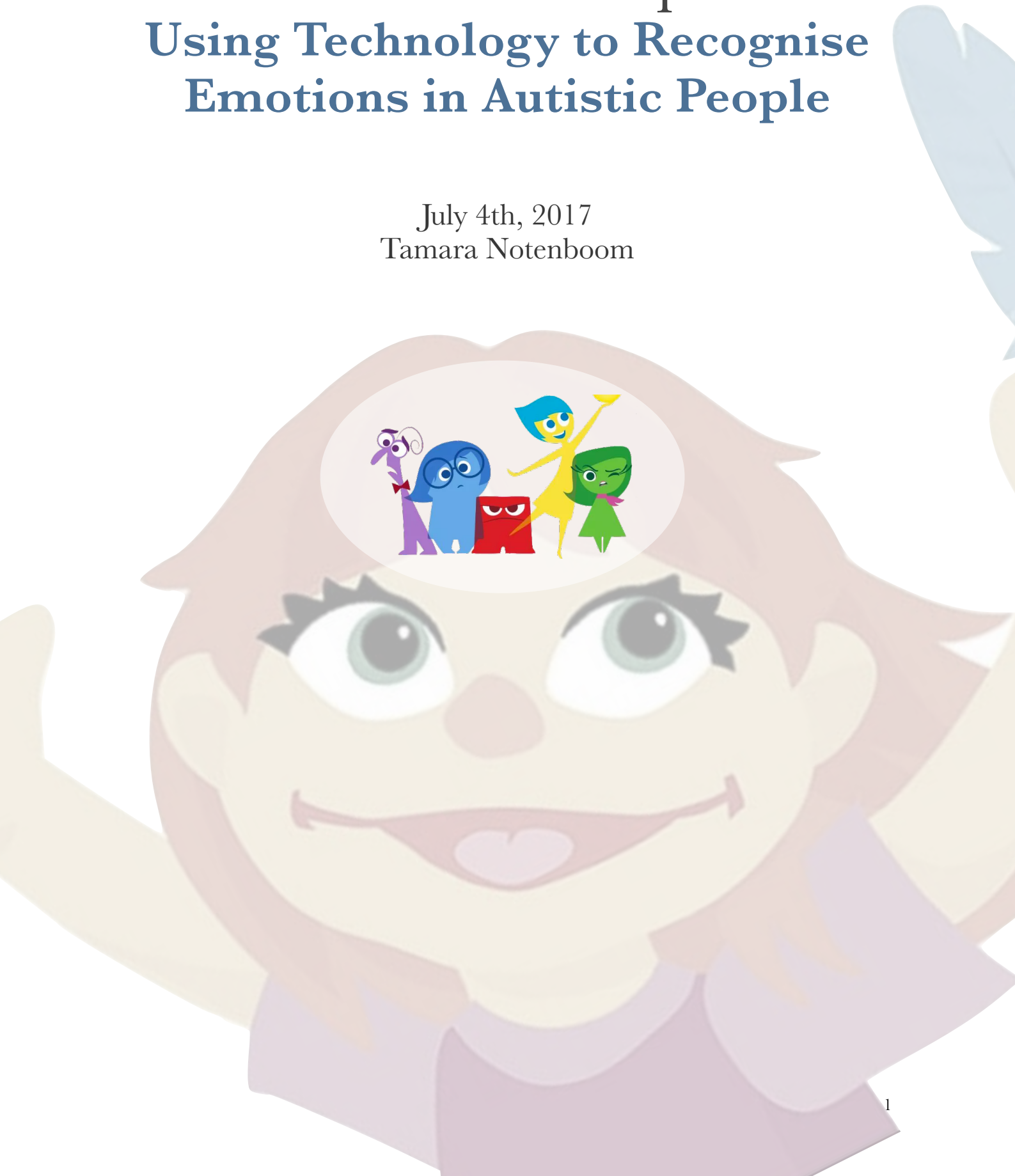
Graduation Report

Using Technology to Recognise Emotions in Autistic People

July 4th, 2017

Tamara Notenboom



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The girl on the cover represents Julia, the autistic puppet from Sesame Street (Image courtesy of MaryBeth Nelson/Sesame Street Workshop, retrieved from http://www.pbs.org/newshour/rundown/sesame-street-debuts-julia-first-character-autism/)

The emotions in her head are represented by the characters of the Pixar movie Inside Out (retrieved from http://www.jugavi.com/noticias/descubre-lo-ultimo-de-disneypixar/)

Abstract

This graduation report approaches the application of emotion recognition technology for autistic people from a different angle. In this research the technology focussed on the situation where the emotions from the autistic person are measured instead of the emotions from a typically developed person. Autistic people express their emotions differently, which makes it hard for others to interpret the emotions correctly. This is especially troublesome for autistic children, whose parents have difficulty reading their emotions. The different expression of emotions by autistic people influences affective signals, which makes technology based on facial recognition, body language or voice intonation unreliable. Therefore physiological signals should be used as input for the emotion recognition. Sensors for these physiological signals can be placed in a variety of products, but these products should adhere to specific design guidelines based on user requirements of the target group. These design guidelines are necessary because the target group is sensitive to stimuli and has difficulty adapting. User requirements were investigated using an online survey and semi-structured interviews. A smartwatch, a patch and an infrared camera were evaluated as possible designs. The evaluation of these designs led to the guidelines. The smartwartch was the preferred design, followed by the patch. An infrared camera is not a suitable design. The guidelines can be used when designing a wearable that measures physiological signals of autistic children.

Acknowledgement

I would like to thank my supervisors for giving me the opportunity to work on this great project, which I believe could be a real addition to the lives of autistic persons and their social circle. I would also like to thank them for the support, advice, help and feedback they gave during the process.

I want to show my gratitude to schools De Ambelt Zwolle and Thorbecke College Zwolle for aiding in the search for participants and providing a space to conduct the interviews. Also to Oresti Banos, Hans Notenboom and the SmartXP for letting me borrow the materials needed for the interviews.

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1. Introduction

Autism, or autism spectrum disorder (ASD), is a neurodevelopmental disorder that is increasingly recognised. On average, it affects between 1% and 2% of people in the world. It is 4.5 times more common in boys in contrast to girls ("Facts About ASDs", 2017). The symptoms differ per person but are in most cases seen in behaviour, most significantly the deficiency in social skills, communication skills and repetitive behaviour (Matson, Dempsey, LoVullo & Wilkins, 2008). This deficiency is further impaired by the inability to recognise emotions in oneself, and in an interlocutor (Rump, Giovannelli, Minshew & Strauss, 2009).

Not only the autistic person[1] has trouble recognising emotions in an interlocutor, also the other way around. Autistic people have different ways of conveying emotion (Samson, Huber & Gross, 2012). Friends and family often report having difficulty assessing what the autistic person is feeling. Imagine an autistic child that is frustrated because he is not able to wear his favourite shirt, but the child does not show this on the outside. The parent or teacher will not be able to take into account that the child is frustrated and might escalate the situation instead of de-escalating it. Knowing the mental state of the other person, plays an important role in social interactions. This is acknowledged by parents[2] and teachers, who strain to assess the mood of autistic children, which can lead to stress in the assessor and the child (Baker-Ericzn, Brookman-Frazee & Stahmer, 2005; Dawson, Hill, Spencer, Galpert & Watson, 1990; Kasari & Sigman, 1997). But also peers experience this, which can lead to a diminished social life of the autistic child because not knowing the others mental state complicates creating and maintaining friendships (DiSalvo & Oswald, 2002; Orsmond, Krauss & Seltzer, 2004).

There is an extensive list of interventions and training for autistic people to improve their social skills and make interaction with other people easier (Williams White, Keonig & Scahill, 2006). However, the gap in emotion expression and recognition between autistic people and others can also be approached from a different perspective. Next to training and thus change the autistic person, it might also be possible to give the social circle of the autistic person tools to improve readability of this person by means of emotion recognition technology. There is not much literature on emotion recognition technology in combination with autism. The research and products are mainly focussed on the typical population i.e. people without developmental disorders.

[1] "Autistic person" is preferred instead of "person with autism" as pleaded by Sinclair (2013)

[2] The use of "parents" in this report always means parents and caregivers.

Figure 1 shows the customary situation of this research, excluding autism. In this case, the emotion recognition is between typically developed people. One person is the expresser of an emotion. The other can perceive this emotion. This can optionally be aided using emotion recognition technology.

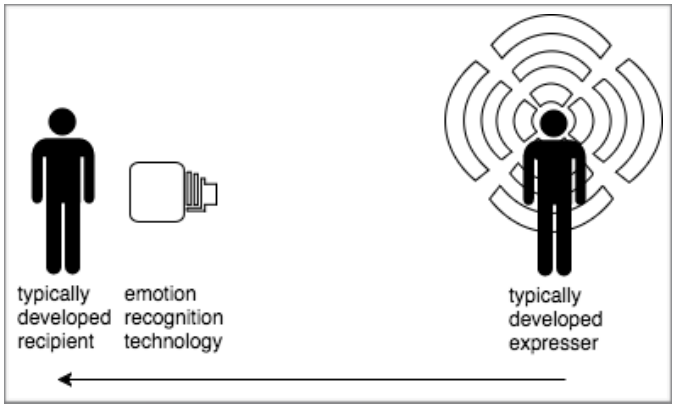


Figure 1: Customary situation excluding autism

An autistic person could also use the emotion recognition technologies on a typically developed person (figure 2). The typically developed person is the expresser of an emotion here. The autistic person has difficulty perceiving this emotion and can benefit from emotion recognition technology. The information from the emotion recognition technology then has to be translated to be used by the autistic person.

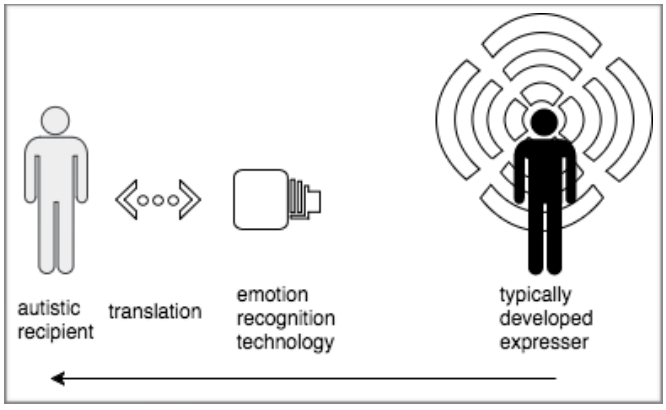


Figure 2: Customary including autism

The situation in figure 2 has not yet been proven to work the other way around, which would create the situation in figure 3. Here, the autistic person is the expresser of an emotion. The typically developed person has difficulty perceiving this emotion and can benefit from emotion recognition technology. The information from the emotion recognition technology

then has to be translated to be used by the typically developed person. Figure 3 shows the target situation of this research.

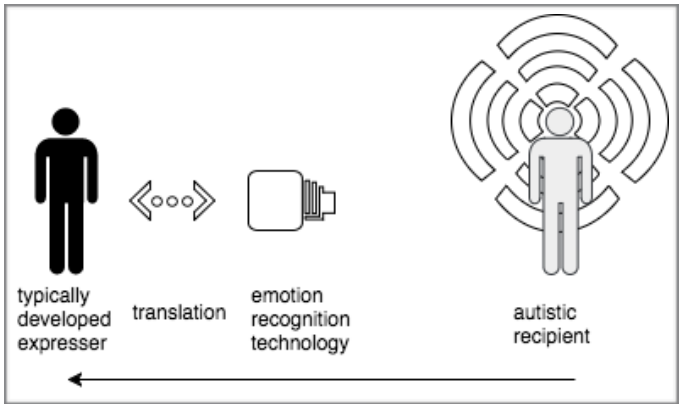


Figure 3: Target situation

The state-of-the-art explains the appropriate technology for emotion recognition on autistic children, with a focus on the measurement of physiological signals. But more information is needed to design a usable emotion recognition product for autistic children. The identification of the user requirements is also challenging for autistic children because of their decreased capability to communicate, their high sensitivity to stimuli and their shallow area of interests. Next to this, the importance of these user requirements is even higher for this target group because of their sensitivity and restricted adaptability. So the product should adhere closely to the user requirements to ensure that autistic children are willing to use this technology. This challenge leads to the following research questions:

Research question: Can emotion recognition technology be applied for autistic children?

- Subquestion 1: What is the state-of-the-art of current emotion recognition technologies?
- Subquestion 2: What are guidelines for designing emotion recognition technology for autistic children based on their user requirements?
- Subquestion 3: What would a possible design using these guidelines look like?

These research questions are attempted to be answered. This is done using an online survey and through interviews with the target group. The methods for the online survey and the interviews are described in chapter 3. The answers are described and analysed in the results of chapter 4. This chapter is expanded by setting a list of user requirements and guidelines that are concluded from the answers to the online survey and interviews. These guidelines are attempted to put into practice in a possible design described at the end of chapter 4. The relevance of the results are discussed in chapter 5, together with the coverage of the online survey and the interviews. The discussion in chapter 5 also mentions other problems and noteworthy observations. The most important conclusions of the report are summarised in chapter 6. Chapter 6 also looks back at the research questions and includes recommendations for future work and research.

This report uses footnotes to give extra information that may clarify definitions, and give sources for images and show links. This extra information is not relevant to the story and would break up the flow of the paragraphs.

2. State of the art

The goal of this state-of-the-art was to investigate how emotion recognition technologies can be used to work on autistic people. First, emotion recognition technologies that work on typically developed people can be distinguished into technologies that are focussed on facial expressions, on body movement, on voice intonation and on physiological responses. Subsequently, it is necessary to explore if, and how, cues that are commonly used for emotion recognition might be conveyed differently in autistic people according to literature. This could give an indication for their reliability on this target group. If these cues prove to be different in autistic people, current emotion recognition technologies might not work on them. Then the emotion recognition technologies that are known to work on typically developed people might need adaptation to work on autistic people. Possibilities for adaptation of these technologies so that they can be applied to this target group are discussed at the end of this chapter.

Existing emotion recognition technologies

All emotion recognition technologies follow a similar process towards determining emotions, consisting of 1. data gathering, 2. data pre-processing, 3. feature extraction, 4. feature selection and 5. classification for multiple cues to an emotion. Combining cues into multi-model systems show significant better results than uni-model systems (D'Mello & Kory, 2012). Pantic, Sebe, Cohn and Huang (2005) support this theory by explaining that a multi-model system is in line with the way humans analyse affect; using the face, body and voice as input. “Affect” is used interchangeably with the term “emotion”. However, the term “affect” is closely related to the expression of emotions through means of communicative signals humans have such as facial expressions, body language, and voice intonation. When technology is used to recognise emotion there is room for another cue: the physiological signals. These physiological signals cannot be recognised by humans with the naked eye, but can be measured using technology and can add insightful information for emotion recognition.

For data gathering, there are three possibilities which are dependent on the cue to be measured: acted emotions, natural spontaneous emotions or induced emotions (D'Mello & Kory, 2012). For facial expressions, body movement and voice intonation, Kessous, Castellano and Caridakis (2009) use actors to act out the emotions because acted emotions minimise ambiguity and thus are easier for computers to recognise. On the other hand, Hoque and Picard (2011) invalidate this as acted facial expressions are heavily influenced by the actor and far from reality. However, El Ayadi, Kamel and Karray (2011) claim that vocally acted data is more exaggerated, but not contradictory to natural speech and is a viable testing option.

Natural spontaneous emotions are harder to control and process because of environmental variables, but they are closest to reality (Siddiqi et al., 2017). When measuring physiological signals, the emotions have to be truly experienced by the test subject, so acted emotions are not an option as these are faked. The argument of truly experiencing the emotion is why Jerritta, Murugappan, Nagarajan and Wan (2011) use induced emotions to gather data. These induced emotions are truly felt by the test subject, but are not spontaneous in the sense that they are evoked using a trigger, thus offering more control for the researchers. Triggers can for example exist of music, smell, colour and sound or a combination of those. For each case, the asserted emotions are recorded using a camera, microphone or biosensors.

Pre-processing of the gathered data ensures that the signal of interest will become isolated and clean. Kessous et al. (2009) claim that pre-processing for facial expression recognition is defined by applying a face recognition algorithm that is able to identify the boundaries and position of the face. Siddiqi et al. (2017) pointed out that pre-processing should be able to deal with noise and changes in ambient settings. Likewise, pre-processing of the body movement, voice intonation and physiological signals would have the same goal: identifying boundaries and baseline, removing noise and/or coping with the dynamic environment (Jerritta et al., 2011; Pantic et al., 2005). Pre-processing is not always needed, only when the data is not clean enough.

When the data is ready to be used, the feature set should be extracted. This feature set is dependent on the cue used. For facial expressions, Kessous et al. (2009) applied facial animation parameters of MPEG-4 that contain the displacement of feature points as compared to a neutral frame (Pandzic & Forchheimer, 2002). The facial animation parameters (e.g. raising the eyebrow, bending the nose, pouting the lip or closing the eyelid) of MPEG-4 include most facial features and is compatible with many configurations, thus offering a practical option for feature set extraction (Tao & Tan, 2005). Voice features are less uniform because feature sets are created using frequency analysis. To simplify the extensive set of voice features, El Ayadi et al. (2011) grouped the possibilities into four domains: continuous speech features, voice quality features, spectral based speech features, and Teager-energy-operator based features. Which features, or combination of features, to use is dependent on the classification task (El Ayadi et al., 2011). Most studies at least include continuous speech features describing prosody, such as pitch and intensity (Busso et al., 2004; Kessous et al., 2009; Tao & Tan, 2005). For physiological signals, there is a finite list of bio signals that can serve as input: electrocardiogram, electromyogram, electro dermal activity, skin temperature, respiratory rate, blood volume pulse and others (Kim, Bang & Kim, 2004). Jerritta et al. (2011) verified this finite list of biosignals with a literature review where no other signals were found. On each signal mathematical and statistical analysis can be applied to extract the feature set.

