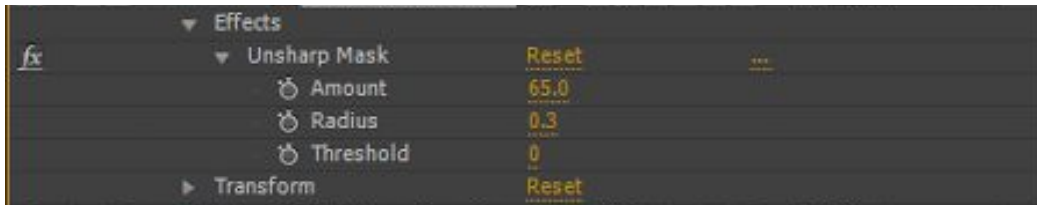


Figure 24: Amount of sharpness

Original sound from the recording was decided to be kept, to make the settings as realistic as possible and therefore enhance the immersion of the participant.

7. 4 Implementation constraints

One of the main constraints and limitations was the placement of the camera, that introduced unwanted particles inside the field of view. Camera itself had to be hidden properly, in order not to draw any unnecessary attention towards it, since the video had to be the best representation of the first person's view and was meant to be shown as a training tool for the adolescent with ASD, any superfluous attention from the people around could have caused unwanted reactions from the user during the treatment sessions.
Another constraint was the camera which takes only 180 degrees instead of 360 degrees, so we got only the front 180 degree view. Looking from the positive perspective it turned out to be an advantage, since it was quite easy to hide the fly360 camera.
Supposingly, different camera with 360 degree field of view would have introduced the whole range of new issues. Such as enough hidden placement of the camera, or stitching problems could have been present. Different ways of filming for finding out the most optimal way stays as a topic for further research.

The next chapter will introduce test results, discussion and redesign considerations.

8 Results

8. 1 Baseline phase

As the decision was to collect data from both, the participant and his teacher, the answers collected from the teacher can be described separately and compared.

Mervan's answers. On the confidence rating scale, the self-assigned number was 6. On the motivation rating scale it was 4. His reasoning behind it was that he feels very comfortable taking the bus alone, but he does not need to take the bus, because his father can always take him. "You only go to the bus, pay, and you go out." "If I have to take the bus I would, but I can go by car."

Teacher's answers. For the Mervan's confidence taking the bus, teacher circled number 2 (on a scale from 0 to 6). For the motivation, he circled number 1. "Mervan does not want to admit his anxiety of taking the bus. He finds a different excuse every time he is asked to take the bus on his own. However, if he would decide he wants to do it, as currently he doesn't, he would be able to."

Additional interview with the teacher revealed that his father feels like he has to take him by car. However, from the next scholar year Mervan will be forced to take the bus, as father says that he won't take Mervan from school as he finishes work four hours later. However this information is not revealed to Mervan yet.
The reasoning behind why Mervan does not want to take the bus is questionable from all perspectives, as there might be different factors that the teacher is not aware of. To be reminded, compared to the first interview (that served as a foundation for the case's description and persona, see Methods chapter) with the teacher where he stated Mervan's reason as not taking the bus because of the motion sickness.

To conclude those findings, it can only be assumed what the reason might be. However, the person's anxiety, confidence and motivation towards certain action are all linked together and interconnected (Bandura, A.1997; Kenow, L. J., & Williams, J. M. 1992), with a direct influence of one to another.

8. 2 Treatment phase

Similarly to the baseline phase, the data was collected from both- the participant and his teacher.

This data was collected from one treatment phase:
Mervan's answers. On the confidence rating scale, the self-assigned number was 6 (on the scale from 0-6). On the motivation rating scale it was 4 (on the scale from 0-6). His answer was that "It is a pity that I do not have my radio".

