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ADVANTAGES AND PROPOSITIONS OF LEARNING EMOTION RECOGNITION IN VIRTUAL REALITY FOR PEOPLE WITH AUTISM

Anna Schwarze
University of Siegen, anna.schwarze@uni-siegen.de

Henrik Freude
University of Siegen, henrik.freude@uni-siegen.de

Bjoern Niehaves
University of Siegen, bjoern.niehaves@uni-siegen.de

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Research paper

Schwarze, Anna, University of Siegen, Siegen, Germany, anna.schwarze@outlook.de

Kampling, Henrik, University of Siegen, Siegen, Germany, henrik.freude@uni-siegen.de

Niehaves, Bjoern, University of Siegen, Siegen, Germany, bjoern.niehaves@uni-siegen.de

Abstract

People with an autism spectrum disorder face the daily challenge of social interactions – particularly in non-verbal communication. These difficulties make adequate interpersonal interactions "in real-time" a challenging obstacle to overcome in many cases and can lead to excessive demands, frustration and isolation (low level of Theory of Mind). Emotion cards are usually used in autism therapy to learn basic skills for recognizing emotions. Learning with autism is characterized by spontaneous – sometimes-extraordinary – mastery of complex contents. People with autism learn facts, details and routines well but have difficulties to transfer the learned contents to another context (Weak Central Coherence) or to react flexible to unpredicted events (low Executive Function). In addition, research has shown that autistics learn social competences while using a computer and performing practical exercises. Such systems provide the possibility to use an accepted computer simulated (virtual) environment in which autistic children can be taught social competences as emotion recognition. Consequently, we assume that learning emotion recognition in virtual learning environments can remove barriers and obstacles for autistics as they are more successful in solving social problems. Therefore, we are discussing in the paper at hand the potentials of how emotion recognition can be learned in virtual reality.

Keywords: Virtual Reality, Emotion Recognition Learning, Autism, Case Study Research

1 Introduction

People with an autism spectrum disorder face the daily challenge of social interactions – particularly in non-verbal communication (Lord, Cook, Leventhal and Amaral, 2000ß). Such difficulties often arise due to a deficit in the competence area of emotion recognition. This deficiency makes adequate interpersonal interactions “in real-time” a difficult obstacle to overcome in many cases and can lead to excessive demands, frustration and isolation (Lord and Bishop, 2010). Emotion cards are usually used in autism therapy to learn basic skills for recognizing emotions. The autistic person learns to recognize the rigid representation of an emotion on a card and to name it. However, these emotion cards have deficits with the emotions of people in reality. Therefore, people with autism have problems to transfer the learned competences into everyday life.

The aim of this research is to develop a virtual setting that will enable autistic people to better learn how to recognize emotions. Through facial expressions in a virtual reality (VR), emotions of people can be presented. These virtual presentation of emotions can be close to real world because of the possible level of depth enabled through the technology, on the one hand, and by any possible number of virtual people, on the other hand. The number of people and the number of emotions virtually projected can be individually adjusted in VR and, thus, enables a more precise promotion, than a limited repertoire of an (analogous) emotion card set. As a consequence, individual learning in VR is possible for a respective person with autism. During the learning process an autistic is in a controlled environment in which he or she is comfortable since social interactions are minimized (Parsons and Mitchell, 2002). The use of a virtual environment is seen as an advantage, as people with autism usually have a high degree of technical affinity which makes it possible to break down barriers in the area of acquiring social skills (Moore, Cheng, McGrath and Powell, 2005; Ehrlich and Miller, 2009; Newbutt, Sung, Kuo and Leahy, 2017). Nevertheless, the autistic person has the possibility to interact with people and their emotions without really having to get in touch with them. Moreover, within a virtual setting, a misinterpretation of an emotion has no negative consequences or effects for an autistic learner. In turn, during a real social interaction a misinterpretation could have negative consequences because it could lead misunderstandings or emotional overreactions (Strickland, Marcus, Mesibov and Hogan, 1996). However, we assume that learning emotion recognition in virtual learning environments can remove barriers and obstacles for people with autism as he or she is more successful in solving social problems. Therefore, we are discussing in this paper at hand the potentials of how emotion recognition can be learned in VR. To do so, our work is guided by the following research question:

> *RQ: Can children with autism learn emotion recognition in VR and how should the VR environment be designed?*

To answer this research question, our work is structured as follows: First, we present the research background of autism, learning emotion recognition with autism and VR learning environments. Second, the methodology, i.e. a case study approach with five autistic people, is outlined. Here, we provide information about a self-developed VR demonstrator for learning emotion recognition for people with autism and some background information about our participants. Subsequently, we present our major findings and a discussion with implications. Finally, the study limitations and an outlook are given.

