A Touching Connection

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Robot-mediated interventions for children with autism spectrum disorder

Claire Huijnen

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Prof. dr. P.E.H.M. Muris

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Jonathan

"Jonathan, our little whirlwind like the similar cartoon from Mickey mouse 1941.

When Jonathan is at home things happen. Our home is alive as Jonathan runs around doing things , asking questions, picking up toys and leaves them, chasing our poor dog Tommy …

Yes, at the end of such day the house looks like a whirlwind has visited it.

The reason for this is Jonathans small concentration span related to his ASS. He's unable to do things for a long period and so is the tidy up after an activity. Although he's 9 years, old we do it for him ☺.

And then KASPAR enters the scene … Jonathans concentration span suddenly increases and so his ability to communicate. What's even more special is the developing friendship ... between Jonathan and KASPAR. So yes we (parents of Jonathan) were and are astonished.

Mr. KASPAR thank you for all your help, The Touching Connection is there, you're more than welcome again."

October, 2018

Parents of Jonathan, the boy from the documentary: "Scenario's voor een normaal leven".

Chapter 1

General introduction

Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a complex pervasive developmental disorder characterised by persistent impairments in social interaction and communication and restricted, repetitive patterns of behaviour, interests, or activities.[1] The term “spectrum” is used to denote the large variations between individuals in the manifestation of the heterogeneous disorder. People with ASD often show difficulties with approaching other people, social-emotional reciprocity, non-verbal communication behaviours, and developing, maintaining and understanding relationships.[1] Moreover, selective (inward) attention, a deficit in focused attention and a lack of or poor responsiveness are characteristics of many people with autism.[2] The symptoms often cause severe impairments in social, occupational, or other important areas of functioning throughout a person’s life.[1] The severity of the impact on daily life also varies greatly among people with ASD. Some people are able to function relatively independently (with some support), whereas others cannot live alone by themselves. Between 5 and 15 % of the adults with ASD are able to function independently without any means of support.[3]

Little is known about the exact cause of autism. It is evident, however, that ASD is largely hereditary, with a higher incidence among boys/men than among girls/women. Besides nature, also nurture (environmental factors) seems to play a role, although the precise mechanisms are not known.[3] On both ends of the spectrum, comorbid psychopathology is common (e.g. anxiety disorders, depression, ADHD, and learning disabilities).[4] From the people with ASD, about half has some form of intellectual disability.[3]

Recent studies report prevalence estimates of 1 child in 68[5,6] or even more recent (April 2018) 1 child in 59 children.[7] The number of children diagnosed with autism is rising the recent years.[5,8,9] Different explanations are suggested for this increase in prevalence, of which expanded diagnostic criteria, increased awareness of the disorder, diagnosis at earlier ages, and the recognition that ASD is a lifelong condition are the most common.[3,9] What is clear, however, is that more people with ASD, as well as their relatives/peers around them, are in need of adequate support and that this creates a strain on the current support system in terms of costs, provision and organisation of health, social and educational supports for children with ASD.[10,11] The symptoms of ASD often create a burden and stress for the involved parents, siblings and grandparents.[12]

There is no cure for autism (yet) and there is no intervention or therapy that guarantees effectiveness for all children.[13,14] However, it is unmistakable that children benefit from early and personalised interventions.[13] The aim of interventions and therapy is not to treat or to cure, but rather to optimally support children with ASD in coping with the ASD associated symptoms and their participation in education, daily life and society.[3,13,15] A multitude of different interventions targets the core deficits of children with autism, based on various different theories and professional practices, focusing on different aspects of their lives (school, recreation, independence, building up social networks and later in life, for some, also work).[13,15] Interventions can be very diverse, ranging from behavioural approaches (e.g. applied behavioural analysis, discrete trial training, pivotal response training), cognitive (e.g. cognitive behaviour intervention), sensory interventions (e.g. sensory integration), educational (e.g. Picture Exchange Communication System (PECS), parental interventions (e.g. parent implemented intervention), to the use of medication (such as antipsychotics, serotonin reuptake inhibitors to treat mood and repetitive behaviours, or medications to treat attention deficits and hyperactivity) to alternative interventions (such as acupuncture or dolphin therapy).[12,15,16] Most individuals with ASD continue to receive some form of support throughout their entire life.

Although there is no one-size fits all solution with respect to the effectiveness of certain interventions, in The Netherlands there is consensus about which elements should be included in the support and supervision of people with autism. This includes: psychoeducation, treatment of somatic symptoms (e.g. visual or hearing problems), treatment of comorbidity, and psychosocial interventions (such as behavioural interventions, family support and support in education and employment).[3] Notably, there is no best approach with respect to choosing a certain combination of interventions; what works well for one person, might have adverse effects for another person.[13] Professionals working with children with autism have the challenging task to choose and apply interventions, based on their experience and a child's (changing) needs.

The context of special education for children with autism in The Netherlands

In The Netherlands, children attend school from their fourth year of life. When they reach the age of five, full-time education is obliged until they turn sixteen. Children with ASD often have different ways of information processing and language acquisition (compared to children without ASD) making mainstream primary school or regular education too difficult.[3] Dutch schools are obliged by law to offer suitable and tailored education to all pupils. The inspection for education of the Dutch government stimulates and inspires schools to come up with innovative solutions when implementing suited education for each student.[17] As a consequence, additional special education and forms of autism therapy or interventions can be given at mainstream primary schools, or children with more severe symptoms or impairments can attend special schools. These are schools especially intended for children with learning disabilities, physical disabilities, developmental impairments or behavioural problems.[18] Four clusters of special education can be distinguished in The Netherlands.[18] Cluster 1 is for blind or visually impaired children, cluster 2 is intended for deaf children or those with an hearing impairment. Children with physical or motor disabilities, cognitive impairments or long-term illness attend schools in cluster 3. Cluster 4 contains the schools that are specialised in and optimally equipped for offering education for children with developmental disorders, such as autism, and behavioural problems.

The number of children with ASD receiving special education (either at mainstream primary schools or at special schools) has been growing the recent years.[17,19] In the school year of 2016/2017 almost 1.5 million children attended mainstream primary schools in The Netherlands, slightly more boys than girls. About 34.000 children received special care at primary schools (twice as many boys than girls). Slightly more than 67.000 children were in special needs schools, more than twice as many boys than girls.[20]

Both at regular primary school as well as at special education children with autism often run into problems related to social communication, attention, and executive function. An overview of the difficulties they experience is given by Mesibov and Shea (2010). In their work they indicate that children with autism can have a heightened attention to details, but difficulty with sequencing, integrating, connecting, or deriving meaning from these details.[21] A large variability in attention can be seen as well; they can be very distractible at times and intensely focused at other moments, with difficulties shifting attention efficiently. Moreover, they experience difficulty with the concept of time, including moving through activities too quickly or too slowly, having problems recognizing the beginning or end of an activity, how long the activity will last, and when it will be finished. Subsequently, they have a tendency to become attached to routines and the settings where they are established, so that activities may be difficult to transfer or generalize from the original learning situation, and disruptions in routines can be uncomfortable, confusing, or upsetting. Furthermore, often they show very intense interests and impulses to engage in favoured activities and difficulties disengaging once engaged. And finally, often they have remarkable sensory preferences and aversions.[21]

Current teaching programmes and techniques used in special education for children with autism are often based on the TEACCH (Training and Education of Autistic and related Communication Handicapped Children) methodology (also called Structured Teaching).[21] It takes into account the above mentioned difficulties. The essential mechanisms of TEACCH are: a) structuring the environment and activities in ways that these are understandable to the child; b) using the child's relative strengths in visual skills and interest in visual details to supplement relatively weaker skills; c) using the child's special interests to engage him/her in learning; and d) supporting self-initiated use of meaningful communication.[21] Structured Teaching is not a curriculum, but a framework to support achievement of educational and therapeutic goals. Within this framework, different interventions can be applied to support learning and development, but also communication challenges, which are common among children with autism.

Current estimates suggest that between 10% and 25% of the people with autism do not master speech proficiently enough to meet ongoing communicative needs in daily life.[13] Augmented alternative communication (AAC) may help to facilitate the person's ability to understand communication from others, and to communicate more effectively to others.[13] It can be applied within the TEACCH framework and supports functional communication and language production. AAC can use various techniques, such as the use of various types of symbols, but also fine gestures manual signs, and gross motor body movements or sequences (e.g. pointing, yes/no head movements, waving). The Picture Exchange Communication system (PECS)[13] is an early nonverbal AAC technique that is often used in natural education and home settings (also in special schools in The Netherlands). The child learns to exchange graphic symbols to request desired items. PECS can be used to communicate a request, a thought, or anything that can be captured in a picture. At first, single pictures or real objects are used, and later on in the process, simple words or sentences are made. TEACCH and PECS are examples of multiple strategies and methods are currently applied in the environment of children with autism to stimulate their learning and to help them cope with the symptoms of autism in daily (school) life.

The potential of robots as assistive tools in interventions for children with autism

The World Health Organization (WHO) defines the meaning of disability as not being intrinsically part of the person, but rather a function of the person's interaction with the environment.[22] People with mental conditions including dementia and autism have been identified by the WHO as people who most need assistive technology.[23] Advances in the development of innovative technological tools, combined with research achievements and increased insights on its use and application, provide novel educational opportunities for people with autism, their teachers, and their families.[14,24-27] Ongoing research showed the acceptance and efficiency of interactive technologies and applications in educational settings.[25,28,29] Examples include the use of interactive environments, computer-assisted therapy, virtual reality approaches, serious gaming and also robots.[28,30-33]

Robots have already been applied in various healthcare application domains (e.g. for rehabilitation, surgery, medication delivery or support of daily living).[34] A socially assistive robot (SAR) focuses on supporting people through social interactions rather than physical interactions with the robot.[35,36] Autism is one of the first application domains for SAR (or social robots). More and more studies highlight the capabilities and possibilities of using different social robots for addressing educational and interventional goals for children with ASD.[24,32,37-43] Examples of robots used in this context are Probo,[44] Nao[45] and KASPAR.[46] Social robots can be used as assistive tools to play with children, to teach them skills or to elicit certain desired behaviours from them.[47,48] How robots can be used and embedded in interventions for children with autism is the focus of this dissertation. Robots have a number of characteristics that may work well for children with autism.