When the feature set is known, the relevant features should be selected. This is because the extraction of features usually leads to an extensive set which sometimes contains hundreds of features. Yet not all of the features are relevant to discriminate between emotions so it can be advantageous to remove redundant features, especially in large sets (Jain, Duin & Jianchang Mao, 2000). Though not all studies apply this selection, Busso et al. (2004) as well as Jerritta et al. (2011) and Jonghwa Kim and Andre (2008) run a feature selection algorithm. Jonghwa Kim & Andre (2008) placed the side notes that feature selection algorithms are only favourable when the classifier used for the the classification, is already known and can be used to discriminate between most defining features. Secondly, the effectiveness of the selection is subordinate to the data set.

Finally, the classification takes place. For this, a classifier is trained to distinguish emotions based on the relevant features. When executing classification in a multi-model system there are two options. One option is to integrate the cues first and then classify for a feature-level fusion (see [a] in figure 4) or first classify the separate cues and then integrate those classifications for a decision-level fusion (see [b] in figure 4). Pantic et al. (2005), Banos et al. (2014) and Busso et al. (2004) all conclude that the decision-level fusion is preferred, while Kessous et al. (2009) contradictorily claim that the feature-level fusion reached better results. It is a possibility that the superiority of fusion method is conditional to factors such as the range of emotions or the employed classifier.

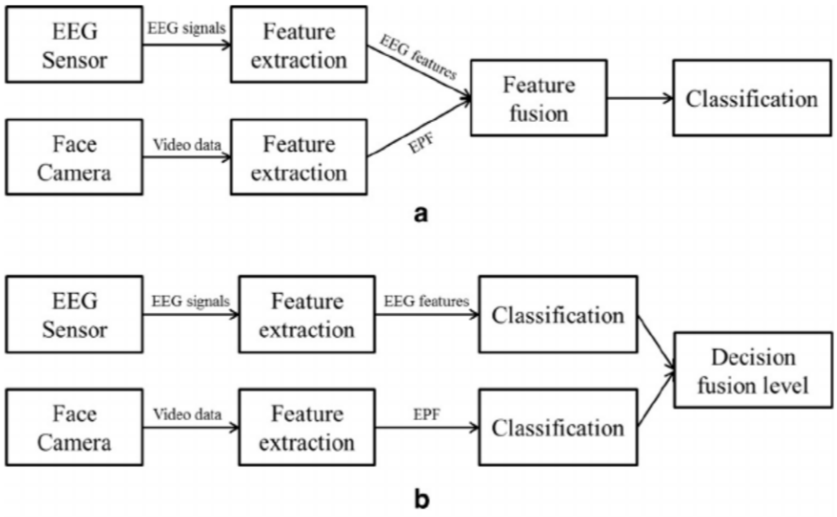


Figure 4: Feature level fusion (a) and decision level fusion (b) by (Huang et al., 2016)

Emotion expression in autism

The emotion expression of autistic people is different from typically developed people, which complicates the application of existing emotion recognition technologies without adaptation on autistic people. While a lot of research on expressing emotions in typically developed people has been done, emotion expression in autistic people is barely present. But autistic people, though not fully emotionally incompetent, often convey emotions discordantly (Begeer, Koot, Rieffe, Meerum Terwogt & Stegge, 2008). This is supported by the American Psychiatric Association's (1995) description of expressing affect for autistic people: "marked impairments in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction". The impairment is only relevant in this case for cues that are used in the current emotion recognition technologies: facial expression, body movement, voice intonation and physiological signals.

Autistic people have a facial impairment that causes divergent facial emotion expressions. Facial expressions by autistic people are often described as flat, neutral, robotic and weird. Yirmiya, Kasari, Sigman and Mundy (1989) observe that autistic people show less positive affect and display more neutral expressions as well as atypical expressions. Additionally, Czapinski and Bryson (2003) show that autistic children display reduced and weak movements for the muscles around the eyes and mouth (peculiarly, the eyebrows are unaffected). An interesting example is that the corners of the mouth were barely raised when autistic children smile, making the smile almost invisible, which is also described by Loveland et al. (1994). Next to the flat expressions, both Czapinski and Bryson (2003) and Yirmiya et al. (1989) detect atypical expressions[3] that might account for the description of weird aspects.

Also emotion expressive body movement is often limited for autistic people because expressive gestures are lacking and basic motor functions are impaired. The use of body language and movement to indicate emotion in autistic persons has scarcely been studied, though motor functions are shown to be flawed. Problems with motor functions in autistic people have decidedly been proven by Fournier, Hass, Naik, Lodha and Cauraugh (2010a) in a rigorous meta-analysis on the subject of gait, postural balance, arm motor functions and motor coordination. Fournier et al. (2010b) have extended on the subject of postural balance, by pointing out that the whole posture is imbalanced both when standing still and in motion. When standing still, autistic people had bigger balance sways and displayed repetitive movements for their centre of pressure (Fournier, Amano, Radonovich, Bleser & Hass, 2014). On the subject of gestures, Attwood, Frith and Hermelin (1988) demonstrate that autistic people did not convey expressive gestures that signify emotion, whilst instrumental and deictic gestures were applied as much as the control groups. Attwood et al. (1988) therefore establish that autistic people do not express emotions using gestures.

[3] Atypical as in: not indexed in the Maximally Discriminative Facial Coding System (Izard 1979)

Voice intonation in autistic people is also impaired, especially on emotional intonation. A lot of research has been done on the use of (non-emotional) intonation in autistic people where the prosodic qualities have been found dysfunctional. But McCann and Peppé (2003) note that the results are ambiguous, which makes it hard to draw a final conclusion. However, McCann and Peppé (2003) did not focus on emotional intonation. Macdonald et al. (1989) state that autistic people are lacking in vocally expressing angriness, happiness, fear and especially sadness. Nadig and Shaw (2011) observed a higher pitch range for emotional speech in autistic people.

Physiological signals are a reaction on emotions that are fully functional in autistic people. Autistic people show the same skin response patterns to pleasant, unpleasant and neutral pictures as typically developed people, leading to the conclusion that skin response is not impaired (Allen, Davis & Hill 2012; Ben Shalom et al. 2006; Blair, 1999). Bölte, Feineis-Matthews and Poustka (2007) observed that blood pressure and heart rate do not differ between autistic people and typically developed people. Interestingly, Allen et al. (2012), Ben Shalom et al. (2006), Blair (1999) and Bölte et al. (2007) all report alexithymia[4] in autistic persons. This inability to describe feelings did not seem to influence the physiological responses.

Existing emotion recognition technologies in autism

Emotion recognitions based on physiological signals do not need adaptation to work on autistic people. Since physiological signals have the same response to emotions in autistic people as in typically developed people, bio signals can be used to classify emotions in autistic people. Picard (2009) proposed putting a skin response sensor in a wristband for comfortable wearing and tested it with an autistic person. Krupa, Anantharam, Sanker, Datta and Sagar (2016) expanded the skin response wristband with a pulse meter and assessed it with 30 autistic persons. Krupa et al. (2016) were able to distinguish between neutral, happy and interested emotions with 90 percent accuracy. Liu, Conn, Sarkar and Stone (2008) used even more signals (electrocardiogram, electromyogram, photoplethysmogram, heart sound, bio impedance, electro dermal activity and skin temperature) to analyse liking, anxious and involved emotions with 6 autistic test persons to reach 82.9 percent accuracy. All studies use cognitive tasks such as math puzzles or videogames as emotion elicitation to trigger emotional data and personalise the system to the test subject through an individual baseline per test person.

[4] "Alexithymia is the inability to identify and express or describe one's feelings" (Medical Definition of Alexithymia, 2017)

Insights from the state-of-the-art

The goal of this state-of-the-art was to investigate how emotion recognition technologies can be used to work on autistic people. An overview of signals and the accompanying sensors that can be used for emotion recognition can be found in table 1. Emotion recognition technologies using physiological signals can be applied on autistic people, as long as individual differences are taken into account and emotions are elicited or spontaneous so truly felt by test subject. Alexithymia in autistic people further complicates matters because self-reports on emotions can be unreliable. If spontaneous emotions are used as input, physiological signals should be applied to check what emotion is truly felt because the autistic test subjects might not be aware themselves, which complicates verifying whether the right emotion is measured.

For facial, bodily and vocal input, it is necessary to adapt the feature set and classifier to the autistic person because emotional expressions differ per person, if expressed noticeably at all. Using an autistic training set for these emotion recognition technologies is not a possibility because every autistic person is different and uses different expressions (Sherer & Schreibman, 2005). Existing emotion recognition technologies use five steps: data gathering, data pre-processing, feature extraction, feature selection and classification. These steps offer room for personalisation, especially in the extraction, selection, and classification, where there can be chosen from different feature sets and classifiers. This is most probably necessary for autistic people because they have different facial expressions, body movement and voice intonation related to emotions in comparison to typically developed people. Physiological signals however seem to represent emotions as well in autistic persons as in typically developed persons.

Whilst emotion recognition technologies have extensively been tested on typically developed people, these technologies have barely been argued to work or proven to work on autistic people. This state-of-the-art shows that facial, bodily and vocal emotion recognition on autistic people is complicated, and studies that try these kinds of emotion recognition should take into account the different and reduced expressions autistic individuals employ to be able to validate their findings. Studies that employ physiological signals are backed up by medical and psychological literature, as long as personal baselines are considered because individuals can have different average values.

The limitations to this state-of-the-art are also on individual properties of autistic test subjects. The autistic spectrum disorder subtypes are all summarised under autism. While DSM-IV distinguished between subtypes, DSM-V uses the all-including term of autism spectrum disorder, thus removing the division between subtypes. Therefore generalising all subtypes under the word autism is a reasonable premise, whilst keeping in mind that differences in subtypes are not fully negated. It is also important to note that accuracy of emotion

recognition technologies depend heavily on the categories of emotions chosen. Studies that differentiate between less emotions score higher on accuracy than studies where more discrete emotions are differentiated.

Table 1: Overview of signals and sensors for emotion recognition.

Type emotion expression	Different in autism?	Signal	Sensor
Affective	**Yes**	Facial expression	Video camera Infrared camera
		Body language	Video camera Infrared camera
		Voice intonation	Microphone
Physiological	**No**	Heart rate variability	Electrocardiogram (skin electrodes) Polyplethysmograph (pulse oximeter) Infrared camera
		Blood volume pulse	Polyplethysmograph (pulse oximeter)
		Skin temperature	Thermometer Infrared camera
		Electrodermal activity	Galvanic skin response sensor
		Respiratory rate	Polyplethysmograph (pulse oximeter) Video camera Infrared camera
		Brain activity	EEG

3. Methods

This section describes the method used to conduct the research. Both quantitative and qualitative tools were used to gather data in order to answer the research question. The quantitative data was gathered through an online survey, the qualitative data was gathered through interviews. The online survey provided a more widespread picture, while the interviews allowed for a more in-depth analysis.

Each methods section consists of four parts. Firstly, the selection of participants is discussed. Next, the materials needed are described, including the three variations of possible designs for physiological signal measurements: the smartwatch, the patch and the infrared camera. Then, the procedures for both tools are laid out and lastly, the questions asked in the survey and interview are motivated.

Online Survey

Participants

The problem statement described a target group of autistic children aged 10 to 18 years old. Autistic children are a vulnerable target group that might be irresponsible to use in research without safety measures. Several measures have been taken to ensure the safety of the children. These measures have been discussed with, and approved by, the Ethics committee of the University of Twente.

Asking autistic children to fill in an online survey is ethically problematic. Because they are children and have a disorder, they are twice as vulnerable. Therefore the online survey has been filled in by a proxy target group. Proxy in this case stands for approximate and consists of people close to the original target group who can represent them. For the results to still be relevant to the original target group, the proxy group needed to be closely connected to autistic children. That led to the parents/caregivers of the autistic children, and autistic adults. For optimal coverage, both were chosen as proxy group. Teachers, other family members and friends were not considered as proxy group because they might be not familiar enough with the autistic child to answer all the questions.

~ The first group of proxy users were parents with one or more autistic children.

~ The second group of proxy users were autistic adults aged 18 years and older.

There were a few restrictions that made sure only suitable participants fill in the online survey. The inclusion and exclusion criteria for both proxy users (parents of autistic children and the autistic adults) can be seen in table 2.

Table 2: Inclusion and Exclusion criteria for the online survey

Criteria/ Participants	Parents/caregivers of autistic children	Autistic adults
Inclusion	The child has a diagnosis in the autistic spectrum	The adult has a diagnosis in the autistic spectrum
	The child is between 10 to 18 years old	The adult 18 years or older
	The child lives in the same home as the parent/caregiver	
Exclusion	The parent/caregiver is also autistic	

Materials

Several materials were used that are summed up below:

- SurveyMonkey
- Online survey questions (appendix A)
- Device with active internet connection and browser or a paper printout
- SPSS by IBM

For the online survey an online survey tool called SurveyMonkey[5] was used together with the online survey questions (see appendix A). This required a device with an active internet connection and browser. It was possible to print out the online survey and fill it in on paper or ask the questions orally, and then manually fill in the answers given by the participants. SPSS was used to analyse the results.

Procedure

The online survey was filled into SurveyMonkey and an open URL was spread on online platforms. The platforms used were: Facebook[6], a forum for autistic people[7], and the website of the dutch organisation for autism[8]. The online survey was open for two weeks, during

[5] © SurveyMonkey 1999-2017 https://www.surveymonkey.com

[6] https://www.facebook.com/

[7] http://autsider.net/forum/index.php

[8] http://www.autisme.nl/prikbord/deelnemers-aan-onderzoek-gezocht/actuele-oproepen.aspx

which participants could respond. After the two weeks, the online survey was closed and responses were analysed using the analysis tool from SurveyMonkey and SPSS.

Questions

The questions and pages can be found in appendix A.

Group

The first question of the survey asked who was filling in the survey, which could have been an autistic adult or a parent of an autistic child. This was important to determine so that the responses could be split per group to allow for statistical analysis and comparison. It could have been possible that the responses were different for an autistic child compared to an autistic adult, which was taken into account in this way. Merging these two groups might have lead to incorrect or missed conclusions.

Expressing emotions

These questions aimed to index the size of the problem that the emotion recognition technology will target. They were answered through a 5-point rating scale: never, almost never, sometimes, often, very often, with the added option for when the respondents did not know the answer. The rating scale was chosen because this would be easier to answer than first having to translate the answer into a grade for instance. The "I don't know" option was added because of two reasons. The first reason was that parents might not always know the child's attitude to one of the questions and was maybe not in the position to ask the child, this "I don't know" option prevented the parents from guessing. The second reason was that autistic people might not always know themselves how they feel about a posed problem. This could be caused by alexithymia. This was exactly one of the problems this research was aimed at.

The first question on this page tried to index the general size of the problem of emotion expression in autistic people. The second question asked if the respondents ever feel that others do not understand what the respondents are feeling. This question was important because this is where the emotion recognition technology might be very beneficial. The third question targeted a second application of emotion recognition technology: aiding autistic people with alexithymia so this question tried to clarify how big of a problem confusion about their own feelings is for autistic people. The fourth and the fifth question both asked if the respondents would like others to know their feelings. The fourth question did this by focussing on certain situations and therefore asked if this wish is incidental, while the fifth question addressed this wish in a more continuous setting, a general feeling. The last question on this page polled how many autistic people use non-technological methods to communicate their emotions (e.g. a feelings-thermometer). If these non-technological communication methods for emotions are barely used (especially for children, to whom they are usually aimed at) it

might be relevant to find out why they are hardly used and if the reasons for that might also influence the adoption of emotion recognition technology.

Wearing accessories

This page started with an explanation about biosensors and signals. Then the question was asked if the respondents are familiar with a biosensor. This question might also give information that could be relevant for the adoption of emotion recognition technology. Then there was a list of options including various kinds of accessories, where the respondents selected which accessories are bothersome to wear for them (multiple selections possible). The respondent could also type their own answer with objects that are bothersome to wear. This would give a clue about the location on the body and the design for the biosensor. An explanation could be given to motivate why these object are bothersome to wear to give further insight and allow for a more qualitative evaluation.

Wearing patches

Next, the wearing of patches was addressed. The respondent was asked if wearing a patch (such as a band-aid) is bothersome for them and if so, why it is bothersome. A patch might potentially be a good design for a biosensor, like the VitalSigns patch. The patch could pose a nice alternative to the biosensor wristband/smartwatch if these turned out to be bothersome to wear for the target group. However, this is only a good option if the patch is not more bothersome to wear. The design of the patch was also up for evaluation, with the question if nice pictures would alleviate the wearing experience.

Being watched

The focus in the survey shifted to the design of the infrared camera. This was done by asking if the respondents have trouble with being photographed and why. Then the question was repeated for being filmed instead of photographed, and why. If an infrared camera is problematic, the distinction between photographed and filmed should make it clear if the problem is being captured or being continuously observed. It might be possible to design a camera system that would only work with intervals instead of a device that is always monitoring. For instance when the need to know the state of an autistic person arises, the camera can be turned on.

Demographics

The last question asked for the gender (male/female/don't want to say) and the age. This was to make sure that the respondents were within the target group and allowed for statistical analysis and finding correlations between age, gender, and the answers.

Interviews

Participants

The goal of the interviews was to test the reaction of the target group to several possible designs for emotion recognition technology. A proxy group would likely not have responded

in the same way as the original target group, thus it was important to interview the actual target group. The interviews were held with 10 autistic children. To ensure the safety of the participants, several measures had been taken. These can be seen in the inclusion and exclusion criteria in table 3. Some extra measures had also been taken. These can be found in table 4.