2 Background

2.1 Autism

Autism is one of the most profound developmental disorders. Autism consists of a variety of symptoms that vary from person to person (Lord and Bishop, 2010). In addition, a gender-specific relationship can be observed because more male people are affected by the disorder than females. Literature implicates that the autistic characteristics are linked to biological factors (Baron-Cohen, 2008; Ryan and Charragáin, 2010; Manning-Courtney et al., 2013). In general, the spectrum of disorders of people with autism includes impairments of social relationships, social communication and social imagination (Frith and Happé, 2005; Lord and Bishop, 2010). There are three different categories of the profound developmental disorders: Asperger autism, a-typical autism and core autism which are mentioned in the ICD-10 (Taylor et al., 1999). People with autism have a low level of or deficits in their *Theory of Mind* (i.e. a human ability for relationship capabilities or bonding abilities such as the recognition of desires, intentions, beliefs or opinions): they are not in the position to put oneself in someone else shoes (Baron-Cohen, 1989; Burnette et al., 2005). For instance, an autistic cannot react with empathy to someone's else sadness because an autistic did not understand the emotion. The *Theory of Mind* is also responsible for the feeling of empathy for a person (Morgan, Maybery and Durkin, 2003). People with autism are focused on an individual piece of information rather than the overall context which is caused by a W*eak Central Coherence* (Morgan et al., 2003). For example, an autistic person is just focusing on the mouth of a face while all other aspects are ignored. Moreover, the E*xecutive Function* describes processes such as planning processes, mental flexibility, foresight as well as targeted and problem-oriented action. People with autistic disorders has difficulties with these abilities because they have problems by completing tasks they have started or in reacting flexible to unforeseen events (Robinson et al., 2009) such as something unexpected happens in their life that is not in a common order. All these three deficits in social interrelations of *Theory of Mind*, *Weak Central Coherence* and *Executive Functions* make it difficult for autistic people to recognize emotions for communication.

Learning with autism is characterized by spontaneous – sometimes-extraordinary – mastery of complex content. People with autism learn facts, details and routines well but have difficulties to transfer the learned contents to another context (Dawson, Mottron and Gernsbacher, 2008; Solomon et al., 2015). For instance, people with Asperger autism are in most cases visual learners, so autistic people learn differently apart from non-autistic people (Dawson et al., 2008). The entire spectrum of the child's or adolescent's abilities has an influence on education and not just the diagnosis of autism. Therefore, for each child with autism it is necessary to decide individually of what kind of education might is the best such as which school to attend and which support is needed (Lord and Bishop, 2010). Autistic people have unusual learning patterns which manifest in the early years of life such as the name of objects, numbers and long and unusual words (Dawson et al., 2008). In the age of two or three, children with autism are already to acquire specific skills. Kanner (1951) mentioned that children with autism are difficult to teach in a traditional way, they *"learn while they resist being taught"* (Kanner, 1951, p. 23; Dawson et al., 2008). As an example, parents of an autistic child vain attempt to teach their child to talk. At a single blow, the child begins to talk in full and in complex sentences at the age of two. In addition, research has shown that autistic persons learn social competences while using a computer and performing practical exercises. People with autism have natural affinity for technologies and for controlled environments which are generated by computers (Moore et al., 2005; Fridenson-Hayo et al., 2017). Such systems provide the possibility to use an accepted computer simulated (virtual) environment in which autistic children can be taught social competences as emotion recognition (Newbutt et al., 2017; Berggren et al., 2018). The traditional way in autism therapy for learning emotion recognition is the use of analogous emotion cards. These cards are used to teach basic skills by recognize the rigid representation of an emotion and to assign or name the respective emotion. However, the use of these cards show practical problems because each learning session takes place with a therapist (Serret et al., 2014). Hence, the use of emotion cards needs social interactions in a perceived less controlled environment than in a virtual computer generated one (Bormann-Kischkel, Vilsmeier and Baude, 1995).

2.2 Virtual Reality

The year 2016 marks the second wave of virtual reality, in this year the VR head-mounted display (HMD) Oculus Rift (development kit) entered the market. These VR-HMD creates an individual immersive virtual reality experience and cause a hype around immersive systems (Gleasure and Feller, 2016). The focus of VR systems relies on the game industry but it is also used in other areas such as medicine or education (Martín-Gutiérrez, Mora, Añorbe-Díaz and González-Marrero, 2017; Stone, 2017). VR is an three-dimensional computer simulated interactive environment (Wexelblat, 1993). There are different degrees of immersion: On the one hand, non-immersive VR which is presented on a 2D desktop display and, on the other hand, immersive VR which includes complex interface technology (e.g. HMD) that surrounds the user by an enclosed virtual space (Anthes, Garcia-Hernandez, Wiedemann and Kranzlmuller, 2016).

Immersion, as a central characteristic of immersive VR systems, can be defined as “a mental state of being completely absorbed or engaged with something” (Dede, Jacobson and Richards, 2017, p. 3). The immersive system allows the user to fade out the real world and to be immersed in the virtual environment. A VR session is a single user-experience and is typically limited to 30 minutes (Schultze, 2010). Within a VR, a user can interact, manipulate or create objects through provided controllers (Khalifa and Shen, 2004; Seibert and Shafer, 2018). The user receives continuous feedback about movements such as head movements and his or her position (Martín-Gutiérrez et al., 2017).