Reasons for expected success of robots in context of special education

Using robots in autism interventions to support children who have difficulties with social interaction and communication may sound contradictory: aren't we as humans, with all our senses, emotions, expressions and feelings, best capable to teach them these skills? Compared to humans, a robot does not get frustrated, does not show emotions, is never tired and can be completely consistent in its behaviour. Moreover, its non-verbal messages coming from facial expressions, gestures and the tone of voice never contradicts with what the robot verbally says. In humans, this discrepancy of what message is conveyed using words versus using nonverbal communication is much more common. This is difficult to comprehend and process for children with autism.

In the literature, multiple reasons are given for the expected success of robots for these children: interacting with a robot can be easier or less complex for (some) children with autism than interacting with a person, but also more neutral and controllable, more predictable and more appealing.[36,42,48] A robot can be an interaction partner children may feel more intrinsically motivated to be around with than a person/human. People send (unconsciously and often unintended) non-verbal messages with their face, body and voice along with verbal messages. Making sense of non-verbal communication (whether or not in line with verbal communication) is difficult/challenging for children with autism. Robots do not have these non-verbal elements in their communication. Making contact, interacting and learning with robots may be easier and more pleasant for children with autism.

Encouraging effects such as increased engagement, increased levels of attention and novel social behaviours have been reported when children interact with robots.[36] In other cases, children showed reduced repetitive and stereotype behaviour as well and began to speak spontaneously.[49] Other examples are effects in the area of collaborative play,[50,51] turn-taking behaviour,[40] and imitation in social interaction.[52,53]

Current state of robots for children with ASD (prototypes vs interventions in practice)

Despite the above mentioned research findings, robots have only made minimal progress towards the clinical application in autism interventions.[54] The current state of application and implementation of robots is still in an early stage. The majority of the research on educational social robots is still based on highly controlled studies in lab settings (and using prototypes), causing limitations with respect to the transferability and applicability of the results to real-world learning environments.[55] According to Diehl et al. (2012) many of the conducted studies are explorative in nature, are limited in terms of methodological quality and do not necessarily focus on the clinical application of the robots, but on the development of technology.[48] More efforts and research is needed to understand the actual clinical effects and potential of using robots in autism practices.[48]

Robot KASPAR

One of the social robots that has been applied in recent studies with children with autism is robot KASPAR (see Figure 1.1). It is developed by the Adaptive Systems Research Group of the University of Hertfordshire (UK). KASPAR is a minimally expressive humanoid robot and its name stands for Kinesics And Synchronization in Personal Assistant Robotics.[56] It is a low-cost iteratively designed robot (prototype) built using off-the-shelf hardware components and materials and is suitable for human-robot interaction studies. KASPAR can be used in three operation modes: 1) automatic behaviour or autonomous control in which the robot fully relies on the activation of its sensors and actuators (no use of the remote control function); 2) a (remote) controlled operating mode in which the professional who accompanies the child controls the robot; 3) a combination of both (a semi-autonomous mode in which both the sensors and the remote control functionality are used). Customisation software allows for the creation of new (personalised) KASPAR scenario's.[57] These scenarios can use KASPAR's movement of arms, torso, head and hands to create various poses, speech and sounds can be played, and (minimal) facial expressions can be shown (by movements of KASPAR's eyes, eye lids and mouth) (see Figure 1.1).

Figure 1.1 Robot KASPAR, in a boy and girl version

It has been applied in the area of play,[40,50,58,59] body awareness and sense of self,[60-62] collaboration,[63] mediating and encouraging social interaction,[64] tactile social behaviour[65] and learning appropriate physical interaction.[61] Professionals (e.g. special need teachers, ASD trainers, caregivers) consulted in The Netherlands, expect that KASPAR can contribute to achieving various educational and therapy objectives for children with autism.[66]
KASPAR is the platform that is used in the studies conducted in this dissertation. Main motivations for selecting robot KASPAR were the positive effects using KASPAR in previously conducted research in the UK, the fact that new and personalised scenarios can be made for KASPAR without the need of technical assistance or complex programming skills, and the fact that KASPAR is relatively affordable for practices such as special education schools.

Need for user focused innovation approach to develop robot-mediated interventions

In order for robots to be of future benefit to teachers, trainers and children with autism, their interaction style, social behaviour, appearance and application must match the children's needs and the changing needs of educational contexts.[55] More and more consensus is seen, that in order to achieve this, it is crucial to actively involve teachers, trainers, and other professionals in the process of designing and developing these robots.[55,67] Users of innovative systems, such as robots, are nowadays considered as co-producers of technological practice rather than passive consumers. In contrast to the earlier dominant technologically driven robot development process, user-driven and open innovation approaches such as participatory design, user centred design and co-creation are now increasingly being put in place to give the users an active role in the design and development of the technology they will use in the future.[55,68-70] In these approaches the valuable expertise of engineers, professional designers, occupational therapists, teachers, and other stakeholders comes together with the same goal of creating qualitative interventions for people in need of support.
With this research we aimed to make a contribution to bridging the research-practice gap in the area of robot-mediated interventions for children with autism, and to assist autism practitioners by co-creating robot interventions that meet their and their pupils needs and fits to the dynamics of an educational context.

Aim and outline of the dissertation

The main focus of this dissertation is on the potential of robot-mediated interventions in autism practices for children. More specifically, robot KASPAR was used as the robot platform for which interventions were co-designed and tested in the context of (special) education.

This dissertation aimed to answer the following research questions:

1. What are objectives that professionals work on in practice with children with autism and what is the state of the art of robotics targeting these objectives?
2. To which objectives for children with autism can robot KASPAR contribute according to professionals?
3. What roles are possible for robots in interventions for children with autism, and what are strengths and challenges to take into account?
4. How can robots be practically implemented into current practices? What are important requirements to take into account?
5. What is the effect of a KASPAR-mediated intervention on making contact with children with autism?

Chapter 2 describes the process and results of the state of the art robotics found in a systematic literature study mapped to the objectives for children with autism originating from focus groups with professionals (e.g. teachers, trainers, care givers) working with children with ASD. Chapter 3 details the results of an online questionnaire distributed among ASD professionals to identify the expected potential contribution of robot KASPAR to the therapy and educational objectives that are relevant for children with autism. Chapter 4 describes the findings from a study to better understand where the potential lies for robots in interventions according to professionals working in practice. Results of focus groups delivered different roles for robots, as well as strengths and challenges to be taken into consideration. How to actually utilise this potential, co-create, embed and implement robots in current practices and interventions is outlined in Chapter 5. If and how a KASPAR-mediated intervention contributes to one of the main objectives for children with autism, namely making contact, is presented in Chapter 6. These are the results of a study conducted at a special school with children with autism interacting with KASPAR. Chapter 7 provides a general discussion about these five studies, including limitations and implications for practice, future research and policy.

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Chapter 2

Mapping Robots to Therapy and Educational Objectives for Children with Autism Spectrum Disorder

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Abstract

Aim

The aim of this study was to increase knowledge on therapy and educational objectives professionals work on with children with autism spectrum disorder (ASD) and to identify corresponding state of the art robots.

Method

Focus group sessions (n=9) with ASD professionals (n=53) from nine organisations were carried out to create an objectives overview, followed by a systematic literature study to identify state of the art robots matching these objectives.

Results

Professionals identified many ASD objectives (n=74) in 9 different domains. State of the art robots addressed 24 of these objectives in 8 domains. Robots can potentially be applied to a large scope of objectives for children with ASD. This objectives overview functions as a base to guide development of robot interventions for these children.

Introduction

An increasing number of children across the globe are being diagnosed with autism spectrum disorder (ASD).[1-4] From recent studies, a best prevalence estimate of children with ASD of 0.66 % or 1 child in 152 children can be made although also higher numbers have been reported.[5] The Diagnostic and Statistical Manual of Mental Disorders (DSM-V) describes the diagnostic criteria for ASD.[6] According to the DSM-V, people with ASD often experience persistent problems in social communication and social interaction across multiple contexts on the one hand, and show restricted, repetitive patterns of behaviour, interests, or activities on the other hand. Clinically significant impairments in social, occupational, or other important areas of functioning are apparent.[6] The symptoms manifest on a continuum, a spectrum, with some individuals showing mild symptoms and others having more severe symptoms and challenges in daily life, and demanding more support.[7] Together with these differences in severity of symptoms, large variations in symptoms cause ASD to be a highly heterogeneous disorder.

Children with ASD benefit from early and ongoing intervention that is tailored to their specific needs.[5] Even if children reveal progress in some areas during their school time after receiving care, for example in language proficiency, many other areas nevertheless require extensive support, for example in social interaction and communication skills.[5] Most children with ASD continue to have ASD as an adult and continue to experience challenges related to independent living, employment, social relationships and mental health.[8]

Ongoing research has proven the acceptance and efficiency of technology as a support tool for the therapy and education of individuals with ASD and the people who support them on a daily basis.[9-13]

Theory of Mind (ToM) refers to the ability to understand one's own and other people's beliefs, intentions, desires, imagination, and emotions.[14] Often children with autism have difficulties in ToM. Technologies might provide tools to address these impairments because they can create situations or environments in which children can practice and learn in a safer (e.g. more predictable) and more pleasant manner than when they would practice this (only) with a person. Technologies can deliberately focus on targeting the strengths and weaknesses of the disorder by creating controlled environments that might reduce the anxiety that ''real'' social situations may cause for children with ASD.[9] More specifically, socially interactive robots or robot assisted therapy are suggested to be of potential added value in the therapy of children with autism.[15] Boucenna et al. (2014) suggest a number of reasons for this expected beneficial effect; it might be easier for children with ASD to interact with robots than with humans. Robots (less complex, more predictable, and simpler) can also provide novel sensory stimuli and tend to occupy a special niche between inanimate toys (which do not trigger novel social behaviours for these children) and humans (which can be a source of confusion or even distress for them).[16] In other words, robots enable embodied interactions that are appealing for children with ASD. Possibly robots can simultaneously provide humanlike social cues (e.g. waving, smiling) while maintaining object-like simplicity (e.g. in a consistent manner, limited facial expressions).[17] Thill et al. (2012) summarized a number of advantages of using robots for children with ASD: robots can be applied in a controlled manner so that only relevant information is presented minimising the risk of creating stressful and complex situations, robots are better in endless repetition than people, and variations can be made in a conscious (and safe) manner.

