Faculty of Science

Department of Information and Computing Sciences

Utrecht University

Master's thesis

Let me show you how I feel: How simple emotional gesturing affects child engagement during vaccinations

First Supervisor: Almila Akdag

Second Supervisor: Marit Bentvelzen

Daily Supervisor: Anouk Neerincx

Jessica Leven

Van Heuven Goedhartplein 28D

j.leven@students.uu.nl

Human Computer Interaction

Matriculation Number: 5222095

Abstract

Assistive robots are being increasingly applied in the health care domain to socially support humans in medical procedures. A special field is laying focus on the interaction between children and robots, because their abilities and expectations, like strong human capacities, differ and socially engaging interactions are challenging. Therefore, in this project, it was examined if a child's engagement can be increased by adding emotional gestures, a general human skill and simple act of conveying emotional information, to a robot interaction. In two experiments, 249 children either interacted with a robot executing emotional gestures (i) or not (ii) on group vaccination days in the Netherlands. Engagement was measured with an adjusted quantitative coding approach for video analysis (Kim, Paul, Shic, & Scassellati, 2012) measuring the current engagement during the interaction. Further, participants reported engagement, anxiety, fear and trust via a questionnaire. Results show a higher engagement for the interaction under emotional gestures compared to no executed gestures. In addition, the interaction reduced state anxiety independent from one's level of engagement. It is concluded that emotional gestures are a powerful distraction technique for a non-spoken interaction and support an enhanced human-like interaction. This thesis contributes important insights to the field, given that there is a lack of research comparing engagement quantitatively by observation in a real-life settings and by providing an effective strategy for increasing engagement and lowering state anxiety.

Contents

1 Introduction

In recent years, the use of socially assistive robots (SARs) in health care has increased and being widely researched (Dawe, Sutherland, Barco, & Broadbent, 2019; Rabbitt, Kazdin, & Scassellati, 2015; Šabanović, Chang, Bennett, Piatt, & Hakken, 2015). When there is a shortage of professionals in paediatric health care the demand for social robots rises because they are able to support patients social and psychological needs. Their applications ranges from assisting children in managing chronic illness or distracting children undergoing acute medical procedures.

For instance, an SAR interaction was successfully applied on the group vaccination day in the Netherlands for the BMR/DTP vaccine. The interaction was part of a project collaboration with the Centrum voor Jeugd en Gezin (CJG), an organisation that provides youth and family coaches, youth nurses as well as psychologists to support children in different activities. Among other things they organise group vaccination days, where a lot of young people can receive the most important vaccines. Here, medical professionals saw the beneficial effects in having such a SAR present and they showed great interest in using it again in order to optimise their utilization.

In general, the outcome reflected positive experiences regarding the vaccination experience of child and parents. The robot interaction was perceived as fun and positively influenced the child's distress as parents reported reduced stress levels in their children and a positive attitude towards the robots (Borghardt, 2021).

Because of their ability to communicate in a social way (such as talking, changing posture, and gesturing), SARs have the potential to create relationships with humans and being perceived as trustworthy. As a result, they can act as a social companion in the field of health care. Nevertheless, although SARs have the ability to execute a variety of these sociable skills, in theory, their application is not maximally utilized because their effects are not fully explored. They still hold weaknesses in the design of sociable traits like e.g. the adaption and conveyance of emotional information. Yet, this is necessary for the response to individuals' needs or moods. The lack of these traits can impact the human's or child's perception and be a threat to the evocation of desired effects like trust, acceptance or potential engagement.

Getting people to engage with a robot is easy, but keeping them engaged over time, regarding an entire interaction and beyond, remains a challenge. It is precisely engagement with such technologies for humans but especially for children that is important and needed if we want to integrate robots into our daily lives to assist us in real life challenges.

To achieve the goal of engaging humans more with robots, they should be equipped with appropriate social skills and behaviour as this is even expected from the human's side. Therefore, expressive behaviour has been introduced into the field of human-robot interaction (HRI). Expressive motions, including movements or gestures, contain information about the sender like affect, personality or style (Venture & Kulić, 2019). Gestures are an essential part of non-verbal behaviour in human interactions and can express emotions as well as intensity of emotions. People can judge and infer emotions from non-verbal behaviour quite well (Dael, Goudbeek, & Scherer, 2013). Thus, it can be assumed that gestures that express emotions can be seen as an anchoring sociable skill. However, what direct effect the addition sole emotional gestures have on engagement during a non-spoken interaction has not been considered in literature yet. Although engagement has been widely researched in HRI, it remains elusive in different situations and contexts (Nasir, Bruno, Chetouani, & Dillenbourg, 2021).

Further, the number of studies that measure engagement quantitatively in such interactions is limited despite it being an essential requirement in the application of robots in paediatric settings. Engagement is essential in not only in learning but also for influencing a child's emotional state. Here, the surroundings can differ from a robot that is used at home, because the child is more likely to be distracted. Therefore, it is important what social techniques can be applied to evoke engagement in situations where it is complicated achieve and if emotional gestures, in particular, can remedy the situation. The following question is addressed:

RQ: How does emotional gesturing in a social assistive robot influence child engagement and interaction during the group vaccination event?

Given the distractive environment, it is a challenge to engage the child in the interaction because attention is a rare source and can be fragile. But not only context influences the child's attentive state and subsequently engagement, but also the internal state such as felt emotions. Especially in acute medical procedures, like vaccinations, a variety of negative emotions can be present like increased levels of distress, fear or anxiety.

Jacobson et al. (2001) found that a high percentage of children experienced serious distress during vaccinations. To identify interplay of emotions, robot interaction and engagement, potential internal influencing factors, like state anxiety and fear, are addressed in this thesis. Nevertheless, it is not only engagement that is essential when aiming for the successful integration of SARs into our daily lives and for long-term relationships (Del Duchetto, Baxter, & Hanheide, 2020), but also trust.

The SAR must provide a certain degree of trust so that the human sees the robot as a social actor and not only as a tool (Naneva, Sarda Gou, Webb, & Prescott, 2020). Especially in health care trust plays an important role when it comes to effectiveness of the therapeutic strategy. Hence, the impact of the emotional gestures on trust is addressed.

SubRQ: How do state anxiety, fear and trust influence engagement and the effect of emotional gesturing?

2 Theory

2.0.1 Socially assistive robots: Introduction

Due to the many benefits that robots have, regarding productivity, time safety and many other aspects, they are being integrated more and more into our everyday lives. They are deployed to support humans and children in various situations and environments. A special field that developed increasing interest in assistive robots over the last years is the health care sector. Here, they are especially applied in child and elderly care (Dawe et al., 2019). Robots that are being applied in this context are mostly referred to as Socially Assistive Robots.

A socially assistive robot (SAR) is a robotic system that employs hands-off interaction strategies, including the use of speech, facial expressions, and communicative gestures, to provide assistance through social interaction in a particular context (Feil-Seifer & Mataric, 2005). SARs combine assistive robotics, which are mainly used for physical interaction, and social robotics, which are mainly used for social bonding and provide social interaction and physical assistance (Pulido et al., 2019). In order to provide social interactions and to lead to bonding the robot must be sociable. Sociability, here, refers to the "tendency and accompanying skills to seek out companionship, engage in interpersonal relations, and participate in social activities" (APA Dictionary of Psychology, 2022).

However, there is less clarity about how social different robots are being perceived and how sociability should be increased. In order to heighten the sociability, current focus has laid on generating natural human-like interactions, because they are essential for developing social relationships. Natural human-like interactions take the human's emotional state into account in order to provide more personalised responses (Cen, Wu, Yu, & Hu, 2016). This can allow for a more personal interaction and the build stronger long-term relationships. Bonding in turn is important for building trust and support self-disclosure.

Hence, one of the first questions to address in SARs is how the sociability can be increased and what is required of SARs to allow for an appropriate use among children? To answer this question a look into the conditions from the paediatric health sector is provided.

2.0.2 Requirements in SARs for paediatric health care

In order to apply SARs successfully they need to fulfil requirements regarding appearance and functionality. Depending on the application of the robot, different functionalities are needed. Hence, diverse robots have been developed that are differently beneficial for different scenarios.

In general, social robots come in a variety of appearances, ranging from humanoid robots like Nao or iPal, to more toy-like or animal-like robots such as Huggable or icat. All of these robots can move some of their body parts, speak, and execute facial expressions to a certain extent. Due to these capabilities, the robots are able to convey social cues and can be used to provide a natural interaction. As mentioned earlier, this is important to build a platform to bond with the child. Especially in the context of health care, stakeholders and patients ascribe these social skills as being from utmost importance (Neerincx, Rodenburg, de Graaf, & Masthoff, 2021).

On the one hand, physical and technical characteristics are required in order to have a stable and safe interaction. On the other hand, behavioural and social characteristics are needed, which allow for the adoption of the child's "momentary state" and taking emotion or mood into consideration, as well as, responding to it. Here, the "momentary state" refers to one's emotional state at a given time. The adoption however is a complex requirement due to varying reasons, such as adequate emotion capturing. Emotional adoption and expression contributes to the child's comfort in the interaction which is fundamental for trust and bonding (Neerincx et al., 2021).

These requirements are being applied more and more and have been evaluated in research. In the following, some application scenarios will be described with special focus on the application of emotional responsiveness.

2.0.3 Application of SARs in paediatric health care

As stated earlier, multiple SARs are used in paediatric care (T. T. Lewis et al., 2021; McCarthy et al., 2015), because there is a rising interest and need from the health care domain. Here, such robots are applied in various fields but mainly for mental health interventions. For instance, in rehabilitation, where the SAR acts as a therapeutic intervention, providing demonstrating, motivational, distractive and monitoring aid, (McCarthy et al., 2015) or social skill training for children with autism. Here, an improvement in social skills regarding recognition and application under the use of social robots could be found (Yun, Choi, Park, Bong, & Yoo, 2017).

Additional use includes the information of in cancer treatment procedures. In general, different interaction types, free or guided interactions, can be applied for the different activities. Some examples for guided interactions are breathing exercises, playing games, showing videos, story-telling or playing music.

The combination and application of existing interaction techniques in SARs can benefit child's engagement, which can be fragile, due to its social capabilities. For instance, Fowler et al. (1987) researched if music has an effect on the perceived pain level of injections and distress as part of a distraction technique. This includes the level of pain that the children reported as well as the observed distress. They found that this simple technique could lower pain perception of the children. However, it was not equally effective for every age group, as it was less effective in young children. They suggest thus that younger children could benefit from more interactive participation techniques (Fowler-Kerry & Lander, 1987) This, for instance, could be provided by combining the technique with a social robot, which allows for a richer interaction.

Many positive effects have been recorded by applying SARs in paediatric health care such as reduced stress (Alemi, Ghanbarzadeh, Meghdari, & Moghadam, 2016; Rossi, Larafa, & Ruocco, 2020), depression, anger, (Alemi et al., 2016) and perceived pain (Beran, Ramirez-Serrano, Vanderkooi, & Kuhn, 2013). Thus, a scenario where SARs are used and applied with success is for needle insertions or vaccinations. Here, children experience such negatively valenced emotional states. Nevertheless, the findings in the effectiveness of social robots are mixed and SARs can not always provide the desired effects.

In the following, a short overview of existing applications and research will be given.

2.1 Application and previous research of SARs in paediatric vaccinations

Paediatric vaccinations are very beneficial and useful. Still, the fear of needles and insertions in children can be high which withholds parents from letting their children receive a vaccine. Thus techniques and strategies are being deployed to lower stress and fear in children. Therefore, over the last years research in using SARs in such environments, has been conducted. However, the findings vary due to multiple influencing factors as contexts, robots used, and emotions that are experienced. In order to have a better overview of their effects, research of SARs in vaccinations will be discussed.

In research from (Rossi et al., 2020) the impact of emotional distraction, namely a social robot that conveys emotional information, on anxiety reduction was examined. Here, it was found that a robot is able to catch the child's attention and subsequently reduce anxiety and pain. This shows that a cognitive-behavioural strategy is effective and that the distraction capability was powerful enough. Still, when the child's anxiety was very high, no reduction could be found. This might be critical because highly anxious children could benefit a lot from such a distraction.

Further, they examined an adaptive emotional strategy, and found that it is effective. An adaptive strategy means that the robot's emotional state corresponds to the child's emotion state. Still, in situations like group vaccinations, it is hard to test for the child's emotional state and adjust the robot's emotional state accordingly. Sometimes, also more children with different emotional states might want to interact at the same time.

Moreover, an adaptive strategy requires an additional person to be there that can evaluate the state and subsequently control the robot as Wizard of Oz (WoZ). A WoZ is one person that controls the robot from the back but this is not notices by the participant. Therefore, in group vaccination scenarios, strategies that can be applied in any case (regardless of the child's individual state) and that can engage and decrease anxiety levels independently are of interest.

In addition, interactions on such group vaccination days are short and therefore, must be engaging enough to have an actual influence on anxiety levels. Another issue in the experiment of Rossi et al. (2020) was the high variation in age. Further, despite a large sample size only a few children with a high anxiety state got tested. Another interesting finding was the effect of age as the effectiveness of the strategy for levels of fear varied. It was more effective in young children.

The authors point out that other observational metrics of engagement, like interaction-level or length of interaction, should be examined and could gain more insights into the robot child interaction. Subsequently, they can tell us more about the use and effectiveness of SARs in the respective domain. Furthermore, the robot intervention in the study of Rossi et al. (2020) took place during the vaccination, but children already experience severe distress levels before the vaccination (Jacobson et al., 2001). An intervention before the vaccination could be advantageous because state anxiety levels are lower and children might be more open to the robot interaction.

During the vaccination and it is the case that two tasks interfere at the same time, receiving the vaccine and interacting with the robot. Whereas before the vaccine the vaccination procedure as a task is less salient. Therefore, an early intervention could lower these stress levels before the actual event in children that are less anxious before the vaccination. However, the strategy also works during the vaccination if it is engaging enough.

For instance, Rossi et al. (2020) could show a decrease in anxiety, Crossman (2018) in contrast could not find such effect. Here, no difference in anxiety levels or negative mood was found although an increase in positive mood could be shown. An explanation could be the duration of the interaction, as it could not have been intense enough to lower the anxiety levels (Crossman, Kazdin, & Kitt, 2018). This indicates the interaction needs to be rich enough to engage the child and to be distractive.

Further, experiments with robot interventions were indeed carried out, before the receiving of the vaccine, namely during the waiting time for a vaccine. Here, it was examined what effect a social bot has on the waiting time experience (Hiwat, 2020). A between subjects design was used, whereby one group received a robot interaction and the other group received an intervention with a tablet. Fun, tension and engagement were measured via a self-report survey. Also, interaction time and video observations including gaze, facial expression and verbal response were analysed. Here, no difference was found in fun or tension between the robot and tablet group. Further, interaction time showed no significant difference, although people interacted slightly more with the robot. They smiled more and permitted more verbal responses. This might be an indication for the human's social behaviour towards the robot, as it was especially observed when the participants were greeted by a hand gesture. It shows that a the human is prone to act more social when more social cues are given (Rosenthal-von der Pütten, Krämer, & Herrmann, 2018).

Further, the robot group was less distracted by their surroundings. An explanation could be that the person is more focused on the task, namely more engaged or sees his opposite as a social interactive partner and uses manners as it would be the case with real humans (e.g. using one's phone less). However, also higher levels of boredom were reported in the robot group. This again might be contrary to high levels of engagement. Thus, from this study it is not clear what aspects lead to boredom or engagement and moreover, how we can keep children engaged. Because getting children engaged is easy but keeping them engaged is harder.

In addition, here, gestures were only used for emphasizing one's message but not emotional information. It could be that the implementation of emotional gestures, using more emotional cues, could lead to higher focus and lower states in boredom. Perhaps, people are not yet sure how to interact with the robot, in other words what the possibilities are, whereas tablets are more commonly known and easy to use. Therefore, trust, comfort and interest must be high in such an interaction. Once a child finds out the limits of the robot, it can become problem. In particular, when the child realises such social cues are not existent and the robot can not fulfil their expectations (Beran, Ramirez-Serrano, Kuzyk, Fior, & Nugent, 2011).

Likewise, the child's arousal can decrease after a while and lead to less engagement during the interaction. The robot, that was used in this research can not be considered as very social as he provided no gestures or dialogues. Further, the variation in age was again high in this research (range 4-15), which is a problem in HRI since first of all the effectiveness of distraction techniques differs in age (Fowler-Kerry & Lander, 1987) but also the use of a robot due to the aforementioned reasons e.g. that younger children are in general more excited to see robots (Neerincx et al., 2021) or prescribe them with different abilities. Thus, testing effects in a narrower age range could reveal more insights or different effects.

Moreover, instructions for the interaction were provided in the present studies, so it remains unclear how a more free and self-intended interaction would have engaged the participants. These limitations go along with other research as they are hard to control, especially in field experiments. Ruocco (2019) investigated the effect of emotional distraction by a SAR on anxiety reduction. They made use of Robot NAO and the distraction procedure included the robot asking the child about interests while using social emotional cues like changing eye colour sound and motion (sequenced in WOZ mode). The results show that anxiety varies over time when interacting with the robot proving that the strategy is effective , because anxiety levels during the interaction were lower.

An important finding is that the strategy was not effective when the robot did not inhibit an emotional state. This might be a possible explanation for the low effectiveness in Borghardt's (2021) research. In line with former research, for high state anxiety no effect was found, which might be due to limited capacity of attention that is left for the intervention. This indicates emotional cues are actually needed in such interactions.

In conclusion, it can be seen that a lot of research has been done in the field. Nevertheless, it is leaving lot questions open and a lot of room for possible improvement regarding interaction style, effect and engagement in such vaccination scenarios.

2.2 Child engagement in HRI

2.2.1 Engagement: Introduction

Engagement is one of the main investigated concepts in human-robot Interaction. It remains one of the most important goals in HRI, as it builds the platform for long-term uses of the device, in this case the robot. However, the definition of engagement varies across fields as it is complex. Although it is widely researched it still remains elusive in different contexts (Nasir et al., 2021). Nevertheless, when speaking of engagement it is generally related to terms such as interest, attention and immersion.