Virtual reality has the potential to commit and motivate the learner in a deeper way (Kerawalla, Luckin, Seljeflot and Woolard, 2006; Martín-Gutiérrez et al., 2017). This provides new possibilities to integrate the VR in the learning context (Martín-Gutiérrez et al., 2017). By creating a virtual environment, nearly any kind of information can be visualized and through interactive actions in it, knowledge acquisition can be improved (Taxén and Naeve, 2002; Huang, Rauch and Liaw, 2010). This part of the VR can support the learning process, for example, a student of history wants to learn the Greece’s history. In a virtual environment he or she has the possibility to walk through the ancient Greece and can talk to the people instead of reading books. The VR is more impressive in this case and the student can get a better felling of the people’s historical life (Pan et al., 2006). Slater and Sanchez-Vives (2016) outline four positive factors of learning in VR environments: First, the VR can transform abstract settings to tangible ones. In this context, three-dimensional mathematic lines and shapes can better be visualized in VR than on a two-dimensional coordinate system such as on a sheet of paper (Slater and Sanchez-Vives, 2016). Second, in the VR the user is not just a spectator, the user can interact with the presented content. As an example in medicine, by appropriately configuring the virtual space, team activities can be trained in a surgical operating room of a hospital or students can take different roles in the team and train the diverse perspectives (Slater and Sanchez-Vives, 2016; De Liu, Santhanam and Webster, 2017). Third, practical things can be done which are desirable but practical infeasible. For instance, a class wants to visit the Grand Canyon in week one and Stonehenge in week two. Here, VR allows to be more time and place independent. Fourth, VR environments allow to break the bounds of reality. For example, a VR user can explore what happens if gravity is reduced and the surroundings such as playing football changes (Slater and Sanchez-Vives, 2016).

For people with autism there can be some more positive effects for using the VR technologies. First, the VR can provide a safe environment where the autistics can make mistakes without negative consequences. Second, a positive aspect in this context is that autistic children are mostly visual learners (Dawson et al., 2008) and with a VR system this competence can be supported. Finally, the reduction of social interactions during the learning process of emotion recognition combined with the high technology affinity of autistics are assumed to have a positive effect on this process.

3 Methodology

3.1 Method Selection

For the investigation of whether children with autism can learn emotion recognition in VR and how this environment should be designed, we have chosen a case study method. To get insights of such complex phenomena which have not been fully explored yet, a case study is considerably useful (Yin, 2013) but does not allow an analysis of causal relationships (Benbasat, Goldstein and Mead, 1987; Yin, 2013; Keutel, Michalik and Richter, 2014). Case studies allow an in-depth analysis of phenomena that are related to the context where those phenomena occur (Keutel et al., 2014). Since both aspects are relevant to this study, case study research in well-suited for our endeavor.

The internal validity of the case study is generally seen as a strength, whereby external validity is often seen as a weakness. To increase the external validity, we make sure that in every step or phase of our study at least two researchers were involved. The advantage here is that idiosyncratic perceptions were reduced. Moreover, with the use of multiple investigators, we were able to implement triangulation (investigator triangulation) (Patton, 2005).

3.2 Case Design

The purpose of this study is to investigate whether children with autism can learn emotion recognition in VR and how this environment have to be designed. Therefore, the unit of analysis is an individual, i.e. children with autism. In order to answer this research question, we focus on autistic children with different autism disorders and how and whether these use a VR learning environment. As outlined above, we conducted each phase by at least two researchers and included in our study a single observation of each autistic children itself and an overall observation of all participants. Therefore, we are able to strengthen our findings in light of replication logic (Eisenhardt, 1989; Yin, 2013). The conduction of our case study includes four phases: pilot study, case selection, data collection and analysis (c.f. Figure 1). A brief description is given in the following.

For our case, we developed a virtual reality learning environment for emotion recognition with the Unreal Engine 4 (UE4) and by use of an HTC Vive system. The virtual reality is chosen because can become more immersed than in a regular computer setting. Within this setting, a virtual room was created in which a virtual table, windows, ceiling, floor, walls, plants etc. are depicted. On this table, the virtual emotions cards appear, which were previously taken by a camera by the first author with a professional actress and transferred to the virtual room. The emotions were the six basic emotions: happiness, sadness, surprise, anger, disgust and fear (Eimer, Holmes and Mcglone, 2003). The emotion-related photos (hereafter virtual emotion cards) have taken with an actress to ensure that the imitation of the emotions are precisely correct (c.f. Pilot Study for more information)(Yan, Liu, Ye and Liu, 2018). The virtual emotion cards show a brown hair and brown eyes young woman (mid of twenties).