Scassellati et al. (2012) report encouraging effects such as increased engagement, increased levels of attention and novel social behaviours, for example joint attention and imitation, when the children interact with robots.

Earlier work[15] presented a compilation of robots that have been studied for children with autism and distinguished a number of benefits and roles that robots could have. These roles range from a ‘‘friendly playmate’’, a ‘‘behaviour eliciting agent’’, a ‘‘social mediator’’ or a ‘‘social actor’’ to a ‘‘personal therapist’’.[18] A review of the clinical use of robots for individuals with ASDs identified four categories for the roles for interactive robots in clinical applications: the response of individuals (often children) with ASD to robots or robot-like behaviour in comparison to human behaviour, the use of robots to elicit behaviours, the use of robots to model, teach or practice a skill and the use of robots to provide feedback on performance.[9]

Although most of these studies yielded positive effects using robots for children with autism (e.g. show an increase in desired target behaviours, increased response times, show appreciation/interest for robot interaction), not all children would benefit from (the same) robotic support[18] or would perform better with a human counterpart compared with a robot.[19] Mixed results and variability in the nature of the affective response (e.g. positive or negative reaction towards the robot) are also reported; children are not likely to always react positively to the robot.[20] This, again, underlines the need for personalised and tailored interventions for this heterogeneous target group.

With respect to teachers’ acceptance on the use of robots in education, one study found that pre-school and elementary teachers accepted a human-like robot to serve as an interactive tool in the teaching process.[21] Other findings regarding attitudes towards the use of robots in (psycho)therapy or education for children show that people, overall, tend to have positive attitudes, considering them as useful and potentially effective tools in psychological treatments or interventions.[21-23] Despite this work with promising results, the actual current state of application of robots for children with autism in care/therapy and education practices is still relatively in an early stage. More research is needed to understand the actual clinical effects and added value in therapy and education.[18] Moreover, it would be interesting to better understand in what areas robots can actually add value to the functioning of children with autism, and how this relates to the ''International Classification of Functioning, Disability and Health'' (ICF).[24] The ICF for children and youth (ICF-CY) provides a classification for health and health-related domains and addresses all aspects of functioning specifically for children and youth.

A critical review by Diehl et al. (2012) concluded that many of these studies are explorative in nature and have methodological limitations and do not necessarily focus on the clinical application of the technology but more on the development of the technology.[18] The exploration of robot-based autism intervention has often been directed at clinical or therapy settings and less on educational settings in which children might also benefit from the use of robots in the curriculum.[25]

Furthermore, although research has proved the potential added value of different kinds of technologies for children with autism, however, often these tools currently lack the ability to personalise to a specific person's needs.[6] Especially for such a diverse and heterogeneous target group as children with autism, it is extremely important that interventions address challenges in different dimensions and a personalised offering is possible.[5] Technologies, including robots might be able to fulfil this requirement as they allow for personalisation and customisation to the individual's specific needs.

Actual clinical application of robot technology in practice requires the expertise of both technology developers as well as experts in the area of children with ASD. Although public opinion and press devote more and more attention to the use of robots in the therapy or education for children with ASD, scientific peer reviewed publications of systematic clinical effectiveness of the actual implementation of robot based interventions for children with ASD are still scarce.

For robots to be of clinical added value, obviously, teachers and/or care professionals have to accept, adopt and embed these robots in their daily practices. To be used, interventions need to meet the needs of children as well as the needs and practices of these professionals. This is a rather challenging task. For robot developers, it can be quite hard to understand and relate to the needs of this heterogeneous target group and therefore difficult to develop appropriate robot systems to be used as part of interventions. For professionals working with children with ASD on the other hand, the world of social robots seems quite invisible, far away or unreachable. Yet, in order for robot assisted therapy to bring added value to the lives of children with ASD and their carers, connecting professionals from the robotic community with experts in the area of ASD makes a lot of sense.

This study aims to contribute to this by providing a systematic overview of objectives that are important for children with autism and to provide a mapping of available robots to these objectives. This may facilitate the awareness and creation of common understanding between robot developers and ASD professionals (both educators at (special) schools or therapists working in care settings) who are (intending to become) active in the area of robot assisted therapy for children with autism. For ASD professionals it may provide an overview of robots that are currently presented in peer reviewed literature. For the robotic developers on the other hand, it may give insight into relevant ASD domains and objectives that professionals in the field are actually working on.

In short, this research entailed two main goals:

1. To create an overview of relevant therapy and educational objectives that professionals are actually working on in practice for children with ASD.
2. To identify robots focusing on children with ASD that are presented in peer reviewed articles and to relate them to the overview of objectives.

Methods

A mixed methods approach was used in this study. For the part of creating an overview of ASD objectives that professionals work on for children with ASD, focus group sessions were carried out in which practitioners from the field were involved. For the part of identifying which robots are presented in peer reviewed journals, a systematic literature study was conducted.

Focus groups

Care organisations, medical day care centres and special schools, all specialised in supporting children with ASD, were invited to participate in the focus groups to gain insight into the therapy and education objectives professionals work on for children with ASD. At each organisation a session was organised at a moment that was most convenient for the participants from that organisation.

The main principles of the Metaplan method were used for conducting the sessions and the data collection.[26] Main principles of this method include collecting individual input of the participants (one idea on one card), then sharing these in the group in an open non-judgemental brainstorm and ending with organising them collectively.

Participants

In total nine focus group sessions were conducted with employees from nine organisations who work with children with ASD on a daily basis. One session was organised for each organisation. This relatively high number of sessions was chosen deliberately in order to be able to identify a large range of objectives inherent to the heterogeneous nature of the disorder and to include both therapy and education settings. The participating organisations all provide care, therapy or education for children and youngsters with ASD (e.g. special need schools, youth care organisations, centres for orthopedagogical treatment, medical day care centres). Professions of the participants ranged from speech-language pathologist, occupational therapist, applied behaviour analyst, game therapist, special needs teacher, psychologist, family coach, to team leader or director.

Procedure

For both practical (e.g. busy schedules of care professionals and teachers) and motivational reasons (e.g. increase commitment of professionals), the sessions took place at the premises of the care organisations and/or special schools. The focus groups were carried out in separate sessions (ranging from 4 to 9 participants in each group) at the different locations and took about 2 h each. All participants in one session were employed by the same organisation. Two researchers from the project team were present in each session, one person in the role of focus group moderator, and the other person as preparation assistant, observer, and note taker. As preparation of each session, informed consent papers, post-its and pens were distributed among each participant. To facilitate both the individual and the group aspect, the procedure consisted of 3 main steps. After an introduction, the participants started with listing as many ASD objectives as they considered to be relevant for children with ASD (independently and individually they wrote down one objective per note). The second step was to discuss these individual notes in the group to share results among participants. Finally, all the separate notes with objectives were collectively organised on a large sheet of paper in the middle of the group. For facilitating grouping of the objectives, a categorisation of 12 overall areas was shown as presented in[4] on evidence based practices for children, youth and young adults with ASD. Participants were free to change, alter or expand these categories where they considered this appropriate. The goal was not to strive for consensus, but to create a realistic overview of the range of objectives that professionals work on with children with ASD. Differences were considered to be valuable, not troublesome.

Data analysis

A picture was taken of the grouping that was done and all notes were collected and digitalised individually. Focus group sessions were recorded (audiotaped, after collecting informed consent) and a transcript was made of each session. The objectives and the clustering that the groups made were collected by two project members who participated in the sessions and they made the overall overview based on these results. An analytical session was organised in which they studied the results and found commonalities or patterns in the mentioned objectives and grouping of the domains. In order to provide a common language for sharing these findings, ICF-CY codes were provided for the objectives. The International Classification of Functioning, Disability and Health (ICF) of the World Health Organisation (WHO) provides a uniform classification of health and health-related domains (World Health Organization 2007). The ICF-CY is the Child and Youth version that is applicable to this study. A member check of the created ASD objectives overview was done by means of an online questionnaire (the participants indicated to agree to the resulting overview) afterwards.

Systematic literature study

Procedure

Research articles were obtained through an electronic library search (queried in February 2015) according to the principles stated in the Cochrane Handbook.[27] A systematic search was conducted in a number of major databases from various disciplines (ranging from social and behavioural sciences to educational to technology expertise). The consulted databases were: PubMed, CINAHL, EMBASE, ERIC, IEEE Xplore digital library, Science Direct, SpringerLink and Taylor and Francis. Furthermore, a Google Scholar search was performed. For a comprehensive search of the literature, search terms were formulated very broadly to increase the likelihood of inclusion of relevant articles. Three main elements of the search query were used: robot, autism and child. The search terms were tailored to the requirements of the respective databases where necessary (e.g. appropriate use of MeSH terms, headings, thesaurus and free text words). Only articles written in English were included and the search was conducted based on the articles metadata. For more details on the search strategy used in the literature study we refer to the ‘‘Appendix 2.1’’.

Data extraction

All full articles were read by the first author who extracted the following data from these articles: what robot is used in the presented study and for what ASD objective(s) or goal(s) is this robot applied in the specific study? The ASD objectives overview based on the results from the focus groups was used as a framework (see Table 2.2). For each study, the robot used and the objective that best represents the goals described by the authors was identified. These goals were matched with the objectives in the framework, resulting in a mark in the table.

Results

Therapy and educational objectives for children with ASD (from focus groups)

Descriptive characteristics

In total, 53 ASD professionals (41 female, 12 male) participated in nine focus group sessions. They were all trained and specialised in working with children with ASD, mostly in multidisciplinary teams with varying backgrounds such as child psychology, psychiatry, behavioural science, speech and language therapy, occupational therapy, physiotherapy, art therapy, special needs education and care or general management. The years of working experience in practice ranged from 1 to 35 years. The large majority of the professionals had an experience of over 5 years (average 12.7 years, SD 7.8 years).