In order to narrow the term down, in HRI it can be further distinguished between social and task engagement (Oertel et al., 2020). Social engagement, for instance, is related to an affective component, like fun or entertainment, but also inhibiting non-verbal components or cues like head rotation and gaze. On the other side, task engagement refers more to what extent someone is engaged in a task. Thus, task and social context, as well as their inter dependencies, are influencing the engagement with the robot in different scenarios (Castellano et al., 2012).

In HRI, it is mostly the social engagement that it is referred to. Hence, a definition that is often used in this context is the one from Poggi Mind (2007). It refers to the value of the interaction and inner state of a person. Thus, engagement can be understood as the "value that a participant in an interaction attributes to the goal of being together with the other participant(s) and continuing interaction" (Poggi & Mind, 2007). The definition demonstrates also the importance of the emotional level, as it is even part of engagement. If the person is not emotionally attached to the interaction no social engagement can take place.

2.2.2 CRI

Children engage differently from adults, as their goal systems and expectations are different. Therefore, child-robot interaction (CRI) is to be regarded separately as robots are not only seen as a device by children. Children are in general are more open to robots, more forgiving and ascribe certain characteristics to the robot (Tielman, Neerincx, Meyer, & Looije, 2014).

In particular, affective characteristics, which are deduced by facial expressions and movement, are being attributed by children, next to behavioural and cognitive characteristics. Here, children that are younger than 12 years old are even more likely to do that (Beran et al., 2011). This in turn means that children hold higher expectations for robot interactions (Beran et al., 2011). As a result, robots must equipped with certain abilities. Notably, when emotions are being assumed and when engagement is to be aspired. Hence, in CRI it is even more important to provide natural interactions in order to fulfill the child's expectations and to establish engagement.

2.2.3 Measuring engagement

As engagement is a complex concept, and definitions differ across and within fields, many different techniques have been developed over the years to measure it. The different techniques bring advantages and disadvantages, which will be briefly discussed. Subsequently, it will be explained why we decided on the quantitative video approach to measure engagement. Due to the different benefits, the techniques are more or less suitable for different scenarios and experiments.

For instance, engagement can be measured computationally via an engagement detection system. This is one of the most precise ways to measure it. However, the detection system requires expensive equipment. It makes the setting more experimental and less natural. This means, the participant realises throughout that he is participating in a study and usually what is being measured. Since this is a field experiment it is not the ideal way of measuring it.

The most common way to measure engagement is via self reports by questionnaires. Multiple measuring scales exist. The disadvantage is that in a field experiment it can not be ensured that the participant is filling in the questions at the right moment and there are a lot of uncontrolled variables around.

In this thesis we want to validate the engagement *during* the current interaction, but the survey will be filled out by the participants after the vaccine injection took place. Thus, the results are more distorted. To circumvent this, the interactions will be recorded and qualitatively as well as quantitatively evaluated. As mentioned earlier, there is a lack in quantitatively evaluated engagement when in comes to child-robot interactions.

As a solution, we adjusted a coding scheme according to the vaccination scenario. The participant will know that the interaction will be recorded by a camera, however no other devices need to be placed. Thus, results will thus be made comparable. Further, to ensure reliability in the method, it will be made use of "intercoder reliability" (O'Connor & Joffe, 2020).

2.3 Emotional gesturing in HRI

2.3.1 Emotions: Introduction

Emotions are experienced by every human being on a daily basis in various situations. They occur in a different intensity Depending on the individual, context, and other factors, emotions can be differently strong expressed and perceived.

In general, there exists no universal definition for emotions because they are a " complex phenomena, including more or less intense pleasant or unpleasant states of mind, linked with a vision of the surrounding circumstances, involving bodily manifestations, and initiating specific forms of behaviour and action". Moreover, the state of having an emotion is a delimited episode (Plantin, 2015) and can occur precipitously in different settings in contrast to a person's mood, which can be considered as a longer emotional episode.

Ekman (1992) identified 6 basic emotions that all human beings experience regardless of culture, namely *happiness, sadness, disgust, fear, surprise, and, anger.* Later, this list was extended with more emotions. In his approach emotions are clearly separable (Ekman, 1992). However, emotions are found to me more complex and can further be categorized into discrete or continuous. Thus, it allows for a more specific classification of emotions.

Here, the most popular classification is made by Russell (1980), which is often used in robotic systems for emotion recognition and display (Russell, 1980). Here, emotions can be mapped in a 2-dimensional space, regarding their level of arousal and valence. This leads to more complex emotional states as well as smoother transitions between emotions. Another more advanced classification approach of emotions is the wheel of emotion (Robert, 1980).

Plutchik (1980) uses a color wheel to describe the composition of emotions, which can be presented by different hues whereby 8 basic emotions act as the foundation. These two approaches are used often for emotion analysis as they allow to map a wide range of emotion by a small set of categories (Williams, Arribas-Ayllon, Artemiou, & Spasić, 2019). It is important in human-robot interaction to be aware of the recognition and expression of emotions as they build the platform for possible relationships.

This project will focus on how emotions can be best expressed in HRI. In general, they can be expressed by vocal characteristics but also by bodily expressions including face expressions, posture, movements or gestures (Wallbott, 1998).

2.3.2 Human's expression and perception of emotions: How to create a natural human-like interaction

Usually, facial expressions are the most important or richest messenger of emotions containing a lot of information and being mostly universal. Nevertheless, robots that are able to express such facial expressions are very expensive and still not very evolved and cheap robots lack in expressing enough information through the face.

Further, very human like robots with complex facial expressions might fall under the uncanny valley effect (Mori, MacDorman, & Kageki, 2012). This means, if a robot looks very human-ike but is no human can be perceived as creepy. Interestingly, for young children this remains less of a problem (Brink, Gray, & Wellman, 2019) assuming due to the early exposure of machines and animations. However, it remains a problem for older children.

Another way of conveying emotion is by voice. Nevertheless, it was found that an emotionally adapted voice can lead to higher levels of comprehension problems, due to high or low pitches in the voice that makes words less understandable (Tielman et al., 2014). Therefore, it is important to look for other ways to convey emotional information in robots.

In general, the perception of people is further affected by their gestures, body movements and posture as they contain a lot of emotional information and the person's state of a person. This means, humans show their emotions not only by facial expressions or voice but also by gesturing (Lhommet & Marsella, 2014; Castellano, Kessous, & Caridakis, 2007). Thus, one way of expressing emotions is through gestures. This is the focus of this research as especially in robots this is can be one of the main transmitter of emotions due to aforementioned reasons.

2.3.3 From facial expressions to nonverbal communication

In order to understand the use and impact of emotional gestures more we start by having a look into human-human interaction first.

In human-human interaction, gestures have been researched for a long time, starting way back with Darwin's (1872) work "The expression of the emotions in man and animal", where he outlines some postures and movements that are expressing certain emotions. Gestures fall under the term nonverbal communication. Nonverbal communication, or so called body language is the way using gestures and posture which can be applied consciously or unconsciously for communication.

As a result, gestures are part of non-verbal behaviour in human interactions and can express emotions as well as intensity of emotions. In general, people can judge and infer emotions from non-verbal behaviour quite well (Dael et al., 2013). Here e.g. the state of the emotion anxiety can be expressed by "Touching or pulling the hair, plucking eyebrows, wriggling or interlocking the hands, opening and closing the fist, aimless fidgeting, hiding the face " (Lhommet & Marsella, 2014).

Some gestures can be understood universally such as jumping for happiness, or holding the hands in front of one's face for sadness (Shen, Cheng, Hu, & Dong, 2019). Other gestures are less universal and can change its meaning during to context, culture or other factors. Those gestures are needed to have a natural human like interaction and to experience and express emotions during interactions. Still, whereas human gestures are well understood by humans, as they are normally accompanied by voice and facial expressions, for robots this is not always the case. Thus, it remains a lot of uncertainty about the direct effects on humans.

2.4 Emotional gestures

2.4.1 Emotional gesturing in robots: A way of conveying emotion

Further, the gestures that a robot is able to do are more abstract than from humans, due to their restricted doFs. Nevertheless, those gestures, or more the act of showing emotion, is even expected by humans. This is due to the the "robot equation", an extension of the media equation (Reeves & Nass, 1996). The media equation assumes that people assign human characteristics to media like machines or computers and treat them as social actors. Since robots are an embodied version of such machines with even human like behaviour, it is assumed that the theory also applies to robots in an even stronger manner (Li, Chignell, Mizobuchi, & Yasumura, 2009). Because of this, the communication of emotions in social robots is crucial for the human-robot interaction including affective responses. Hence, it has been more in focus of research over the last 30 years whereas the role of emotions in robotics can be regarded as input, output or for internal system processing (Savery, Zahray, & Weinberg, 2021).

So far, a lot of focus has been laid on facial expressions in displaying emotions or head and arm movement, whereby emotional gesturing as a from of displaying emotion has been researched less with its effects and importance on human perception.

In most of the research, facial expressions are used to convey emotions and affective state of the robot (Breazeal, 2009) rather than conveying it in form of gestures. Hence, in this thesis we are focusing on displaying emotions in form of gestures since these have been less researched up to date and effects on attention and engagement as well as other concepts are still unclear. The goal of using such gestures is to generate more human-like interactions and to support the expression of emotions. Especially, since humans are the only species that make use of gestures to express emotions (Flaisch, Häcker, Renner, & Schupp, 2011), that skill would delimit robots more from being just "technology" and into being seen as more human-like.

2.5 From emotion to attention to engagement

As previously mentioned, engagement is dependent and related to a child's emotional state. Therefore, the emotions that can be experienced, especially in therapeutic scenarios, can influence the child's engagement. Engagement inhibits cognitive processes such as attention, affect and interest , and in order to have a high engagement focused attention is required (Lagun & Lalmas, 2016). Here, in cognitive sciences the impact of emotional states on attention is frequently pointed out. It it thus important to consider the emotional salience in attention regarding the perception of emotional stimuli, especially in situations where high span of attention is required or desired.

2.5.1 Limited attention capacity theory

In order to understand how emotional gestures, acting as emotional stimulation, can impact engagement we will look at the limited attention capacity theory by Kahnemann (1973). This theory provides an explanation for the relation between emotions and attention and subsequently engagement.

The limited attention theory is a bottleneck theory assuming that there is a pool of attentional resources that is limited. Thus, the attention that can be applied or expended to an object or act is limited. As a consequence, the amount of engagement with the mentioned object or act is restricted. In general, it is possible to engage in more than one task simultaneously, but with limited attention. The available capacity of attention is impacted by various sources of arousal.

As it can be seen in Figure 1 arousal, that comes from a person's emotional state, has a direct impact on the attention resource pool. It occupies resources and subsequently limits the capacity for other entities. Here, the level of arousal is controlled by two factors.

Firstly, the demands that are imposed by the activity the person is engaging in or prepares to engage in. In this project this activity would be the vaccination, meaning the injection of the needle. Secondly, other various determinants, such as the intensity of stimulation, emotional state, or drive state. In this study, the anxiety that a person might experience during the vaccination is one of those determinants.

In conclusion, internal but also external states have an influence on the person's ability to engage (Kahneman, 1973). Thus, it is expected by making the distraction more natural and to trigger emotional responses in the child, we can influence this external circumstances in order to make it more engaging. However, the internal state can not always be influenced, and thus, it is important to see how the internal state of anxiety is affected by it or also how it affects the interaction.

2.5.2 Emotional gesturing in social robots: Previous research

A variety of approaches for interpreting emotional gestures and expressions exist for human-human interaction. Likewise, approaches and design considerations for human-robot interaction have been developed. The most important ones will be addressed and discussed in this chapter, leading to the chosen gestures for this project.

First of all, a lot of research has been done in industrial settings, where fast and accurate motions from robots are needed. However, those movements and accurate motions are also required in interactions because they influence the perception of the robot, as e.g. scary or entertaining. Movements, that convey information for the sender are being called expressive motions (Venture & Kulić, 2019).

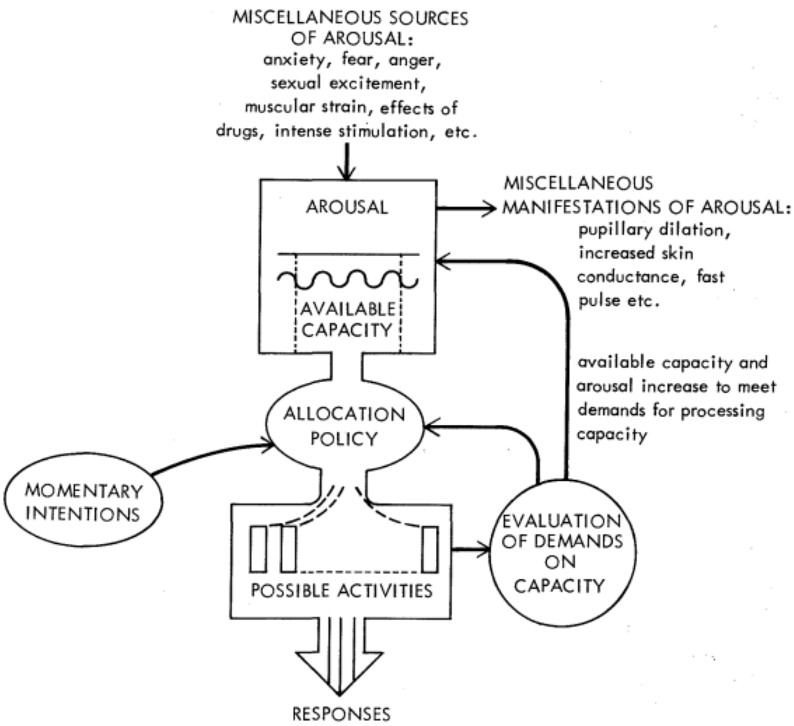


Figure 1: Model of limited attention capacity from Kahneman (1973)

Expressive behaviour inhibits the conscious or unconscious action of conveying emotions, desires, intents and or personality by means of behaviour (OxfordReference, 2022) and is essential for the formation of relationships between children and robots. By showing interest and empathy through behaviour (Tielman et al., 2014) the child's expectations of the robot's social skills are met, which serves as basis for the development of further effects and bondings.

Emotional gestures can be seen as some kind of subset of expressive motions because those are gestures that "only" or primarily convey emotional information. Here, a distinction is made between gestures that support a message or emotional information. For instance, gestures can contain semantic and non-emotional information with emblematic meaning like a thumbs up (Li et al., 2009). Nevertheless, in this thesis the focus lies on gestures that convey emotional information to the receiver.

As mentioned earlier those gestures are essential in order to suggest social skills, which are impacting factors like attitude towards the robot, engagement and other things. Therefore, it is important to know is how to implement those emotional gestures best, because they contain a lot of information about the sender, like affect, personality or style (Venture & Kulić, 2019).

Effects of emotional gestures were found in former studies. For instance, the effect of portraying emotions through movement in robots has been investigated (Tielman et al., 2014). Here, it could be shown that it is considered as a positive trait and children enjoyed interacting with that robot. In fact it could be shown that children enjoy the interaction with expressive motions while expressing more emotions themselves (Tielman et al., 2014). Still, Tielman el al. (2014) distinguish between the concepts of showing emotion and gesturing, whereas gesturing is more targeted as a way of supporting one's meaning. Here, the gestural model was chosen on one's type of narrative and type of gesture to reflect such. Subsequently, gesture movements are dependent on the input of gesture options and not directly on the emotional input like emotional occurrence, valence, and arousal of a child.

However, gestures can express certain emotions directly without having to be presented along other behaviour. It is not immediately clear from their research what influence the sole presence of emotional gestures has on the children's feelings and experience. Moreover, to what extent emotional gestures alone influence the child's state needs to be determined.

Also, in their research they used the Nao Robot. Nao is able to perform a wide range of gestures and movements. Yet, he can not be used in any environment e.g. slippery floors, because the mobility can be limited and he can fall over. This leads to the problem of Nao not being able to execute the required motions (McCarthy et al., 2015). The iPal robot is more stable and can be easier applied in varying environments, where the floor is not optimal. Nevertheless, he is also less flexible than NAO and can perform less body movements and gestures. Moreover, iPals movements are less smooth than human ones and come with a noise.

Although the gestures of robots are more abstract than humans gestures, this has been shown to be no major threat into recognizing emotions correctly (Embgen et al., 2012). In their research, they examined if displayed emotions in form of emotional body language can be successfully recognized and interpreted by humans. Therefore, they made use of robot Daryl, with 10 doFs, and presented the participant with primary (happiness, sadness and fear) and secondary emotions (curiosity, embarrassment and disappointment). Participants then assessed these emotions in a survey. Results showed indeed that emotions were clearly identified, including primary and secondary emotions. However, some emotions remained more ambiguous than others, like e.g. embarrassment.

Furthermore, they also made use of robot-specific nonverbal behaviour, like using LED-colours for portrayal of emotion, in addition to gestures. Thus, it still remains unclear how sole gestures were evaluated. However, other research shows that robot-specific nonverbal behaviour, is not as powerful as human-like (affective) nonverbal behaviour in robots including emotional gestures (Rosenthal-von der Pütten et al., 2018). Therefore, it can be assumed that indeed the gestures in isolation are a powerful instrument to convey emotions.

Nevertheless, an important factor in interpreting gestures correctly might depend on the simplicity and possible movements of the robot. Li et al. (2009) found in contrast that simple gestures were not as easily recognizable. Here, the tested gestures with a robot than can only move his arms and head vertically. It was presenting different emotions which were beforehand created by non-experts. The results show that emotions were judged correctly in isolation but the evaluation was poor and included a lot of mistakes. Providing context, e.g. in form of a story, improved the identification. An important finding resulted from gesture complexity. Whereby increasing complexity in arm gestures increased the perceived life-likeness of the robot, it decreased the identification of emotions.