Table 3: Inclusion and Exclusion criteria for the interviews

Criteria	Autistic children
Inclusion	The child has a diagnosis in the autistic spectrum
	The child is between 10 to 18 years old
	The child is average- or high-functioning
	The child is communicative
	The child wants to participate
	The parents/caregivers give consent
Exclusion	The child is non-verbal

Table 4: Extra measures for the autistic children

Extra measures	Reason
A familiar room	To make the participant feel at ease and so the participant is not busy processing the new environment
A trusted adult present	To make the participant comfortable and ensure his/her safety
Printouts of the designs and colouring supplies	So that the participant can draw instead of orally explain what he/she means
No hypothetical questions	The target group of autistic children often have trouble processing hypothetical situations

Materials

Several materials were used that are summed up below:

- Interview questions (appendix B)
- Microphone
- Samsung Gear S3 Frontier Smartwatch
- Angel Sensor M1
- VitalConnect VitalPatch
- Microsoft Kinect for Xbox 360
- Information pamphlet (appendix C)

- Informed consent forms (appendix D)
- Printed pictures of the devices (appendix E)
- Colouring supplies
- A trusted adult for the participant
- A room familiar for the participant with 3 chairs, a table and a power outlet

During the interviews, three example products that could be used as emotion recognition technology were presented:: a smartwatch, a patch and an infrared camera. Other materials used were the interview questions in appendix B. To make sure that the interviews adhered to the informed consent regulations, the information pamphlet (appendix C) and informed consent form (appendix D) were handed out and signed. A microphone was needed to record the interview so that this could later be processed to written text. The extra measures for this target group that were described in table 4 also called for extra materials during the interviews. Printed pictures of the devices for the participant to colour on and colouring supplies were provided. The goal of which was to aid with the interview if the participant prefered drawing over explaining verbally (the printouts can be found in appendix E). A trusted adult and room that was familiar for the participant to make him/her feel comfortable. The rooms minimally included a table, three chairs and a power outlet for the interview. This room was personal and thus different for each participant.

Smartwatch

The smartwatch used was the Gear S3 Frontier from Samsung as can be seen in figure 5. The smartwatch has a black design with a touchscreen, a rotating gear and two buttons. Optical sensors are visible on the back of the smartwatch. The sensors include an accelerometer, barometer, gyro-sensor, heart rate monitor, ambient light sensor, GPS and microphone.

Figure 5: Samsung Gear S3 Frontier Smartwatch[9]

[9] Adapted from Gear S3 Frontier by Samsung n.d., Retrieved June 14th 2017 from http://www.samsung.com/us/mobile/wearables/smartwatches/samsung-gear-s3-frontier-sm-r760ndaaxar/

Another wearable offered was the Angel Sensor M1 in figure 6. The significantly different design allowed the participants to compare and choose their favourite. This sensor does not have a (smart)watch function, it only senses biosignals with optical sensors visible on the back of the wearable. The Angel Sensor is an open-source wearable sensor that tracks tracks heart rate, blood oxygen, skin temperature, steps, sleep quality, calories, acceleration, and orientation.

Figure 6: Angel Sensor M1[10]

Patch

The VitalPatch from VitalConnect is a patch that can be placed on the chest using an adhesive layer. An image of the patch is shown in figure 7. A wearable biosensor that measures ECG, heart rate, respiratory rate, skin temperature, body posture and steps taken. The patch could be placed somewhere else during the interview to avoid uncomfortable situations and this also gave insight into what location the participants prefer.

Figure 7: HealthPatch[11]

[10] Adapted from Angel Sensor by Angel n.d., Retrieved June 14th 2017 from https://angel.co/angel-sensor

[11] Adapted from HealthPatch® MD by MediBioSense n.d., Retrieved June 8th 2017 from http://www.medibiosense.com/products/healthpatch/

Infrared camera

The Kinect for Xbox 360 from Microsoft is an infrared camera for tracking the body. An image of the camera is shown in figure 8. It consists of an infrared projector and camera that tracks the body and allows 3D reconstruction. The Kinect also has an RGB camera, a depth sensor, and a microphone. The Kinect was put in a box that only shows the lenses, so that the participants did not immediately recognise it as a Kinect. That recognition could have influenced the experience and answers because the Kinect is already adopted for another purpose (gaming) and might therefore have felt familiar to the participants.

Figure 8: Kinect for Xbox 360[12]

Procedure

Before the interview, the participant and parent had read the information pamphlet and signed the consent form. The interviews were held in a room that is familiar to the participant with a trusted person present. The interviews took no longer than 30 minutes (excluding introduction and ending). The interview was semi-structured as laid out in appendix B. During the interview, the participant also used printouts of the designs if preferred to draw what he/she means. When each product was presented, they were placed on the table, after which participants were encouraged to pick them up. Then the participants were asked if they were ok with putting/turning the products on, after which they were asked to motivate their answers. The results from the interviews have been used for a more insight into the user requirements.

Questions

The interview started off with a brief introduction before the actual inquiry. The questions were comparable for all three products. The product was placed on the table before any of

[12] Adapted from Microsoft Xbox 360 Kinect review by CNET.com November 18th 2010., Retrieved June 8th 2017 from https://www.cnet.com/uk/products/microsoft-xbox-360-kinect/review/

the questions were asked. Participants were encouraged to look at the product and pick it up. If they did not start to talk about the product automatically they were asked what their first thoughts about the product were. The first impression can give a general impression about the adoptability of the product.

The next question asked the participants if they were OK with trying the device and turning it on. If the answer was yes then the device was put in place and turned on. If the answer was no, they were asked to explain why they did not want the device to be turned on. The explanation could give information about what needs to be improved so that the participant would use it. Once the device was on the participants were prompted to describe the experience and the aspects that they liked or disliked. Follow-up questions were asked if the answers were too vague because the motivation was important for distinguishing what is relevant and what not. The participants were asked how they would stop the measurements if they would be fed up. The answers to this showed if the design script of the product was clear enough and if they felt like they knew how to control the device.

The children were asked to give scores from 0 to 10 on four different topics for the device. 0 meant totally not and 10 meant very much. The four topics were the general likeability, the feeling of control over the device, the ease of use at home, and the ease of use at school. The general likeability helped to compare devices and decide which was liked best. The feeling of control was another question to show if the design script of the product was clear enough and if they felt like they knew how to control the device. The ease of use at home could be compared to the ease of use at school and give insight into the preferred use context.

Participants got the opportunity to name and draw the changes they would make to the product. This revealed the personal preferences of the children. It also concretely pinpointed all the problems with the product that the children would like to see fixed and how these should be fixed.

Some questions on the topic is privacy were asked after the three product were presented and discussed. These questions exposed who were be allowed to see the emotions from the children and when they were allowed to see. This also gave information about the use context. Lastly, age and gender were asked for statistical analysis. There was a debriefing and thanks after the interview ended.

4. Results

This chapter starts off with a section describing the results from the online survey based on the answers of the respondents. This section also contains a statistical analysis of these results. The second section is made up of the answers given in the interviews. The third section combines the results from the online survey and the interviews into guidelines that could be taken into account when designing emotion recognition products for the target group of autistic children. The last section puts those guidelines into practice with a hypothetical design for such an emotion recognition product for the autistic target group.

Online survey results

Data selection

The survey was closed after two weeks, with 99 responses. Of these responses, 26 were not completed and thus filtered out. This resulted into 73 complete responses. Of these complete responses, one response was removed because the respondent is a parent of a child younger than 10 years old and therefore fell outside the target group. Subsequently, the final 72 responses were then split up in two groups based on the first question of the online survey: one group for the autistic children between 10 and 18 years old filled in by the parents, and one group for the autistic adults of 18 years and older. These two groups might differ fundamentally and should not be aggregated, until statistically proven that the means can be considered to be equal. There were 18 responses for autistic children represented by parents (repr. by parents) to the online survey, and 54 responses from autistic adults. The distribution can be seen in figure 9. The pie chart shows the consistency of the total responses. From the 99 total responses, 26 responses were not complete, one was outside the target group, 18 were filled in for autistic children by parents and 54 were filled in by autistic adults.

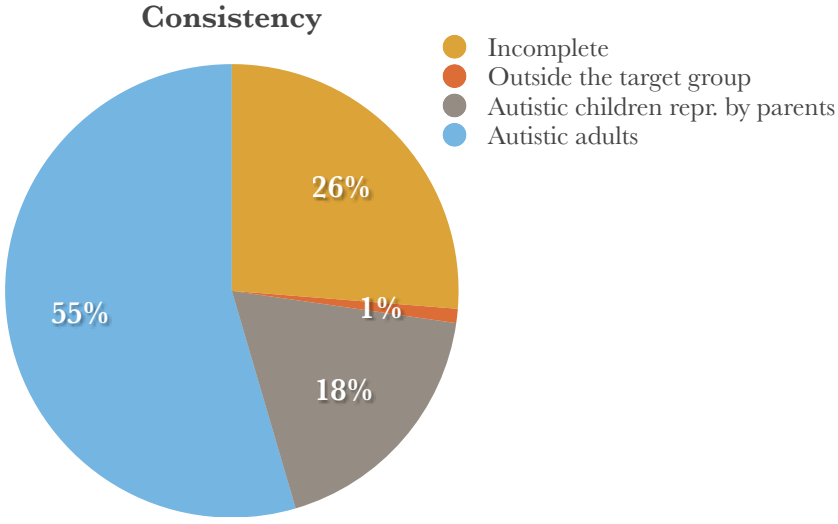


Figure 9: Consistency of the total responses

Sample demographics

The online survey was filled in by a sample group which left 72 responses after filtering. The limitation of the size of the sample complicated the representation of each segment of the demographic. The gender and age were recorded with the online survey to give some insight in the sample group. For more elaborate evaluation of the sample demographics, more factors would be needed such as education level and financial status, but these were knowingly not recorded to keep the survey short and to avoid people not finishing the survey because of privacy concerns.

Gender

Gender distribution was uneven over the two groups. The autistic children were overrepresented by males and the autistic adults were overrepresented by females, as can be seen in figure 10. It is peculiar that the overrepresentation was mirrored in the two groups. Overrepresentation was to be expected, it would have been very unlikely to get an even 50/50 distribution for male and female respondents and forcing this equal distribution might have resulted into leaving out valuable information. However, it would have seemed more likely that males would be overrepresented in both groups, since an ASS diagnosis is 4.5 times more likely in males ("Facts About ASDs", 2017).

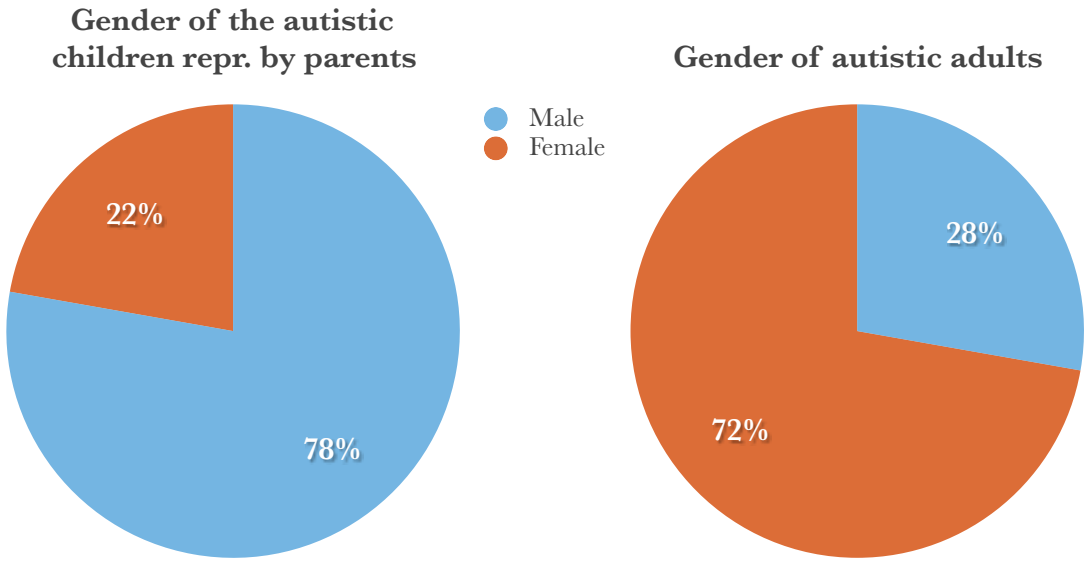


Figure 10: Gender of the respondents

It might be possible that females are more active in online forums and social networks and that the used methods for spreading the survey did not reach enough men. This suspicion could be investigated by asking the gender of the parent who is filling in the online survey for their child. If these parents were mostly mothers, it is likely that the online survey reached less males. Even though Facebook users in the Netherlands are predominantly male according to Statista (2017), it is still possible that females are more involved with Facebook groups on

autism, have more connections or are more likely to fill in an online survey. Another explanation could be that the questions in the beginning of the online survey appealed more to females than to males. Men are less prepared to talk about emotional expression as observed by Brody and Hall (2000). Questions 2 to 7 asked about emotional expression, it might be that men stopped answering there.

Age

The age distribution was fluctuating, but this is logical when each age is counted separately and could be solved by using age categories of equal size. This is especially relevant in the case of the autistic adults, because there were a lot of separate ages. Therefore the autistic adults were aggregated into 5-year segments. As can be seen in figure 11, autistic children of 15 years old and autistic adults around their thirties and in their fifties and sixties were underrepresented. Autistic children of 17 years old had the highest representation with 5 responses for this age. The underrepresentation of seniors above 50 might be contributed to two factors. On the one hand the smaller presence of seniors online might have made the online survey less reachable for them. This seems less likely because the percentage of seniors online is closing in (Pew Research Center: Internet, Science & Tech, 2017). On the other hand, autism diagnoses are steadily rising in numbers, which means that a diagnosis was much rarer in the 1960s and 1970 ("Facts About ASDs", 2017). It could be that there are just less seniors (diagnosed with) autism. The underrepresentation of autistic adults around their thirties and autistic children of 15 years is surprising and needs further research to be able to make suggestions as to why these gaps occurred.

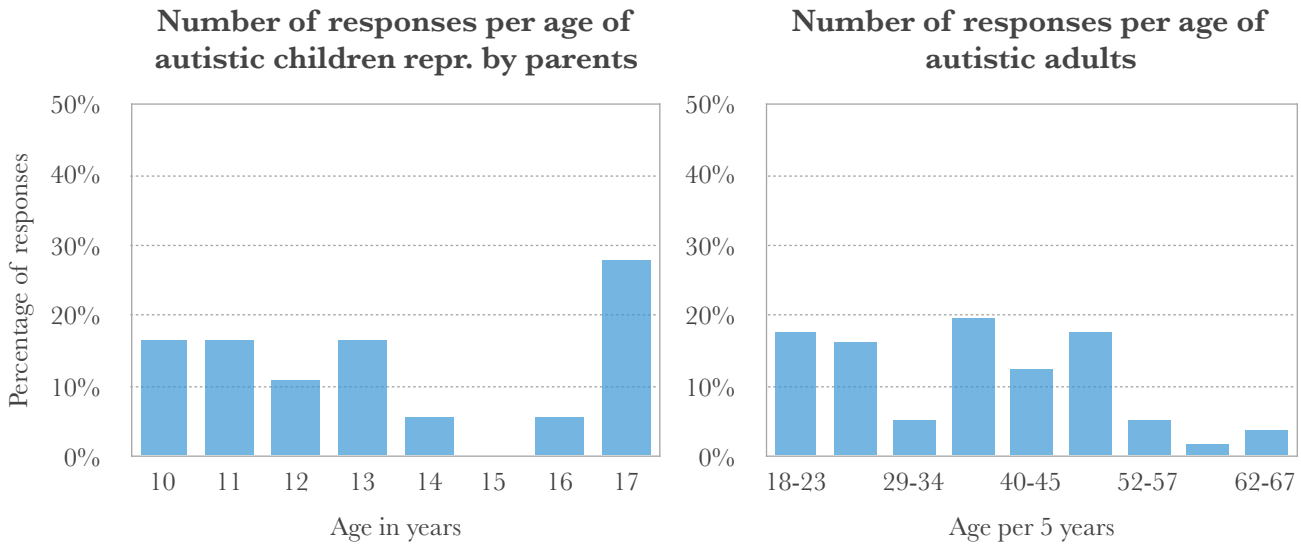


Figure 11: Percentage of responses per age

Expressing emotions

The online survey contained 5 questions with the purpose of indicating the problem of emotion expression and space for an emotion recognition product to determine the added value it could bring to the lives of the respondents. The responses to each question were visualised in a column chart, split between the group of autistic children represented by parents and the group of autistic adults. The answer scale used was translated to numerical values (table 5) to allow for statistical analysis. It should be noted that the scale was ordinal, and therefore no parametric analysis could be done with the data. Normality was rejected in all cases with the Kolmogorov-Smirnov test of normality, which could be due to the ordinal scale that complicated a normal distribution, and the small sample size per group.

Table 5: Answer scale to numerical values

Answer	Never	Almost never	Sometimes	Often	Very often	Don't know
Value	1	2	3	4	5	0

Do you ever have trouble expressing your emotions?

Both autistic children and autistic adults seemed to have trouble expression emotions, as can be seen in figure 12. For the autistic children represented by parents, 78% answered having trouble expressing emotions (very) often, compared to 63% of the autistic adults. The mean and median for both sample groups were around 4. The confidence interval (95%) for autistic children represented by parents was from 3.55 to 4.34 and for autistic adults from 3.57 to 4.17. These intervals fell in the "often" category. There was no statistically significant difference between the two groups according to the Mann-Whitney U test (Sig. of 0.939). It could therefore be stated with 95% confidence that the autistic population often has trouble expressing emotions.