Overview of therapy and educational objectives for children with ASD

During all these sessions, a total number of 489 notes with ASD objectives were created by the participants describing the therapy or educational goals that they consider important for children with ASD. The first two columns of Table 2.2 present the results from the focus groups and highlight the main areas and objectives that ASD professionals identified as being important goals. The overview is divided into nine main domains; communication, social / interpersonal interactions and relations, self-care / independent living, play, emotional wellbeing, sensory experiences and coping, motor experiences and skills, preschool skills, and functioning in daily reality; each of these domains entail a number of more concrete and specific objectives (linked to ICF-CY codes).[24]

Some domains are very closely related, such as communication and social / interpersonal interactions and relations. The objectives within the domains provide more detail of what is meant, and the domain provides the overall context. Participants indicated that all objectives are relevant for children on the spectrum; but not all objectives are urgent for a particular child at any given moment in time. Due to the heterogeneous nature of ASD, the objectives that professionals worked on, differed per child and were dynamic over time. Professionals mentioned that they choose to apply different interventions to work on this variety of objectives. Professionals work with more than one child with ASD, so in their working day at special schools, medical day care centres or ASD care organisations, they are working on multiple objectives using different interventions to achieve their goals. There was a relative equal mix of people working for care organisations providing therapy and professionals working for special needs schools or medical day care centres.

Participants mentioned that a large share of their work is targeted at supporting children to be able to live as independent as possible in different areas of life (e.g. home, school / work, hobby, society). They argued that they focused on improving children's level of functioning in daily life rather than focusing on the problems they experience.

Tuning of and deciding upon the objectives per individual child is an important task done. Professionals stressed that each child with autism is unique and an enormous variety can be seen between the needs, capacities and challenges of these children. Therefore, they indicated tailoring the objectives to the needs of a particular child at a given time is a crucial task for them. As a result, the range of objectives that professionals worked on differed per individual child and changed over time within each child as well. What works perfectly for one child might lead to a panic attack or discomfort for the other child. Adjusting the detailed and flexible application of interventions to each child is often required to meet the delicate needs of each child. What is a natural reaction for the one child, might seem an almost impossible demand for the other.

Available robots (from literature study)

With all this in mind, we were interested in how robotic support fits in this ASD objectives overview that professionals work with. The initial broad search of the literature search yielded 578 unique references (see Figure 2.1 for a visual representation).

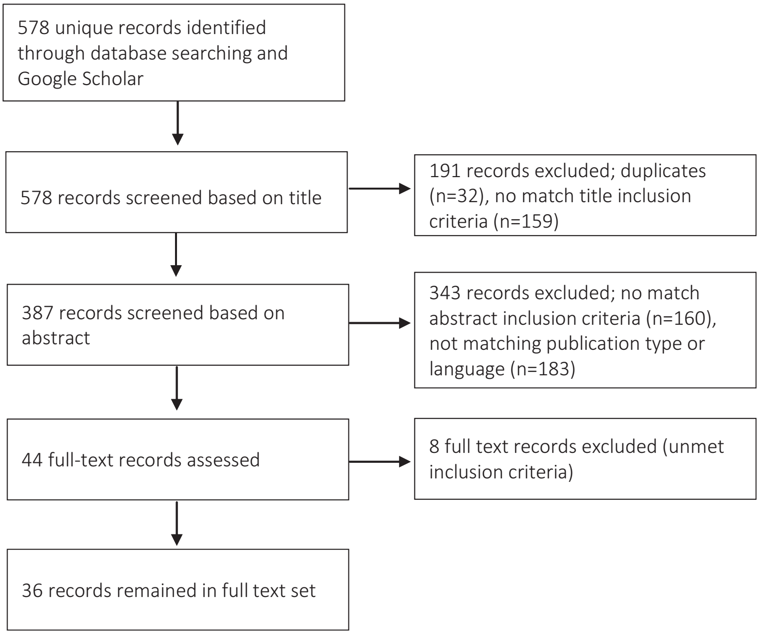


Figure 2.1 Flowchart of steps in systematic literature search

Three reviewers from the research team (RvdH, ML, and the first author CH) first screened the titles of these articles according to predetermined inclusion criteria using a 3-point scale (0=not relevant, 1=maybe relevant, 2=relevant). The reviewers were instructed by means of a scoring and inclusion manual. In order to minimise the risk for excluding relevant articles, all references with a minimal score of 2 were included. The second step, abstracts screening (n=387), was conducted by the same 3 reviewers, again based on a scoring instruction manual. For more details about the inclusion criteria manuals we refer to the appendix. The search resulted in 36 articles that matched our criteria (e.g. robot for children with autism spectrum disorder, tested with children of the target group). Only peer reviewed journal articles were included; book chapters and conference proceedings were excluded.

The reviewers' Inter-Rater Agreement (weighted Cohen's kappa coefficient) for scoring the titles and scoring the abstracts between the three reviewers varied between 0.76 and 0.85 (average 0.81).

Identifying robots for children with an autism spectrum disorder

In total 14 different robots were identified. A number of robots were discussed in multiple articles (e.g. NAO, Robota, Probo, Keepon, Isobot, GIPY-1, KASPAR, and Labo-1), while other robots were identified in one article only (e.g. Cat robot, Tito, HOAP 3, Robot arm, Pleo and Ifbot) (see Table 2.1).

One characteristic in which these robots differed was the operation mode, which can vary on a scale ranging from a remote controlled robot (used in many Wizard of Oz studies) to a semi-autonomous robot to a (fully) autonomous robot. Fully autonomous robots (or systems) can act and perform tasks with a high degree of autonomy; without direct input of a person.[28] In this case, often, a larger technical environment (e.g. with intelligent sensing camera's and smart algorithms) is used to observe, analyse and provide input to the robot to act based on a (small) number of pre-programmed tasks. A (remote) controlled robot on the other hand is operated by a person. The operation mode has consequences for the applicability in practice; many differences exists, for example with respect to the technical complexity, infrastructural demands for the use environment, differences in flexibility, price differences as well as different requirements for the people using them.

Table 2.1 Identified robots in peer reviewed journals applied in studies with children with ASD

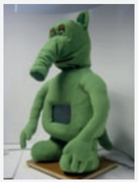
Robot	Picture	Description	Operating mode	References
Nao		Nao is a commercially available, programmable multiple degrees of freedom, humanoid robotic platform used in multiple contexts, domains and for varying target groups. More information on Nao can be found on http://www.aldebaran.com/.	Autonomous Semi-Autonomous Controlled / Wizard of Oz Autonomous Autonomous Controlled / Wizard of Oz Controlled / Wizard of Oz Autonomous	(Z. Warren et al., 2014) (Z. E. Warren et al., 2013) (Tapus et al., 2012) (Anzalone et al., 2014) (E. Bekele et al., 2014) (Huskens, Palmen, Van der Werff, Lourens, & Barakova, 2014) (B Huskens, Verschuur, Gillesen, Didden, & Barakova, 2013) (E. T. Bekele et al., 2013)
Robota		Robota is a non-commercially available, multiple degrees of freedom doll-shaped mini-humanoid robot, that was created on the base of a commercially available doll.	Controlled / Wizard of Oz Controlled / Wizard of Oz Controlled / Wizard of Oz	(Billard, Robins, Nadel, & Dautenhahn, 2007) (Ben Robins, Dautenhahn, & Dubowski, 2006) (B Robins, Dautenhahn, Boekhorst, & Billard, 2005)
Probo		Probo is developed as multi-disciplinary research platform for human-robot interaction and to develop robot assisted therapies for different children. At the time of writing there are plans for a start-up for Probo. http://probo.vub.ac.be/Probo/buy.htm	Controlled / Wizard of Oz Controlled / Wizard of Oz	(Anamaria et al., 2013) (Vanderborght et al., 2012)

Table 2.1 (continued)

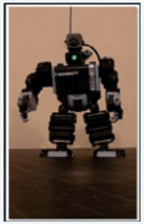
Robot	Picture	Description	Operating mode	References
Keepon		Keepon is a commercially available toy robot, designed to study social development by interacting with children, not specifically for ASD. More information at: http://www.mykeepon.com	Controlled / Wizard of Oz Controlled / Wizard of Oz Controlled / Wizard of Oz	(Kozima, Nakagawa, & Yasuda, 2007) (Kozima, Michalowski, & Nakagawa, 2009) (C. A. Costescu, Vanderborght, & David, 2014)
Cat robot		An early model of a robot with cat design features, non-commercially available, developed by a multi-disciplinary researchers group (for children with ASD).	Controlled / Wizard of Oz	(Mun, Kwon, Lee, & Jung, 2014)
I-sobot		I-sobot is a very small commercially available “humanoid” robot: http://www.isobotrobot.com/eng/	Controlled / Wizard of Oz Controlled / Wizard of Oz	(Srinivasan, Lynch, Bubela, Gifford, & Bhat, 2013) (Kaur, Gifford, Marsh, & Bhat, 2013)

Table 2.1 (continued)

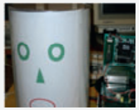
Robot	Picture	Description	Operating mode	References
Tito		Tito does not seem to be commercially available, it was built using other robot's existing modular distributed subsystems https://introlab.3it.usherbrooke.ca/mediawiki-introlab/index.php/CRI.	Controlled / Wizard of Oz	(Duquette et al., 2008)
GIPY		GIPY is a non-commercially available, cylindrical-shaped robot home made by IBISC. Picture from "Giannopulu (2013) and Giannopulu & Watanabe (2015) copy with the permission of the author"	Controlled / Wizard of Oz Controlled / Wizard of Oz	(Giannopulu & Pradel, 2012) (Giannopulu & Pradel, 2010)
Hoap 3		Hoap 3 is a programmable Linux robot developed by Fujitsu Automation in Japan that was commercially available. HOAP stands for "Humanoid for Open Architecture Platform". http://home.comcast.net/~jtechsc/HOAP-3_Spec_Sheet.pdf	Autonomous	(Fujimoto, Matsumoto, De Silva, Kobayashi, & Higashi, 2011)
KASPAR		KASPAR is a humanoid robot designed by University of Hertfordshire as therapeutic toy for children with autism. Commercialisation plans for KASPAR are in progress. http://www.herts.ac.uk/kaspar/introducing-kaspar/developing-kaspar	Autonomous Semi-Autonomous Semi-Autonomous Autonomous	(Wainer, Dautenhahn, Robins, & Amirabdollahian, 2013) (Ben Robins & Dautenhahn, 2014) (Costa, Lehmann, Dautenhahn, Robins, & Soares, 2014) (Wainer, Robins, Amirabdollahian, & Dautenhahn, 2014)