Also gestures that convey messages and gestures that convey emotions are perceived in different ways and as stated before more complex gestures do not necessarily support a better understanding of message and emotion (Li et al., 2009).However, in Li et al. (2009) research the robot inhibited limited doFs and not a lot of information could be conveyed which might have led to the poor results.

Another problem in using emotional gestures is the intensity and complexity of gestures. They must be intense enough to be understood. Indeed, Tielman (2014) found that when the robot moved more it was perceived as more fun by the children. But it was also perceived as less trustworthy when not being calm enough. Also in tasks like playing a game, emotional gestures should not be too distractive or physically hinder a possible interaction. The complexity however depends on the simplicity of the robot.

In conclusion it can be said, that gestures are indeed recognizable, but it depends on the robot's abilities and other stated factors if they can be easily recognized. It applies to determine how powerful their impact can be and what their impact is and how it can be improved.

Applying emotional gestures in an SAR for group vaccinations

The robot iPal has a high range of opportunities to convey emotional information due to its high degrees of freedom (dofs), which is comparable to robot Daryl. In order to ensure that the right emotional information is being conveyed, we will make use of the basic emotion joy, as basic emotions should be recognizable universally (Ekman, 1992).

All used gestures have been proven to be recognized to convey the emotion joy, in different set ups. Also, the focus lies on the effect on engagement and not on the design of emotional gestures. It is important that the intended emotion thus will be conveyed. Therefore, 5 validated simple emotional gestures, that represent joy, have been used. The used gestures are presented in the method section.

2.5.3 Social communication for child engagement: emotion and attention

As stated earlier, there is connection between attention and emotion. According to the cognitive emotion theory, emotions focus attention and influence motivation, which are two necessary components for engagement (Reisenzein, 2009, 2020). This is in line with the limited capacity model, which states that attention capacity is influenced by emotions.

It could be shown that positive experienced emotions have a positive influence on engagement (X.-Y. Xu, Niu, Jia, Nthoiwa, & Li, 2021). This can be explained by the fact, that such emotions lead to greater attention and thus to higher engagement. Further, it was stated that children expect that robots inhibit emotions (Beran et al., 2011). Thus, with emotional gesturing the expectations should be met more, than when the robot is interacting without conveying such emotions.

It can be assumed that when the emotions of the robot trigger or induce positive emotions in the child also the engagement for the interaction will be higher. In contrast, negative emotion induction could evoke fear and anxiety which leads to internal arousal and the restriction of attention capacity. However, the child needs to be attentive. This can be an issue on days like group vaccinations, where a child experiences different negative emotions at the same time and the environment is hectic. Thus, attention resources can be easily occupied, which leads to the fact that an engaging interaction is challenging.

This means, the interaction provided by the robot needs to inhibit a high state of emotional arousal in order to engage the child, if the child inhibits such a state. It is important to to what extent that child is impacted by these emotional stated and if the interaction can be engaging enough.

Findings do not always support that adding social characteristics benefits the child's experience or can increase engagement. For instance, the addition in child's software showed no positive effects (Chiasson & Gutwin, 2005). Therefore, the relation has to be explored more. What kind of intervention or interaction is powerful enough to actually heighten engagement? As robots come in a humanoid form it is expected that adding social traits have a stronger effect than in sole software and can indeed heighten engagement.

Further, it could be shown that the sole presence of emotional gestures in humans guide visual attention and are preferentially processed and show similarly active ERPs as visual emotional cues(Flaisch et al., 2011). By focusing attention, also engagement can be evoked. Emotional gestures are a way to catch the attention in an interaction. Due to the power of emotional gestures it is assumed that:

H0: There is no difference in (a) observed or (b) self-reported engagement between an SAR interaction with emotional gesturing or without emotional gesturing

H1a: Emotional gesturing in a SAR-interaction leads to higher observed engagement than a SAR-interaction without emotional gesturing

H1b: Emotional gesturing in a SAR-interaction leads to higher self-reported engagement

than a SAR-interaction without emotional gesturing

2.6 Anxiety: A threat to CRI

As discussed before, attention is limited and emotions can actually limit the resources by occupying them (Beran et al., 2013). Thus, depending on the emotional state of the child, like intensity (arousal) or valence, emotions can also interfere with engagement. This applies especially for task engagement but also social engagement whereas especially emotions with a high arousal might pose a threat as they take up attentional resources.

Especially in situations, like vaccinations, children might experience a certain level of anxiety, excitement or nervousness which according to Russell's model of affect (Russell, 1980) inhibits different levels of arousal and valence. These levels of arousal and valence might then influence the child's perception , acceptance and responsiveness towards the robot. In the current setting for example it is likely that children experience a higher state anxiety.

2.6.1 Anxiety: A sub-concept of fear

Anxiety can be defined "as an emotional state, with the subjectively experienced quality of fear as a closely related emotion" that is unpleasant and negative (A. Lewis, 1967). Anxiety can occur as a trait or state.

State Anxiety is a timely restricted state and a subordinate emotion of fear (Russell & Barrett, 1999) which is experienced with high a high level of arousal and comes with feelings of apprehension, dread, and tension. Trait anxiety is more a predisposition that a person inhibits to act in certain situations (Spielberger, 1966). Due to the high level of arousal that it comes with it has an impact on the attention resources, and thus the ability to engage.

2.6.2 The impact of anxiety on attention and engagement

Drawing on the limited attention theory, it can be conducted that if a stimuli towards pain or the anxiety is too intense, then the capacity for the distraction task is restricted. This is, because the intensity of the task that the person wants to engage in, the injection, plus the high arousal and negative valence in anxiety takes all the attentive resources and limits the remaining available capacity.

Especially emotions with a negative valence, such as state anxiety or state fear, can limit the resource pool of a child's attention span or redirect it to stimuli with negative valence which leads to the issue of having a greater challenge to reengage the child. Thus, the distraction might not be equally powerful for every child.

Ruocco et al. (2019) found that children with a high anxiety state could not be as effectively distracted as children with a medium anxiety state. Further, only when emotional cues were present the distraction worked for the children with a high level of anxiety. This means if the stimulation of the interaction is not intense enough, as the anxious stimuli, its impact is only limited. Beran (2011) thus deduces, that the valence towards the distraction must be higher than towards the needle of the vaccination event. In order to do so,an emotional valence and arousal need to be conveyed to be powerful enough in order to redirect and attract the valence and arousal (Beran et al., 2011).

In the past VR distraction techniques showed mixed findings in the past, and were not always powerful enough. However, it is assumed that the use of a robot will be more engaging and distractive, (Beran et al., 2011) than other techniques. It is assumed that the stimulation by robot is higher and more distracting because the child will be addressed on a deeper emotional level. However, in the mentioned findings the level of arousal through the experienced anxiety is not regarded.

Further, the general problem remains that not enough people with a high anxiety state were taking part in the study (Ruocco, Larafa, & Rossi, 2019) and it remains unclear how emotional gestures can impact engagement under high state anxiety. Therefore, it will be examined, how the state of anxiety impacts engagement in an interaction under emotional gestures. Regarding the influence of anxiety on such attention levels, meaning that high anxiety limits the attentive resources for the robot interaction, we assume that it also impacts the relation between emotional gestures and engagement. It is assumed that the high levels of arousal impact the attentive capacity for the distraction intervention. Thus, the level of engagement will be lower in children that inhibit a high state of anxiety.

H0: Pre-state anxiety leads to no decrease (a) observed or (b) self-reported engagement.
H2a: Pre-state anxiety leads to decreased observed engagement
H2b: Pre-state anxiety leads to decreased self-reported engagement

While state anxiety can inhibit the potential engagement, the opposite effect is also possible. Engagement can lower the arousal induced by state anxiety. This is, because the more engaged one is the more attention is paid and used. Hence, more attention resources are occupied with regards to the task which leads to less available capacity for internal arousal, and thus displaces the state anxiety from the resource pool, or at least can lower it.

Subsequently, it is assumed that when children are highly engaged in the interaction it distracts more from the upcoming vaccination,by taking up more attentional resources through focusing on the present task, and lowers the post-state anxiety.

H0: (a) Observed or (b) self-reported engagement leads to no decrease in post-state anxiety
H3a: Observed engagement leads to decreased post-state anxiety
H3b: Self-reported engagement leads to decreased post-state anxiety

As mentioned before, due to the restriction of the available capacity in attention by negative valence and arousal, the capacity for potential engagement is restricted. Hence, even though emotional gestures are proven to catch and guide the attention (Flaisch et al., 2011), if there is not enough capacity available due to the the child's internal emotional state also external stimuli might not be powerful enough to draw attention and engage the child. This means emotional gestures might not be effective for children that are highly anxious and such an intervention would not be necessary.

For the investigation of this possible moderating effect, however, we will look at state fear instead of state anxiety as state anxiety and state fear are two closely related concepts and the non emotional condition was only measuring state fear. In order to compare the effects, state fear will be examined.

H0: The effect of emotional gesturing on (a) observed or (b) self-reported engagement is not weakened by pre-state fear
H4a: The effect of emotional gesturing on observed engagement is weakened by pre-state fear
H4b: The effect of emotional gesturing on self-reported engagement is weakened by pre-state fear

By testing this hypothesis, it will give us an indication on how anxiety might act as a construct as fear and anxiety are highly dependent and former research found similar effects in the two emotional states (Rossi et al., 2020).

2.6.3 SAR-Interaction: Application and Challenges

An emerging and remaining problem is that children with high state anxiety are less open for the interaction with a robot according to experiences nurses that were present at the vaccination events. (Rossi et al., 2020) As mentioned before this might be due to the fact that there is no capacity left for the child to be willing to engage in anything else. Still the setting in a group vaccination center, when children see other children interact with the robot might rise a bit more interest.

However, similar behaviour by highly anxious children same was observed during the group vaccination day in 2021 (Borghardt, 2021). Still, if the children might be too anxious before the vaccination they will get a second opportunity to speak to the robot after the vaccination took place. Insights could be gained thus, if they participate in the second interaction.

Furthermore, the perception of emotions in children can be dependent on age and subsequently the capabilities that a child attributes to the robot. Therefore, by looking at studies with a wide age range in participants we always have to keep in mind that the social skills can be perceived differently. Thus, it needs to be explored more in children how such emotion gestures work. The challenge it thus, that robot doesn't meet child's expectations. If that is the case, then the interaction could not be distracting enough and no effect would be found.

Further, age is not only influencing the robot's perception but also the effectiveness of the distraction technique used. Here, it could be shown that there is an age effect in such techniques, which means that e.g. some are more effective for older children, whereas others work better in younger children (Fowler-Kerry & Lander, 1987). Hence, age is an important co variable that should be considered in this project.

2.7 Trust, engagement and richness in an SAR interaction

Especially in the field of health care, trust in a social robot is related to its therapeutic effectiveness as well as one's satisfaction with the SAR. In addition, it is not only important for the interaction's quality but also how willing a person is to make use of such an SAR, cooperate with it or accept it, as well as, share information (Naneva et al., 2020; Khavas, 2021). Respectively, trust is a determining factor on how rich and/or engaging the interaction with the robot can be and how likely it is that the human will make use of the SAR again.

When it comes to richness of the interaction it is referred to the level of self-disclosure and how deep or long the exchange of information is (Panyasorn, Panteli, & Powell, 2008). Therefore, a look at expressed sentiments and words can provide indications about the level of richness of the interaction. Due to these effects, trust is a central condition when we want to achieve a successful interaction (Kellmeyer, Mueller, Feingold-Polak, & Levy-Tzedek, 2018). Trust is hereby mainly effected by the robot's design or performance (Naneva et al., 2020). Regarding that, it is assumed that a more social performance of the SAR (including the execution of emotional gestures) leads to higher levels in trust. It is assumed that the more trust is perceived by the humane the richer the interaction will be.

Hence, exploratory, it will further be looked at the perceived trust levels and how this can effect engagement or the richness and quality of the interaction. This will give important insights because the impact of trust in social robots is unclear. Findings in past research differ, demonstrating that further evaluations regarding trust are necessary (Kessler, Larios, Walker, Yerdon, & Hancock, 2017).

2.8 Previous Project with the Family and Youth Center on SAR application on group vaccination days

As mentioned earlier, the request for the application of SARs in vaccination scenarios is high. Thus, in 2021, a study has been conducted on the group vaccination day in collaboration with the Family and Youth Center (in dutch: Centrum voor Jeugd en Gezin) to explore a child's experience of the vaccination after the interaction with a social robot.

2.8.1 Collaboration with the family and youth center

As mentioned earlier this is a follow-up study for an experiment that was carried out in 2022 by Borghardt (2021). His research was conducted in collaboration with the Family and Youth Center in Capelle aan den Ijssel. The center supports young children in different procedures and situations. There are appointed life coaches and nurses, that can advise children and teenagers in their problems and questions. One of their program points is to help children receiving beneficial vaccinations and make them easily accessible for them.

They own two humanoid robots. Here, their goal was to examine how children and robots interact with each other to gain more insight and clarity. This knowledge will help us to use SARs better and expand their use to different application fields. Therefore, in 2021 an experiment at the group vaccination day was conducted, where the robots were applied with success.

2.8.2 Impact of an SAR on child's engagement during the vaccination day

The former experiment took place on the child vaccination day in the Sporthal Schenkel in Capelle aan den Ijssel for the BMR (mumps, measles and rubella) / DTP (Difteria, Tetanus and Polio) vaccine. Those vaccinations should be received a couple of times in one's lifetime starting with a young age. In the research two groups were formed and compared, the interaction-group and non-interaction group. The interaction involved watching a video that was presented on a tablet attached to the robot iPal.

Quantitative and qualitative data was collected and analysed. On the one hand, observations of behaviour were extracted via video analysis. On the other hand, an evaluation in form of a survey, which measured different HRI related concepts, including trust, empathy, and engagement, was carried out. Further, parents' reports and observations of their child's experience were regarded.

Unexpectedly, the results showed no difference in the child's experience regarding fear when the child interacted with the robot or not. This means the robot interaction had no influence on the vaccination experience and was not powerful enough to lower levels of fear.

In general, the robot was positively perceived, whereby girls preferred the robot slightly more. These findings were insignificant and are in line with other research, stating inconsistency in gender effects or reporting no such effects at all (Gallimore, Lyons, Vo, Mahoney, & Wynne, 2019). Results showed that there was an overall moderate engagement with the robot. Interestingly, parents indeed reported that their children were influenced in their stress levels when the interaction with the robot took place. In addition, the robot was positively accepted by parents. An important finding is that the parent's opinion toward the robot is strongly impacting to the child's opinion.

A limitation of this study was that the vaccination took place during COVID-19 times under certain restrictions. This means, it was less crowded and the waiting times were shorter than usual which might have hindered a possible stronger effect of the interaction. For instance, parents were dragging away their children from the interaction in order to stay in line.

Further, although engagement was measured, it was done by only self-reported data in a survey and observational cues. Regarding the many different influencing factors at the vaccination day, these results can be less accurate and thus are not an authentic indication on how engaging the interaction was. Also, the survey sheet was not filled out immediately after the interaction what makes the self-reports less reliable.

On the whole, in this experiment it is questionable to what extent the robot can be regarded as social, as no emotional information was conveyed during the interaction and only limited social cues, like hand waving, were used.

As a result of the aforementioned positive experiences and the need of investigating more of the robot's possibilities, this follow-up research was planned. In addition, due to the shortcomings, in this project the possibilities of the robot interaction are being stretched out more as well as an extension of the measurements.

3 Method

In order to test the hypotheses empirically, a mixed approached will be used, using quantitative and qualitative data for the analysis. The experiment took place in cooperation with the CJG on the group vaccination days for BMR, DTP, HPV and meningococci in the Netherlands. The first day for the group vaccination took place on the 15th of March where mainly boys in the age of 17 were vaccinated. Here, the collected data will be used for a pilot study. The second vaccination day takes place on the 19th of April for boys and girls around the age of 9. Here, the final experiment took place.

3.1 Participants

The full sample consists of 253 participants. The sample includes collected data from experiments of the group vaccination days of two years in a row (2021 and 2022). The sample consists of an arbitrary amount of children that were invited to the vaccination day from the CVJG. The participants were approached by convenience sampling and not informed of the main purpose of the study. 4 participants were excluded from the final sample as they were too high in age and could hold different perceptions and expectations about the robot. Hence, the final sample consists of 249 participants ranging from 8-10 years old (M_{age}= 8.34, SD_{age}= 0.49, 120 *boys*, 89 *girls*, 40 *unknown*).

3.2 Design

A between-subject design is applied in this research and the two conditions were formed in the respective year. The children in 2021 received an interaction with no gestures (NG) (n = 149) and in 2022 an interaction with emotional gestures (EG) (n = 100). Both received a survey that measures fear, engagement and trust. Within the groups, fear and anxiety were measured at two different points in time, namely before and after the robot interaction.

*NG condition.*The data set without emotional gestures includes 149 participants, with 129 participants reporting age and gender (M_{age}= 8.33, SD_{age}= 0.49, 77 *boys*, 52 *girls*, 20 *unknown*).

EG condition. For the emotional gestures 104 participants filled out the survey. After the exclusion there were 100 participants left, from whose 80 reported their age and gender (M_{age}= 8.38, SD_{age}= 0.49, 43 *boys*, 37 *girls*, 20 *unknown*).

3.3 Study procedure for EG interaction

At first the children, in the following stated as participants, entered the Sporthal Schenkel in Capelle aan den Ijssel. There, they were welcomed by students and invited and attracted to take part in the study. To attract the participants they were told to have the chance to interact with the robot. If the parents agreed and signed the consent form and a short questionnaire was handed out. After the participants filled in the first part of the questionnaire the participants continued in the queue in order to get to the registration (as it can be seen in Figure 2, step 3) for the vaccination.