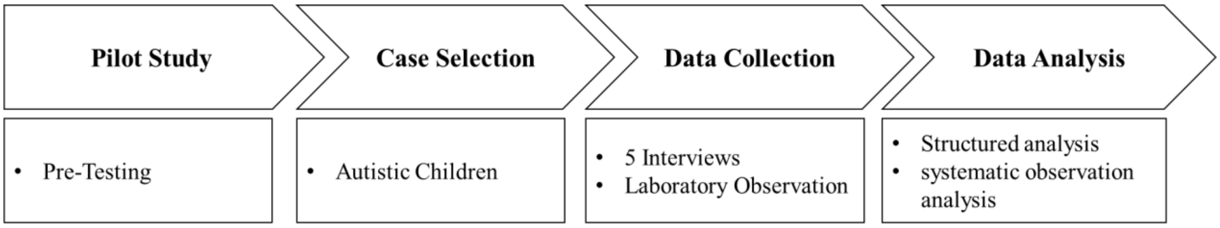

Figure 1. Case study design

3.3 Pilot study

As outlined above, we produced six virtual emotions cards with a professional actress (c.f. Figure 2). Within a pilot study, we ensured that each of the emotions cards, first analogous, present the expected emotion with non-autistic people. To do so, we recruited six employees from a European university and asked them repeatedly to assign the emotion card to the intended emotion. Subsequently, we repeat this step with the virtual emotion cards in the virtual setting. Here, we asked the same people again and, in addition, to reduce a bias from the first step, we recruited another six employees who assigned virtual emotion cards to the intended emotions. Consequently, we were sure that each virtual emotion card represents the intended emotion and that autistic children can also recognize the emotions.

3.4 Case selection

After finishing our pilot study, we were able to cooperate with a local autism therapy-center. As a selection criterion, the autism therapy-center has a need within their therapies to support the autistics to better communicate and social interact with real life people. Against the background of children, therapists and the researches asked for autistics who would voluntarily participate and who had consent form of the parents. Five autistic children have agreed to participate. Here, we can conclude that our target group is well-suited for our research question and should enable us to provide insights about VR learning environments for emotion recognition of autistics.

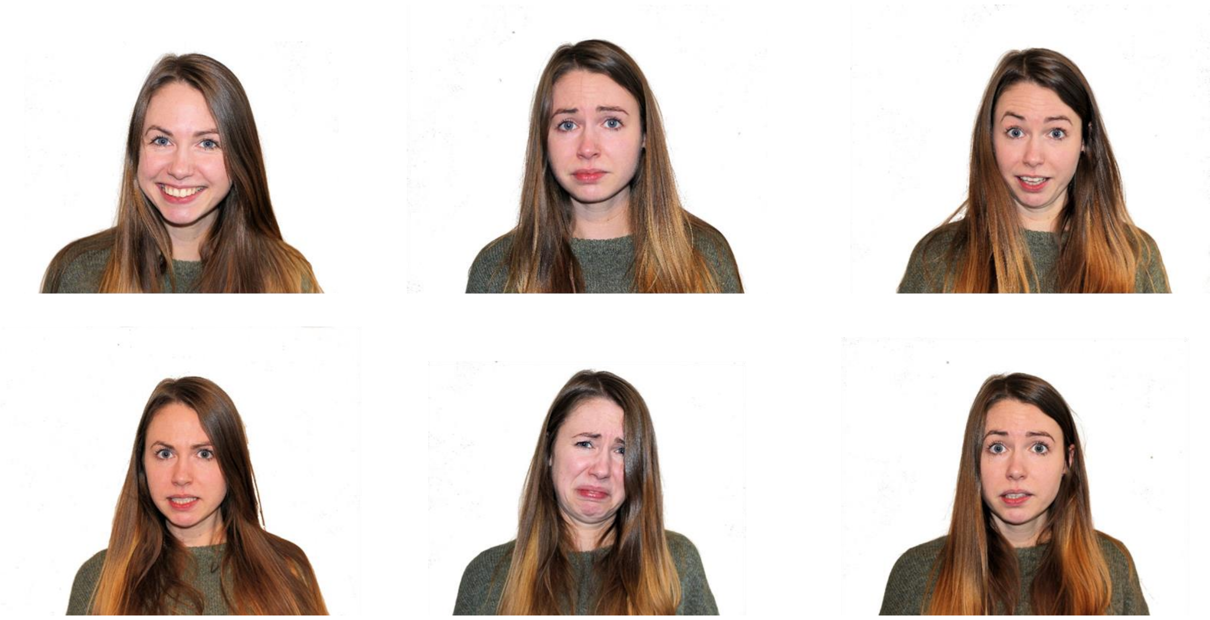

Figure 2. Virtual emotion cards (From top left to bottom right: happiness, sadness, surprise, anger, disgust and fear)

3.5 Data collection

Before the actual data collection started, we collected background information about our participants. The autistic children form the autism therapy-center have an average age of 13.6 years and are male. One of the autistics was diagnosed in his early childhood with a-typical autism and the other four were diagnosed with Asperger autism. In addition to the profound developmental disorders, some of the children have other disorders and deficits associated with autism diagnosis. Here, the therapy center told us that these five are ‘typical’ examples of children with autism. All five autistic children attend a regular school and are participating an IT-related therapy group in which computer programs are developed. Moreover, all of them had pre-experience related to VR technologies because they had already played with a PlayStation VR.