Table 2.1 (continued)

Robot	Picture	Description	Operating mode	References
Robot arm		A non-commercially available robotic arm model performing a reach-to-grasp action towards a spherical object.	Controlled / Wizard-of-Oz	(Pierno, Mari, Lusher, & Castiello, 2008)
Pleo		Pleo is a commercially available toy dinosaur robot designed to express emotions and attention, using body movement and vocalization. http://www.pleoworld.com/pleo_rb/eng/index.php	Controlled / Wizard-of-Oz	(Kim et al., 2013)
Labo-1		Robot Labo-1 is a platform with four wheels that drives and turns. http://www.aai.ca/robots/labo1.html	Autonomous Autonomous	(Dautenhahn, 2007) (Dautenhahn & Werry, 2004)
ifbot		Ifbot robot was used as a prompter for showing different facial expressions.	Controlled / Wizard-of-Oz	(J. Lee, Takehashi, Nagai, Obinata, & Stefanov, 2012)

All pictures are used with permission of the authors

The operating mode of the presented robots varies between a fully (tele-)operated Wizard of Oz style, to a semi-autonomous or a fully autonomous style. In most of the identified studies, (n=19, 60 %) the robots are tele-operated and use a kind of Wizard of Oz mode, meaning that a person is (remotely) controlling the robot's behaviour without the child noticing this. In 31% of the identified studies, the robots (n=10) are used in an autonomous manner meaning that no person is controlling the robot, but an autonomous system determines the entire behaviour of the robot. Often an extensive technical and intelligence system is required besides the robot alone to realize a fully autonomous (technical) environment (e.g. sensor input based control logic, vision or camera systems, (head, body parts or eye) tracking devices like a cap to monitor/detect/track child's behaviour, gazing or even vital signs). In 9% (3 studies), the robot was used in a semiautonomous manner, in which part of the robot's behaviour is triggered autonomously based on the child's behaviour, and a part of the robot's actions are tele-operated by a person.

The robot Nao was used in all the three operating modes, in some studies it functioned completely autonomous, in one study semi-autonomous and in others it was tele-operated. Most other robots were most often used in a tele-operation manner except for Robota, HOAP-3, KASPAR and Labo-1 (they were either functioning autonomous or semi-autonomous).

Table 2.2 shows the overview of identified robots mapped to the ASD objectives overview that was created on the basis of the results of the focus groups. It shows which robots relate to what objectives. Together these 14 robots relate to 24 different objectives out of the total number of 74 ASD objectives identified by the professionals.

Some robots (e.g. NAO, Robota, Probo, Keepon, Isobot, Tito, GIPY-1, KASPAR, Ifbot, Labo-1) have been applied to multiple objectives, and other robots have been reported in the context of one ASD objective only (e.g. cat robot, HOAP 3, Robot arm and Pleo). The Nao robot is discussed in the highest number of different articles (8) and addresses 5 different objectives. KASPAR is presented in 3 articles in the set and is applied to address 12 different objectives.

Table 2.2 Overview of ASD areas and objectives (results from focus groups) with mapping of robots from literature

Area	Objectives	ICF-CY code	Nao	Robota	Probo	KEEPON	Cat Robot	Isobot	Tito	GIPY-1	HOAP-3	KASPAR	Robot arm	PLeo	Ifbot	Labo-1
Communication	Orientation to listen	d115													■	
	Making contact	d3				■						■				
	Learn a new form of communication	d3														
	Understand intention of gesture	d3150														
	Understand intention of image / symbol	d3151 d3152														
	Understand intention of word	d310														
	Use gesture	d315														
	Use nonverbal abilities	d335													■	
	Talk – use verbal abilities	d330												■	■	
Social / Interpersonal interactions and relations	Imitation	d130	■	■				■			■		■			
	Attention	b140	■									■				
	Appropriately cope with own anger / sadness /…	d7202														
	Awareness of feelings, wishes, behaviour, thoughts of others	d7104			■		■									
	Appropriately react to behaviour of others	d7				■						■				
	Social routines (greet, say goodbye, introduce)	d72			■											
	Turn taking (behaviour)	d720		■								■				■
	Respect / value others (or things)	d71														
	Appropriate behaviour w.r.t. physical proximity / contact or personal space	d7										■				
	Collaboration / joint attention	b1403	■						■							
	Ask for help	d132														
	Conflict management	d175														
Self-care, independent living	Potty training	d53														
	Eating, drinking	d550 d560														
	(un)Dressing	d540														
	Self-care, personal hygiene	d5														
	Domestic skills	d6														
	Mobility	d4														
	Hobbies, leisure time	d920														
Play	Imitation	d130		■					■							■
	Develop interest in play	d8808														
	Development own play	d880				■				■						
	Parallel play (next to each other, same material)	d8802			■					■						
	Playing together – collaborative play	d8803	■									■				
	Variation in play (expand play)	d8808														
	Negotiate about rules	d8808														

Table 2.2 (continued)

Area	Objectives	ICF-CY code	Nao	Robota	Probo	KEEPON	Cat Robot	Isobot	Tito	GIPY-1	HOAP-3	KASPAR	Robot arm	PLeo	Ifbot	Labo-1
Emotional wellbeing	Recognise and regulate own emotions	b1520														
	Self-image, ASD awareness, who am I?	b1800										■				
	Resilience (detect and guard limits, defend oneself)	b1268														
	Confidence, self esteem	b1266														
	Rest, relaxation	b152														
	Having fun, experiencing pleasure	d920														
	Safety	b152														
	Making thoughts positive	b1251														
Sensory experiences and coping	Adequate processing sensory triggers, regulate, stimulate	b156										■				
	Understand what body is “saying” (pee, hunger, noises)	b2										■				
	Change stereotype behaviour	b1250														
	Prevent panic reactions	b1521														
	Be able to postpone urge / want	b1304										■				
Motor experiences and skills	Balance and equilibrium	b235														
	Body awareness	b260														
	Grove and fine motor skills	b7														
	Movement	d4														
	Coordination	b7		■												
	Strengthening of muscles	b7306														
Preschool skills	Work posture (sit still, no wobbling)	d815														
	Train or practice skills	d155														
	Be able to start/stop independently	d210														
	Work on his/her own, task approach	d2102														
	Cope with schedule/program	d198														
	Pose a question / ask for help	d815	■													
	Distinguish main from minor issues	d198														
	Follow up instructions	d3102														
	Execute task (simple / complex task)	d2														
	Didactic subjects (e.g. maths, reading)	d820														
	Spatial concepts	b114														
	Learn to wait	d815														
	Perseverance	b1254														
	Learn to choose, make decisions	d177														
Functioning in daily reality	Cope with unexpected situations or changes	d2304														
	Flexibility, switch smoothly, less rigid	b1643				■										
	Problem solving skills	d175														
	Taking initiative	d179									■	■				
	Transfer of skills / knowledge	d179														
	Open mind to tasting / eating food	b126														

A number of objectives are targeted by these 14 robots while a rather large number of objectives (n=50) remain unaddressed by the robots. Objectives that were most often targeted (either presented in more than 2 articles and / or addressed by more than 2 robots) are: imitation (in domain Social / Interpersonal interaction and relations; 7 articles, 5 different robots), turn-taking behaviour (in domain Social / Interpersonal interaction and relations; 5 articles, 3 different robots), imitation (in domain Play; 4 articles, 3 different robots), collaboration / joint attention (in domain Social / Interpersonal interaction and relations; 5 articles, 2 different robots), playing together—collaborative play (in domain Play; 3 articles, 2 different robots), and attention (in domain Social / Interpersonal interaction and relations; 3 articles, 2 different robots).

Table 2.2 also shows the number of robots that provided support to the different domains. The most commonly addressed domains are: ‘‘Social / Interpersonal interactions and relations’’ (11 robots), ‘‘Play’’ (8 robots) and ‘‘Communication’’ (4 robots). The domain of ‘‘Self-care, independent living’’ is left unaddressed by all robots. ‘‘Preschool skills’’ is the domain where the ASD professionals identified most objectives (n=14), however, it can be seen that (only) 1 (‘‘pose a question / ask for help’’) of these 14 objectives was targeted by 1 robot (Nao) in 1 article. For the domain of ‘‘Emotional wellbeing’’ also 1 robot (KASPAR) could be identified in 1 article addressing 1 objective (‘‘self-image, ASD awareness, who am I’’).

Discussion

The main results of this research indicate that professionals work on a broad variety of therapy and/or educational objectives in a wide range of domains for children with ASD and that state of the art robots focuses on only a small set of these objectives.

The wide range of therapy and educational objectives for children with autism, resulting from the focus groups, is in line with the heterogeneous nature of the disorder.[6] Professionals indicated that they are focused and driven by supporting these children in coping with their ASD in daily life towards independent living rather than trying to ‘‘fix’’ their impairments, challenges or differences. These objectives could be categorised into 9 domains and 74 objectives.

Best matching ICF-CY codes were collected for each objective.[24] Since the ICF-CY offers an universal standardised categorisation, it is not specifically constructed for children with ASD. Therefore, in some cases it was challenging to find the best matching ICF-CY code to the objectives, so it was ensured that this task was done with utmost care and attention of multiple project members who were actively involved in the sessions with the professionals.

The participants of the focus group sessions are all highly specialised experts in the area of education or therapy for children with ASD. In The Netherlands many children with ASD attend special schools where they receive special education and dedicated therapy at school. This implies that these professionals are highly specialised in autism, and that the groups of children at schools are rather small (maximum 7-12 children in a classroom) and mostly existing of children with autism. This might be different in other countries and is also changing in The Netherlands (more children with autism will be integrated in regular education).

The results of the literature study, on identifying state of the art robots for this target group, showed that at this moment in time a relatively small subset (n=24) of this ASD objectives (n=74) is addressed by the identified robots (n=14), leaving quite a large number of ASD objectives unmet by robotic support.