Here, the first interaction with the robot took place. The participants were asked to place themselves in front of the robot and the video along with the execution of emotional gestures was presented. All of the interactions were recorded. After the video has finished (optimally, because the child can leave at any point during the interaction) the participant continues to be in the queue and can fill out the rest of the survey and continue to the registration.

After that, the participant received the vaccine and continued towards the exit direction as the arrows show in Figure 2 after step 4. Before reaching the exit door, the participants were asked return the survey and to fill out the rest of the survey, if they haven't done it so far. Then, once more, they were asked to interact with the robot and the child has the option to interact again. The survey was put respectively into one of two mailboxes, depending on the willingness to interact again (i) or not (ii) (step 5 in Figure 2). If the child agreed to have a second interaction, just before the exit door, (as it can be seen in step 6 of 2) another interaction with the robot took place.

This time the interaction contained two questions that were asked by the robot. The participant was asked to verbally answer to the robots questions. The programme for the robot's output was remotely controlled in WoZ mode, so that the different response times could be considered. Lastly, the participants were being thanked for their participance and could leave the room. In general, the experiment was kept as short as possible as Looije et al. (2018) recommend, to have a reasonable experimentation time and to decrease the cognitive workload for children.

3.4 Study procedure for NG interaction

The study set up was mostly similar for the NG condition, although the time point of the intervention differed. The children entered the Sporthal Schenkel in Capelle aan den Ijssel via the same entrance. They were getting to the registration immediately (corresponds to step 4). After being registered, the children queued in different lines to receive the vaccine. In one of the lines, the no gesture SAR interaction took place. This happened just before the event of the vaccination. The parents were asked to give consent, fill in the survey and then the child was requested watch the vaccination video on the robot (corresponds to step 3).

After receiving the intervention, the child continued in the line to receive the vaccine. In the next step, the child continues towards the exit. There, the surveys were collected and the children were thanked for their participance and were free to go. No second optional interaction took place.

A map of the study set up can be seen in Appendix A.

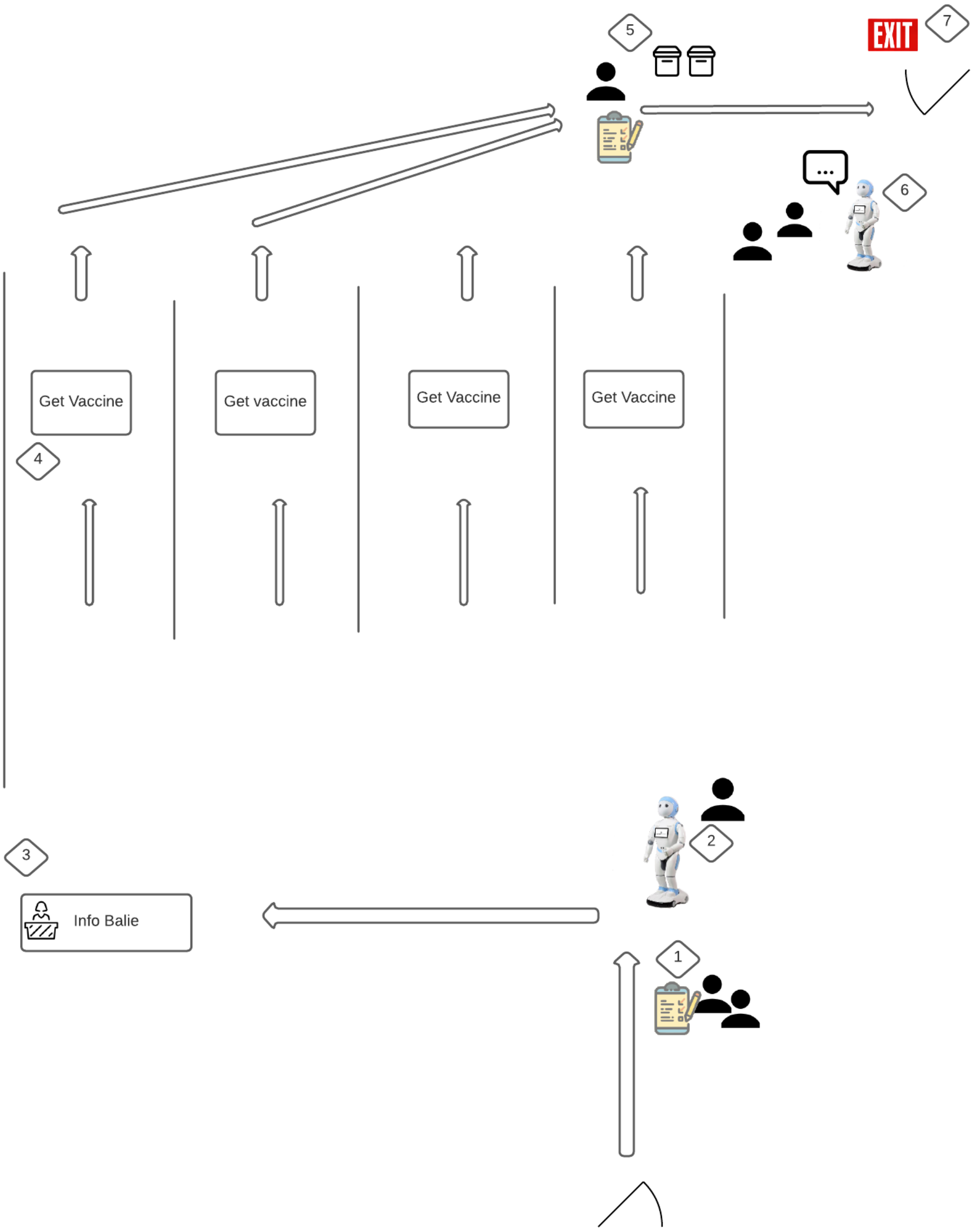


Figure 2: Map of Sporthal Schenkel and EG study procedure

3.5 SAR interactions

3.5.1 SAR: iPal

The robots that the center has purchased are the social robots iPal. iPal is a 3.5 feet tall humanoid robot that can talk, track someones gaze, move and gesture to a certain extent and has an integrated 6 inch tablet on his chest where a child can interact with. iPal has been used in the former experiment and has 10 doFs. Due to its robustness and moderate number of doFs the robot is well suited for the application as and assistant for the children by allowing distraction and entertainment but also convey emotional information.

3.5.2 No gesture SAR intervention

The SAR-intervention involved watching an animated video about the sense and benefit of a vaccine that was presented on a tablet attached to the robot iPal. The interaction lasted 1:15 minutes and contains a high pitched voice and joyful music effects to trigger emotions of happiness. A greeting gesture was executed at the end. No other gestures or movements were executed by the robot.

3.5.3 Emotional gesture SAR intervention

The robot intervention is supposed to inform and distract the participants by engaging them in the interaction. Since the surrounding on the group vaccination day is very hectic and noisy, the arousal for the robot interaction should be kept high because the participants are likely to be aroused already, by their environment or internally by e.g. state anxiety. For the reason that the counterbalancing both arousal levels would be hard to achieve, especially with such a noisy environment it was decided to implement emotional gestures with a high arousal and positive valence. High levels of arousal can increase the levels of distraction (Tecce, Savignano-Bowman, & Meinbresse, 1976) and the gestures should attract the attention from the distracting environment.

Furthermore, the video that is presented to the participant is containing a high pitched voice and joyful music effects to trigger emotions of happiness. It is desired to activate the concept of emotional contagion, meaning that the children then are influenced by the robot's emotional state as it could be proven that mood contagion or evoking positive emotions is indeed possible with a robot (J. Xu, Broekens, Hindriks, & Neerincx, 2015; David & David, 2022). Further, positive emotions lead to higher engagement as it was mentioned earlier (X.-Y. Xu et al., 2021). Hence, by presenting positive emotional gestures it is assumed that engagement will be higher.

As a result, the gestures are conveying emotions of joy and the robot will execute the following set of universally understood gestures:

1. Arms are stretched out and hands point to the front following the 4-key frame steps from (Glowinski, Camurri, Volpe, Dael, & Scherer, 2008). An order of that can be seen in Appendix B.
2. Robot cheers to side (Greczek, Swift-Spong, & Matarić, 2011).
3. Robot cheers to front (Savery et al., 2021).
4. Arms are stretched out and hands pointing to the front (Glowinski et al., 2008).
5. Robot is dancing (Shidujaman, Zhang, Elder, & Mi, 2018).

Figure 3 shows the study set up while children are interacting with the robot.

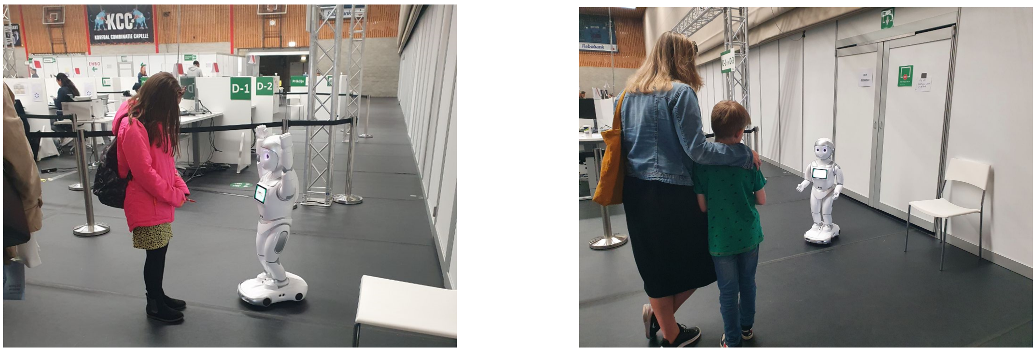


Figure 3: Study Set Up and iPal executing emotional gestures

3.5.4 Spoken SAR interaction: Optional interaction two

The second robot intervention is held at the end of the vaccination procedure. This interaction consists of the robot introducing itself, (here, the robot was not assigned to any gender and was given the unisex name "Robin" in order to circumvent gender effects) and two posed questions. The questions are: "How did you find the vaccination?" and "What are you going to do now?". The complete original conversation can be seen in Appendix C. The questions are accompanied by simple semantical (greeting gestures and questioning gesture) to catch the child's attention and make the interaction more interesting, as it was observed in the pilot study that an interaction without gestures seems less livelier and is less attractive. If the child was not answering, a prompt was given by the experimenter in order to keep the conversation alive, so that the robot can continue to the next question or statement.

3.6 Measurements

3.6.1 Observed engagement for SAR intervention

The interactions will be qualitatively and quantitatively analyzed. Not many quantitative measures for engagement exist in this field and therefore, a quantitative video coding approach for a robot child interaction (Kim et al., 2012) will be used and modified to the conditions of the present interaction.

The original approach was created by Kim et al. (2012) to measure engagement in a child-robot interaction for children with autism. The scheme was applied in a seated spoken intervention and values of engagement were annotated on a 6-point Likert-scale. Also a confederate was present who was requesting the child to answer and take part in the interaction. Here, the child was seated next to a table that was covered by a play-mat, that portrayed the interaction space for the dinosaur-shaped robot Pleo. The child was then instructed to guide Pleo through the map by talking to him. Although the purpose of the interaction differs to the present set-up the goal remains the same, in creating an engaging interaction for a child under the use of an SAR. For intervals of 5 seconds rated judged engagement.

Therefore in the OG set-up, the act of walking away represented "intense non-compliance". For hanging the head and refusing to comply a rating of 1 ("non-compliance") was annotated. Ratings of 2 and 3 display neither non-compliance nor engagement and were annotated for more or less required reinforcement during the task. Complying after multiple prompts led to a rating of 2, and the complying after 2 or 3 prompts to a rating of 3. Ratings of 4 and 5 indicated positive task engagement , or also other people.

Due to the different set-up adjustments are undertaken for the scale and value classification. Respectively, the coding scheme will be applied as follows. First, there is no confederate present that is trying to engage the child in the interaction as in the original coding scheme. Instead of a 6-point Likert Scale, an adjusted 5-point Likert scale will be used where value 3 will be excluded. This decision was also made based on the observations of existing video material from 2021 and later on observations from the pilot study. Other research has also been using 5-point Likert scales in order to assess engagement, ranging from strong engagement to strong disengagement (Mango, 2015; Diemer, Fernandez, & Streepey, 2012), therefore it can be adjusted as stated above. Since there is no spoken interaction between participant and robot the respective observations are disregarded and newly annotated.With the adjustment of the scale and values also adjustments of the observations are made.

For "Intense Noncompliance" no observational changes are made. Just the setting is different as participants will not be seated.

For "noncompliance" the classification was mostly adopted, meaning that when the participants hang their head it will be assigned as such. In addition, based on observations of former video recordings, the participants were sometimes distracted by their surroundings. They looked elsewhere and not at the actual interaction, but they were still not intending to discontinue the interaction. Such a behavior will therefore be classified as noncompliance, which corresponds to slight disengagement.

For the "neutral" assessment the observations also were adjusted, since the instruction in the present experiment is to watch the video (which is not directly but indirectly instructed, because the video is played) and not to speak to the robot. Therefore following the video indicates that the engagement is neutral.

For "slight engagement" the whole observation needs to be adjusted because the child is never requested to speak in the current interaction. The participant is classified as being slightly engaged when he or she shows slight interest. This means, his posture changes like leaning forward, or the participant smiles while concentrating (mouth angles directing upwards) or approximates the robot (Looije, Neerincx, & Lange, 2008). Although the participant is not requested to speak, it can still make statements at any given time, and positive utterances will be assigned as slight engagement.

Value	Evaluation	Observation
1	Intense noncompliance	Participant walks away from the area where the interaction takes place
2	Noncompliance	Negative utterances: Participant looks around, or hangs head and is distracted and interested in different things, signs of boredom
3	Neutral	Participant is gazing towards robot and follows video
4	Slight Engagement	Positive utterances: participant walks towards the robot or close stand, smile of participant, slight attempts to interact
5	Intense Engagement	Mimicking of robot, excitable bouncing, strong attempts to interact, signs of concentration , Laughter of a participant

Table 1: Adapted coding scheme for measuring engagement during the SAR intervention (NG and EG)

Lastly, for "intense engagement" the value is assigned when children are mimicking robot gestures, smile strongly or make any other attempts to interact proactively with the robot such as trying to touch or speaking to the robot. Laughter (smiling with unveiling the teeth) and very strong signs of concentration such as disregarding external distraction, having fingers in their mouth, and excitable bouncing (Looije et al., 2008) are seen a as strong engagement.

The adapted coding scheme can be seen in Table 1. The original coding scheme can be seen in Appendix D.

The values were assigned for frames of 5 seconds, starting from the second the video starts. If the participant was not visible a value of 0 was assigned. Therefore the adjusted coding scale ranges from values of 1-5.

3.6.2 Self-reported engagement

Engagement is measured with two items from a questionnaire that Looije et al. (2008) developed and used to evaluate engagement for different robot interactions. It contains items such as " Would you like to use the robot again?". The participants are asked to respond on a 5-point Likert scale from 1 (Surely not) to 5 (Yes, very much), with corresponding smileys. The mean value of the 2 answers is formed for presenting self-reported engagement. Respectively, low values indicate a low engagement.

3.6.3 State Anxiety

State Anxiety is a timely restricted state and a subordinate emotion of fear and contains a negative valence and a high level of arousal (Russell & Barrett, 1999). It can be measured with the Modified Short State-Trait Anxiety Inventory for children (Nilsson, Buchholz, & Thunberg, 2012) which is adapted from the original State-Trait Anxiety Inventory for Children (Spielberger, 1970) and uses symbols with facial expressions for the presentation of the emotional state. It is assured that children, aged 7-9 years are able to understand the meaning of the symbols and the modified inventory could show good construct validity and internal consistency (Nilsson et al., 2012) and hence, is used for this study. It consists in total of 6 items whereby only one statement is used for this experiment that is "In this moment - I feel calm". The participant responds to the statement on a 5-point Likert scale ranging from "Not at all" to "Very much" before and after the EG interaction. The item before indicates pre-state anxiety, and the item after the interaction demonstrates post-state anxiety.

3.6.4 State Fear

State fear, and "activated, aversive emotional state" (Öhman, 2005), is measured with an item from Looije's et al. (2008) questionnaire. The participants are asked to respond on a 5-point Likert scale from 1 (Surely not) to 5 (Yes, very much), with corresponding smileys. State fear is measured before and after the interaction (pre-state fear and post-state fear).

3.6.5 Trust

Trust is a mental state (Khavas, 2021) and can be seen as the "willingness to rely on an exchange partner in whom one has confidence" (Moorman, Deshpande, & Zaltman, 1993). It is measured with and item from Looije et al. (2008), namely "Do you think the robot tells the truth?". The participant is asked to respond to this item on a 5-point Likert scale. High values indicate high levels of trust. The full survey is presented in Appendix E.

3.6.6 Sentiment Analysis

The affective state of a child is also related to engagement as stated earlier. Hence, emotional responses in children will be analysed in order to infer the child's emotional states or to what extent it discloses its emotional state. Therefore, the child's responses will be assigned with a positive, neutral or negative value for the respective sentiment. For that, the statements were assessed by the dutch NLP-based language model RobBert, which is finetuned for sentiment analysis (Delobelle, Winters, & Berendt, 2020). After that, the values were once more independently assigned from a dutch native speaker to ensure ICR.

3.6.7 Word count

To infer the level of richness of the interaction or amount, the words of the interaction will be counted. Since length of the interaction is no good indicator, because hesitation and non-compliance leads to a longer interaction, the word count will regarded instead. One would assume that a longer interaction will be richer, but it was observed that this is not the case. Short interactions, in comparison, do not reflect a rich interaction either. Hence, the use of words indicate a better degree of a detailed answer, and subsequently, a richer interaction.

3.6.8 Observed Engagement for optional spoken interaction

Observed engagement was also measured with the coding scheme for the optional spoken interaction, after the vaccination took place. Here, the coding scheme is also adjusted, but less adjustments are needed than for the EG interaction. That is, because it resembles the set-up of the original coding scheme (Kim et al., 2012) more. The second interaction was also hold spoken and prompts for the child to answer were given. Therefore, most values are adopted. The scale is adjusted for values ranging from 1-5 in order to equalize the schemes as a part of an easier annotation and evaluation of the experiment. The adjusted coding scheme for the spoken interaction can be found in Appendix F.