This research follows a conversational interview approach and a unstructured laboratory observation (Mulhall, 2003; Tsang, 2018). We have chosen these complementing approaches because a structured or semi-structured interview guide approach is difficult to conduct as autistic people do have concerns about social interactions as verbal communications (c.f. chapter 2.1). In accordance with literature and the therapist of the autism therapy-center, open questions which are not purely related to yes or no are avoided by autistics. Therefore, we decided to conduct a conversational interview with each autistic, whereas each participant was surprisingly open-minded as long as they wore the VR head-mounted display. Moreover, we complement our research by an unstructured observation in a laboratory setting by two researchers which has the advantage to be more flexible and open-minded to the observation object (here, the autistic children) (Mulhall, 2003).

For the data collection, we established together with the autism therapy-center a VR laboratory room at the center. We explained each participant how the system works how the procedure runs. The VR glasses and the headphones were put on each test person and the controllers were put in their hands, then the VR program was started. The researchers observed and monitored the participants for their safety and to collect observational data (participants’ real movements and their interaction in VR through an external screen). In addition, the researchers were available for questions and hints. Each participant was able to spend an average of 10 minutes in the virtual reality to test the program. Within the virtual scenario, one of the six emotion cards appear on a table in front of the participant (c.f. Figure 3). Here, a participant has to grab the emotion card and to assign it to a related yellow box. On each box is a writing with the related emotions (happiness, sadness, surprise, anger, disgust and fear). To grab the virtual emotion card participants used a provided controller (i.e. the HTC Vive controllers). In case the assignment was correct, a green confirming visual and auditory feedback occur. If the assignment was incorrect, a red disconfirming visual and auditory feedback occur and the virtual emotion card was going back to its starting point on the table. In the latter case, the participant had the chance to try it again. Moreover, the system consists of a motivational factor. Each participant was able to earn points, as a reward, for conducting correct assignments. In case of an incorrect assignment and a correction, a participant earned one point. The virtual emotion card appearance was random, so that no participant could recognize a scheme.

In relation to a system related *bug* (which makes the system stop working) and feedback about the virtual scenario (conversational interview during and after the VR session), we decided to have two sessions with each participant because the bug caused a high distraction and we adjusted some detail elements into the virtual setting. Hence, for the second session, we fixed the problem with the bug and added details such as the color of the ceiling and a landscape behind the virtual window to make the autistics feel more comfortable in the virtual learning environment (c.f. Figure 4). After finishing all session, all autistics, the researchers and the therapist from the autism therapy-center come together to have a final feedback round and to give all children the opportunity to exchange views.