Most of the reported studies in this work used a tele-operated Wizard of Oz style in which a person operates the behaviour of the robot. This creates a benefit of flexibility for the human who can sensitively read the social situation and the child and accordingly control the robot to act appropriately. At the same time this also creates a burden (increase of workload) on that person and often extra technical personnel is required to smoothly operate the robot. This is in line with other work stating that few of the current approaches (in robot assisted therapy for children with ASD) use autonomously interactive robots.[17] Thill et al. (2012) actually call for a need for more autonomous therapeutic robots rather than remote controlled robots.

For a detailed insight into the effects of the robots and types of the studies identified in Table 2.1, we refer to earlier reviews on the use of robots in the context of ASD.[15,18] When focusing on the domains, we conclude that the majority of the robot studies were related to 3 of the 9 domains; ‘‘Social / Interpersonal interactions and relations’’, ‘‘Play’’ and ‘‘Communication’’. Other domains such as ‘‘Self-care, independent living’’, ‘‘Pre-school skills’’, ‘‘Emotional wellbeing’’, and ‘‘Functioning in daily reality’’ were (largely) unaddressed by the identified robot studies. This is not a surprising result since the main challenges of children with ASD are indeed related to social and communicative challenges as well as impairments in play behaviours.[6] Typical ASD objectives in these domains, such as imitation, collaborative play, (joint) attention, as well as turn taking behaviour, were often targeted by (quite similar) robotic support in studies. These rather typical ASD objectives are primary difficulties that children with autism experience that in turn create challenges in different areas of their daily living as can be seen in the overview (for example ‘‘follow up instructions’’). Robotic solutions can possibly also be of surplus value in other (more indirect) areas as well.

When mapping the robotic studies to the objectives overview, we aimed to find the objective in the overview that matches the focus of specific study best.
The overview can function as creating awareness of the scope of objectives for children with autism that professionals are actually working on with children with ASD. The intention is not to suggest to use a robot for all objectives for all children. Developing meaningful robot assisted therapy requires a profound understanding of the target group. To better understand the possibilities and impossibilities, appropriateness or inappropriateness of robotic support in the objectives and domains, more research is needed. For example, using robots to learn children to follow up instructions might be more appropriate than using robots to teach them to negotiate about rules. Moreover, professionals might express a stronger need for additional interventions targeting some objectives rather than others. And some children might react better to interventions using robots than others.
The next step would be that these objectives will be specified and translated into possible robotic interventions that matches the user requirements of both the children and professionals.
As indicated before, especially the diverse and heterogeneous nature of the ASD calls for a high degree of tuning / adaptation / personalisation or individualisation in the interventions. It asks for a bottom-up, client centred, tailor made approach. Robotic interventions might be very well capable of addressing this need due to their many potential advantages, however, current state of the art robots for children with ASD has probably not reached its full potential yet in terms of interventions / clinical application. Furthermore, most of these studies (still) present the robots [operated by a (technical) researcher] as a platform focusing on robot-child interactions rather than a robot assisted intervention in the hands of the care professional embedded into care protocols and actual therapy/educational settings. This is in line with conclusions of earlier work.[18,29] This also corresponds with a meta-analysis done on innovative technology based interventions that concluded that no evidence based robot interventions are currently available for children with ASD.[12] Robot assisted interventions can be seen as a therapy or education tool in the hands of the professionals. In order to be used, these robots do not only have to address the needs of the children with ASD, but they also have to be sensitive to the requirements posed by the professionals. Making it work / happen in practice requires more than the stability and availability of a meaningful robot. If the robot is not incorporated in the care or education provision and application of interventions no child nor professional will ever benefit from robots. In order to do so, we need to better understand the professionals requirements for robot assisted interventions. It is crucial to investigate how robot based (interaction) scenarios can be integrated into existing

therapy/education environments for children with autism.[25] Taking this work to the next level implies moving beyond focusing solely on the robot towards embedding a robot in a clinical intervention or therapy / education protocol. For this, more applied research in an education / therapeutic context (e.g. in a school or care setting) is required to understand better what is needed in terms or intervention / education requirements from ASD professionals, the envisioned end-users of robot assisted therapy.

Research has proven the efficacy of many technologies for people with autism. However, although these tools are useful, often these are rather general in nature, resulting in a lack of personalisation to a person's specific needs.[6] It is crucial to design appropriate interventions that can be tailored to the individual needs of this target group in order to increase people's independence and productive functioning.[5]

Technology becomes more and more part of everyday life and activities, and it is inevitable that technology will be integrated into autism intervention as well.[30] However, in order to specify and develop meaningful robot based interventions, it is crucial that professionals, stakeholders as well as technology developers co-create.[30] This research aimed to provide a the base for understanding relevant objectives in the therapy and / or education of children with ASD, which is a necessary first step in user centred design process for developing robot assisted interventions. In conclusion, this work is expected to be valuable for experts in the area of children with ASD who are considering using robots as innovative tools in education or therapy. Simultaneously, it is considered to be useful for robot developers who are interested in application domains and are in need of a better understanding of the needs of the target group of children with autism.

It may contribute to the creation of common understanding between ASD professionals and robot developers in their (joint) mission to create meaningful robot interventions for children with autism in the quest to support these children to become the best possible version of themselves in life.

2

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2

Appendix 2.1

Search strategy used in literature study

Queries were tailored to the specific databases used, the query for PUBMED for example was

AUTISM + CHILD + ROBOT

((((((((((((((((((((((((("Child Development Disorders, Pervasive"[Mesh]) OR "Asperger Syndrome"[Mesh]) OR "Autistic Disorder"[Mesh]) OR “pervasive child development disorders”) OR “pervasive development disorders”) OR “pervasive development disorder”) OR “autism spectrum disorders”) OR “autism spectrum disorder”) OR “asperger's syndrome”) OR “aspergers syndrome”) OR “asperger's disease”) OR “asperger's disorder”) OR “aspergers disorder”) OR “asperger disorder”) OR “asperger disease”) OR asperger*) OR “kanner's syndrome”) OR “kanner syndrome”) OR “kanners syndrome”) OR “infantile autism”) OR “early infantile autism”) OR ASD) OR PDD*) OR PDD-NOS) OR autis*)) AND ((((("Child"[Mesh]) OR "Child, Preschool"[Mesh]) OR “preschool child”) OR preschool children) OR child*) OR teenager)) AND ((((("robotics"[Mesh]) OR robotics) OR “humanoid”) OR “non humanoid”) OR "socially assistive robotics") OR SAR) OR robot* [tiab])
The number of results found per source is displayed in Table S2.1.

Table S2.1 Number of references found per source

Source	# of results
CINAHL	20
PUBMED	76
EMBASE	5
ERIC	10
IEEE	175
Science Direct	106
SpringerLink	96
Taylor&Francis	1
Google Scholar	117
Journal Social Robotics	6
Manual search	12
Total references incl duplicates	623
Remove bachelor/master thesis	*7*
Remove duplicates	*38*
Total unique references	578

Inclusion criteria for scoring based on titles only:

- overall question: which **robots** are used (in the therapy or education) for **children** with an **autism** spectrum disorder?
- only titles are provided to minimize the risk for biases (e.g. based on authors or journals)
- English language
- (semantically, not necessarily literally) in title: autism **OR** robots **OR** children
- we don't want to restrict too much already only based on the titles. In the next step of scoring abstracts, we will look for autism AND robots AND children. So if in doubt, score 1.
- no medical nor surgical robots
- scorings scores for the titles of the articles
  - 0 = not relevant
  - 1 = maybe relevant
  - 2 = relevant
- All references with a total score of 3 and higher will go to the next step (scoring abstracts)

Inclusion criteria for scoring based on abstracts:

- English language
- type: journals, conference proceedings, book chapters
- autism + robots + children
- Which **robots** are used (in the therapy or education) for **children** with an **autism** spectrum disorder?
- no medical or surgical robots
- Scorings scores
  - 0 = not relevant
  - 1 = maybe relevant
  - 2 = relevant

Chapter 3

Matching Robot KASPAR to Autism Spectrum Disorder (ASD) Therapy and Educational Goals

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Abstract

Aim
The aim of this study was to identify the potential contribution of therapy robot KASPAR to the therapy and/or educational goals for children with autism spectrum disorder (ASD) according to professionals and practitioners in the field.

Methods
An online questionnaire and focus groups were applied to elicit the expectations of a group of 54 multidisciplinary ASD practitioners about therapy and/or educational goals KASPAR can contribute to.

Results
Findings indicate that professionals expect KASPAR to be of added value to ASD objectives in domains such as 'communication', 'social/interpersonal interaction and relations', and 'play', but also in objectives related to 'emotional wellbeing' and 'preschool skills'. A top 10 is created of professionals' expectations of potential added value for robot KASPAR for working on therapy and educational goals for children with ASD. Professionals are convinced that KASPAR can be useful in interventions for a broad range of therapy and education goals for children with autism spectrum disorder.

Introduction

Children with autism spectrum disorder (ASD) experience challenges in communication and social interaction across different contexts (e.g.at home, school) and show "restricted, repetitive patterns of behaviour, interests, or activities", that cause impairments in their daily life.[1] Autism is a life-long developmental disorder for which (unfortunately) no cures have been found yet, but early and individualised interventions are considered to be crucial for children in increasing the level of functioning in daily life. Not all children require the same (level of) support. ASD manifests itself in many different forms and severities and there is not one best therapeutic approach for every person with ASD. People need different support, what is beneficial for one person, might harm the other.[2] Interventions using robots might be capable of addressing the broad range of needs of children with ASD in an individualised manner.[3]

Interactive technology, and robots in particular, can be used in interventions for the therapy and education for children with autism spectrum disorder (ASD).[4] Robots possess a number of characteristics (e.g. predictability, embodiment, interactivity) and can adopt various roles in therapy that can be valuable properties in therapy and/or education settings for (some) children with ASD.[3,5] Children are reported to enjoy interaction with a robot more, show more communication, initiative or proactivity, learn quicker and more pleasantly compared with an human counterpart or other interventions.[2,3,5]

A systematic literature study, consulting peer reviewed journals, identified 14 different robot platforms that have been used in studies with children with autism spectrum disorder.[6] Together, these 14 robots address a (small) subset (n=24) of the broad variety of therapy and/or educational objectives (n=74) that professionals work on with these children.[6] Some robots (e.g. Nao, Robota, Probo, Keepon, Isobot, Tito, GIPY-1, KASPAR, Ifbot and Labo-1) addressed multiple objectives, while other presented studies using robots (e.g. Cat robot, HOAP 3, Robot arm and Pleo) have been reported in the context of a single objective. Often these studies focused on objectives such as imitation in social interaction,[7-12] turn-taking behaviour,[9,13-16] imitation in play,[9,15-17] collaboration/joint attention,[17-21] playing together/collaborative play,[22-24] or attention.[7,14,18]

In order for socially interactive robots to actually make a difference to the lives of children with ASD and their carers, they have to find their way out from case studies with 'standalone' robots in robotics labs to the children's therapy and/or education environments as part of daily activities/therapies. Being effective in eliciting a certain target behaviour of a particular child in a lab environment, will not automatically ensure effective clinical implication in therapy settings for all children[4,25] and adoption of use by professionals in the field.