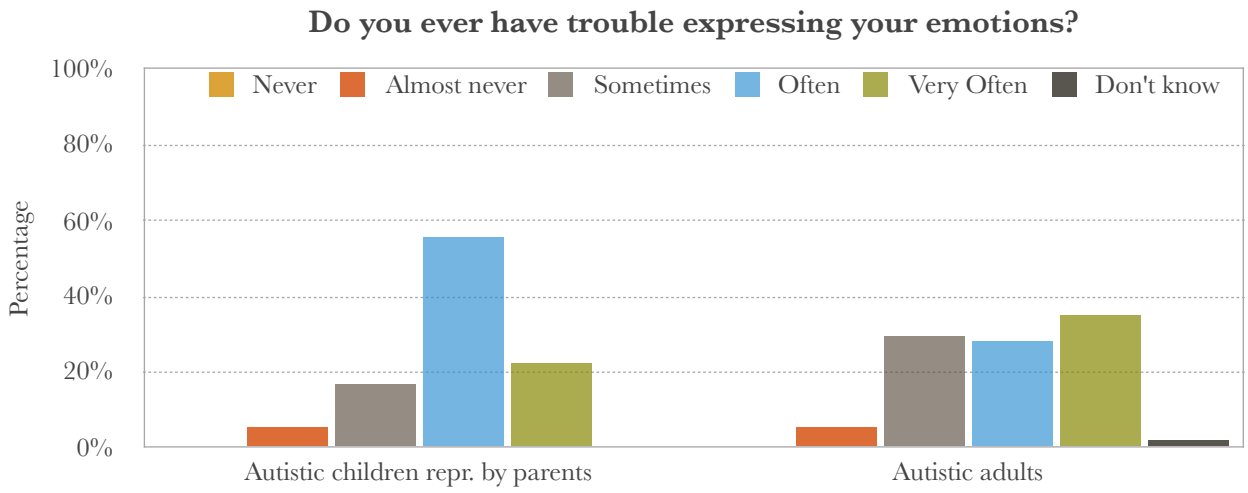


Figure 12: Trouble with expressing your emotions

Do you ever have the feeling that others don't understand what you feel?

An overwhelming 89% of the autistic children often or very often have the feeling that others do not understand what they feel as reported by the parents. The feeling of being misunderstood is still present in autistic adults, where 74% reported feeling this (very) often. The distribution of answers can be seen in figure 13. The mean and median of both sample groups were around. The confidence interval (95%) for autistic children represented by parents had a lower bound of 3.46 and an upper bound of 4.68, this was respectively 3.81 and 4.38 for autistic adults. These intervals fell in the "often" category. here was no statistically significant difference between the two groups according to the Mann-Whitney U test (Sig. of 0.849). It could therefore be stated with 95% confidence that the autistic population often has trouble expressing emotions.

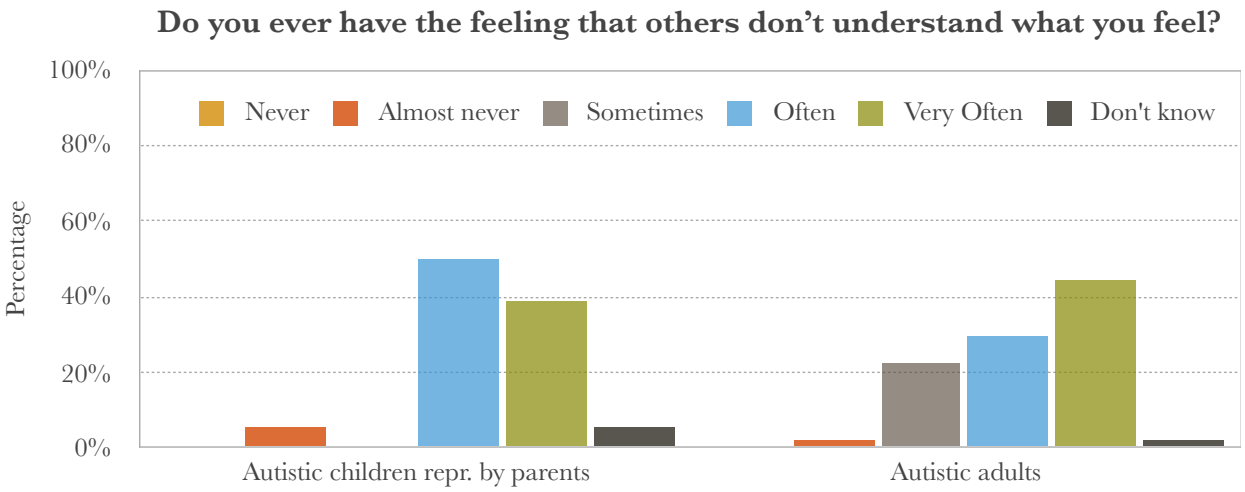


Figure 13: Feeling like others don't understand your feelings

Are you ever confused about what you are feeling?

Confusion about ones own feelings seemed less frequent than feeling misunderstood by others as can be seen in figure 14. 61% of the autistic children are (very) often confused about their own feelings. For autistic adults, 44% reported confusion about their own feelings. The autistic adults might be more skilled in recognising their own emotions because they are older and thus have had more time to practice. Feeling that their emotions are misunderstood by others also seemed to be the bigger issue, whilst 74% of the autistic adults reported this. The mean for autistic children lay at 3.72 and the median at 4, while the mean for autistic adults lay at 3.42 and the median was 3. It seemed like the being emotionally misunderstood is a bigger problem for children than for adults. The Mann-Whitney U test could not verify this though (Sig. of 0.208). For autistic children the confidence interval was between 3.07 and 4.38. For autistic adults the confidence interval was between 3.10 and 3.73. This was between "sometimes" and "often".

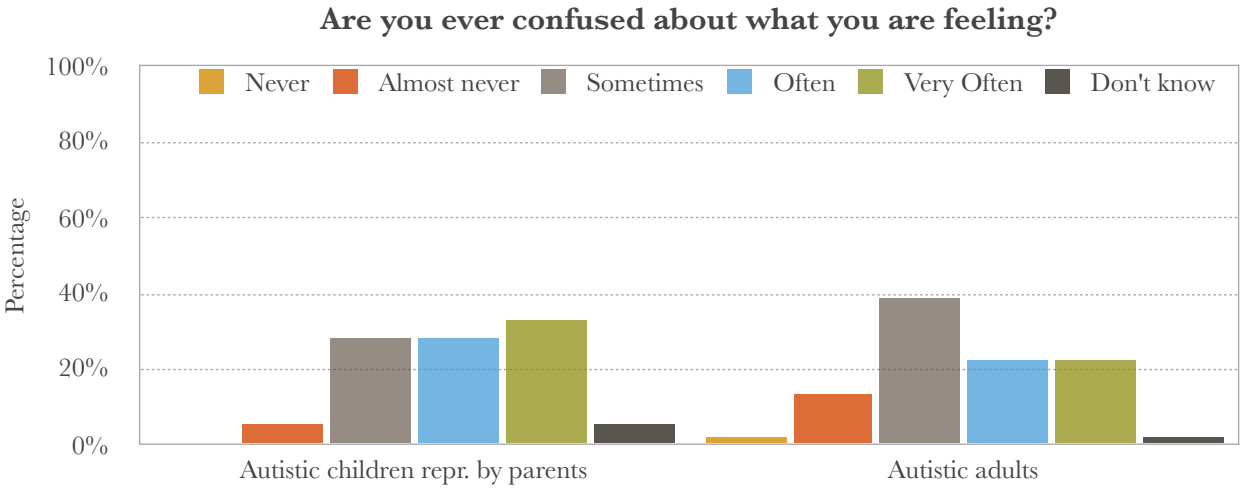


Figure 14: Confused about your feelings

Are there situations where you would like others to know what you are feeling?

Both autistic children and autistic adults have the wish that others would know what they are feeling in certain situations as can be seen in figure 15. 61% of the autistic children and 59% of the autistic adults wishes this often or very often. For the autistic children, the mean lay at 3.61 and the median at 4, with a confidence interval between 2.99 and 4.23. The autistic adults showed a mean of 3.79 and a median of 4, with a confidence interval between 3.50 and 4.08. The mean therefore lay between "sometimes" and "often". It is important to note that "sometimes" was chosen a lot, which lead to the impression that autistic people do not always want others to know what they are feeling but only in specific situations. It might therefore be better if the emotion recognition product can be turned on and off as the user wishes. The Mann-Whitney U test showed no statistical difference between groups (Sig. of 0.724).

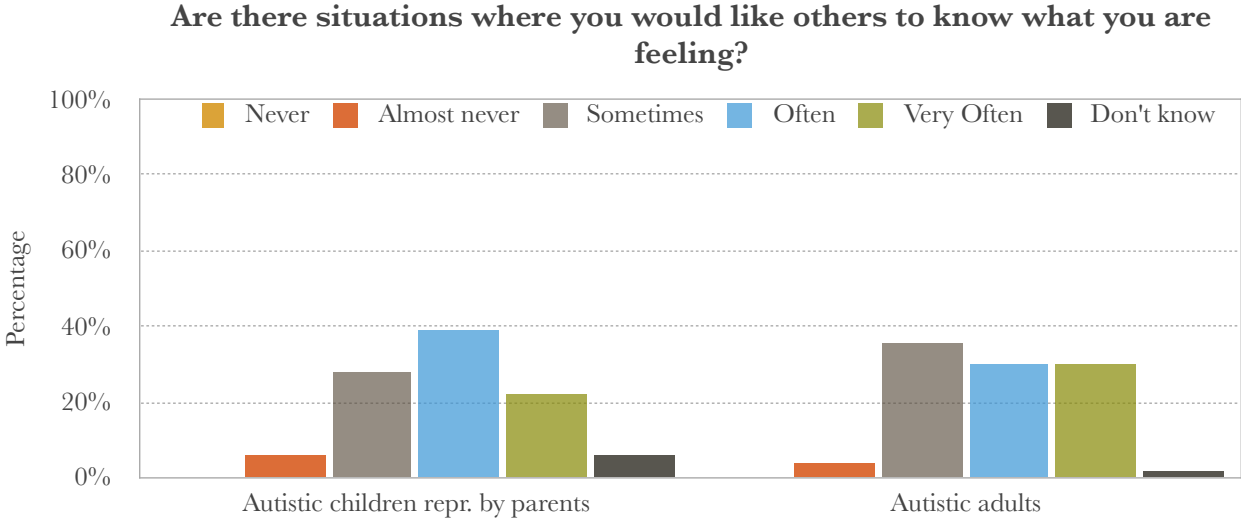


Figure 15: Situations where you like others to know your feelings

Would you like it if others would know what you are feeling?

A general feeling of (very) often wanting others to know their emotions is also present in autistic children, where 78% reported this. For the autistic adults this is 59% as shown in figure 16. The mean for autistic children is 3.83 and the median is 4, with a confidence interval between 3.26 and 4.41. For autistic adults, the mean lay at 3.77 with a median of 4. The confidence interval was between 3.46 and 4.09. These values fell on "sometimes" and "often". The Mann-Whitney U test showed no statistical difference between groups (Sig. of 0.722).

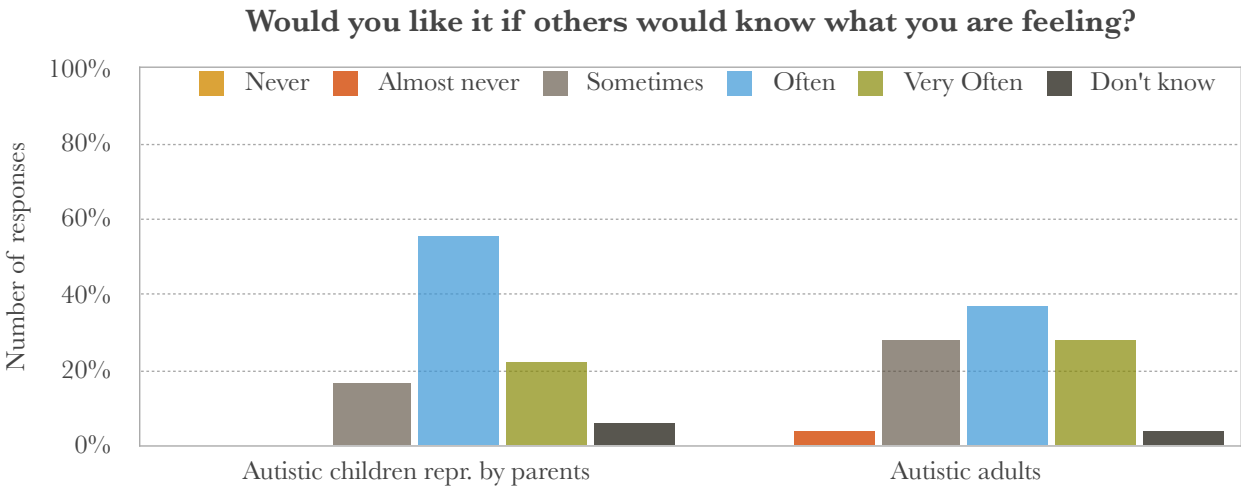


Figure 16: Wanting others to know your feelings

Do you use an emotion communication technique?

Non-technological emotion communication techniques (such as a feelings thermometer, for example at school or at home) are barely used by both autistic children and autistic adults, see figure 17. 6% of the autistic children use this agains 4% of the autistic adults. A higher usage frequency for autistic children was to be expected, since these solutions are often aimed at children. However the difference between groups was not significant according to Fishers exact test (Sig. of 1.000).

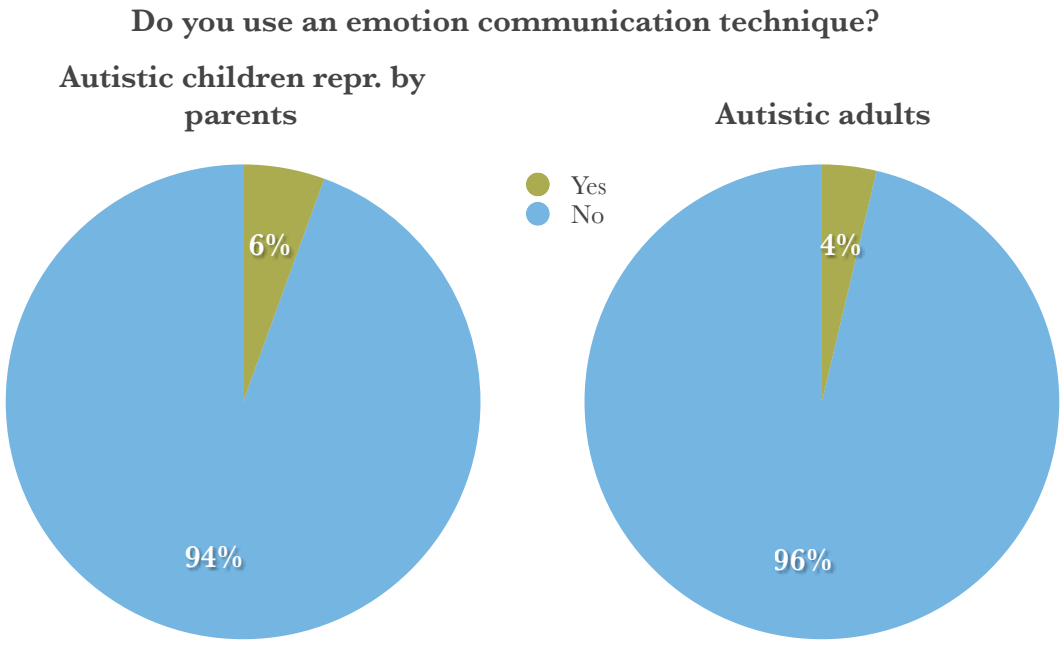


Figure 17: Usage of emotion communication techniques

Wearing accessories

A small group of the autistic people had experience with a biosensor as can be seen in figure 18. The mentioned products were all based on a heart rate monitor (with the exception of the microsoft band, which also included an electrodermal sensor). Heartrate was also an example given in the in the survey, explaining what a biosignal is. The mentioned products were mostly fitness trackers aimed at sports, although the heart rate monitor can also be worn for medical purposes. The E4 wristband and Vitalsigns patch mentioned in the survey as examples of products based on biosignals, seemed to be unfamiliar to the respondents since these were not stated in the answers.