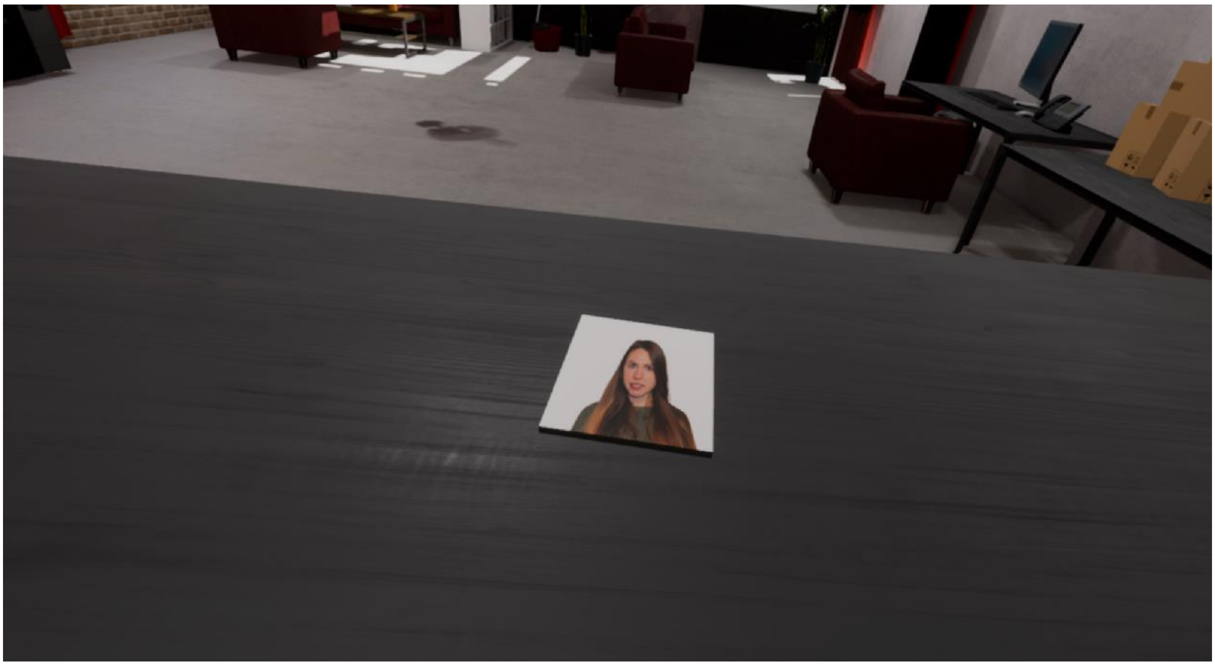

Figure 3. Virtual emotion card within the virtual learning scenario

Figure 4. Virtual reality learning environment

3.6 Analysis

As outlined above, out data collection is two-fold: conversational interviews and unstructured observations in a laboratory setting (Mulhall, 2003). We reviewed the interviews by two researchers (first and second author) and looked for indicators of how useful the autistics perceive the VR system for learning emotion recognition. Moreover, we looked for specific indicated design elements of how a virtual learning environment for autistics can be designed. Against the background of monosyllabic or very short answers to our questions, we additionally (the first and second author) conducted unstructured non-participating observations. Here, both researchers and a therapist of the autism therapy-center were present during each virtual reality session. The aim was to observe each autistic participant in detail to assess their behavior such as positive and negative reactions as well as if they reach a learning progress during both sessions.

As this research is exploratory in nature, it is validated by means if concatenation (Stebbins, 2001; Nunamaker Jr, Briggs, Derrick and Schwabe, 2015). Concatenation is similar to replication logic in experimental research, where relationships are discovered and evaluated limited to different conditions in various studies. Note that the point of saturation, the case when no new aspect or concept emerge, distinguishes this approach from experimental research. In addition, an experiment is mainly used to test hypotheses, whereas new variations are undesirable. In our case, in which exploratory research is conducted, concatenations provide further insights into a phenomenon.

4 Major Findings

Against the background of limited comprehensive answers to open questions of our target group, adequate quotations to our direct questions are presented. Moreover, we complement these answers by our observations.

Before the actual first session started, the autistics had the possibility to look around in the virtual environment without direct interaction with the virtual environment. They gave their feedback to the design of the VR room, such as problems with the ceiling and the emptiness outside the virtual windows (they did not like these). The autistic children would like to have a detailed virtual environment and, therefore, it is important for them that the environment looks natural. They do not like if the VR surrounding looks unnatural because they feel uncomfortable and are easily distracted. The following quotations illustrate these findings:

“When you look out of the window it looks like Windows XP.” (Interviewee 5).

“The ceiling looks like if it had burned in this room.” (Interviewee 3).

“In front of the windows are no trees and other houses, that’s really unrealistic.” (Interviewee 2).

In the first session, the participants were confronted with different emotion presentations. While interacting and sorting the emotions, the participants could earn points for correct recognitions and decisions. Here, we observed that the autistic children had difficulties to make a difference between surprise and fear. One of them had also problems in the distinction between sadness and disgust. Moreover, they were not always sure, where to sort the pictures, in some cases, they were very uncertain they ask the authors and the present therapist about their opinion about the emotion. Here, we decided to let him try an assignment to not bias the process, just little hints e.g. how do you feel if you look like this. For instance, interviewee two mentioned:

“Sadness is hard to recognize and surprise and fear is very similar.” (Interviewee 2)

In one of the sessions, there was a bug in the system and, therefore, no more interaction within the virtual scenario was possible. One participant reacted very upset and began to bluster. In another session, a participant interacted just with the controller because in this setting it was possible to change the virtual simulation of the controller (this one differs between Vive controller and a hand with white fingers). Consequently, the participant did not further interact with the virtual environment and the virtual emotion cards. He was just focusing the controller and what happens if he presses the button to interact with virtual objects. Here, we were able to observe that autistic children are very easily distracted by small things and are able to react very impulsively to diversions or unexpected behaviors.

In the second session, it could be observed that the allocation of emotions was much easier for the children than in the first session. We observed that they were faster with each interaction and that the recognition of each emotion, also the one that were more difficult before, were better. The autistic’s score also support this observation, which was higher than in the first session (c.f. Table 1).

Session	**Ø Minutes**	**Ø Points**	**Ø Failed attempts**
First	10.2	65.4	15.6
Second	9	134	8.5

Table 1. Comparison of the first and second session with the autistic children

Human emotions that are mostly appear in everyday life such as happiness and anger (Ekman, 1992), were less difficult to recognize by the autistic children than, for instance, sadness and disgust. We observed here that happiness and anger were most easily to distinguish and that the autistics were able to routinely sort the two emotions into the right boxes and made hardly mistakes. Mistakes only happened when they became hectic or an emotion appeared several times in a row, so they became insecure and classify this emotion somewhere else than the previous one because they seem to assign thses as a different one. Interviewee 5 mentioned here:

“Anger and happiness are easy to recognize.” (Interviewee 5)

One key finding refers to the high motivation to use and to learn with VR technology. The autistics had fun in interacting with the VR, the objects and the appearing emotion cards. In turn, the autistics were disappointed when the session was finished and they took off the VR-HMD. When the second session started, they were very happy to enter the VR environment again.