Teacher's answers. For the Mervan's confidence taking the bus, teacher noted down number 4 (on the scale from 0-6). On the motivation rating scale it was 2 (on the scale from 0-6). For the effectiveness of the tool for training daily life skills, he have chosen 3 (on the scale from 0-6). And for the question how comfortable was the child with the learning tool, teacher answered 4 (on the scale from 0-6).
Additionally, teacher noted down that Mervan was motivated to try VR, he had a good experience of the VR bus ride and would like to try it again. Moreover, Mervan did not show any signs of motion sickness.

8. 3 Conclusion

According to the first session results that were obtained before the research could be concluded, compared with the results before intervention, there is not any significant change between the Mervan's answers. He still claims to feel confident, with slightly lower motivation, and different reasoning behind why he feels unmotivated. When looking at the teacher's answers, the student's confidence improved by two numbers, and motivation by one.
For the usability of the solution, hardly anything can be concluded from the obtained results since there are not enough data to support the collected results. However, the obtained data shows that the student enjoyed and felt comfortable with the design.

9 Discussion

In this chapter evaluation results, success criteria, and possible future implementation improvements are going to be reviewed and discussed.

9. 1 Validity and reliability

Confound factors and biases:
The research drew only one set of results, with one treatment phase, which makes it difficult to see any significant changes in the student's behavior. Therefore research can not be concluded yet, whereas more results are needed.
Since we had the limited access to the case/student, our main source of data was a stakeholder (students' teacher), which might have influenced the results greatly, because of potentially subjective interpretations of participants behavior.
Moreover, many potential factors could have influenced student's answer as well. There could have been more unknown psychological reasons behind Mervans' unwillingness to take a bus, which was not revealed by him to the teacher, as the main purpose of this project was to increase his confidence and motivation to take the bus.
Usability testing part of the research is also questionable. Since the usability questionnaire did not follow any specific regulations, only supposed questions that made sense to know the answer to were asked. Further, only one usability test was conducted with the participant, which had a positive feedback. Those findings can not be concluded yet, since more usability tests have to be conducted. Moreover, during the usability testing we did not have the ability to collect data via observations due to limitations.

9. 2 Meeting success criteria

Through the success criteria which were originally aimed for, it is apparent that not every criteria was fully achieved. The reason not all of it were fully achieved was the lack of time and resources, as well as research and implementation constraints.
One of the core requirements for this project, which is 360 degree video, due to technical constraints could not have been fulfilled.
The point of view video modeling system is missing multiple scenarios, which are most likely to occur in real life situations. Instead only one scenario was implemented - a half empty bus, which means that user is not presented with other most common situations that one can encounter. This influences the overall efficiency of the solution, as situations that triggers the person's specific emotions might not have been accessed.
Additionally, there was not enough time to conduct more video training sessions to be able to see any significant behavioural change of the user. Since optimal session time varies from 2 to 4 days per week, for 3-4 weeks (see more in the Design requirements chapter). However previously mentioned problem above is highly related to the frequency of training sessions. If the more training sessions are wanted the more scenarios should have to be created, in order not to make the user suffer from boredom and the lack of concentration.
Moreover, due to the time constraints and resources spacial 360 sound was not implemented, instead the original sound taken with the camera microphone was used. It could have caused an ambiguity and taken away some of the credibility form visual part of the video.

9. 3 Future Implementation and improvements

After the evaluation of the product it was ascertained what possible future implementation and improvements can be done.
First of all, to see the significant changes in the participants behaviour, as mentioned previously (in the Procedure, Methods chapter) longer data collection period for both pre- treatment and treatment phases is required.
Further improvements has to be done on taking the video itself, choosing the most optimal way of filming with as less unwanted particles inside the field of view as possible. The possible adjustments could be instead of attaching camera on the chest, attach it on top of the camera man's' head (constraints concerning this solution are mentioned previously in the Constraints subchapter).

Another useful improvement would be to stabilize camera with a special camera stabilizer (Figure 25), which could be attached to filming man's body, so all of the walking sequences could be included to represent the bus taking trip more accurately to the user (National School Transportation Specifications and Procedures). That would include two buses with changing a bus stop as well as walking back home.