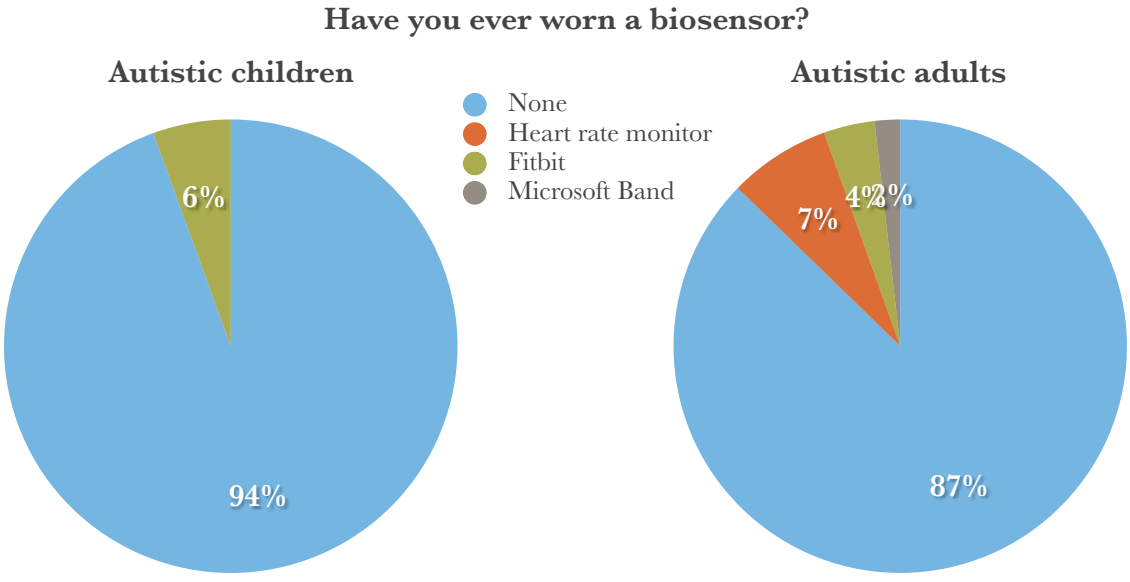


Figure 18: Familiarity with biosensor

Wearing accessories

Mentioned accessories that are bothersome to wear to autistic children can be seen in a word-cloud in figure 19. The word-cloud for autistic adults can be seen in figure 20. The size of the words denotes the frequency of that element as being labeled bothersome. The color and location are random. Most elements were given in a list where multiple options could be selected, there was also an option to fill in custom elements.

Interesting to see is that the statement "Nothing is bothersome to wear" is much more present in the word-cloud for autistic adults. This lead to believe that it could be possible that autistic people learn to cope with bothersome accessories when they age. The objects answered by the respondents were divided into three groups: tightly worn objects, dangling objects and objects with a specific texture.

Noticeable is that suspenders are most annoying to both the autistic children and adults. The suspenders are closely followed by other objects that are usually worn tightly around the body, such as a watch and ring. The belt, glasses, bra and heart rate monitor were less mentioned but could also be classified as worn tightly around the body. Necklaces and earrings could be either tight or dangling, depending on the design. A tie would classify as being both tight and dangling. Objects with a specific texture (itchy, inflexible, denim, clothing labels, wool, plastic) were not predefined, respondents added these themselves in the customisable option. It could be that these would be more present in the word-cloud if they were added as a predefined option because maybe not every respondent took the trouble of thinking about extra things other than the predefined list or just forgot. Considering that there were people that added these problematic textures themselves, and that they overlapped, is a strong clue that this might be a bigger problem than the survey showed.

Both children and adults have trouble giving clear and concise explanations as to why wearing these objects is annoying to them, which gave the impression that they often do not know themselves as was shown by given statements such as: "I don't know" "It is annoying" "Difficult" and "Does not feel nice". When a clear motivation was given, that motivation could almost always be led back to sensory overstimulation, which is a common problem in autism. Examples of this could be found in given statements such as: "I continuously feel the presence of the object" "Itchy/Stinging" "Too tight/pressing" and "Feels heavy". Another explanation named is that they are simply not used to the object. This is also logical since difficulty in coping with changes and new things is a symptom of autism.

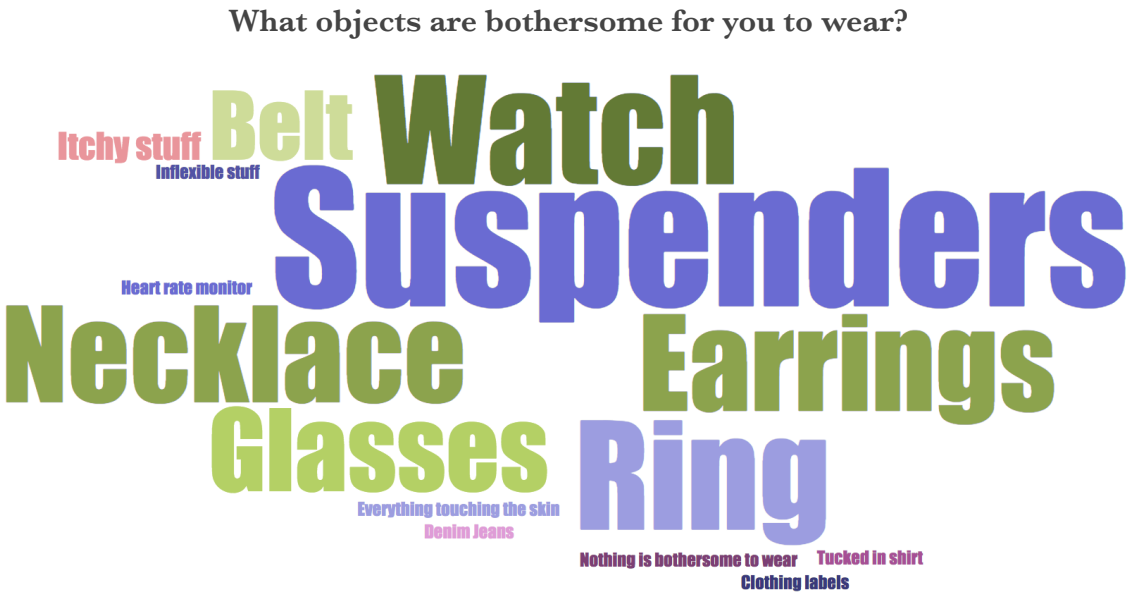


Figure 19: Objects that are bothersome to wear for autistic children repr. by parents[13]

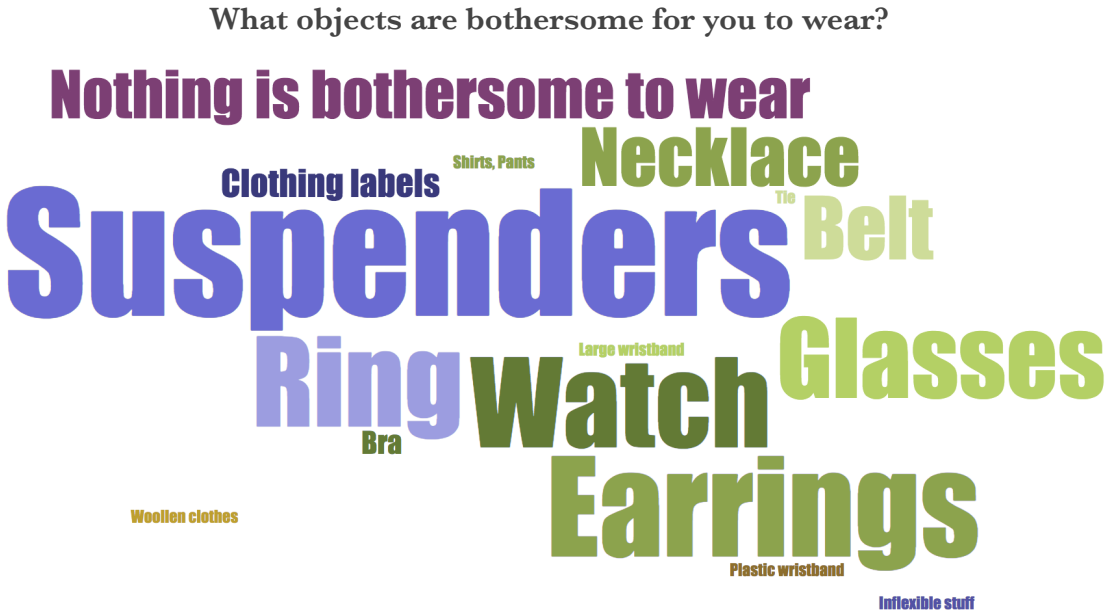


Figure 20: Objects that are bothersome to wear for autistic adults[14]

[13] Created with Wordcloud by JasonDavies. Retrieved on July 3rd 2017 from https://www.jasondavies.com/wordcloud/

[14] Created with Wordcloud by JasonDavies. Retrieved on July 3rd 2017 from https://www.jasondavies.com/wordcloud/

Finding a watch bothersome might be representative for the adoption of a smartwatch because the design is much alike. The frequency of a watch being mentioned as bothersome in the previous question has been extracted to create the pie chart of figure 21. Autistic adults seemed more adapted to wearing a watch, with 23% reported to be bothered by them, against 31% of the autistic children represented by parents.

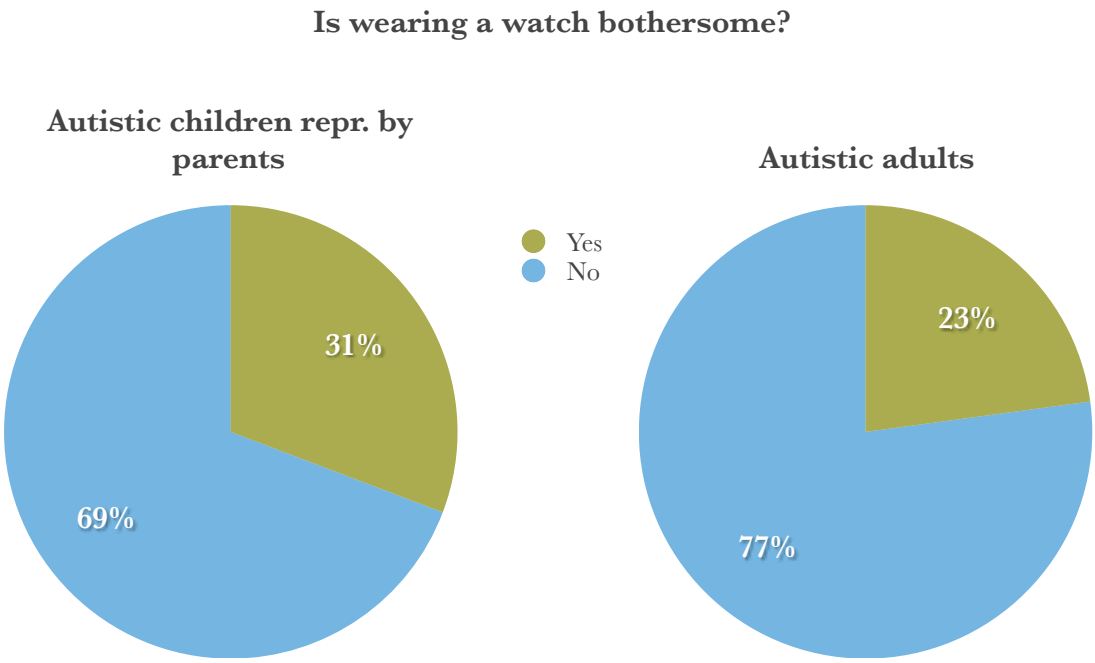


Figure 21: Percentage of respondents who selected a watch as bothersome in the previous question

Wearing patches

Not only accessories are sometimes bothersome to wear, patches such as band-aids annoy 28% of the autistic children and adults, though the majority is not bothered by having to wear a patch, as can be seen in figure 22. Both groups barely think changing the look of the patch with a nice picture is an improvement as can be seen in figure 23. Surprising was that a slightly bigger percentage of autistic adults think a nice picture is an improvement as compared to the autistic children represented by parents. This seemed contradictory with the cheerful and colourful band-aids with pictures sold in stores specifically aimed at children. It is unclear if this contradiction is caused by autism, or if typically developed children also do not see improvement in pictures on patches.

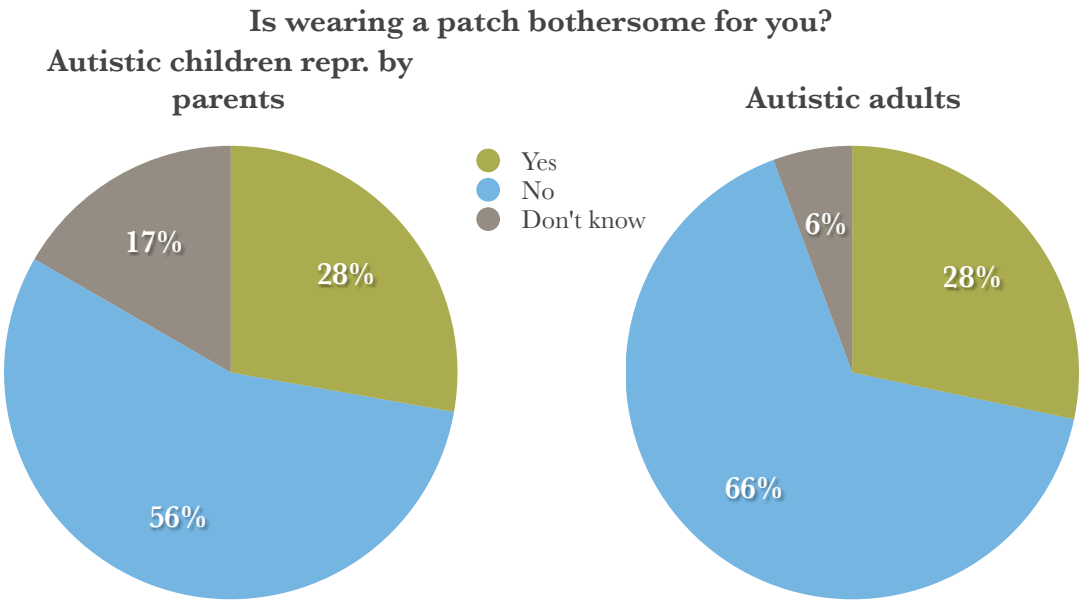


Figure 22: Are patches bothersome to wear

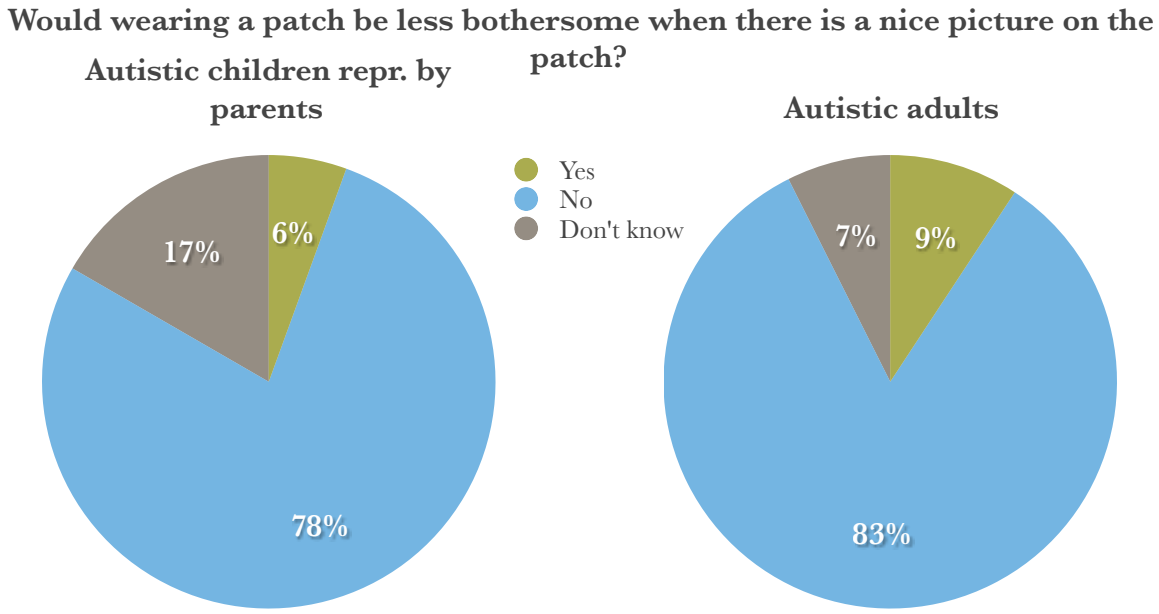


Figure 23: Is wearing patches improved by a nice image

Being watched

Figure 24 shows that 56% of the parents reported that their autistic child does not like to be photographed. For autistic adults, this is still 50%. Being filmed was even more disliked with 67% of the parents reporting this for their autistic child and 69% of the adults reporting this (figure 25). The motivation for this was diverse, with responses like "Uncomfortable" "I don't like being observed" "Insecurity" "I act different when being photographed/filmed" "I don't want to see myself" and "I don't want others to see me".

When looking at the data set it became clear that the respondents who did not know if being photographed is bothersome for them, in 67% of the cases also do not know if being filmed is bothersome for them. The other 33% answered that being filmed is indeed bothersome, never that being filmed is not bothersome. Another visible trend was that the respondents who answered that being photographed is bothersome, in 100% of the cases also found being filmed bothersome. The cross-tabulation from SPSS figure 26 shows the frequencies. The Chi-Square tests all rejected the null hypothesis that there is no correlation (Sig. of 0.000). The answer to "Is being photographed bothersome for you?" was therefore related to the answer of "Is being filmed bothersome for you?".