“I like the scoring system.” (Interviewee 2),

“I like the design of the room, it’s like an office.” (Interviewee 1),

“I like playing the game, it’s fun.” (Interviewee 4) and

“I would like to learn with this program.” (Interviewee 5).

A further aspect for the motivation in the system would be the creation of a high score system, so that the autistic players can measure themselves against themselves repeatedly.

"It would be cool, if I have a high score to beat myself". (Interviewee 2)

Against the background of the suggested technology affinity, each autistic was highly interested in the VR technology, the programming language and asked us questions about many details in and about the VR. For instance, they were interested in: which hardware components does the computer have such as graphics card and processor performance, which software is installed and used for the VR setup, how the scoring system works or how are certain elements are integrated into the VR scenario.

At the end, when all autistics come together with the researchers and the therapist, all children could give a final feedback and exchange their ideas with each other. Here, we were able to gain further insights for future design. On the one hand, the choice of emotions should be increased, such as nuances of the six basic emotions and non-basic emotions, different persons with diverse characteristics should be include and the difficulty level should be changeable such as separate levels for sarcasm and irony. The latter, for instance, could also refer to a flexible degree of expression of autism spectrum disorder:

"I would like to have male faces, it is more complicated to recognize emotions in male faces. […] A level with sarcasm and irony would be nice, it is so difficult to understand." (Interviewee 3)

"Can you implement some easter eggs?" (Interviewee 5)

Finally, the autistic children mentioned that they also wish such a system to be used for school. They see the advantage to be more motivated for learning. Here again, we can see that a high motivation and acceptance arises through the use of technology.

"I would be nice, if I have such a system for learning in school. It would motivate me much more to learn for school." (Interviewee 2)

5 Discussion and Implications

To answer our research question *"Can children with autism learn emotion recognition in VR and how should the VR environment be designed?"* we conducted a case study in which we collected observational and conversational interview data. Initial insights have been found by reviewing recent literature about VR and autism within the context of learning. Literature provides some interesting perspectives, which we integrate in our research for autistic learning in the VR environments. Again, the effects of the *Theory of Mind*, *Weak Central Coherence* and *Executive Function* can be shown and observed by the researchers within our case study (Baron-Cohen, 1989; Morgan et al., 2003; Robinson et al., 2009). Extending the previous literature of *Theory of Mind*, we have noticed that at the beginning the autistics could hardly recognize the emotion, also after the authors have given first hints. For instance, we suggested to imitate the facial expression and asked how they would feel. Moreover, one child was just entirely focused on the controller and just interacted with the controller, here the *Weak Central Coherence* was expressed. The effects of the *Executive Function* could be observed when the same emotion appeared twice in a row. Here, the children tried to classify this emotion somewhere else than the previous one because it was interpreted as another one, independently that it was the same as before. In addition, we have identified factors that influence autistic's learning in VR.

5.1 Design Virtual Elements

Our case study shows that the detailed design of the VR learning environment is very important for autistic children. They prefer and like it when surroundings look very similar to reality and they recognize things from their familiar surroundings in way as they expected them, such as the view out of the window to see houses, trees or streets. In that case, virtual elements are very important for the design of the VR environment for learning scenarios. This is also in line with recent literature that autistic children are visual learners (Dawson et al., 2008) and that they like detailed simulations. However, this also includes the individual feelings and needs of autistic children. These are as different as the entire spectrum of the disorders and, as a consequence, there are may also be deviations. Hence, there is an important factor for a successful learning experience for autistic people in virtual learning environments that contributes to existing literature (Baron-Cohen, 1989; Moore et al., 2005), i.e. the individual design of the VR surroundings. This leads to our first proposition:

Proposition 1: The details of the design in a VR environment are very important for the well-being and feeling of comfort of autistic people.

5.2 Motivation through VR Technology

In accordance with existing literature about technology affinity of people with autism (Moore et al., 2005; Newbutt et al., 2017), VR systems are perceived as highly motivating for interactions and learning contents. In relation to the mentioned design elements, a VR learning environment seems to be satisfying and fun for autistics. They like to interact with virtual elements and they are curious about all shown contents. They are motivated through virtual rewards (such as points) and their own intrinsic motivation to be successful (such as beating themselves in repeating sessions). Therefore, research of autism in VR settings should take into account gamifications elements, such as points or leader boards because these are could further motivate the autistics to learn important aspects of emotion recognition and, therefore, non-verbal communication skills. Consequently, our second proposition follows:

Proposition 2: VR learning environments should exhibit gamification characteristics to motivate autistic people to learn specific skills.