3.6.9 Observation of anxiety and willingness to take part in study

As it was observed in the previous vaccination day, that highly anxious children are rejecting the participance, it was noted how the child's state anxiety level was and if the child wanted to participate by random choices. State anxiety was assessed by the observation of two students, e.g. if the child was crying or highly nervous.

3.7 Qualitative observations

Further some general observations and the child's behaviour will be reported and analysed. The interactions with EGs and NGs are being compared and differences will be reported, as not all behaviour can be captured by the coding scheme. Further, it will be assessed qualitatively how the child perceived the vaccination. For that the responses of the children from the spoken interaction will be transcribed and

3.8 Data pre-processing

In order to obtain the values for the observed engagement, 15 slots of 5 seconds needed to be annotated for the EG interaction. The amount of missing slots (Value = 0) was calculated per participant. If more than 30% of the slots were missing for a participant, he was not considered for the final computation anymore. As 30% of missing data slots are an acceptable amount for further imputations (Acuna & Rodriguez, 2004) the slots were filled up with the median of the assigned values per participant. After that, the mean value was computed.

The pre-processing resulted in a total number of 71 participants for the EG condition and 40 for the NG condition. For the spoken interaction there was no fixed amount of slots. Most answers were given within 5 seconds and therefore for most participants 2 slots were annotated.

3.9 Intercoder reliability

Intercoder Reliability (ICR) stands for "a numerical measure of the agreement between different coders regarding how the same data should be coded" (O'Connor & Joffe, 2020). Since the applied coding scheme is adjusted due to the different set up it is important that the annotations can be seen as reliable. Hence, a part of the whole annotated data will be once more evaluated by a second person.

All conditions and interactions were double coded regarding engagement, including EG condition, NG condition and second interaction of EG. It is aimed to double code at least 20% of the total data set, as this can be seen as a gold standard (Syed & Nelson, 2015) and can be deemed sufficient in generalizability for a moderately big data set ($N > 30$). For the computation of the ICR, a one-way random model with absolute accordance will be regarded as not every participant was assessed by both raters and a systematic error needs to be regarded. It applies, values above $0.50 - 0.75$ show a moderate agreement. Values between 0.75 and 0.9 show a good agreement, and values > 0.9 an excellent reliability (Koo & Li, 2016). Some disagreements were discussed and resolved before the final calculation between the two annotators resulting in an overall good agreement of $= .816$ for EG; a moderate agreement for NG (Cronbach's $= .642$), and an almost excellent reliability for the spoken intervention (Cronbach's $= .896$). Given these values, it can be assumed that the codes are in accordance and can be used for the statistical analysis. Further, the sentiment analyses annotations were compared. Here, all data was double coded, leading to an accordance of Cronbach's $= 0.928$ for the first answer and Cronbach's $= 1.0$ for the second answer.

3.10 Pilot study

To test the study set-up and coding scheme a pilot study was carried out on the group vaccination day in march. The pilot sample consists of 40 participants in total (Mage= 11.39, SDage= 2.20, 22 boys, 16 girls, 2 unknown) ranging in age of 9-17. Due to the high age span, assumptions should be taken with care as robot's expectations and perceptions differ strongly among age and could impact the expected results. From the 40 participants, only the data 10 participants could be analysed for observed engagement as in most cases they were obscured, or the robot interaction was not correctly attended. Sometimes, gestures were not rightfully executed or the program was stuck in a loop.

After collecting the data it was pre-processed and led to adjustments in the survey regarding the distribution and the data annotation from the coding scheme. It was found out that it is hard to decide between a value of 3 and 4. Therefore, this issue was discussed with externals and the second coder and the distinction was once more clarified. As a result, the observed engagement (M=3.06, SD= 0.43) and self-reported engagement was averagely high (M=3.42, SD= 0.83). The results also showed a significant difference (z= -2.577, p = .005) in pre-state anxiety (M=3.40, SD= 1.24) and post-state anxiety (M=3.95, SD= 1.16) suggesting that the anxiety is lower after the robot interaction. Pre- and post-state fear did not differ significantly (z= -0.943, p = .243). In the pilot study the observed engagement can not be linked to the other examined variables from the survey no IDs were assigned. Some general observations were that children usually look at the robot's screen and at the gestures and the head when the movements are being executed.

Furthermore, also older children did enjoy the intervention. Nevertheless, they seemed to be uncomfortable by their surrounding whereby young children were more immersed. Interestingly, it was remarked by some that the robot was not being interactive enough, as the first interaction let no room for the child to give any kind of response. Although the second interaction was allowing for a more interactive interaction, the participation was lower. The second interactions in general were short and unlively, which was also due to the robot not gesturing or moving. Thus, it was intended to also integrate emotional and semantical gestures in the second interaction and make it more "exciting" and human-like. Here, another interesting observation is that children sought for the approval by parents or students before giving a response the robot.

In addition, it was observed that parents have a big impact on their children of being willing to take part in the interactions and also during the interactions. Parents in general reacted very positive towards the interaction. Still, if the parents did not want their child to interact, although there was a desire from the children's side, this led to no participation. This also occurred the other way around, meaning that parents also motivated their children interact with the robot. As a result, interactions often took place with the parents next to the participant leading to interactions between child, robot and parent. Also, siblings and friends favored to have interactions together.

Another interesting observation is that children were, without being told so, placing themselves on a green point in front of the robot and would not move until the conversation is over. This mark was not part of the study, but a general mark of the vaccination days. This could inhibit the possible engagement and an important observation, namely the approximation towards the robot, because the child thinks it is supposed to be placed there. Further, it was observed that when children were very anxious or nervous, they were less willing to take part in the study.

4 Results

4.1 Descriptive data

Full Sample. To provide a short overview the means of the collected variables are shown in table 1 over the conditions, as well as for each condition in separation. The mean observed engagement for the full sample was about average (M = 3.19, SD = 0.48).

The emotional gesture (EG) group resulted in a higher mean (M = 3.33, SD = 0.45), followed for the observed Engagement as opposed to the no gesture (NG) group (M = 2.95, SD = 0.43). Participants reported slightly higher values of engagement through the survey (M = 3.73, SD = 0.48). Here, we can find a higher reported engagement in the EG group (M = 3.89, SD = 0.92) and a lower engagement in the NG group (M = 3.60, SD = 1.06).

In, general, pre- and post-state fear were higher in the EG group, and trust was lower in the EG group than in the NG group.

In general though, trust was high (M = 4.49 , SD = 0.91) among all participants. Pre-State fear among all children was higher than average (M =3.19, SD = 1.10), whereas pre-state anxiety (M = 2.64, SD = 1.15) was below the average.

A full overview of all study variables, for the full sample, EG condition and NG condition can be seen in Table 2.

	N	Emotional Gestures		*N*	No gestures		*N*	Full Sample	
		M	*SD*		*M*	*SD*		*M*	*SD*
Observed Engagement	71	3.33	0.45	40	2.95	0.43	111	3.19	0.48
Self-Reported Engagement	94	3.95	0.88	126	3.60	1.06	220	3.75	1.00
Pre-State Anxiety	100	2.64	1.15				100	2.64	1.15
Post-State Anxiety	94	2.31	1.08				94	2.31	1.08
Pre-State Fear	100	3.22	1.07	124	3.16	1.13	225	3.19	1.10
Post-State Fear	95	3.36	1.10	119	3.19	1.18	215	3.27	1.14
Trust	83	4.34	0.83	122	4.45	0.96	205	4.40	0.91

Table 2: Overview of mean values

4.2 Engagement: Comparison of self-reported and observed engagement

To detect how self-reported and observed engagement are associated a Spearman's rank correlation was conducted, as self-reported engagement is not normally distributed. Unexpectedly, self-reported engagement and observed engagement are not significantly correlated ($\rho(67) = 0.04$, p = 0.366).

4.3 Comparison of engagement regarding emotional gesturing

In order to see if EGs can increase child engagement it will be tested if there is a significant difference in engagement between the EG group (n = 71) and the NG group (n = 40). Child engagement was was assessed on the basis of observed and self-reported engagement. Mann-Whitney U tests were computed for the comparison as variables are not metrical or no normal distribution can be assumed (Kolmogorov-Smirnov = $p < .05$).

EGs on Observed Engagement. The mean difference is significant (U = 781.00, Z = -2,37, p =.017), which indicates that participants in the EG group (M = 3.33, SD = 0.45) were more engaged than participants in the NG group (M = 2.95, SD = 0.43). This supports **H1a: Emotional gesturing in a SAR-interaction leads to higher observed engagement than a SAR-interaction without emotional gesturing**.

EGs on self-reported engagement. There was a statistically significant difference in self-reported engagement between EG and NG (U = 4836.00, Z = -3.93,p = < .001) leading to the assumption of **H1b: Emotional gesturing in a SAR-interaction leads to higher self-reported engagement than a SAR-interaction without emotional gesturing**. It shows participants in the EG group (M = 3.89, SD = 0.92) were more engaged than participants in the NG group (M = 3.60, SD = 1.06).

A comparison of engagement for the gesture conditions is demonstrated in Figure 4. A general overview of the differences for the examined variables can be found in Table 3.

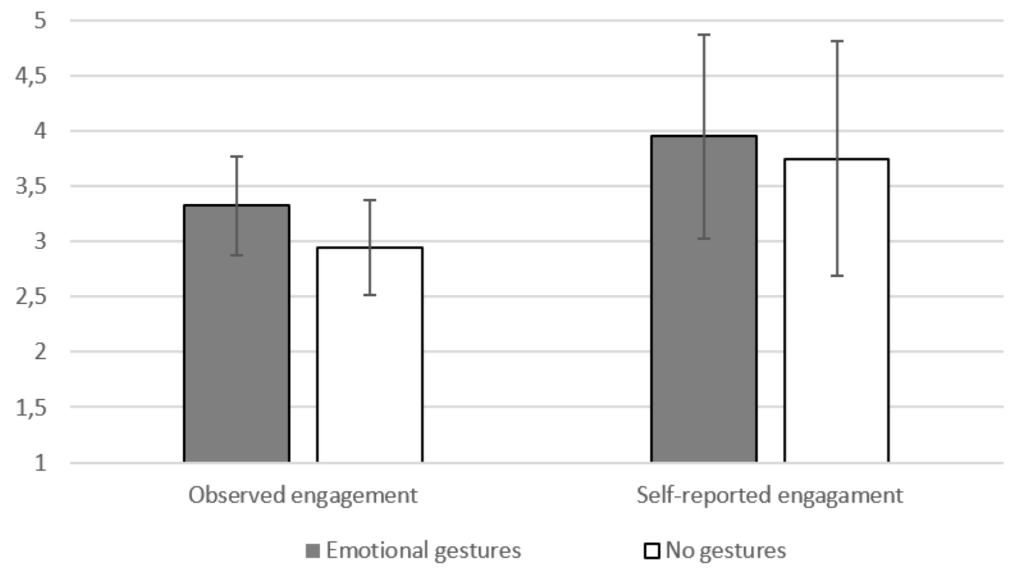


Figure 4: Comparison of EG and NG group among observed and self-reported engagement

Index	Condition	N	Mean Rank	Rank Sum	U	Z	p
Observed Engagement	Emotional Gestures	71	65.00	4615.00	781.00	-3.93	<.001
	No Gestures	40	40.03	1601.00			
Self-Reported Engagement	Emotional Gestures	94	122.05	11473.00	4836.00	-2.37	.009
	No Gestures	126	101.88	12837.00			
Pre-State Fear	Emotional Gestures	100	112.97	11296.50	6153.50	-0.10	.460
	No Gestures	124	112.13	13903.50			
Post-State Fear	Emotional Gestures	95	111.79	10620.00	5245.00	-.94	.175
	No Gestures	119	104.08	12385.00			
Trust	Emotional Gestures	83	95,.62	7936.50	4450.50	-1.70	.045
	No Gestures	122	108.02	13178.50			

Table 3: Mann-Whitney U tests comparing engagement, state fear, and trust in EG and NG group

4.4 Relation of anxiety and engagement

In the following it will be tested if there is a (causal) relation between (pre- and post-) state anxiety and engagement. For the evaluation of the hypotheses bivariate Spearman Rank correlations and linear regressions will be computed within the EG condition (n = 100).

Observed Engagement and pre-state Anxiety. There is no significant relation between observed engagement and pre-state anxiety ($\rho(71)$ = .00, p = .492), which leads to the rejection of **H2a: Pre-state anxiety leads to decreased observed engagement**.

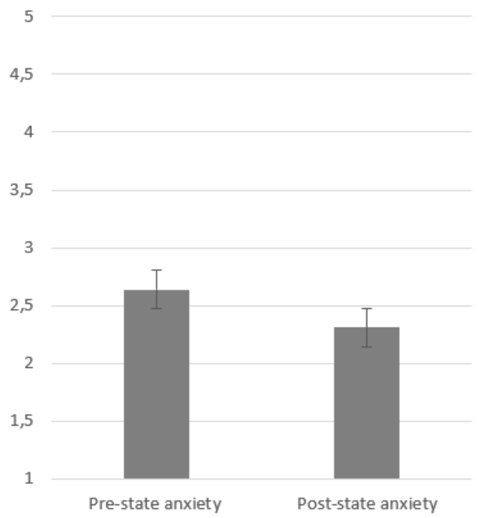
Observed Engagement and post-state Anxiety. There is no significant relation between observed engagement and post-state anxiety ($\rho(67)$ = .03, p = .396). This leads the dismissal of **H2b: Pre-state anxiety leads to decreased self-reported engagement**.

Self-reported engagement and pre-state anxiety. Here, the test showed that there is no significant association between self-reported engagement and pre-state anxiety ($\rho(94)$ = .05, p = .302) leading to the rejection of **H3a: Observed engagement leads to decreased post-state anxiety**.

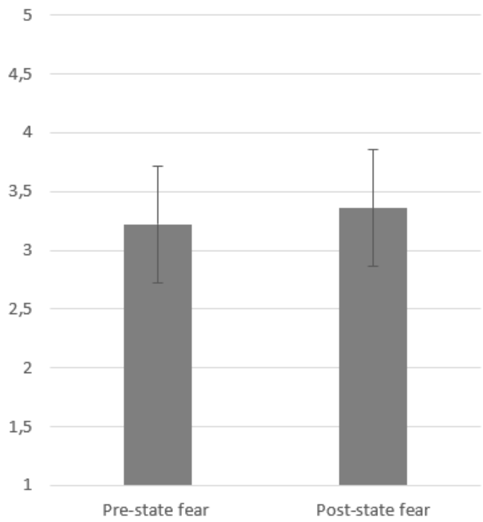
Self-reported engagement and post-state anxiety. There is only a marginally significant small positive association between self-reported engagement and post-state anxiety ($\rho(34)$ = .15, p = .076). Thus, **H3b: Self-reported engagement leads to decreased post-state anxiety** can not be assumed.

An overview of all values with all intercorrelations for the EG group can be seen in Appendix G. As no correlation turned out significant, no linear regressions will be computed.

However, there is a significant difference between pre- and post-state anxiety (z = -1.81 , p = .035) suggesting that state anxiety before the interaction was higher (M = 2.64, SD = 1.15) than after the interaction (M = 2.31, SD = 1.08). Here, a paired sample Wilcoxon signed-rank test was computed. A direct comparison can be seen in Figure 5 (a).



(a) Comparison of pre-state and post-state anxiety



(b) Comparison of pre-state and post-state fear

Figure 5: Comparisons of state anxiety and state fear before and after the EG intervention

4.5 Pre-state fear as moderator between EGs and engagement

Pre-state fear, EG, and observed engagement. Fear has no influence on the observed engagement and therefore **H4a: The effect of emotional gesturing on observed engagement is weakened by pre-state fear** gets rejected. However, when auditing self-reported engagement an effect can be found.

Pre-state fear, EG, and self-reported engagement. First, a Spearman's rank correlation was computed between pre-state fear and self-reported engagement and turned out significant ($\rho(220)$ $= 0.13$, $p = .030$) suggesting a small effect. Likewise, the regression model is significant ($F(2{,}217) =$ 4.13, $p = .017$, $R^2 = 0.04$) showing the causal influence of pre-state fear on self-reported engagement. Nevertheless, pre-state fear would explain only 1.6 % of the variance in self-reported engagement (R^2 =.02). Further, EG have a significant effect on self-reported engagement (b = -0.34, $t(219) =$

-2.55, p = .012), suggesting that on average EGs are related to a 0.34 point higher self-reported engagement. Moderator and independent variable are not collinear (ρ(247)= 0.01 p =.460). While the regression model is significant (ΔR^2 = .04 , F(3, 216) = 3.12, p =.027, 95% CI[3.62, 3.88]) the interaction term is not (t(3, 216) = -0.87, p =.388, 95% CI[-0.37, 0.14]). This leads to the rejection of a possible moderation and of **H4b: The effect of emotional gesturing on self-reported engagement is weakened by pre-state fear**.

Post-state fear and engagement. There was also a small significant negative relation between self-reported engagement and post-state fear (ρ(213)= 0.19 p =.003), suggesting that an increase in engagement leads to a decrease in post-state fear.

Pre-state fear, EG, and post-state fear. Further, there was no significant difference between fear before and after the interaction in the EG group (z = -1.29, p =.100). Neither, when no gestures were present (z = -0.60, p = .275) indicating that pre-state fear had no impact on the child-robot-interaction and the interaction did not influence the child's post-state fear.

Pre-state anxiety and willingness to interact with robot. In addition, it was examined if pre-state anxiety is related to the willingness of children to take part in the study. A chi square test indicates that there is a trend in the relationship between feeling anxious and willingness to participate ($X^2(1) = 3.0127$, p = .083.) presenting that the willingness to participate in the study was lower when the child was very anxious. The majority of children that were participating were not highly anxious (n = 27). Around half of that amount were not willing to participate (n = 14). When the observed anxiety was high, the amount of children that did not want to participate was higher (n = 11) than to participate (n = 8).