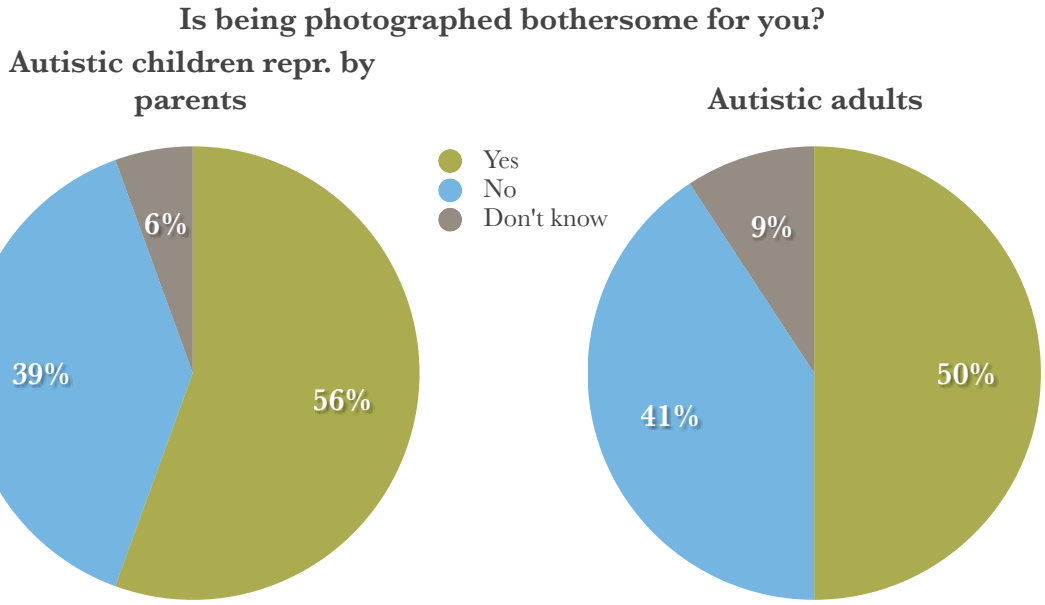


Figure 24: Is being photographed bothersome

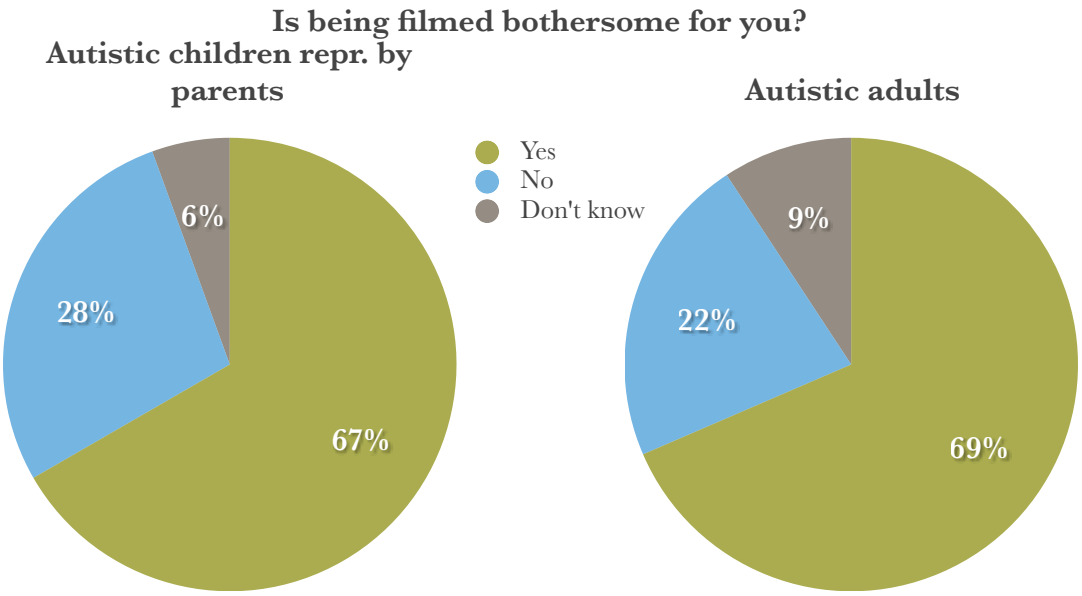


Figure 25: Is being filmed bothersome

Is being photographed bothersome for you? * Is being filmed bothersome for you? Crosstabulation

			Is being filmed bothersome for you?			
			0	1	2	Total
Is being photographed bothersome for you?	0	Count	4	2	0	6
		% within Is being photographed bothersome for you?	66.7%	33.3%	0.0%	100.0%
		% within Is being filmed bothersome for you?	66.7%	4.1%	0.0%	8.5%
	1	Count	0	37	0	37
		% within Is being photographed bothersome for you?	0.0%	100.0%	0.0%	100.0%
		% within Is being filmed bothersome for you?	0.0%	75.5%	0.0%	52.1%
	2	Count	2	10	16	28
		% within Is being photographed bothersome for you?	7.1%	35.7%	57.1%	100.0%
		% within Is being filmed bothersome for you?	33.3%	20.4%	100.0%	39.4%
Total		Count	6	49	16	71
		% within Is being photographed bothersome for you?	8.5%	69.0%	22.5%	100.0%
		% within Is being filmed bothersome for you?	100.0%	100.0%	100.0%	100.0%

Figure 26: Cross-tabulation from the answers to being photographed and filmed

Interview results

Data selection

The interviews were conducted with 10 autistic teenagers between 10 and 18 years old. All the participants finished the interview, so no selection was required because of incomplete responses. All the participants fulfilled the target group so no selection on age was necessary.

Sample demographics

Gender

The gender was fairly evenly distributed, almost 50/50. The slight unevenness of the distribution could be attributed to two factors. The first factor was a small sample size, a larger sample size could show a different trend. The second factor was that males are more often diagnosed with autism than females. That could mean that a bigger sample size might even have shown a larger percentage of males. This could be corrected by selecting participants based on gender to get an even distribution, but because finding participants was already challenging, that was not an option for this research.

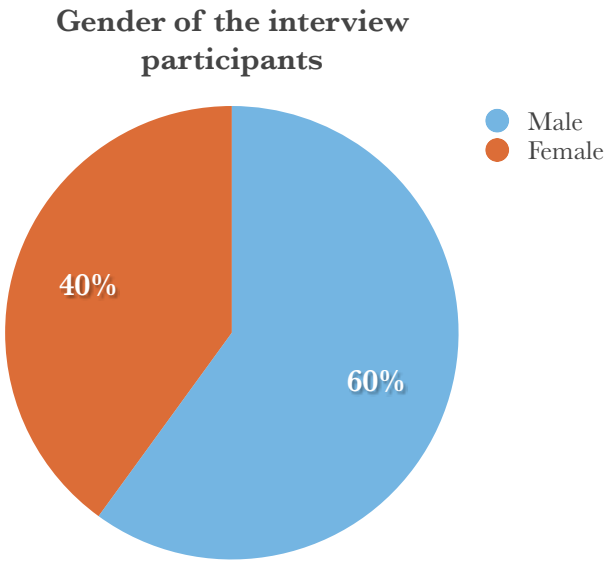


Figure 27: Gender of the interview participants

Age

There was at least 1 participant for each age in the target range from 10 to 18, except for the boundary number of 10 (see figure 28). The middle of the range was 14 years old and most participants fell exactly in this range. This seemed coincidental because the participants were gathered from different schools and families. But it is possible that during the recruitment, a psychological factor was of influence here. “Between 10 and 18” could be interpreted as

"around 14". This is not problematic because the spread has the form of a normal distribution, which cannot be rejected by the Shapiro-Wilk test (Sig. of 0.795).

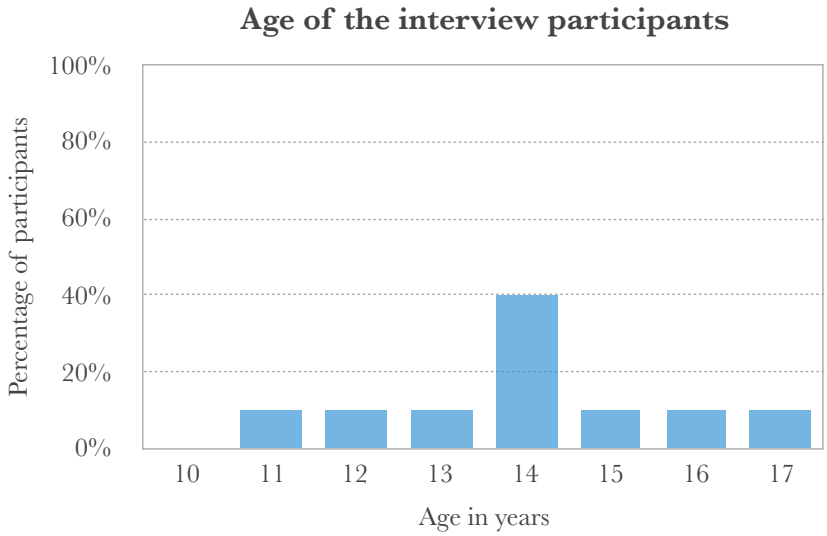


Figure 28: Age of the interview participants

Smartwatch

All of the participants were willing to wear the Samsung S3 Gear smartwatch and turn it on. They were curious about the functions and did not need any encouragement to pick it up and turn it on. Both the boys and the girls expressed the wish that the design was less black. The boys redesigned the smartwatch with black, grey, dark blue and dark green while the girls chose a combination of bright blue and pink/purple. The smartwatch was too heavy for the children and they redesigned it smaller and lighter. Many participants also had trouble taking the smartwatch on and off, and disliked the material of the band. Two participants had a leather allergy, this was not leather but it is notable that autistic people can have sensitive skin).

The Angel M1 wearable was not preferred even though it was smaller and lighter. The reason for this was that the M1 wearable does not have a touchscreen and is not multifunctional, it is only a sensor. Also, the sensors on the back were raised a bit so the surface touching the skin was not flat, which felt irritating to the participants. One participants would prefer a wearable on the ankle instead of the wrist but most thought that this would annoy them because it might move around and be scraped by socks and shoes.

The feeling of control was sufficient for most children, though two children gave grades lower than 5 for the feeling of control. The solutions to abort measurements when they would be fed up varied between the two possibilities: taking of the smartwatch or shutting down the

smartwatch. None of the children suggested stopping only the measurement function while still using the rest of the smartwatch. This is correlated to the two insufficient grades, which were given because the children felt like they did not know if the smartwatch was measuring or not. The measurements of physiological signals should be a separate function that can be controlled independently to facilitate the multi-functionality that the children preferred. Some children also redesigned the smartwatch with an on/off button for solely the measurements. The children were all convinced that an on/off button should be red so that it can immediately be recognised as such. A signal that the device is measuring was also discussed, but this should not be a light since the children found lights distracting.

The scores given to the smartwatch can be seen in figure 29. Interesting is that the participants gave higher scores for using the smartwatch at school than using it at home. The explanations they gave led to the impression that they associate a watch with working and being active, while at home they want to relax and not have as much stimuli. This might also mean that even though the children did not describe the watch as bothersome during the wearing and could not pinpoint irritating elements, wearing the watch still provides stimuli which may put a burden on the child.

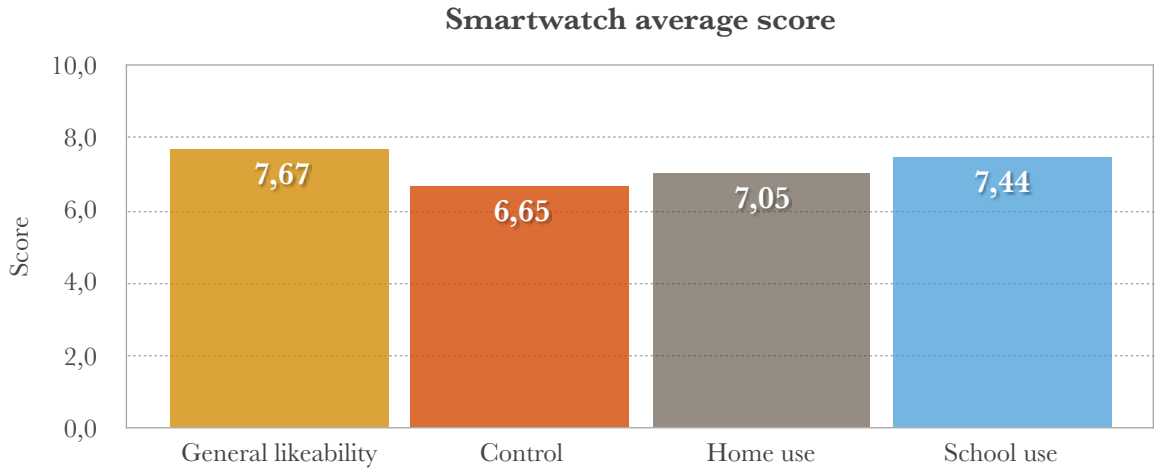


Figure 29: Average scores given to different aspects of the smartwatch

Patch

Most of the participants, except one, were willing to wear the patch. They were more hesitant to pick it up and described the patch as "medical", "scary" and "weird". They also found the patch smaller than expected, with the exception of one participant that fantasised about the patch being much bigger with chips and wires and LEDs like a bionic arm. The participants were asked where they would place the patch. The upper and lower arm were most frequently answered. Apart from one participant would place it on the back of the torso and another would place it on the stomach. The patch should originally be placed over the heart, which was acceptable for all the participants but they were more inclined towards their own

chosen spots. The participants barely felt the patch on their skin, except for a pulling sensation when moving the body part the patch was placed on, and taking the patch off. Maybe a more flexible patch would improve this, especially when the patch is located on the arm.

The patch was also up for redesign by the participants, they immediately started with changing the surface to a beige skin colour, "like a normal band aid" and so that it "would not be as obvious". The raised middle of the patch where the chip is placed was also disapproved, it should be flat. The general conclusion was that the whole patch should look more like a simple band-aid. There should however be a button included to control if the measurements are on or off, because removing the patch was slightly annoying to most (though less annoying than an actual band-aid said the participants, which is most likely because of the adhesive used). Two participants also mentioned that the electrodes were visible through the cover and that this should be prevented.

The patch scored an insufficient grade on the feeling of control as shown in figure 30, because there was no input on the patch itself and no output visible to them. It is therefore essential that the wearer of the patch can also access the data, for instance through a computer or smartphone. Placing an on/off button on the patch would also improve the score for control. A display or indicating light was not encouraged by the participants because this would look out of place on a patch and could be distracting. It is striking that the home use scored higher than the school use, in contrast to the smartwatch which was the other way around. School use was not valued highly because of the medical design with was deemed scary and weird by the children and they were insecure about what their peers would say.

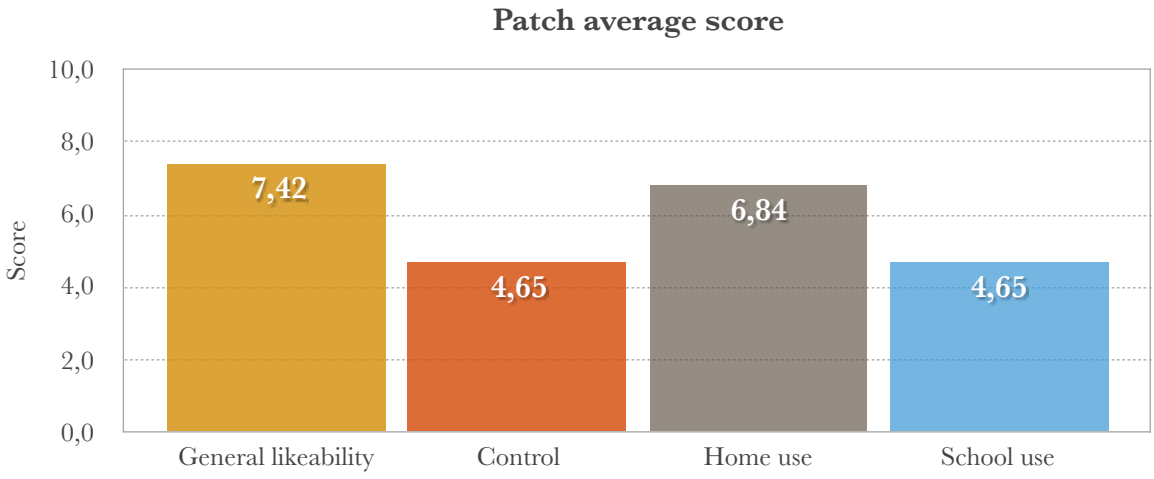


Figure 30: Average scores given to different aspects of the patch

Infrared camera

The infrared camera was placed on the table when setting up the equipment before the start of this section of the interview. 80% of the participants already reported feeling stared at before the camera was even turned on. The interest in the infrared camera was low but turning it on was allowed by all of the children. They reported that the blinking light on the front of the camera was annoying. They also thought the camera was too big, and 4 participants suggested a webcam-sized infrared camera mounted in a corner on the wall.

Turning the infrared camera off posed a small problem. The participants needed more time to think about this and answered hesitantly. The solution they came up with was to pull the power plug or step out of the sight of the infrared camera, neither of which they found convenient. One child suggested a remote control for the infrared camera, and then quickly had the idea that this could be done with a smartphone app. The others wanted to place an on/off button on the camera itself (again, this button should be red).

The infrared camera scored low on all the elements as can be seen in figure 31. The general likeability was barely sufficient, the other factors were insufficient. School use scored lower than home use because the children did not think it was practical to have to drag it with them to every room, plug it in to a power source and set it so that they are in the view of the infrared camera. At home this is also unpractical, but still more feasible to them.

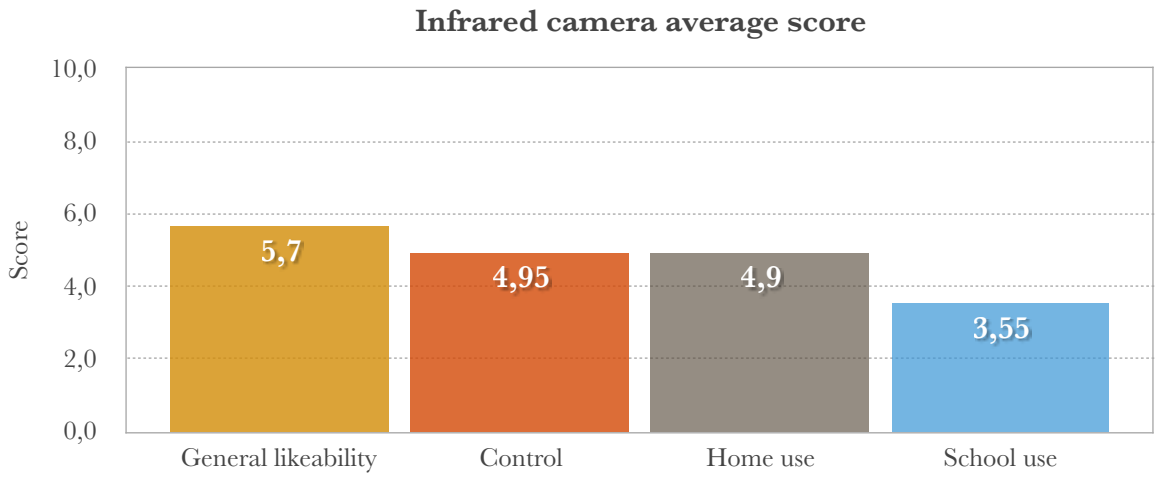


Figure 31: Average scores given to different aspects of the infrared camera

Preferred product

The smartwatch was preferred as usable product for the autistic children participating in the interviews by 70%. The patch came second with 30%. The infrared camera was preferred by no one and also had the least suggestions that would change this preference. The patch might come closer to first place if the suggestions for design are incorporated.