The autistic children are motivated to interact with the virtual environment because they can reduce social real world interactions. Our perception is that the children are prefer to learn emotion recognition in the virtual reality instead of learning with the traditional emotion card set with a therapist. Literature points already out that autistic people prefer computer-generated environments (Moore et al., 2005; Newbutt et al., 2017). Within such a virtual setting, they feel comfortable and like to perform activities and interactions. Literature suggests that people with autism prefer to interact with a computer because they have a natural affinity for computer and controlled environments (Moore et al., 2005). In case of a VR learning scenario for emotion recognition, we assume their feeling of being comfortable and well-being arise through the reduced social interactions with other persons. The advantage of VR is the adherence to expectations of the environment. This lead to our third proposition:

Proposition 3: Autistic children prefer to learn emotion recognition in a virtual reality instead of the real world.

5.3 Usefulness of Virtual Emotion Cards

Against the background of our findings, we assume virtual emotion cards as useful for learning emotion recognition. Traditional emotion card sets are analogous and need direct interactions with other people such as therapists or in case of children with their parents. A VR emotional card does not exhibit the characteristic of a real person-to-person interaction. Recent literature already suggests a higher acceptance of simulated environments because autistics need less social interactions (Newbutt et al., 2017). During both sessions, the autistic participants reached a higher score in the second session than in the first one. On the one hand, we assume a learning-by-doing effect, notably because of the same person which is depicted on the virtual emotion card. In turn, if the same virtual emotion card appears in a row, *Executive Function* was observed which lead to a wrong recognition and assignment. Another argument for the better scoring in the second session could be that a real learning took place or the autistics, as well-known visualized learners (as outlines above), remembered certain marks in the actress' face and assign these to a certain emotion. The latter would induce no real learning effect for emotion recognition. Here, future research should investigate if a real learning effect, for instance, an experimental study, takes place in real life. In summary, we assume a positive learning effect because the autistics like to use the virtual emotion card set, they were happy to participate the second session and they have faced the learning content as a challenge to become better. Hence, our fourth proposition is:

Proposition 4: Virtual emotion cards are better for learning than traditional analogous emotion cards.

5.4 Immersion of VR Learning Environments

Recent literature actually shows that people with autism are calm and avoid interpersonal communication (Dawson et al., 2008). The therapist of the autism therapy-center and the two researcher were surprised by unexpected behavior by a couple of autistic participants: while some of them were using the VR system, they start talking by themselves about aspects they were experiencing. We assume that this behavior emerged for two reasons: first, the VR technology and the shown VR content were intriguing and much liked (a feeling of well-being and comfort, as mentioned before). Second, the central aspect of VR spaces, i.e. immersion, "a mental state of being completely absorbed or engaged with something" (Dede et al., 2017, p. 3) lead an autistic to forget their surroundings and become partially 'extroverted'. This refers to the idea that autistic children start to talk more than usual while they use the virtual emotion training. Therefore, we suggest that immersion can have a positive effect during learning in VR settings such as with virtual emotion cards, particularly because real world surroundings are fade out and social interactions as conversations are not recognized as other social interactions which lead to an uncomfortable feeling. Finally, our fifth proposition is:

Proposition 5: Immersion within a VR environment should be enhanced so that people with autism can fade out the real world for a better learning experience.

6 Limitation and Outlook

We conducted a case study with autistic children to answer the question of how emotion recognition can be learned in a VR learning environment. The study provides new insights for research with autistic people and VR. We contribute to existing literature by providing certain design implications for virtual learning environments. Our findings suggest that VR settings are motivating and useful for learning emotion recognition, particularly by transferring traditional analogous approaches to a virtual context, i.e. virtual emotion cards. The use intention of such systems seems to be very high because the VR environment is intriguing and create a feeling of well-being and comfort and is more immersive than a traditional computer setting. Moreover, we observed an unexpected behavior of the children while they were using the VR system: they start talking 'extroverted'. Here, we conclude that their behavior emerges through the high immersion of VR-HMD technologies because HMDs provide an enclosing, three-dimensional and 360-degree experience in which user, here the autistic children, can interact and perform activities such as how to learn emotion recognition.

However, our research has limitations that leaves space for future research. First, the nature of our study is explorative. Hence, it intends to extend current research of autism and VR. Future research can ground its work on this explorative approach in order to conduct confirmatory research. Notably in terms of further development, this research provides a solid foundation for the design of VR with regard to the target group of autism. Second, we provide promising propositions that need further research and empirical validation. Future research could address these issues by conducting a comparative study. Finally, the used setup in our study was restricted to one female actress. Future research should take into account male people (such as actors who can imitate human emotions) as well as other cultural or person related characteristics (e.g. long and short hair, different eye colors, ethnicities etc.). Moreover, a transfer into the real world, i.e. real social interactions of autistics with non-autistic people, should be investigated. Further research can reveal if learning of emotion recognition in VR environments can have positive effect for autistics in, for instance, real verbal conversations.

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