4.6 Sentiment analysis, interaction richness, and observed engagement of spoken interaction after the vaccination

Sentiments The overall sentiments expressed are more negative, as it was expected regarding the outcome of fear and anxiety values, which are higher than average for question 1. An overview of the sentiment distribution in the answers is shown in Figure 6. In general, the answers were quite short and did not contain any kind of emotionally loaded words. Responses to question one were generally “tensive”, “nice”, “not nice”, "good" or “scary", which describe the current state of the child. Answers for question two were similar among kids as well, including mostly “I am going to school” or “I am going home”, without expressing any further emotionally loaded information.

Richness of interaction In general, the word count amounts to 7.37 words per participant. There is no significant correlation between word count and observed engagement (ρ(55) = .20, p = .070) or self-reported engagement (ρ(68) = .17, p = .083). However, we can see that the values are marginally significant indicating the richer the interaction the higher the observed and

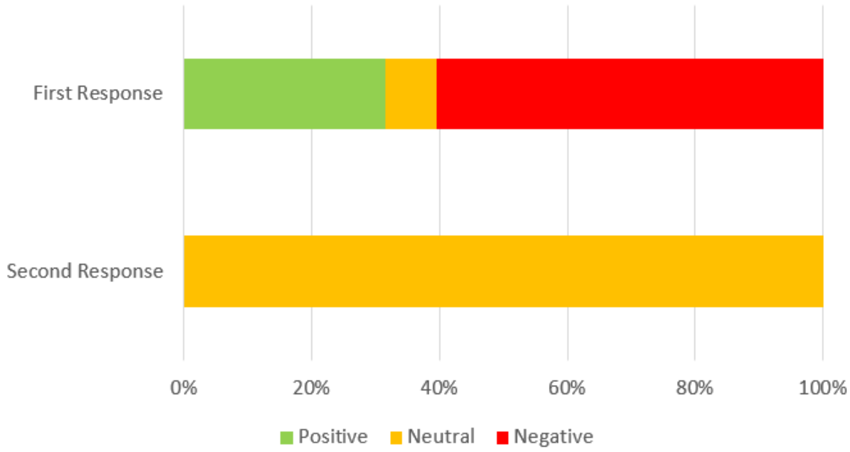


Figure 6: Sentiments of expressed responses in spoken interaction

self-reported engagement and vice versa.

Observed Engagement Observed engagement for the second interaction was also examined after the coding scheme. As a comparison, the observed engagement of the second interaction is positively associated with the word count ($\rho(73) = .36$, $p = <.001$) and marginally significant when looking at the association with the observed engagement of the first interaction ($\rho(68) = .20$, $p = .058$). There is a difference in observed engagement when the SAR interaction before the vaccination and after the vaccination are compared, demonstrated by a significant paired sample Wilcoxon test (z = -2.759 , $p = .003$). Observed engagement in the interaction after the vaccine ($M = 3.49$, $SD = 0.98$) is higher than in the interaction before the vaccine ($M = 3.33$, $SD = 0.45$). Observed engagement in the second interaction is further positively correlated with self-reported engagement ($\rho(80) = .24$, $p =< .016$) and negatively correlates with pre-state fear ($\rho(86) = .18$, $p = .049$). Also, a negative trend can be seen between post-state anxiety and observed engagement of the second interaction ($\rho(80) = .18$, $p = .059$) suggesting that lower post-state anxiety leads to higher the engagement in the second interaction.

4.7 Observations during interactions

Some general observations during the interactions were made. In the NG group, the participants mainly gaze at the screen presenting the video and not at any other part of robot (like e.g. arms or face). In the EG group, on the other hand, participants follow the robot's movements more and gaze more at the robot's head. Regarding the robot's movements it can be said that when the robot executes EGs the participants smile or are exited.

Based on observations, the spoken interaction seems more engaging than the video interaction. Also, the demand for the robot interaction after receiving the vaccine was higher than before. More children finished the second interaction as opposed to the first interaction, and were sometimes even expecting more after the interaction has finished.

4.8 Exploratory analysis: Gender differences and trust

No differences among gender regarding observed (U = 384.50, Z= -0.33, p = .374), or self-reported engagement (U = 651.00, Z = -0.67 p = .254) were discovered. Trust was higher in the NG group (Z = -1.70, p =.045) as it can be seen in Figure 7. Overall, trust correlates with self-reported engagement ($\rho(201)$ = .26, p = <.001), however not with observed engagement ($\rho(59)$ = .10, p = .236). An overview of the correlations for the full sample is presented in Appendix H. No other significant relations with trust were found.

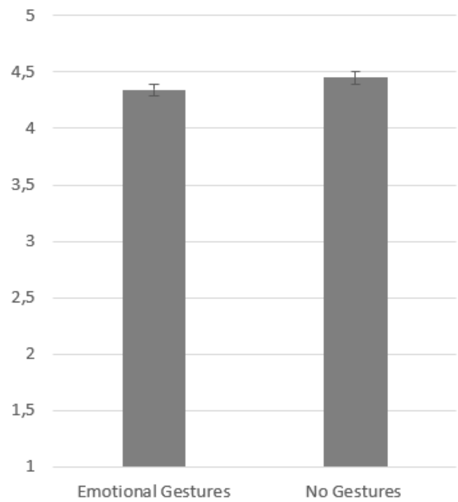


Figure 7: Comparison of mean trust between EG condition and NG condition

5 Discussion

The aim of this thesis is to investigate the effect of emotional gestures in a child-SAR interaction on engagement. Therefore, an experiment was designed and carried out on the group vaccination days in the Netherlands where children got to interact with iPal, executing emotional gestures, before and after receiving the vaccine. The data was compared with a data set from the experiment that was executed the year before, where no emotional gestures were present. An effect of emotional gestures could indeed be found, as observed and self-reported engagement was higher in children when emotional gestures were used in the interaction.

Furthermore, it was examined how engagement and anxiety are related when it comes to child-robot interactions, as negative emotions due to a high arousal might be a threat for potential engagement. Here, it was differentiated between one's state anxiety before the interaction (pre-state anxiety), and the state anxiety after the interaction (post-state anxiety). No significant relation was found between neither pre-state anxiety and engagement, nor post-state anxiety and engagement. There was only a negative trend visible between post-state anxiety and engagement, suggesting that higher engagement lowers post-state anxiety. However, this trend was not significant. Nevertheless, the pre-state anxiety was significantly higher than post-state anxiety, leading to the conclusion that the interaction with emotional gestures is able to decrease the state anxiety in a child, independent from one's level of engagement.

Lastly, it was examined if pre-state fear might impact the effectiveness of emotional gestures on engagement. Here, it was shown that one's level of fear does not impact the effect of an emotional gesture interaction on engagement. In the following section, possible reasons and implications of these findings will be discussed.

5.1 Influence of emotional gestures on engagement

In general, there was a significant difference in engagement when emotional gestures were used in an interaction or not. The difference was found for observed and self-reported engagement. This confirms H1a and H1b, demonstrating that emotional gestures are an effective way of increasing the engagement in child-robot interactions. An explanation for that can be provided when we look more into attention. emotional gestures are attracting the visual attention of the children, leading to higher levels of attention or more use of attentional resources for the task, namely the interaction, and thus leading to engagement. This is in line with previous research that showed that emotional gestures guide attention in humans (Flaisch et al., 2011).

Further, the addition of emotional gestures makes the interaction more human-like, as gesturing is a fundamental requirement when it comes to human-human communication, and subsequently fulfills children expectations about robots (Reeves & Nass, 1996). It is important to prevent children from being unsatisfied and bored by providing them with enjoyment during the interaction (Tielman et al., 2014). Especially for building long-term relationships, an engaging interaction is essential (Del Duchetto et al., 2020).

For instance, former research showed that children can get easily bored when interacting with a robot (Hiwat, 2020), which might be due to unfulfilled expectations or distraction through divided attention. Thus, a more exciting and lifelike interaction can contribute to higher levels of engagement. It was observed that children follow the movements of SAR arms with their eyes and try to mimic them, confirming, once more that they attract attention. Robot interactions need to be engaging, particularly in environments with a lot of external distraction, like group vaccinations.

Distraction can occur in form of noise or other media, but also the mere presence of other children and parents. Therefore, the more engaging an interaction is, the less susceptible it should be to external and internal distractions, like emotional arousal induced by emotions (Kahneman, 1973).

Although both types of engagement were higher in the emotional gesture condition, the two measures do not correlate. This means that children who reported high levels of engagement were not necessarily being observed as highly engaged during the interaction. This shows that it is important to make a distinction between observed and self-reported engagement, especially when it comes to attention. Moreover, it is interesting to look at the attention allocation, as it does not seem that we can easily infer divided and focused attention from the self-reported engagement.

The discontinuity in child engagement makes it challenging to capture their involvement in the interaction. The conducted experiment showed that children can seem very engaged but then all of a sudden disrupt the interaction leading to contrastive results between observed and self-reported engagement. Such behaviour leads to low values in observed engagement, although the internal perception can differ. In future research, more focus should be drawn on the attention span and distribution, as well as on the consideration and handling of external distractions.

5.2 Pre-state anxiety and engagement

H2a and H2b were not supported by the research, indicating that there is no relation between pre-state anxiety and observed engagement. This means high state anxiety does not have a negative impact on one's level of engagement. This stands in contrast to Kahnemann's attention model (1973), which assumes that the arousal of high state anxiety restricts the capacities to engage in the interaction. One potential explanation that such an effect was not found could be that children with such a high amount of state anxiety that is strongly limiting attentional resources refused to take part in the study. This is reflected in the findings of observed willingness to take part in the study, whereby highly anxious children were less willing or not able to participate.

In addition, the sample demonstrated a below-average level of pre-state anxiety, indicating that children with seriously high levels of state anxiety were not taking part in the SAR-interaction. The actual reasons behind the willingness to participate were not further investigated, but, as aforementioned, their intentional resources for any task or activity might be blocked due to the high levels of arousal, induced by anxiety or fear, leaving no remaining available capacity for the interaction.

Nevertheless, in the conducted experiment increased levels of pre-state anxiety do not seem to occupy an enormous amount of attentional resources of the child because the engagement of the interaction was not impacted by it.

An alternative explanation might be that even if the arousal of anxiety limits the full capacity in the first place the subsequent evaluation of the demands on capacity can be increased by the interaction. The evaluation of demands follows the execution of the different tasks and has a direct influence on the available capacity and allocation policy (Kahneman, 1973). A positive evaluation then would prioritise the interaction task and increase available capacity. The increased attention leads to higher engagement in the interaction and can lower the arousal of anxiety by claiming the attentional focus. The evaluation is therefore directly impacted by the interaction, in form of providing arousal or pleasure and thus meeting the evaluation demands.

In general, it would mean that the attention increases while interacting with the robot and impacts the child's internal state by adequately lowering the state anxiety in the beginning, leading to potential engagement. This means that for this type of interaction, it is not necessary to react to one's internal state individually, as it was proposed in former studies (Rossi et al., 2020) as for all participants high engagement was conceivable. Rossi et al. (2020) state that the distraction ability of the interaction is dependent on one's emotional state and has to be adapted to it. However, the simplicity of the present interaction, which is less individual and less long, contrast with these findings. Therefore, in the presented interaction no adaption is needed. This means the maximal achievable engagement, did not require to talk or self-disclose a lot of information but being focused and attentive. Perhaps, in a more complex interaction, the engagement could still be inhibited.

Furthermore, it was found that there is no attentional difference when looking at positive stimuli in highly state anxious children (Quigley et al., 2012). Thus, presenting or inducing these positive emotions through the interaction, might not have an influence of the child's attention and subsequently the observed engagement.

5.3 Post-state anxiety and engagement

Here, no significant correlation could be found. Hence, it can be concluded engagement does not impact one's internal state of anxiety. It could be that the internal anxiety levels stay the same throughout the interaction. This would mean there is enough capacity for varying engagement from the intervention and the arousal is not restricting the required attentional resource to a lower potential engagement. As a consequence, the emotional state is not impacted, and they emotional state and engagement stay independent from one another.

Moreover, self-reported engagement was quite high for the whole sample, not showing the effects of very low engagement, and their impact. Maybe the observed engagement is not the most suitable measuring instrument in that particular aspect, as children that were more engaged or more interactive and closer to the robot, were not necessarily more attentive. This implies that high or medium values would not differ for the attention allocation of a child. Therefore, more attention measuring instruments, like gaze tracking and pupil dilation observation should be regarded in the future. The fact that post-state anxiety is not affected by the engagement, however, would not explain why state anxiety is lowered after the interaction. Because this means regardless of one's level of engagement the anxiety is lowered.

This again supports the first hypothesis that a robot interaction under emotional gestures is a powerful way to lower state anxiety in children and in line with other research showing that emotional gestures, efficiently recruit attentional resources, as it can foster the extraction of affectively salient information (Flaisch et al., 2011).

Thus, it needs to be taken into consideration that the content or the interaction itself is arousing and pleasuring enough to lower the internal arousal level of anxiety. Engagement and task therefore need to be regarded in separate. However, in future research, the interplay should be further examined with regards to attention.

5.4 Child-robot interaction with emotional gestures on Post-state Anxiety

The fact that anxiety was lower after the interaction, however, shows that the interaction had an impact on anxiety. In general, the addition of emotional gestures in the interaction can benefit the attentional focus of an anxious child. For example, anxious children have more difficulty with resting their eye on one point especially in environments that are noisy or stressful (Behan & Wilson, 2008) and less available attentive capabilities due to the restricted pool of attention resources. By providing them with more external stimuli their attention might be caught over a longer period of time and can thus be "catchier" than only watching a video.

Albeit, it needs to be investigated, if the video content only or the video content accompanied by gestures are able to lower the state anxiety. For instance, to follow the video would not necessarily show a very high level of observed engagement, enjoyment or arousal in the child. High attention can be paid to the video, even though the participant is far from the screen and makes no obvious attempts of engaging. As mentioned earlier, more precise measuring methods would be suitable at this point and can provide more indications about the role of attention regarding emotional gestures.

It might be that the presentation of the informative video about the vaccine alone is already enough to lower the state anxiety because it explains the source of threat more in detail. It implies, if we see anxiety as a state where the source of harm is uncertain (LeDoux & Pine, 2016) and as an unfamiliar pre-stimulus (Öhman, 2008) the clarification provided by the video would turn the source of threat into something more certain and could thus decrease the anxiety. However, in other research (Rossi et al., 2020) anxiety was lowered independently from an informative video about a vaccine. Thus, the explanation that regards one's state of arousal could be considered as a more suitable explanation.

Another explanation might be the induction of positive emotions leading to the reduction of negative emotions, as it could be shown in former research that a cognitive reappraisal strategy could actually evoke positive emotions in children, only with the use of a robot interaction (David & David, 2022). Here, anxiety levels were strongly reduced.

In the present research no reappraisal technique was used, but positive emotions were aimed to be induced by mood contagion. Therefore, a direct induction of positive emotions, independent of one's level of engagement could have led to lower anxiety by displacing the negative emotion. Nevertheless, the explicit role that emotional gestures played in lowering the levels of anxiety is can not be clarified. In addition, the findings hint us to the necessity to further distinguish between the concepts of fear and anxiety and the different outcomes as such.

5.5 Child-robot interaction with emotional gestures on post-state fear

As mentioned before, it needs to be inspected why state anxiety could be lowered and state fear not. This could be explained when fear is more regraded as a post-stimulus. This means fear is a more defined stimulus and is occurring after an event (Öhman, 2008) leading to the fact that the fear still remains high before the vaccination takes place, because it is remembered from previous events.

This, however, is not in line with former findings where fear was equally affected as anxiety by an affective SAR intervention (Rossi et al., 2020). Also, both concepts correlate highly, meaning the concepts are strongly related and dependent. Perhaps, the interaction was just not powerful enough to lower the levels of state fear.

Hence, in order to fight against the mental state of fear we might need a different approach.

Longer, more engaging interactions like spoken ones might provide a higher level of distraction and could be an alternative. Here, with regards to the whole sample, it could be seen that engagement and state fear are indeed related, indicating that increased engagement leads to lower state fear. Results show, the more engaged the child, the less afraid it was afterwards. This would again be in line with the fact that focused attention, which is assumed through engagement is leading to higher distraction. In future research, this should be explored more. Maybe different measurements or longer interaction can provide more insights and the reasons behind through qualitative research need to be investigated.

5.6 Pre-state Fear, emotional gestures and engagement

Here, it could indeed be shown that self-reported engagement and pre-state fear, as well as post-state fear are associated, meaning more engagement leads to lower state fear and the other way around. This is in line with the distracting power of the interaction. It means, the more engaged the child is, the more distracted it is, and subsequently less fearful of the vaccine. However, the state fear does not influence the effectiveness of emotional gestures of engagement, meaning that highly fearful individuals are taking the same benefit out of the gesture interactions as less afraid individuals. It means one's internal state is not restricting the attentive resources too much and emotional gestures obtain their effect. Even if a child is highly afraid it can have an engaging interaction. It can be concluded that the arousal induced by state fear is not interfering in the resource pool with the attention and engagement for the interaction task.

5.7 A comparison: Interaction before and after the vaccination

Due to the fact that most interventions are being hold before or during the medical procedure (Rossi et al., 2020; Tielman et al., 2014) the application of interactions after the procedure is sparse. Yet, interactions after the procedure could be an applicable scenario for an SAR, also suggested by Rossi et al. (2020). Although in this research, the second interaction was more used as an optional closing activity to gain qualitative insights, the interaction was of high demand. Therefore, the engagement for the second interaction was measured as well as general observations were made.