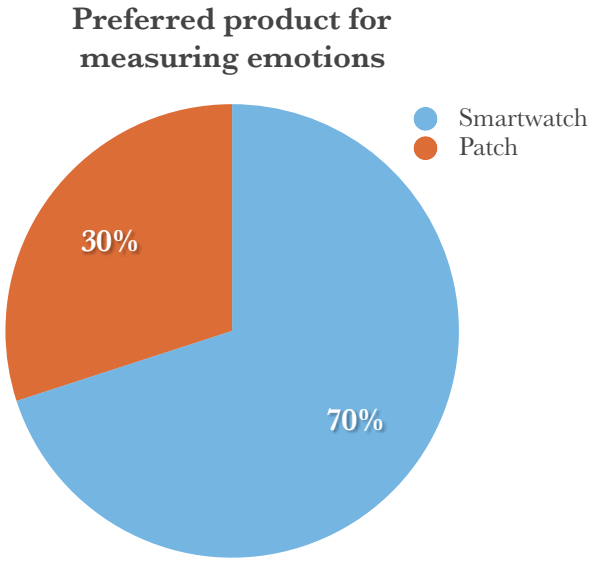


Figure 32: Preferred product for measuring emotions

Privacy

The autistic children showed liking to the idea that their emotions can be measured and that the data can viewed by themselves and others. Multiple children voiced interest in getting to know themselves better. 90% of the participants would allow their parents to view their emotions. One participant would not allow anyone other than oneself to see the emotions. 80% of the participants wanted to be able to decide for themselves when someone could see their emotions and when someone could not, that is why a clear on/off button is essential. It can also depend on time and place who the child allows to see the emotions.

One child mentioned that instead of an on/off button a pause button might also be an option. If the child presses that pause button, measurements would stop for a set amount of time (for instance 30 minutes), after which it automatically turns on again. This would give the child a break to catch one's breath without shutting the observers completely out,. This pauze button would also avoid the hitch of the child having to consciously decide that it is okay to turn it back on again, which might be difficult for the child to know about oneself.

5. Discussion

The results described in the previous chapter have several implications. These are discussed in this chapter with the resulting design considerations, a hypothetical design adhering to those considerations, and a discussion of the limitations of this research.

Resulting design guidelines

The results from the survey and interviews gave a lot of information about the user requirements for autistic children. This information has been processed and adapted into the following guidelines. The guidelines can be used as considerations when designing a wearable for this target group. However, within the autistic spectrum there are still a lot of individual differences and personal preferences, therefore it may be that these guidelines do not apply to every person in target group.

Guidelines:

1. The primary goal of an emotion recognition product for autistic people should be the communication of their emotions to others. Using that information for supporting the self-learning process of ones emotions could be a secondary objective whilst there is confusion in autistic people about their own emotions, but supporting the self-learning process should not be the focus.
2. Use a design that is based on physiological signals, because these signals are trustworthy on autistic people. Other signals such as facial expressions, body language and voice intonation are employed differently by autistic people.
3. An infrared camera poses many challenges and is generally disliked by the target group. A multifunctional smartwatch design around the wrist would be best, a patch would be the second choice.
4. No matter what form the emotion recognition technologies gets, there should be an on/off button for taking measurements with a clear script to give the wearer control over the device, and in line with that control over access to the wearers emotions.
5. The design should be familiar to a product the autistic child already knows: a normal watch or a skin-coloured band-aid.
6. The design should not be dangling, though this is not a risk because electrodes should make contact with the skin for biosensor wearables. Making sure the design is not too tight is a bigger challenge. Flexibility is important. A smartwatch band should have different length possibilities and a patch should be flexible enough not to pull the skin during movements.

7. The design should be smaller and lighter than the smartwatch and patch used in this research.
8. Textures are important because of the sensitivity of the skin of autistic people. For the smartwatch a natural band of smooth texture is advisable. Leather could be possible. Metal or ceramics might be an option because of the smoothness and the thermal properties of this material that keep it at skin temperature. For both of these suggestions counts that allergies should be considered. For the patch, this is important for the glue. The glue of the VitalSigns patch was generally approved, though taking the patch off still posed a problem.
9. Putting the product on and taking it off should be as easy and as possible. The smartwatch took too long to put on and take off, a closing system that is easier to operate would be better. For the patch, the taking off was still slightly painful. It would be a big improvement if a glue or method could be developed that makes taking it off painless.
10. Surfaces have to be flat, so no raised bumps or protruding buttons.
11. An indication that shows is measurements are being taken or not would be nice, but not in the form of (blinking) lights that draw attention and distract the child.
12. Avoid a medical-looking design. This can be done by hiding the electrodes from view and not making the design predominantly white.
13. Make inputs and outputs available to both the wearer and the observer. For instance through a smartphone app with a controller account for the wearer and a viewer account for the observers such as teachers and parents.
14. The viewers should be accepted or certified by the wearer that they are allowed to view the emotions. This should also be easily turned off and back on again per person. For instance, when the child is not at school, the teacher should probably not be able to see the child's emotions. But the next day at school is should be easy to turn back on again.

Proposed design

A possible design based on the guidelines could look like the image in figure 33. The smartwatch has a ceramic band with click system and can be made shorter by removing some of the elements. The smartwatch is smaller than the Samsung Gear S3 and only contains smooth surfaces. There is a noticeable red on/off-button placed in the rim that would turn the measurements on and off. The smartwatch has various sensors to measure physiological signals, such as electrodes for electrodermal activity, a skin temperature sensor, heart rate sensor and oxygen sensor. Data can be viewed on the smartwatch and through a smartphone app that gives control over all the data, settings and allowed viewers. Measurement status is shown on the smartwatch screen.

Figure 33: Possible design

Limitations of the research

There were some limitations to this research because of constraints in time, constraints in resources, and target group constraints. One of the limitations of this research is that it only tested the autistic target group. To determine the user requirements, that is enough. Further insight could be provided by also conducting the survey and interviews with a non-autistic group to see if the autism diagnosis correlates with the answers or that the answers are also true for a non-autistic target group.

The sample size was relevant, but small. A bigger sample size might have given better results. The sample also had some underrepresented age groups and gender was not completely evenly distributed. Age and gender were used to describe the sample, but have not been used to find correlations in the answers. Using age and gender in relation to the data could perhaps have give more insights.

The 5-point rating scale used poses restrictions to the possible statistical tests. This scale was consciously chosen for this target group but a grade from 0 to 10 for example might have been easier to inspect. It could be that parents had difficulty filling in the survey about their children. The parents were encouraged to ask their child if they did not know the answer to a question or to select the "I don't know" option. Those precautions cannot fully prevent the possibility that the autistic children would have filled in the questionnaire differently.

The rooms of the interview were different each time. This might have unforeseen effects on the answers because this variable was not kept constant. The interview was semi-structured so the rooms should have less (if any) effect on the answers than in a structured interview or in an experimental study.

The online survey was evaluated as "clear" "easy to fill in" "short and comprehensible" and "shows understanding of the target group" by several autistic adults that replied to the survey to give their compliments. Results are thus believed not to have been influenced by unclear questions in the survey.

6. Conclusion

This research investigated the application of emotion recognition technologies for autistic children aged 10 to 18. The target situation where an autistic child is subject to measurements for emotion recognition is relatively new and there is still a lot unknown about this application of the technology.

The state-of-the-art determined that emotion recognition technology based on affective signals such as facial expression, body language and voice intonation would not work. Autistic people employ these affective signals differently from the typically developed population. Physiological signals should be used as input instead because these signals are not affected by autism. There were several possible physiological signals described in literature that can be measured. These signals are heart rate variability, blood volume pulse, skin temperature, electrodermal activity, respiratory rate and brain activity.

Sensors for these signals may be placed in different designs. The design is important for this autistic target group because they are sensitive to stimuli and have difficulty adapting. Therefore it was important to investigate the user requirements of autistic people. This was done with an online survey filled in by a proxy group of 72 persons and semi-structured interviews with 10 children from the target group.

The data gathered from the survey and interviews was processed to insights about the user requirements. Those insights were used to draft a set of 14 guidelines to consider when designing emotion recognition technology for the target group of autistic children. Those 14 guidelines are summarised below.

Design guidelines:

1. The primary goal of an emotion recognition product for autistic people should be the communication of their emotions to others.
2. Use a design that is based on physiological signals.
3. A multifunctional smartwatch design around the wrist would be best, a patch would be the second choice.
4. No matter what form the emotion recognition technologies gets, there should be an on/off button for taking measurements.
5. The design should be familiar to a product the autistic child already knows.
6. The design should not be dangling or too tight.

7. The design should be small and light.
8. Carefully consider textures that do not irritate the skin.
9. Putting the product on and taking it off should be as easy and as possible.
10. Surfaces have to be flat.
11. Do not use a light as indicator for measurement status, but something that is not distracting.
12. Avoid a medical-looking design.
13. Make inputs and outputs available to both the wearer and the observer.
14. The viewers should be accepted or certified by the wearer that they are allowed to view the emotions.

A possible design would be a smartwatch with sensors for several physiological signals that adheres to these guidelines.

Recommendations for future work

This approach to emotion recognition technology for autistic children is barely researched and discussed in literature so there are many uncertainties and angles that can still be investigated. This study could be redone with a bigger sample group and compare it to a typically developed sample group. The study could also be expanded to include autistic adults, who might have comparable user requirements.

The discovery of more physiological signals that are descriptive for emotions would also help forward the field. If ways would be found to measure the physiological signals in an even less-obtrusive manner, that would be even better for the autistic target group. For instance a small device that could slip in the pocket or be clipped on the edge of the belt loop.

Market research will also be necessary for the adoption of this product. Software needs to be developed which is suitable for the autistic target group, so user requirements of the interface are also very interesting. Once that research has been done and a suitable prototype has been developed, experimental tests can show the accuracy, efficiency and added value of the emotion recognition technology. Focus can also be shifted towards the secondary goal of aiding the self-learning process of autistic children about their emotions.

7. Appendix

A. Online survey questions

Ontwerp van emotieherkennings-technologieën

Inleiding

Deze vragenlijst is bedoeld voor onderzoek over technologieën die emoties kunnen herkennen. Dit onderzoek wordt gedaan aan de Universiteit Twente. Voor vragen kan je contact opnemen met: Tamara Notenboom (t.notenboom@student.utwente.nl)

Deze vragenlijst is gaat over kinderen met autisme in de leeftijd van 10 tot 18 jaar. Als volwassene met autisme ben je natuurlijk ook kind geweest, daarom is deze vragenlijst ook voor volwassenen met autisme. Als ouder van een kind met autisme ben je vaak goed op de hoogte van hun belevingswereld, daarom is deze vragenlijst ook voor ouders van kinderen met autisme. De vragenlijst is anoniem en zal enkel gebruikt worden voor wetenschappelijke doeleinden. Er zijn 16 vragen verdeeld over 6 pagina's. Bovenin kan je op de voortgangsbalk zien hoe ver je bent. Je kan op ieder gewenst moment stoppen met de vragenlijst.

* 1. Klik aan wat van toepassing is:

- ◯ Ik ben een ouder/verzorger van een kind met autisme tussen de 10 en 18 jaar
- ◯ Ik ben een volwassene met autisme

---> Indien je een ouder/verzorger van een kind met autisme bent, beantwoord de vragen namens je kind voor zover dat kan. Als dat mogelijk is kan je de vragenlijst samen met je kind invullen. Bij vragen die je niet weet over je kind kan je "weet ik niet" aankruisen of eventueel aan je kind vragen. Waar in de vraag "jij" of "je" staat, interpreteer dit dan als "jouw kind" of "je kind".

---> Indien je een volwassene met autisme bent, dan kan je de vragen voor jezelf beantwoorden. Je hoeft daarbij niet terug te denken aan wat je als kind zou antwoorden, maar beantwoord de vragen zoals je ze nu ervaart.

Ontwerp van emotieherkennings-technologieën

Emoties

Deze pagina gaat over het herkennen en uiten van emoties.

2. Heb je wel eens moeite om je emoties te uiten?

Nooit	Bijna nooit	Soms	Vaak	Heel vaak	Weet ik niet
○	○	○	○	○	○

3. Heb je wel eens het gevoel dat anderen niet begrijpen wat jij voelt?

Nooit	Bijna nooit	Soms	Vaak	Heel vaak	Weet ik niet
○	○	○	○	○	○

4. Ben je wel eens verward over wat je zelf voelt?

Nooit	Bijna nooit	Soms	Vaak	Heel vaak	Weet ik niet
○	○	○	○	○	○

5. Zijn er wel eens situaties dat je graag zou willen dat anderen zouden weten hoe jij je voelt?

Nooit	Bijna nooit	Soms	Vaak	Heel vaak	Weet ik niet
○	○	○	○	○	○

6. Zou je het wel eens fijn vinden als anderen zouden weten wat jij voelt?

Nooit	Bijna nooit	Soms	Vaak	Heel vaak	Weet ik niet
○	○	○	○	○	○

7. Gebruik je een emotie kaart of een andere middel om te laten zien hoe jij je voelt? (Bijvoorbeeld thuis of op school)

- ○ Ja (licht hieronder toe wat voor middel)
- ○ Nee
- ○ Weet ik niet

Toelichting:

Ontwerp van emotieherkennings-technologieën

Draagbare sensoren

Emoties kunnen gemeten worden met biosensoren. Dit zijn sensoren die biologische signalen kunnen meten, zoals hartslag, ademhaling en lichaamstemperatuur. De meeste biosensoren draag je op je lichaam, als bijvoorbeeld een armband, enkelband of pleister. Hieronder zie je twee voorbeelden van biosensoren.

E4 Armband

Vitalsigns pleister

8. Heb je wel eens een biosensor gedragen?

- ◯ Ja (licht hieronder toe wat voor biosensor)
- ◯ Nee
- ◯ Weet ik niet

Toelichting:

9. Welke dingen vind je het vervelend om op je lichaam te dragen? Kruis hieronder aan wat je vervelend vindt om te dragen. (Meerdere antwoorden mogelijk)

- [ ] Armband
- [ ] Bretels
- [ ] Bril
- [ ] Horloge
- [ ] Ketting
- [ ] Oorbellen
- [ ] Riem
- [ ] Ring
- [ ] Ik vind niks vervelend om te dragen
- [ ] Iets anders, namelijk:

10. Waarom vind je het vervelend dit te dragen? (Laat leeg als je bij vraag 9 niks hebt aangekruist)

Ontwerp van emotieherkennings-technologieën

Pleisters

Biosensoren kunnen ook verborgen worden in een pleister. De volgende vragen gaan specifiek over het dragen van pleisters.

11. Vind je het vervelend om een pleister te dragen?

- ◯ Ja (licht hieronder toe waarom je dat vervelend vindt)
- ◯ Nee
- ◯ Weet ik niet

Toelichting:

12. Als er een leuk plaatje op de pleister zou staan, zou het dragen van een pleister dan fijner worden?

- ◯ Ja (Licht hieronder toe wat voor plaatje)
- ◯ Nee
- ◯ Weet ik niet

Toelichting:

Ontwerp van emotieherkennings-technologieën

Camera's

In plaats van een biosensor die je op je lichaam draagt, kan er ook gebruik gemaakt worden van een camera die je emoties kan herkennen van een afstandje. Deze vragen gaan over camera's.

13. Vind je het vervelend om gefotografeerd te worden?

- ◯ Ja (licht hieronder toe waarom)
- ◯ Nee
- ◯ Weet ik niet

Toelichting:

14. Vind je het vervelend om gefilmd te worden?

- ◯ Ja (licht hieronder toe waarom)
- ◯ Nee
- ◯ Weet ik niet

Toelichting:

Ontwerp van emotieherkennings-technologieën

Demografische gegevens

De resultaten worden anoniem verwerkt maar om goede conclusies te kunnen trekken uit de resultaten is er wat extra informatie nodig, daarom wordt hier om een paar demografische gegevens gevraagd. Indien je een ouder/verzorger bent, vul hier dan de demografische gegevens van je kind in.

* 15. Wat is je geslacht?

- ◯ Man/jongen
- ◯ Vrouw/Meisje
- ◯ Wil ik niet zeggen

* 16. Wat is je leeftijd?

Dit is het einde van de vragenlijst. Klik op gereed om de vragenlijst af te ronden. Hartelijk bedankt voor het invullen!