Successful application of innovations, such as robots, in practical interventions demands for a number of conditions to be met. Interventions using robots need to be robust and easily targeted to the children at hand.[25] Children have to enjoy interacting with a robot, and practitioners need to consider the robot as a desirable intervention in their day to day care delivery work. As formulated by Scassellati et al.,[2] socially assistive robots shall "balance goal-oriented treatment with a nonthreatening but engaging and productive interaction". To date, only limited emphasis has been devoted to how robots can be best integrated into therapeutic protocols, education and therapy sessions[3] and robots developed "do not provide an individualised system" for each person with ASD.[4] Fridin and Belokopytov[26] indicate that successful integration of robots in preschools and elementary schools depends on teacher's views and acceptance regarding robots for children with special needs. A study on teachers' acceptance on the use of robots in education for children with autism found that pre-school and elementary school teachers indicated that a socially assistive humanoid robot could serve as an interactive tool in the teaching process.[26] This is in line with other work indicating that the attitude towards the use of robots in the (psycho)therapy or education for children is generally considered to be positive.[26-28] This calls for an integration of robots in existing educational programs and environments for children with autism.[29]

As seen earlier, one socially interactive robot that has extensively been used in studies with children with ASD in educational settings is KASPAR.[23,30-33] KASPAR is a child-sized humanoid robot using minimal expressions that allows for multi-modal interaction (see Figure 3.1). KASPAR is developed by the Adaptive Systems Research Group at the University of Hertfordshire.[32]

Figure 3.1 Therapy robot KASPAR

It is designed for social interaction, and can create body movements or gestures using its hands, arms, torso, head as well as show facial expressions. It is important to realise that it is an explicit decision that KASPAR mimics human expressions in a way that is not extremely realistic, yet close enough to resemble human expressions to allow for transfer of knowledge and skills. Furthermore, KASPAR can express (pre-programmed) words or sounds. The robot is placed on the table in front of the child(ren) and is commonly used in a semi-autonomous manner where the professional (remotely) controls some of KASPAR's actions while other actions are triggered by the activation of KASPAR's sensors on the different body parts (e.g. belly, arms, hands, feet). Besides the robot, a KASPAR program running on a laptop or pc is available that can be used to create new KASPAR scenario's.

Earlier studies have shown that KASPAR can (for example) positively contribute to learning/increasing body awareness and prolonging a child's attention span,[34] mediate, facilitate and encourage children in social interaction with other people,[35] help to learn about body parts and appropriate physical interaction,[36] and encourage collaborative skills among children with autism.[23] Based on these promising results, in the current study, this platform was used, in which the focus is not on the (technical abilities of the) robotic platform, but on identifying the possibilities for potential meaningful interventions using this robot.

The aim of this study was to intensively involve ASD professionals to identify the potential benefit of therapy robot KASPAR as a contribution to addressing the therapy and educational objectives for children with autism spectrum disorder.

Methods

Design

A mixed methods design of both qualitative (focus groups) and quantitative assessments (questionnaire) was applied.

This paper presents the results of an online questionnaire; with the purpose of matching robot KASPAR to the therapy and education objectives that professionals work on with children with ASD. Two rounds of focus groups created the basis for the items in the questionnaire (Figure 3.2).

3

Procedure

In order to systematically understand to which therapy and education objectives KASPAR could possibly contribute to according to these professionals, an online questionnaire was applied. The goal was to match the respondents' expectations of the potential of KASPAR to the identified overview of ASD objectives. Two rounds of focus groups created the basis for the items in the online questionnaire (see Figure 3.2). The questionnaire was announced during the focus group sessions and the online hyperlink to complete the questionnaire was distributed by email afterwards.

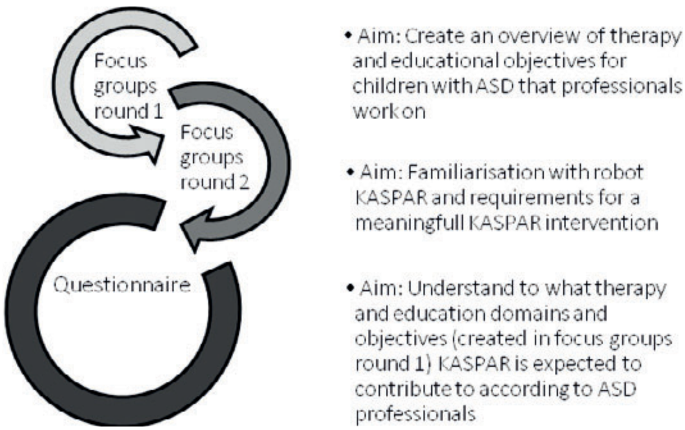

Figure 3.2 Phases and aims in the user involvement process

The goal of the first round of focus group sessions was to identify the objectives that professionals work on with children with ASD both in therapy and educational settings. These resulting objectives were presented in an overview of 9 domains all including a number of objectives.[6] Figure 3.3 shows this overview which functioned as the basis for the items in the questionnaire since these are all the objectives that professionals work on for children with ASD. As can be seen, 9 overall high level domains can be distinguished (e.g. 'emotional wellbeing', 'play', 'communication') that can be further specified into 74 more detailed objectives (e.g. 'recognise and regulate own emotions', 'imitation', 'orientation to listen').
Subsequently, a second round of focus groups sessions was conducted to get insight into the requirements that professionals have for KASPAR-based interventions, as well as to get some first ideas that they have of how KASPAR could be used for children with ASD. One important element of this second round of focus group sessions was that

professionals had an opportunity to get familiar and to interact with KASPAR. They saw a video of children and a professional interacting with KASPAR, and moreover during the focus group, they were part of a live and interactive demo so that they would get a good impression of the robot KASPAR. During the demo the main elements of the KASPAR robot were demonstrated; pre-recorded speech and sounds, movement of various body parts (e.g. head, hands, torso, arms, eyes) and the corresponding remote control. Moreover, it was emphasised that new tailored and personalised KASPAR scenarios can be created (without requiring technical skills) using a corresponding KASPAR program running on a laptop. These scenarios typically combine certain pre-recorded speech and/or sounds and/or movements to create a KASPAR behaviour that is beneficial to work on a certain educational/therapy objective. It was stressed that this way an entire set of scenarios using KASPAR can be created in order to cover the needed scope of objectives.

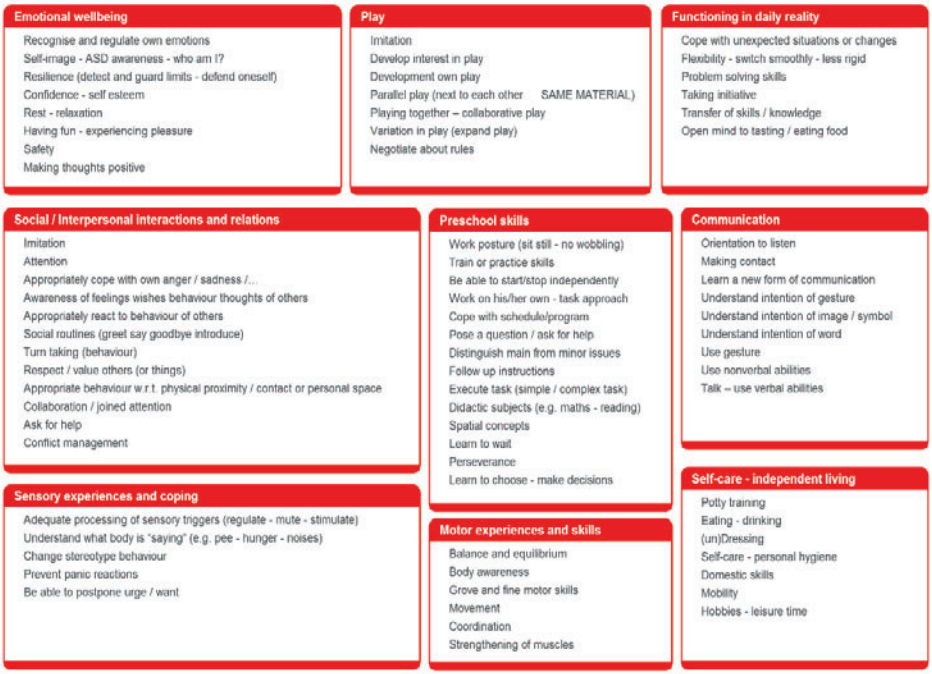

Figure 3.3 Therapy and educational objectives for children with ASD as presented in[7]

The online questionnaire consisted of two main parts. The first part of the questionnaire focused on the nine domains (e.g. communication); these were presented in a list and respondents were asked to indicate (by means of checkboxes) if KASPAR would be able to add value to any of these domains in their opinion. The second part of the questionnaire focused on the objectives within these nine domains. For each of the objectives in the overview (as depicted in Figure 3.3), participants were asked to indicate their expectation of how likely KASPAR is able to meaningfully contribute to that particular objective (on a Likert scale: “probably”, “possibly”, “unlikely”, not relevant). For each of the domains an open question was included after the closed questions to enable respondents to provide some open feedback.

Participants

The respondents that completed the questionnaire were experts in the area of therapy or education for children with ASD and worked for special need schools, youth care organizations, medical day care centres or centres for ASD treatment in The Netherlands. Many children with an ASD diagnosis attend special education schools and receive therapy and dedicated ASD therapy (at school); therefore the therapy and educational objectives are very similar and therefore not considered different in nature.