It was observed that after the medical procedure, children are more open to interact with the robot as the demand for the interaction was higher after the vaccine. However, also here, when kids were highly anxious, crying etc. no willingness for interacting was observed. In general, the level of state anxiety is lower after the first interaction and children might be less nervous after the vaccination event. Subsequently, the attention resources are less occupied for other interest and the demand for an interaction can be higher.

By looking at the second interaction, enjoyment and curiosity in children could be observed. Also, observed engagement was high for the interaction. The interactions were more individual than the first ones, as parents placed themselves further from the interaction, or were less intervening, but rather motivating the children to speak. It demonstrates that a second interaction might be a benefit for parents as well, as they are not as much in a rush to get to the vaccine in time. The positive experience of the second intervention might then have a positive impact on follow interactions, as engagement was high, and as it was said before this might lead to more willingness to interact with robots in the future, building the basis for potential long-term engagement. The second interaction in general was seen as more "interactive" and fulfilling child's and parents' expectations. As it was remarked that the first interaction was not interactive enough. This shows the benefit of having such a second interaction.

The expectations of children and parents, further, refer to the human-likeliness of the interaction. A spoken interaction also connotes a more human-like interaction. More human-like interactions, as mentioned earlier, are able to engage more and this is also in line with the measured and observed engagement in this experiment. Both measured and observed engagement was higher in the second interaction.

However, in future studies even longer spoken interactions could be introduced as children were expecting more from the robot's side. It might be easier to state usual questions, rather than questions about one's feelings, as it was replied faster and answers were more detailed. The second question created a better flow.

Regarding the robot's movements, it can be said that when the robot executes emotional gestures the participants smile or are exited, which portrays the direct effect of gestures on the child. As a result, the interactions with gestures seem livelier and children seem to get less easily bored. This might not have a direct effect on the vaccination event, but maybe on the following vaccination event and the remaining fear and anxiety by providing enjoyment and interest.

5.8 Emotional gestures, engagement and trust

Lastly, it was investigated how trust is related to emotional gestures and engagement. These findings are rather interesting. Unexpectedly, when no gestures were integrated, trust was higher. This is not in line with general findings that gestures, like raised arms or open hands, are supporting and evoking trust and credibility in humans (Umoh, 2018). However, it can be that the executed gestures were too hectic. For instance, joyful gestures are usually executed with speed, and as a consequence can distract from the presented video. Hence, the children were gazing less at the video but gaining trust moreover requires a resting gaze and the gestures did not evoked the desired levels of trust.

Further, the robot was actually not able to open his palms during the execution of the gestures and perhaps, this could have been associated with lying as hiding of palms indicates suppressing the truth. Hands are an essential and important medium when it comes to revealing truths (Kokoski, 2018). Hence, robotic hands that better approximate human physiology, especially including the stretching of fingers, might evoke more trust (Sheikholeslami, Moon, & Croft, 2017).

In general, iPal should be able to execute the gesture of open palms and move fingers. Still, the robots used in this project, were not able to do so for technical reasons. More limitations are addressed in the following.

5.9 Limitations

An unfavourable positioning of the participants resulted in a lot of missing slots for the observed engagement. Consequently, the number of participants for the observed engagement is quite low, especially for the non-gesture condition. A higher number could provide more insights. Furthermore, in retrospect, it can be said that the coding scheme was not optimal for the used kind of interaction. Originally the coding scheme was designed for a spoken interaction (Kim et al., 2012), and it was more applicable on the second interaction.

More factors, like external distraction vs. internal distraction or gaze should be considered and examined in future studies and values of external and internal distraction need to be regarded more in separation. Different values regarding distraction were annotated however in the end not regarded. Moreover, the external distraction in the emotional gesture interaction was higher than in other set ups, which could lead to missing effects and less individual interactions. For example, children were often stopped in the middle of the interaction, when the queue was continuing. Here a calmer space might lead to different outcomes.

Another factor that cannot be controlled is the point in time when participants fill out the survey. I cannot be ensured that this is done immediately after the interaction. This remains a problem in such a field study and holds for other interfering variables, that cannot be controlled. Furthermore, the test strength of the results is lower because the collected data is mainly non-parametric due to the use of simple Likert-scales. This was necessary in order to reduce the workload and to circumvent the response bias and fatigue effect. However, parametric data could allow for more advanced computations. In addition, the qualitative insights are limited due to a short second interaction, which was also shortened due to the aforementioned reasons.

5.10 Future research

Future research was formerly addressed. Yet, there are factors that should be further investigated to optimise CRI. First, the effects of a child's personality or traits of children are not extensively researched yet with regards to engagement and emotional gestures. This could grant more insights about the perception and reactions towards robots, as for example familiarity with a robot is closely related to one's level of trust in a robot (Haring, Matsumoto, & Watanabe, 2013).

Further, the difference, but also the interplay, between semantical and emotional gestures should be further explored because the combination can make the interaction even richer. However, the restricted doFs in the robot and hand movements could limit the execution. Here, the possibilities should be optimally exploited.

In this research, engagement was quantified, in order to observe the direct influence of emotional gestures on the child's attention *during* the interaction. However, the adapted coding scheme might not be too precise for a non-spoken interaction and more differentiation needs to be incorporated in future research.

In general, the results can be interpreted by the allocation of attention resulting from a shared resource pool (Kahneman, 1973) but not all of it. It seems that negative emotions, with a high arousal, do not necessarily restrict the available attention and can coexist when it comes to engagement. It would be interesting to look closer into the exact relation between the present negative emotions and attention in children.

Additionally, it could beneficial to generate more individual interactions. Nevertheless, children were not exposing a lot of sentiments, especially not when not being asked for it, which might complicate to respond to them more individually. Therefore, asking them explicitly about their current emotional state might be a potential solution, as it was realised with the first question. Respectively, the robot can react to the one's individual and current emotional state.

Yet, the sentiment analysis demonstrates once more, that children experience mostly negative emotions during vaccinations. This confirms the need for such an SAR in this scenario and further application and investigation.

5.11 Conclusion

The focus of this work was to reveal if emotional gestures are a useful way to heighten engagement in children. The question formulated for this research was respectively: *How does emotional gesturing in a social assistive robot influence child engagement and interaction during the group vaccination event?*.

A significant increase of engagement was found when emotional gestures were being added to the interaction with a SAR, answering the question that indeed emotional gestures have a positive influence during the group vaccination day.

Besides that, other negative emotional states that are often experiences on vaccinations and HRI related concepts important for successful robot interactions were addressed in the subquestion:

How do state anxiety, fear and trust influence engagement and the effect of emotional gesturing?. Here, the interaction could lower state anxiety independent from one's level of engagement. This means pre-state anxiety and has no impact on engagement. Likewise, state fear did not moderate the effect of emotional gestures on engagement. Despite the fact that the interaction with emotional gestures was held with more people around, the engagement was higher in the individuals. This is an important finding, since in such situations it can't be secured that children are having individual interactions. Engagement can still be high if the interaction is immersing enough. And as being observed it can even help to not have a complete individual interaction, as other children or parents can motivate the individual to stay focused or feel more comfortable in the given situation.

In conclusion, it can be said that adding simple emotional gestures in an interaction is a powerful way to engage a child as well as lower anxiety and to provide enjoyment to children and parents. Hence, in a noisy environment they are a useful way of creating engagement by providing a more human-like interaction.

References

Acuna, E., & Rodriguez, C. (2004). The treatment of missing values and its effect on classifier accuracy. , 639–647.

Alemi, M., Ghanbarzadeh, A., Meghdari, A., & Moghadam, L. J. (2016). Clinical application of a humanoid robot in pediatric cancer interventions. *International Journal of Social Robotics*, *8*(5), 743–759.

Behan, M., & Wilson, M. (2008). State anxiety and visual attention: The role of the quiet eye period in aiming to a far target. *Journal of sports sciences*, *26*(2), 207–215.

Beran, T. N., Ramirez-Serrano, A., Kuzyk, R., Fior, M., & Nugent, S. (2011). Understanding how children understand robots: Perceived animism in child–robot interaction. *International Journal of Human-Computer Studies*, *69*(7-8), 539–550.

Beran, T. N., Ramirez-Serrano, A., Vanderkooi, O. G., & Kuhn, S. (2013). Reducing children's pain and distress towards flu vaccinations: a novel and effective application of humanoid robotics. *Vaccine*, *31*(25), 2772–2777.

Borghardt, J. (2021). Het effect van een robot op de vaccinatie ervaring van een kind. *Bachelor Thesis*.

Breazeal, C. (2009). Role of expressive behaviour for robots that learn from people. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1535), 3527–3538.

Brink, K. A., Gray, K., & Wellman, H. M. (2019). Creepiness creeps in: Uncanny valley feelings are acquired in childhood. *Child development*, *90*(4), 1202–1214.

Castellano, G., Kessous, L., & Caridakis, G. (2007). Multimodal emotion recognition from expressive faces, body gestures and speech. *Doctoral Consortium of ACII, Lisbon*.

Castellano, G., Leite, I., Pereira, A., Martinho, C., Paiva, A., & McOwan, P. W. (2012). Detecting engagement in hri: An exploration of social and task-based context. In *2012 international conference on privacy, security, risk and trust and 2012 international confernece on social computing* (pp. 421–428).

Cen, L., Wu, F., Yu, Z. L., & Hu, F. (2016). A real-time speech emotion recognition system and its application in online learning. In *Emotions, technology, design, and learning* (pp. 27–46). Elsevier.

Chiasson, S., & Gutwin, C. (2005). Testing the media equation with children. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 829–838).

Crossman, M. K., Kazdin, A. E., & Kitt, E. R. (2018). The influence of a socially assistive robot on mood, anxiety, and arousal in children. *Professional Psychology: Research and Practice*, *49*(1), 48.

Dael, N., Goudbeek, M., & Scherer, K. R. (2013). Perceived gesture dynamics in nonverbal expression of emotion. *Perception*, *42*(6), 642–657.

David, O. A., & David, D. (2022). How can we best use technology to teach children to regulate emotions? efficacy of the cognitive reappraisal strategy based on robot versus cartoons versus written statements in regulating test anxiety. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, 1–10.

Dawe, J., Sutherland, C., Barco, A., & Broadbent, E. (2019). Can social robots help children in healthcare contexts? a scoping review. *BMJ paediatrics open*, *3*(1).

Del Duchetto, F., Baxter, P., & Hanheide, M. (2020). Are you still with me? continuous engagement assessment from a robot's point of view. *Frontiers in Robotics and AI*, *7*, 116.

Delobelle, P., Winters, T., & Berendt, B. (2020). Robbert: a dutch roberta-based language model. *arXiv preprint arXiv:2001.06286*.

Diemer, T. T., Fernandez, E., & Streepey, J. W. (2012). Student perceptions of classroom engagement and learning using ipads. *Journal of Teaching and Learning with Technology*, 13–25.

Ekman, P. (1992). Are there basic emotions?

Embgen, S., Luber, M., Becker-Asano, C., Ragni, M., Evers, V., & Arras, K. O. (2012). Robot-specific social cues in emotional body language. In *2012 ieee ro-man: The 21st ieee international symposium on robot and human interactive communication* (pp. 1019–1025).

Feil-Seifer, D., & Mataric, M. J. (2005). Defining socially assistive robotics. In *9th international conference on rehabilitation robotics, 2005. icorr 2005.* (pp. 465–468).

Flaisch, T., Häcker, F., Renner, B., & Schupp, H. T. (2011). Emotion and the processing of symbolic gestures: an event-related brain potential study. *Social cognitive and affective neuroscience*, *6*(1), 109–118.

Fowler-Kerry, S., & Lander, J. R. (1987). Management of injection pain in children. *Pain*, *30*(2), 169–175.

Gallimore, D., Lyons, J. B., Vo, T., Mahoney, S., & Wynne, K. T. (2019). Trusting robocop: Gender-based effects on trust of an autonomous robot. *Frontiers in Psychology*, *10*, 482.

Glowinski, D., Camurri, A., Volpe, G., Dael, N., & Scherer, K. (2008). Technique for automatic emotion recognition by body gesture analysis. In *2008 ieee computer society conference on computer vision and pattern recognition workshops* (pp. 1–6).

Greczek, J., Swift-Spong, K., & Matarić, M. (2011). *Using eye shape to improve affect recognition on a humanoid robot with limited expression* (Tech. Rep.). Technical report.

Haring, K. S., Matsumoto, Y., & Watanabe, K. (2013). How do people perceive and trust a lifelike robot. In *Proceedings of the world congress on engineering and computer science* (Vol. 1, pp.

425–430).

Hiwat, T. (2020). There is a robot in the waiting room?!: The usage of a humanoid social robot in youth health care. *Bachelor Thesis*.

Jacobson, R. M., Swan, A., Adegbenro, A., Ludington, S. L., Wollan, P. C., Poland, G. A., ... others (2001). Making vaccines more acceptable—methods to prevent and minimize pain and other common adverse events associated with vaccines. *Vaccine*, *19*(17-19), 2418–2427.

Kahneman, D. (1973). *Attention and effort* (Vol. 1063). Citeseer.

Kellmeyer, P., Mueller, O., Feingold-Polak, R., & Levy-Tzedek, S. (2018). Social robots in rehabilitation: A question of trust. *Science Robotics*, *3*(21), eaat1587.

Kessler, T. T., Larios, C., Walker, T., Yerdon, V., & Hancock, P. (2017). A comparison of trust measures in human–robot interaction scenarios. In *Advances in human factors in robots and unmanned systems* (pp. 353–364). Springer.

Khavas, Z. R. (2021). A review on trust in human-robot interaction. *arXiv preprint arXiv:2105.10045*.

Kim, E., Paul, R., Shic, F., & Scassellati, B. (2012). Bridging the research gap: Making hri useful to individuals with autism.

Kokoski, C. (2018). The science-based hand gesture to build trust. *The Candid Cuppa*.

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of chiropractic medicine*, *15*(2), 155–163.

Lagun, D., & Lalmas, M. (2016). Understanding user attention and engagement in online news reading. In *Proceedings of the ninth acm international conference on web search and data mining* (pp. 113–122).

LeDoux, J. E., & Pine, D. S. (2016). Using neuroscience to help understand fear and anxiety: a two-system framework. *American journal of psychiatry*.

Lewis, A. (1967). Problems presented by the ambiguous word" anxiety" as used in psychopathology. *Israel Annals of Psychiatry & related disciplines*.

Lewis, T. T., Kim, H., Darcy-Mahoney, A., Waldron, M., Lee, W. H., & Park, C. H. (2021). Robotic uses in pediatric care: A comprehensive review. *Journal of Pediatric Nursing*, *58*, 65–75.

Lhommet, M., & Marsella, S. C. (2014). Expressing emotion through posture. *The Oxford handbook of affective computing*, *273*.

Li, J., Chignell, M., Mizobuchi, S., & Yasumura, M. (2009). Emotions and messages in simple robot gestures. In *International conference on human-computer interaction* (pp. 331–340).

Looije, R., Neerincx, M. A., & Lange, V. d. (2008). Children's responses and opinion on three bots that motivate, educate and play.

Mango, O. (2015). ipad use and student engagement in the classroom. *Turkish Online Journal of Educational Technology-TOJET*, *14* (1), 53–57.

McCarthy, C., Butchart, J., George, M., Kerr, D., Kingsley, H., Scheinberg, A. M., & Sterling, L. (2015). Robots in rehab: towards socially assistive robots for paediatric rehabilitation. In *Proceedings of the annual meeting of the australian special interest group for computer human interaction* (pp. 39–43).

Moorman, C., Deshpande, R., & Zaltman, G. (1993). Factors affecting trust in market research relationships. *Journal of marketing*, *57* (1), 81–101.

Mori, M., MacDorman, K. F., & Kageki, N. (2012). The uncanny valley [from the field]. *IEEE Robotics & Automation Magazine*, *19* (2), 98–100.

Naneva, S., Sarda Gou, M., Webb, T. L., & Prescott, T. J. (2020). A systematic review of attitudes, anxiety, acceptance, and trust towards social robots. *International Journal of Social Robotics*, *12* (6), 1179–1201.

Nasir, J., Bruno, B., Chetouani, M., & Dillenbourg, P. (2021). What if social robots look for productive engagement? *International Journal of Social Robotics*, 1–17.

Neerincx, A., Rodenburg, D. L., de Graaf, M. M., & Masthoff, J. F. (2021). Social robots to support child and family care: A dutch use case. In *Companion of the 2021 acm/ieee international conference on human-robot interaction* (pp. 367–371).

Nilsson, S., Buchholz, M., & Thunberg, G. (2012). Assessing children's anxiety using the modified short state-trait anxiety inventory and talking mats: A pilot study. *Nursing Research and Practice*, *2012*.

Oertel, C., Castellano, G., Chetouani, M., Nasir, J., Obaid, M., Pelachaud, C., & Peters, C. (2020). Engagement in human-agent interaction: An overview. *Frontiers in Robotics and AI*, *7*, 92.

Öhman, A. (2005). The role of the amygdala in human fear: automatic detection of threat. *Psychoneuroendocrinology*, *30* (10), 953–958.

Öhman, A. (2008). Fear and anxiety: Overlaps and dissociations.

O'Connor, C., & Joffe, H. (2020). Intercoder reliability in qualitative research: debates and practical guidelines. *International journal of qualitative methods*, *19*, 1609406919899220.

Panyasorn, J., Panteli, N., & Powell, P. (2008). Interaction model in groupware use for knowledge management. In *Encyclopedia of e-collaboration* (pp. 398–404). IGI Global.

Plantin, C. (2015). Emotion and affect. *The international encyclopedia of language and social interaction*, *9999* (9999), 1–11.

Poggi, I., & Mind, H. (2007). Face and body: A goal and belief view of multimodal communication, ser. *Körper, Zeichen, Kultur. Joachim Weidler Weidler Buchverlag Berlin*.

Pulido, J. C., Suarez-Mejias, C., Gonzalez, J. C., Ruiz, A. D., Ferri, P. F., Sahuquillo, M. E. M.,

... Fernandez, F. (2019). A socially assistive robotic platform for upper-limb rehabilitation: a longitudinal study with pediatric patients. *IEEE Robotics & Automation Magazine*, *26*(2), 24–39.