B. Semi-structured interview

Interview Emotieherkenningstechnologie: User requirements
door Tamara Notenboom

Introductie

Hoi <voornaam van het kind>, welkom bij dit interview. Ik ben Tamara, en ik ben bezig met een afstudeeronderzoek aan de universiteit Twente. Zoals je in de informatiebrochure al hebt gelezen gaat dit interview over drie producten die emoties kunnen meten. Het interview duurt maximaal 30 minuten. Je kunt geen goede of foute antwoorden geven op de vragen die ik stel, het gaat om wat jij vindt van de producten. Graag heb ik dat je heel eerlijk vertelt wat je de producten vindt en wat wat je wel en wat je er niet leuk aan vindt. Ons gesprek wordt opgenomen met een microfoon. Als je niet meer verder wilt met het interview, of je voelt je niet op je gemak, geef dit dan gewoon aan, dan pauzeren we even of we stoppen helemaal. Als je het hier allemaal mee eens bent, dan mag je hier je handtekening zetten op deze toestemmingsverklaring en daarna zullen we beginnen met het interview.

Smartwatch

1. We beginnen met de smartwatch. *smartwatch op tafel* Deze moet contact maken met je huid om emoties te meten. Pak hem gerust op. Wat zijn je eerste gedachten hierover?
   - Hoe denk je dat deze smartwatch werkt?

2. Wil je de smartwatch om doen? Als je dat niet wilt is het ook goed.

> Ja 3a. Hoe voelt dat?
- Zit de smartwatch lekker?
- Waar draag je de smartwatch het liefst? (Enkel, pols, ergens anders?)
- Irriteert er iets van de smartwatch?
- Vind je de smartwatch mooi/stoer/lelijk/neutraal/…?
- Kan je de smartwatch voor langere tijd om houden?

> Nee 3b. Kan je me uitleggen waarom je de smartwatch niet om wilt doen?
- Vind je de smartwatch mooi/stoer/lelijk/neutraal/eng/…?

4. Heb je het gevoel dat je het meten kan stoppen als jij dat wil?
   - Wat doe je als je wilt dat het meten stopt?

5. Kan je deze smartwatch een score geven van 0 tot 10 voor de volgende vragen, waarbij 0 totaal niet is en 10 heel erg is.
Hoe fijn vind je deze smartwatch? …
Hoeveel controle heb je voor je gevoel over deze smartwatch? …
Zou je deze smartwatch gemakkelijk thuis dragen? …
Zou je deze smartwatch gemakkelijk naar school dragen? …

6. Wat zou je willen veranderen om hem wel om te doen of beter te maken?
   - Ander bandje/groter of kleiner/ander materiaal?
   - Je mag hierop tekenen hoe jij de smartwatch zou ontwerpen.

afbeelding

Je mag nu de smartwatch weer teruggeven aan mij, dan gaan we door met het volgende product.

Patch

7. Dit product is een patch. *patch op tafel* Deze patch moet contact maken met je huid om emoties te meten. Pak hem gerust op. Wat zijn je eerste gedachten hierover?
- Hoe denk je dat deze patch werkt?

8. Wil je de patch op doen? Als je dat niet wilt is het ook goed.
> Ja 9a. Hoe voelt dat?
- Zit de patch lekker?
- Waar draag je de patch het liefst? (Borstkas, pols, ergens anders?)
- Irriteert er iets van de patch?
- Vind je de patch mooi/stoer/lelijk/neutraal/eng/…?
- Kan je de patch voor langere tijd op houden?

> Nee 9b. Kan je me uitleggen waarom je de patch niet op wilt doen?
- Vind je de patch mooi/stoer/lelijk/neutraal/eng/…?

10. De patch moet eigenlijk over je hart geplakt worden. Wat vindt je daarvan?
- Fijn/niet fijn, ongemakkelijk etc
- Zou je het dan nog steeds op doen?

11. Heb je het gevoel dat je het meten kan stoppen als jij dat wilt?
- Wat doe je als je wil dat het meten stopt?

12. Kan je deze patch een score geven van 0 tot 10 voor de volgende vragen, waarbij 0 totaal niet is en 10 heel erg is.
Hoe fijn vind je deze patch? …
Hoeveel controle heb je voor je gevoel over deze patch? …
Zou je deze patch gemakkelijk thuis dragen? …
Zou je deze patch gemakkelijk naar school dragen? …

13. Wat zou je willen veranderen om hem wel om te doen of beter te maken?
- Ander bandje/groter of kleiner/ander materiaal?
- Je mag hierop tekenen hoe jij de patch zou ontwerpen. *afbeelding*

Je mag nu de patch weer teruggeven aan mij, dan gaan we door met het volgende product.

Infrarood camera

14. Dit is een infrarood camera. Deze camera meet van een afstandje je emoties. Wat zijn je eerste gedachten hierover?

15. Mag ik de camera aan zetten?
> Ja *druk op een knopje*
16a. Merk je er iets van dat de camera aan staat? Wat vind je ervan?

> Nee 16b. Kan je me uitleggen waarom je niet wilt dat de camera aan gaat?

17. Heb je het gevoel dat je het meten kan stoppen als jij dat wilt?
- Wat doe je als je wilt dat het meten stopt?

18. Kan je deze camera een score geven van 0 tot 10 voor de volgende vragen, waarbij 0 totaal niet is en 10 heel erg is.
Hoe fijn vind je deze camera? …
Hoeveel controle heb je voor je gevoel over deze camera? …
Zou je deze camera gemakkelijk thuis dragen? …
Zou je deze camera gemakkelijk naar school dragen? …

19. Wat zou je willen veranderen om hem wel aan te willen doen of beter te maken?
- groter of kleiner/ander materiaal/feedback?
- Je mag hierop tekenen hoe jij de patch zou ontwerpen. *afbeelding*

Algemeen

20. Welk product vond je het fijnst?

21. Wat vind je ervan dat iemand anders hiermee kan zien wat jij voelt?
- Wie mogen dat zien wat jij voelt? (Ouders, docent, vrienden, familie)
- Mogen ze altijd zien wat jij voelt of alleen soms?

22. Heb je zelf nog ideeën voor producten die emoties kunnen herkennen?

23. Wat is je leeftijd?

24. Wat is je geslacht?

Afsluiting

Dit is dan het einde van het interview. Dank je wel dat je mee wilde doen.

Tijdens dit interview werkten deze producten niet. Ze moeten nog aangepast worden om daadwerkelijk emoties te kunnen meten. Nu ging het er om om te kijken welk product je het fijnst vindt om eventueel te gebruiken bij het meten van emotie. Jouw emotie is dus niet gemeten tijdens dit interview.

Wat wel is opgenomen, is ons gesprek. De geluidsopname zal worden uitgetypt en daarna worden gewist. Alles wat je hebt verteld wordt anoniem opgeschreven. Dit betekent dat niemand weet dat jij deze antwoorden hebt gegeven tijdens het interview. Als je het uiteindelijk toch vervelend vindt dat je antwoorden gebruikt gaan worden voor mijn onderzoek, dan kan je binnen 24 uur contact met mij opnemen met de gegevens op dit kaartje *contactkaartje*. Heb je nog vragen?

C. Information pamphlet

Informatie brochure ouders/verzorgers

Titel van het onderzoek: *Het gebruik van technologie om emoties te herkennen in mensen met autisme.*

Waarom dit onderzoek?

Dit onderzoek gaat over technologieën die emoties kunnen herkennen in mensen met autisme. Mensen in de sociale cirkel van een autistisch kind kaarten vaak aan dat het kind moeite heeft met het herkennen van de emoties van anderen, maar andersom hebben mensen in de sociale cirkel van een autistisch kind ook vaak moeite met het herkennen van diens emoties. Autistische kinderen uiten hun emoties op manieren die door anderen soms niet herkend worden. Hierdoor kan het onduidelijk zijn welke emoties er op dat moment omgaan in het autistische kind. Technologie kan in deze situatie mogelijk een uitkomst bieden.

Er bestaat technologie die lichamelijke signalen kan meten, de zogeheten biosensoren. Deze zijn bijvoorbeeld te zien in de sporthorloges die je hartslag meten. Deze biosensoren kunnen zo toegepast worden dat ze in staat zijn lichamelijke signalen op te pikken die kenmerkend zijn voor bepaalde emoties (denk aan hartslag en ademhaling, maar bijvoorbeeld ook activiteit van het huidoppervlak). Autistische kinderen hebben deze lichamelijke signalen voor emoties ook, derhalve zouden deze biosensoren gebruikt kunnen worden om emoties van het autistische kind te helpen herkennen. Producten met biosensoren zouden dus mogelijk toegepast kunnen worden voor het herkennen van emoties.

Hoe ziet het onderzoek eruit?

In dit onderzoek wordt de deelnemer geïnterviewd over het ontwerp van zulke producten. Dit zal gebeuren in de vorm van een gesprekje waarbij een aantal vragen gesteld worden. Er zullen voorbeelden van producten met biosensoren aanwezig zijn waar de deelnemers hun mening over mogen geven. Er zullen geen gevoelige vragen gesteld worden en resultaten blijven anoniem. Wel wordt er gevraagd om demografische gegevens zoals leeftijd en geslacht. Deze gegevens zijn nodig voor het bepalen van relevantie van de resultaten. Het interview zal niet langer dan 30 minuten duren (exclusief introductie en afsluiting). Tijdens het onderzoek zal de deelnemer en een onderzoeker aanwezig zijn. De deelnemer kan op ieder gewenst moment stoppen met het interview.

Zijn er risico's?

Er wordt gebruik gemaakt van een pleister van het merk VitalSigns. Deze pleister heeft een plaklaagje waar een gevoelige huid in theorie geïrriteerd van kan raken. De pleister is al veelvuldig getest en gebruikt, er zijn tot dusver geen gevallen bekend van irritatie of allergische reactie door de pleister. Ook wordt er in het onderzoek gebruik gemaakt van een infrarood camera. Infrarood is niet schadelijk voor het menselijk lichaam en vormt dus geen risico. Alle data in dit onderzoek wordt vertrouwelijk en anoniem behandeld en zal alleen gebruikt worden voor dit specifieke onderzoek.

Wat is er nodig om mee te doen?

Om mee te kunnen doen is het nodig dat de deelnemer een diagnose in het autistisch spectrum heeft, tussen de 10 en 18 jaar oud is, en verbaal kan communiceren. Het onderstaande toestemmingsformulier moet door de deelnemer en de ouder ondertekend worden en meegenomen naar het interview.

Ik hoop hiermee voldoende geïnformeerd te hebben. Mochten er nog vragen zijn, aarzel niet om contact op te nemen.

Met vriendelijke groeten,

Tamara Notenboom

t.notenboom@student.utwente.nl

Student Creative Technology

Universiteit Twente

Informatie brochure autistische jongeren

Titel van het onderzoek: *Het gebruik van technologie om emoties te herkennen in mensen met autisme.*

Waarom dit onderzoek?

Dit onderzoek gaat over technologieën die emoties kunnen herkennen in mensen met autisme. Misschien heb je wel eens meegemaakt dat je moeite had om de gevoelens van anderen te begrijpen. Vaak hebben anderen ook moeite om jouw emoties te begrijpen. Vaak uiten jongeren met autisme hun emoties op manieren die niet door iedereen begrepen worden. Het zou kunnen dat je zelf wel eens meegemaakt hebt dat anderen niet snapte wat jij voelde op dat moment. Het zou kunnen dat technologie in dit geval kan helpen.

Er bestaat technologie die lichamelijke signalen kan meten, de zogeheten biosensoren. Deze zijn bijvoorbeeld te zien in de sporthorloges die je hartslag meten. Deze biosensoren kunnen zo gebruikt worden dat ze lichamelijke signalen oppikken. Deze signalen kunnen emoties beschrijven, denk maar aan je hartslag en ademhaling die vaak sneller gaan als je bijvoorbeeld bang of boos bent. Producten met biosensoren kunnen dus misschien gebruikt worden voor het herkennen van je emoties.

Hoe ziet het onderzoek eruit?

In dit onderzoek wordt je geïnterviewd over het ontwerp van zulke producten. Dit is een gesprekje waarbij een aantal vragen gesteld worden. Er zijn voorbeelden van producten met biosensoren aanwezig en daar mag jij je mening over geven. De vragen gaan over wat jij van

de producten vindt en je naam zal niet bij de antwoorden komen, je bent dus anoniem. Wel zal je leeftijd en geslacht gevraagd worden. Dat is nodig om goede conclusies te kunnen trekken. Het interview zelf zal niet langer dan 30 minuten duren, en dan hebben we nog een klein stukje vooraf en achteraf. Tijdens het onderzoek zal jij aanwezig zijn, en ik (de onderzoeker), daarnaast mag je iemand meenemen bijvoorbeeld een ouder of een docent. Je kan altijd stoppen of pauzeren tijdens het interview als je dat wil.

Zijn er risico's?

Er is een pleister die je op mag doen als je wilt. Deze heeft een plaklaagje, maar zover bekend zorgt de plaklaag niet voor reacties. Ook is er een infrarood camera, maar infrarood is niet schadelijk voor het lichaam. De risico's zijn dus erg klein. We gaan voorzichtig met je antwoorden om en je naam staat er niet bij. Ook worden je antwoorden alleen gebruikt voor dit onderzoek en niet voor iets anders.

Wat is er nodig om mee te doen?

Om mee te kunnen doen is het nodig dat je een diagnose in het autistisch spectrum hebt (je hoeft niet te zeggen welke diagnose), tussen de 10 en 18 jaar oud bent, en het niet erg vind om met mij (de onderzoeker) te praten. Je moet wel toestemming geven voor het onderzoek, en je ouders ook. Dit kan door het toestemmingsformulier te ondertekenen.

Ik hoop dat je nu een goed beeld hebt van het onderzoek. Mocht je meer willen nemen dan kan je een email naar mij sturen.

Met vriendelijke groeten,

Tamara Notenboom

t.notenboom@student.utwente.nl

Student Creative Technology

Universiteit Twente

D. Informed consent form

Toestemmingsverklaring

Titel van het onderzoek: *Het gebruik van technologie om emoties te herkennen in mensen met autisme.*

Ik verklaar op een voor mij duidelijke wijze, schriftelijk te zijn ingelicht over de aard, methode, doel en belasting van het onderzoek. Mijn vragen zijn naar tevredenheid beantwoord en ik heb voldoende bedenktijd gehad om een beslissing te nemen.

Ik weet dat de gegevens en resultaten van het onderzoek alleen anoniem en vertrouwelijk behandeld zullen worden. De persoonlijke gegevens van het kind zal niet verstrekt worden aan derden zonder mijn uitdrukkelijke toestemming.

Ik verklaar hierbij dat ik het gezag heb om te tekenen voor de deelname van mijn kind in dit onderzoek. Ik stem geheel vrijwillig in met de deelname van mijn kind aan dit onderzoek. Ik behoud daarbij het recht deze instemming weer in te trekken zonder dat ik daarvoor een reden hoef op te geven.

Als ik verdere informatie wil over dit onderzoek, nu of in de toekomst, dan kan ik contact opnemen met de onderzoeker:

Tamara Notenboom

t.notenboom@student.utwente.nl

0645249912

Of de begeleider van dit onderzoek:

Wendy Oude Nijeweme – d'Hollosy

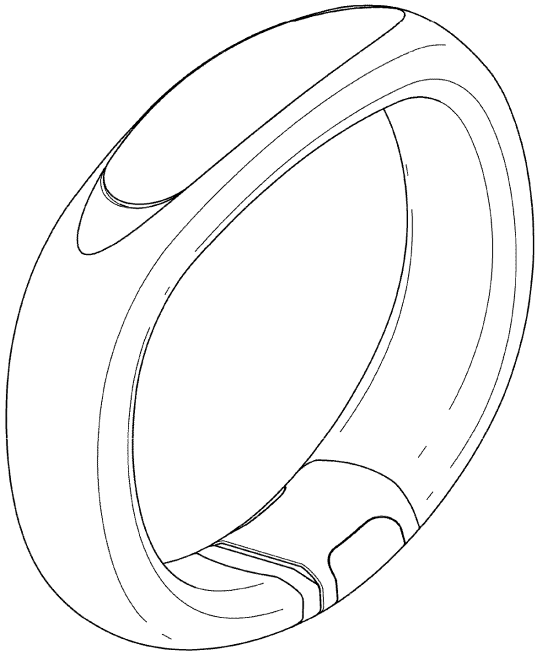
w.dhollosy@utwente.nl

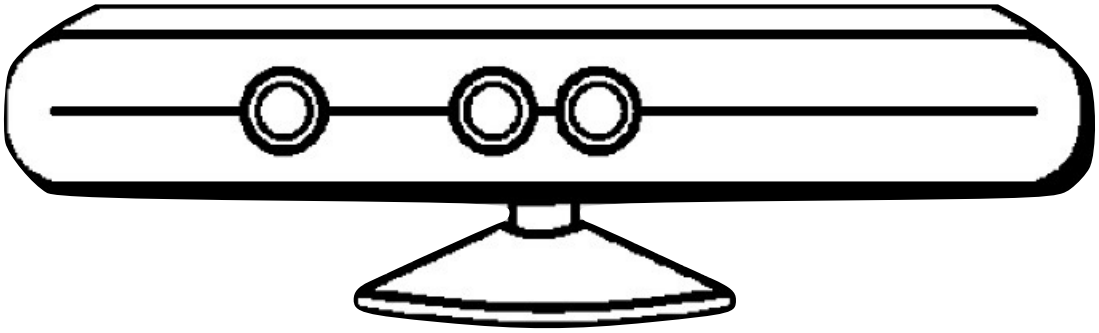
Telefoon: 053 4892766

Bij klachten over dit onderzoek kan er contact opgenomen worden met:
Jorien van Loon
J.vanloon@utwente.nl
Telnr: 053-4893748

Naam deelnemer:	
Datum:	Handtekening deelnemer:
Naam ouder:	
Datum:	Handtekening deelnemer:
Naam onderzoeker:	
Datum:	Handtekening onderzoeker:

E. Printout designs





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Thank you for reading.