Figure 25: Steady wheel camera stabilizer (Steady Wheel camera stabilizer reduces unwanted shake while shooting action footage, 2013)

Moreover, bus trip from home to school would be implemented as well, to make sure that participant is trained for both bus taking scenarios.
As already mentioned before (see more in Want to have subchapter, chapter 5), multiple scenarios with multiple choices would be implemented to provide interactive system for the user. This would be achieved by filming as many possibilities as possible while taking the bus. Such possibilities could be: choosing whether or not to take the bus, or wait for another one, check time table, when entering the bus, choose where to sit or to stand and many more.

10 Conclusion

The initial aim was to investigate the potential of combining virtual reality and point of view video modeling for teaching adaptive skills to students with autism spectrum disorder. From the background research conducted, there seems to be overall encouraging basis of already widely used methodologies, which when combined, bring potential for developing a new approach to adaptive skill training for the individuals with ASD.
Cognitive behaviour therapy and observational learning served as a primary tools for targeting specific problematic skill. By combining point of view video modeling and virtual reality head mounted display, a novel approach that extends the possibilities for targeting one's problematic situation had been developed.
A specific case of a 15 years old student diagnosed with autism was assigned for the evaluation of the proposed solution.

While the purpose of this research was to only serve as a pre-experimental design needing further future investigation, an evaluation consisting of baseline and treatment phase was conducted. Hardly anything can be concluded, even that the findings were in favor of the design, as the treatment phase needs to be longer and more data needs to be collected. Virtual reality combined with point of view modeling offers a variety of different valuable opportunities for extending the benefits of traditional approaches of existing therapies while still serving as a functional tool. The research suggest further research to fully evaluate the potential, while proposing also other directions for investigation.

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Appendix A

The Case baseline establishment questionnaire and observations

The proposed guidelines and questions will aid to find out and learn about the case, getting a better understanding of the user's view on the challenge of taking the bus as well as the potential progress in adapting the skill.

The suggestion is to ask these questions optimally twice a week.
Preferably the questions should be asked in non intrusive way, meaning that the questions should not be asked out of context, and keeping the conversation between the child and the teacher fluent.

The question is as follows:

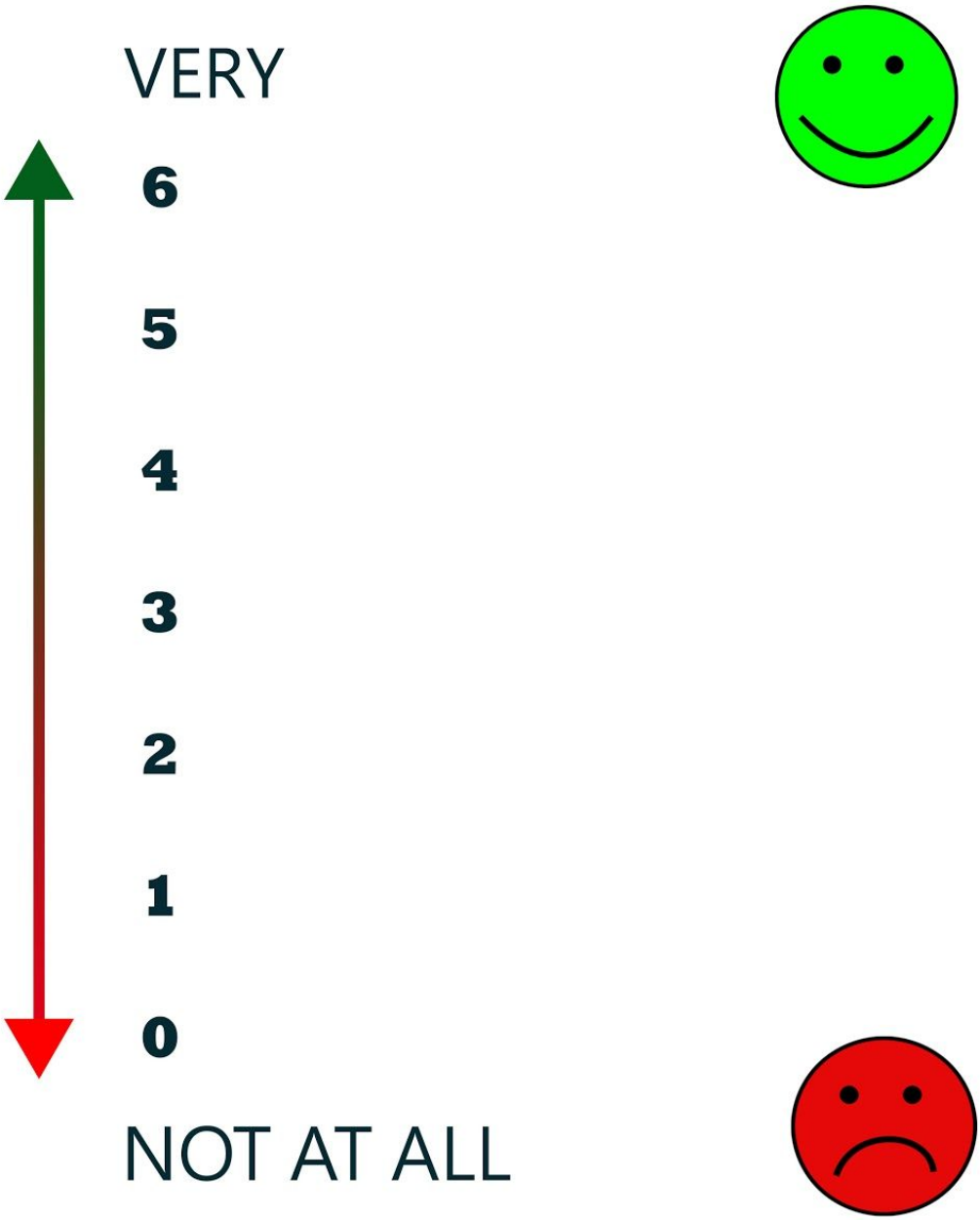
1. What do you think about taking the bus?
2. Do you think you could take the bus alone next time (tomorrow/today)?

On the following scale from 0 to 6, assign an approximate number accordingly to the child's answer.

0-not comfortable at all taking the bus alone
6-very comfortable at taking the bus alone

Also, try to observe the user's reaction and behaviour when asked those questions, and note down any possible reactions, for example such as avoidance, shortness of breath, muscle tension, trembling, etc.

If you had to take a bus today on your own, how comfortable would you feel?



- Baseline establishment procedure
- questionnaires

Appendix B

Test procedure and a short questionnaire

Those are the proposed guidelines for the procedure of the video exposure experiment.

About the experiment

In the video, the user will go through a short sequence of taking his bus 9A home, from the station next to the school. It starts by waiting for the bus, then checking in, finding a seat, and checking out and going off of the bus. The video is about 3 minutes long. Ideally, the proposed minimal amount of sessions would be two, preferably in one week, but not two days in a row.

Approximate instructions for the user

"*I would like to ask you to watch this short video about the public transportation through a VR headset. It is 3 minutes long. In case you feel unsafe, or motion sickness, you may take it off.*"

During the video exposure

As a teacher, please be there and observe the reactions and the behaviour of the user. Also please react anytime you feel the need to interrupt or not to continue the whole experiment, if for example the user seems too stressed or nervous.

Short questionnaire for the participant

After the video finishes, and the headset is removed, please ask the user the following question while showing the scale, as during the baseline establishment, and note the answer. Before writing the answer, please mark the of the video exposure session.

1.*How confident do you feel taking the bus? Please evaluate according the scale. Explain why?*
2. *How motivated do you feel taking the bus? Please evaluate according the scale. Explain why?*

Overall questions for the teacher

Please, as a teacher, we would like to get your feedback regarding the overall experiment. The questions are as follows. Feel free to add any additional comments below.

1.*How comfortable does the student feels to take the bus, according to you?*
2.*How motivated does the student feels to take the bus, according to you?*
3.*How effective it was as a tool for training daily life skills?*
4.*How comfortable was the child with the learning tool?*