Rabbitt, S. M., Kazdin, A. E., & Scassellati, B. (2015). Integrating socially assistive robotics into mental healthcare interventions: Applications and recommendations for expanded use. *Clinical psychology review*, *35*, 35–46.

Reeves, B., & Nass, C. (1996). The media equation: How people treat computers, television, and new media like real people. *Cambridge, UK*, *10*, 236605.

Reisenzein, R. (2009). Emotions as metarepresentational states of mind: Naturalizing the belief–desire theory of emotion. *Cognitive Systems Research*, *10*(1), 6–20.

Reisenzein, R. (2020). Cognitive theory of emotion. *Encyclopedia of personality and individual differences*, 723–733.

Robert, P. (1980). *Emotion: Theory, research, and experience. vol. 1: Theories of emotion.* Academic Press: Cambridge, MA, USA.

Rosenthal-von der Pütten, A. M., Krämer, N. C., & Herrmann, J. (2018). The effects of humanlike and robot-specific affective nonverbal behavior on perception, emotion, and behavior. *International Journal of Social Robotics*, *10*(5), 569–582.

Rossi, S., Larafa, M., & Ruocco, M. (2020). Emotional and behavioural distraction by a social robot for children anxiety reduction during vaccination. *International Journal of Social Robotics*, *12*(3), 765–777.

Ruocco, M., Larafa, M., & Rossi, S. (2019). Emotional distraction for children anxiety reduction during vaccination. *arXiv preprint arXiv:1909.04961*.

Russell, J. A. (1980). A circumplex model of affect. *Journal of personality and social psychology*, *39*(6), 1161.

Russell, J. A., & Barrett, L. F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: dissecting the elephant. *Journal of personality and social psychology*, *76*(5), 805.

Šabanović, S., Chang, W.-L., Bennett, C. C., Piatt, J. A., & Hakken, D. (2015). A robot of my own: participatory design of socially assistive robots for independently living older adults diagnosed with depression. In *International conference on human aspects of it for the aged population* (pp. 104–114).

Savery, R., Zahray, L., & Weinberg, G. (2021). Emotional musical prosody for the enhancement of trust: Audio design for robotic arm communication. *Paladyn, Journal of Behavioral Robotics*, *12*(1), 454–467.

Sheikholeslami, S., Moon, A., & Croft, E. A. (2017). Cooperative gestures for industry: Exploring the efficacy of robot hand configurations in expression of instructional gestures for human–robot interaction. *The International Journal of Robotics Research*, *36*(5-7), 699–720.

Shen, Z., Cheng, J., Hu, X., & Dong, Q. (2019). Emotion recognition based on multi-view body gestures. In *2019 ieee international conference on image processing (icip)* (pp. 3317–3321).

Shidujaman, M., Zhang, S., Elder, R., & Mi, H. (2018). "roboquin": A mannequin robot with natural humanoid movements. In *2018 27th ieee international symposium on robot and human interactive communication (ro-man)* (pp. 1051–1056).

Spielberger, C. D. (1966). The effects of anxiety on complex learning and academic achievement. *Anxiety and behaviour*.

Spielberger, C. D. (1970). Manual for the state-trait anxietry, inventory. *Consulting Psychologist*.

Syed, M., & Nelson, S. C. (2015). Guidelines for establishing reliability when coding narrative data. *Emerging Adulthood*, *3*(6), 375–387.

Tecce, J. J., Savignano-Bowman, J., & Meinbresse, D. (1976). Contingent negative variation and the distraction—arousal hypothesis. *Electroencephalography and clinical neurophysiology*, *41*(3), 277–286.

Tielman, M., Neerincx, M., Meyer, J.-J., & Looije, R. (2014). Adaptive emotional expression in robot-child interaction. In *2014 9th acm/ieee international conference on human-robot interaction (hri)* (pp. 407–414).

Umoh, R. (2018). These 5 simple body language tricks can help you build trust with anyone. *CNBC*.

Venture, G., & Kulić, D. (2019). Robot expressive motions: a survey of generation and evaluation methods. *ACM Transactions on Human-Robot Interaction (THRI)*, *8*(4), 1–17.

Wallbott, H. G. (1998). Bodily expression of emotion. *European journal of social psychology*, *28*(6), 879–896.

Williams, L., Arribas-Ayllon, M., Artemiou, A., & Spasić, I. (2019). Comparing the utility of different classification schemes for emotive language analysis. *Journal of Classification*, *36*(3), 619–648.

Xu, J., Broekens, J., Hindriks, K., & Neerincx, M. A. (2015). Mood contagion of robot body language in human robot interaction. *Autonomous Agents and Multi-Agent Systems*, *29*(6), 1216–1248.

Xu, X.-Y., Niu, W.-B., Jia, Q.-D., Nthoiwa, L., & Li, L.-W. (2021). Why do viewers engage in video game streaming? the perspective of cognitive emotion theory and the moderation effect of personal characteristics. *Sustainability*, *13*(21), 11990.

Yun, S.-S., Choi, J., Park, S.-K., Bong, G.-Y., & Yoo, H. (2017). Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system. *Autism*

Research, *10*(7), 1306–1323.

Appendices

Appendix A

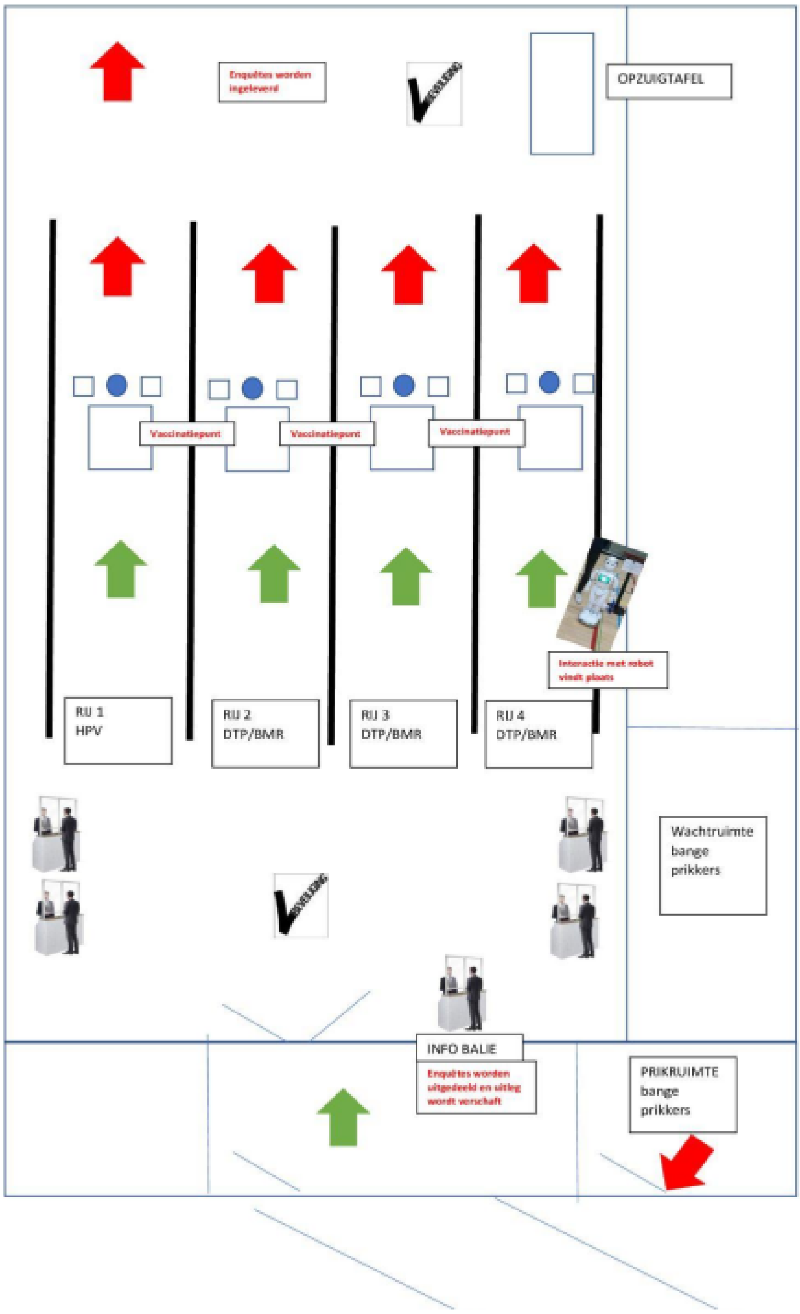


Figure 8: Map of Sporthal Schenkel and NG study procedure

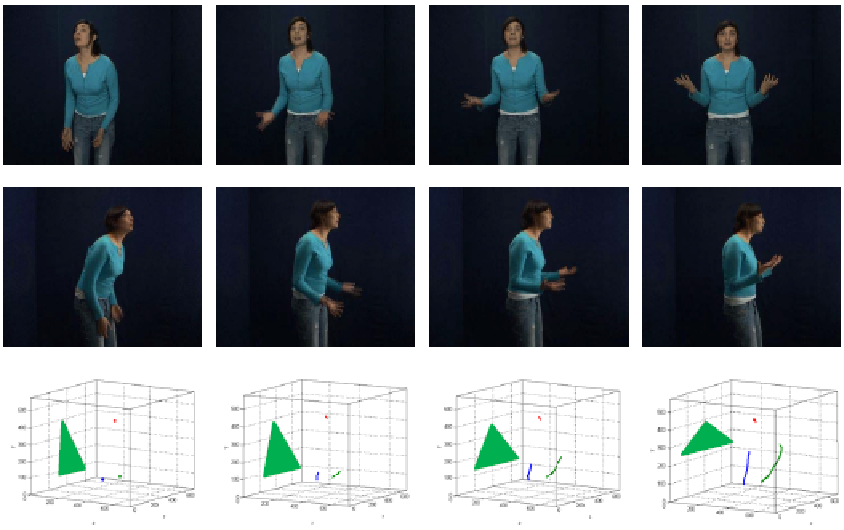


Figure 9: 4 Key frames of a gesture that expresses joy

Appendix C

Part	Utterance
1.	Hoi ik ben Robin. Jij hebt een filmpje gekeken met mijn vriend en jij hebt de vaccinatie gehaad. Goed gedaan! Ik vond de vaccinatie best spannend. Hoe vond jij de vaccinatie?
2.	Dan ben je nu klaar. Ik ga na vaccinatie naar huis een beetje TV kijken en iets eten. En wat ga jij nu doen?
3	Bedankt voor je antwoord. Het was erg leuk je te ontmoeten. Ik wens je dan nog een fijne dag. Doei!

Table 4: Original questions for second interaction

Appendix D

Value	Evaluation	Observation
0	Intense noncompliance	Participant stood and walked away from the table on which the robot interaction took place
1	Noncompliance	Participant hung head and refused to comply with interviewer's request to speak to the robot
2	Neutral	Participant complied with instructions to speak with the robot after several prompts from the confederate
3	Slight interest	Participant required two or three prompts from the confederate before responding to the robot
4	Slight Engagement	Participant complied immediately following the confederate's request to speak with the robot
5	Intense Engagement	Participant spontaneously engaged with the robot

Table 5: Original coding scheme by (Kim et al., 2012)

Appendix E

Utrecht University

centrum voor jeugd en gezin capelle aan den ijssel

Toestemmingsformulier

Betreft: *onderzoek naar spanning onder kinderen bij groepsvaccinaties*

Procedure: Het kind krijgt de kans om een paar minuten met de robot te spelen. Na de vaccinatie is er nog een korte interactie met de robot waarbij het kind 2 vragen kan beantwoorden.

Ik verklaar hierbij op voor mij duidelijke wijze te zijn ingelicht over de aard, methode en doel van het onderzoek.

Ik begrijp dat:

- ik mijn medewerking aan dit onderzoek kan stoppen op ieder moment en zonder opgave van reden
- gegevens anoniem worden verwerkt, zonder herleidbaar te zijn tot de persoon
- de opname vernietigd wordt na de presentatie van dit onderzoek

Ik verklaar dat ik:

- geheel vrijwillig bereid ben aan dit onderzoek mee te doen
- de uitkomsten van dit interview verwerkt mogen worden in een verslag of wetenschappelijke publicatie
- toestemming geef om te filmen wanneer uw kind met de robot speelt en interacteert

Omdat we u als participant de mogelijkheid willen geven zelf een keuze temaken wat er met uw data gebeurt, kunt u voor ieder van de volgende handelingen los een handtekening zetten. U bent niet genoodzaakt alle drie te tekenen om deel te kunnen nemen aan het onderzoek

Handtekening betreffende anoniem verwerken data en delen van beelden met andere onderzoekers:

……………………………………………………………………

Datum: 19-04-2022

➔ Ga naar de volgende zijde

Vragenlijst

Hé! Leuk dat je meedoet aan dit onderzoek. Voordat je de prik krijgt willen we je vragen om eerst de vraag op deze kant van het papier in te vullen. Bij vragen waar je smiley's ziet kun je de smiley die het meest bij jouw gevoel past omcirkelen.

De enquête bestaat uit 10 vragen voor jou.

<u>Vragen voor de vaccinatie</u>

1. **Hoe vind je het om een prik te krijgen?**
   Omcirkel het gezicht dat laat zien hoe jij je nu voelt.

Helemaal niet leuk	Niet leuk	Niet stom/ Niet leuk	Leuk	Heel leuk

2. **Op dit moment voel ik me kalm.**
   Zet een kruisje waar de verklaring van toepassing is.

Zeker niet	Niet echt	Ik weet het niet	Een beetje	Zeer veel

Bedankt!
De vragen op de volgende bladzijde mag je na de prik invullen.

Utrecht University

centrum voor jeugd en gezin
capelle aan den ijssel

Vragen na de vaccinatie

3. Heb je naar het filmpje van de robot gekeken?

Omcirkel jouw antwoord: Ja / Nee

4. Hoe vond je het om een prik te krijgen?

Helemaal niet leuk	Niet leuk	Niet stom/ Niet leuk	Leuk	Heel leuk

5. Op dit moment voel ik me kalm.

Zet een kruisje waar de verklaring van toepassing is.

Zeker niet	Niet echt	Ik weet het niet	Een beetje	Zeer veel

6. Zou je de robot nog een keer willen zien?

Omcirkel het gezicht waar de verklaring van toepassing is.

Zeker niet	Niet echt	Ik weet het niet	Ja	Ja heel graag

7. Zou je nog een filmpje van de robot willen zien?

Omcirkel het gezicht waar de verklaring van toepassing is.

Zeker niet	Niet echt	Ik weet het niet	Ja	Ja heel graag

8. Denk je dat de robot de waarheid vertelt?

Omcirkel het gezicht waar de verklaring van toepassing is.

Zeker niet | Niet echt | Ik weet het niet | Een beetje | Ja helemaal

9. Hoe oud ben je?

Ik ben ____ jaar oud

10. Wat is je geslacht?

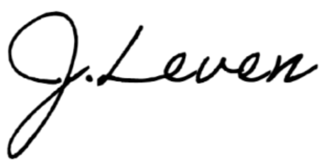
Ik ben een: Jongen / Meisje / Anders

Super! Hartelijk dank voor het meedoen aan dit onderzoek!
Je mag de enquête nu bij de uitgang inleveren.

Verklaring van de onderzoeker:

Ik heb mondeling toelichting verstrekt over de aard, methode en doel van het onderzoek.Ik verklaar mij bereid nog opkomende vragen over het onderzoek naar vermogen te beantwoorden.

Handtekening:



Naam: Jessica Leven (Datum: 19-04-2022)
Email: j.leven@students.uu.nl

Neem vooral contact op als u geïnteresseerd bent in de resultaten van het onderzoek

Appendix F

Value	Evaluation	Observation
1	Intense noncompliance	Participant stood and walked away from the area where the robot interaction took place
2	Noncompliance	Participant hung head and refused to answer or to speak to the robot or needed several prompts
3	Slight interest	Participant needed a prompt before answering or speaking to the robot
4	Slight Engagement	Participant answers or speaks immediately with the robot without any required prompt
5	Intense Engagement	Participant spontaneously engaged with the robot (speaking up by himself or herself or other attempts to engage)

Table 6: Adjusted coding Scheme for measuring engagement during the second spoken intervention

Appendix G

Variable	1	2	3	4	5	6	7	8	9
1. Observed Engagement	-								
2. Self-Reported Engagement	.04	-							
3. Pre-State Anxiety	-.00	-.05	-						
4. Post-State Anxiety	-.03	-.15	-.32**	-					
5. Pre-State Fear	-.07	-.02	.46**	.32**	-				
6. Post-State Fear	-.02	-.13	.34**	.51**	.59**	-			
7. Trust	.10	.30**	-.09	-.16	-.02	-.04	-		
8. Word Count	.20	.17	.16	-0.1	-.00	-.05	-.09	-	
9. Engagement in spoken interaction	.20	.24*	-.11	-.18	-.18*	-.17	-.02	.35**	-

Note. *p <. 05, **p < .01

Table 7: Intercorrelations in EG condition

Appendix H

Variable	1	2	3	4	5	6	7	8	9
1. Observed Engagement	-								
2. Self-Reported Engagement	.04	-							
3. Pre-State Anxiety	-.00	-.05	-						
4. Post-State Anxiety	-.03	-.15	-.32**	-					
5. Pre-State Fear	.07	-.13*	.46**	.32**	-	.			
6. Post-State Fear	-.02	-.19**	.34**	.51**	.54**	-			
7. Trust	.10	.26**	-.09	-.16	-.06	-.10	-		
8. Word Count	.20	.17	.16	-0.1	-.00	-.05	-.09	-	
9. Engagement in spoken interaction	.20	.24*	-.11	-.18	-.18*	-.17	-.02	.35**	-

Note. *p <. 05, **p < .01

Table 8: Intercorrelations in full sample