Participants that filled in the questionnaire also participated in the first and/or second round of focus groups. In the first round we invited professionals who work with children with ASD, for the second round all these professionals were invited as well as a number of people with ASD. They were recruited by means of a snowball sampling method of key experts working in the area of children with ASD, ASD care organisations as well as special education schools were approached to participate in the study. Once these organisations agreed to participate in the project, they pinpointed and selected a number of employees based on their background and expertise in working with children with ASD. In some instances experts provided names of other professionals in the field immediately who were then invited to participate in the study.

Data analysis

Focus groups

The analysis for the first round of focus groups (see ref. 6 for more details) was done based on the principles of the meta plan method,[37] where participants created post-it notes for all the objectives that they could think of and a grouping was made afterwards by two project members. To allow for a common understanding, “ICF-CY” codes were assigned to these objectives by the same two project members. The World Health Organisation (WHO) created the Child and Youth version (ICF-CY) of the

International Classification of Functioning, Disability and Health (ICF) to provide an uniform classification of health and health-related domains.[38]

The analysis of the ideas that were generated in the second rounds of focus groups sessions was done using directive content analysis.[39] In this case, the ASD objectives overview functioned as the framework to which the participants ideas where matched onto.

Questionnaire

Descriptive analyses was performed on the data that was obtained from 54 respondents. For all the objectives the respondents' scores on the Likert scales for all the objectives were collected.

Results

In total 54 ASD practitioners completed the questionnaire. The first round of focus groups consisted of nine sessions with ASD practitioners (n=53) from nine different organisations. The second round consisted of 13 sessions with participants (n=73) of 22 different organisations. Most participants who participants in the first focus groups also participated in the second rounds. The additional professionals were recruited on an ongoing basis during the project.

All the participants were specialised in working with children with ASD. Most of them worked in multidisciplinary teams with diverse backgrounds, varying from occupational therapy, psychiatry, special needs education, child psychology, behavioural science, physiotherapy, speech and language therapy, or art therapy. The large majority of the professionals involved in the study had an experience of over 5 years. All the participants participated in the live and interactive demo with the robot KASPAR.

Matching KASPAR to ASD domains

In the first part of the questionnaire people were asked to indicate their impression of expected potential of KASPAR for the nine overall ASD domains that were identified in the focus groups (see Figure 3.4).

These are domains such as 'communication', 'social and interpersonal interaction and relations', and 'independent living' into which the 74 objectives are categorised. The percentages indicate the number of participants that expected an added value of KASPAR in that particular overall domain. Main results indicate that a (large) majority of the participants expected a meaningful role for KASPAR in several of the nine high level

ASD domains. They expect that KASPAR can contribute to the domains of 'communication' and 'social and interpersonal interaction and relations' (98 and 96% respectively) and 72% of the professionals indicated to see a role for KASPAR in the area of 'play', 56% in the area of 'emotional wellbeing' and half of them expect KASPAR to be of help in the domain of 'preschool skills' as well.

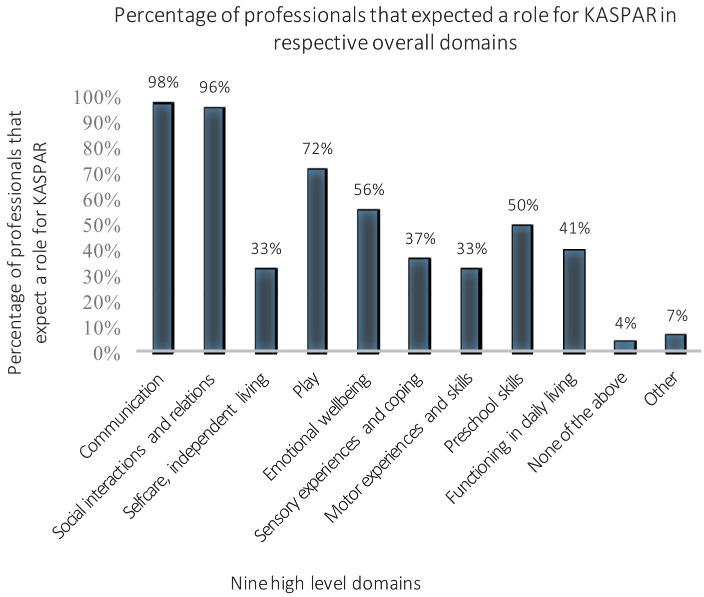

Figure 3.4 Percentage of professionals that expects a role for KASPAR in respective domains

Matching KASPAR to ASD objectives

Within the nine high level domains, more concrete objectives were distinguished in the focus groups as mentioned earlier (see Figure 3.3). Figure 3.5 shows the number of participants that indicated "probably" / "potentially" / "unlikely" that KASPAR can have a meaningful role for the objectives in the three highest ranked domains of 'communication', 'social interaction and relations' and 'play'. For more details about all the scores of all the objectives in the nine domains, we refer to Figure S3.1 in the Appendix 3.1.

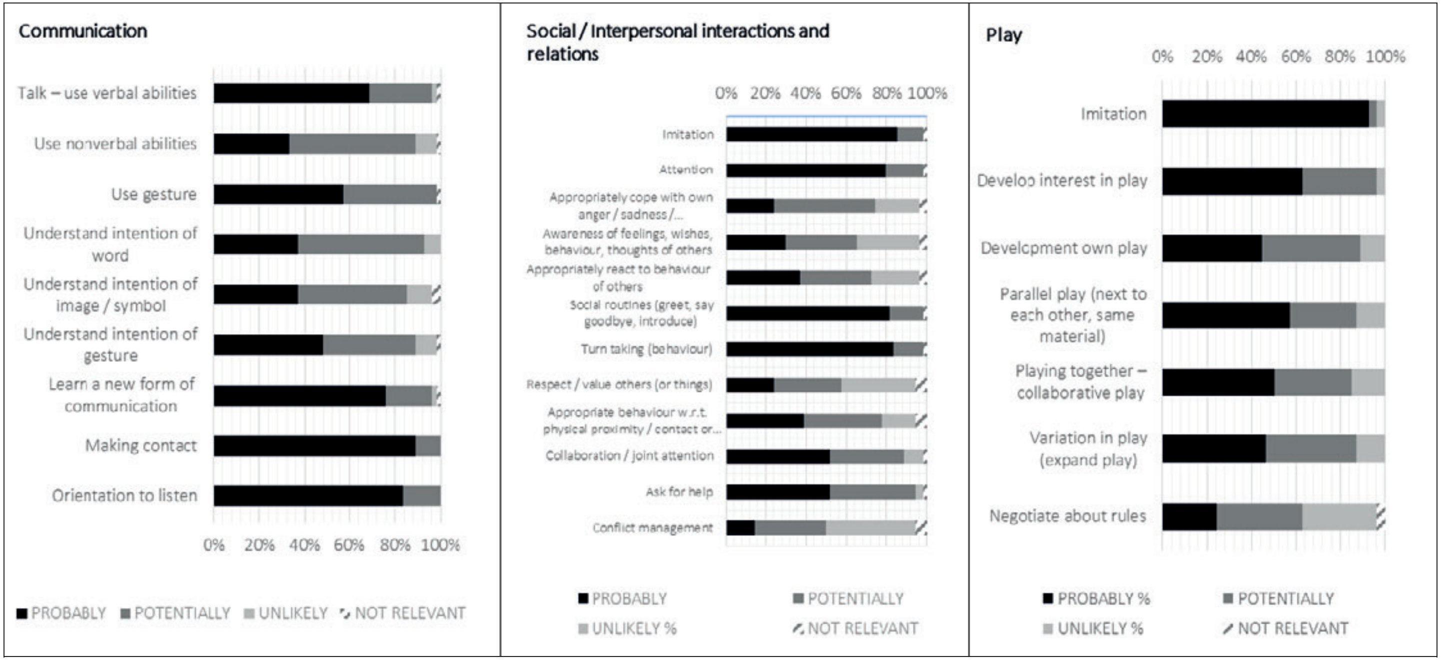

Figure 3.5 Expected role for KASPAR in the objectives of the three highest ranked domains ‘Communication’, ‘Social / Interpersonal interactions and relations’ and ‘Play’

Table 3.1 shows the top 10 of ASD objectives (with corresponding ICF-CY codes) where practitioners expected a meaningful role for KASPAR and their corresponding domains. For all these objectives a high number (ranging from 63% to 93%) of respondents expected a role for KASPAR (i.e. they indicated "probably" can KASPAR contribute to that objective). These are the objectives that overall received most support for using KASPAR in therapy or educational interventions. KASPAR could, for example, "probably" play a role in stimulating 'imitation in play' (93% of the respondents indicated that KASPAR 'probably' can have a meaningful role to working on 'imitation in play'), 'learning to make contact' (89%), 'imitation in social interaction' (85%), 'turn taking behaviour' (83%), 'orientation to listen' (83%), 'learn social routines' (81%), 'devote attention' (80%), 'learn a new form of communication' (76%), 'talk/use verbal abilities' (69%), 'follow up instructions' (65%), 'train or practice skills' (65%), 'ask for help' (65%), 'having fun/experiencing pleasure' (63%), and 'develop interest in play' (63%).

For objectives such as 'strengthening of muscles', 'domestic skills', and 'conflict management', 'distinguish main from minor issues', 'mobility' and 'balance and equilibrium' people expected the least potential for using KASPAR.

Table 3.1 Top 10 objectives (including ICF-CY codes) where a role for KASPAR is expected[1]

Domain	Therapy or educational objective (with ICF code)	Ranking	Percentage respondents indicated "probably"
Play	Imitation in play (d130)	*1*	*93%*
Communication	Making contact (d3)	*2*	*89%*
Social / Interpersonal interaction and relations	Imitation in social/interpersonal interaction (d130)	*3*	*85%*
	Turn taking (behaviour) (d720)	*4*	*83%*
Communication	Orientation to listen (d115)	*4*	*83%*
Social / Interpersonal interaction and relations	Social routines (greet, say goodbye, introduce) (d72)	*5*	*81%*
	Attention (b140)	*6*	*80%*
Communication	Learn a new form of communication (d3)	*7*	*76%*
	Talk – use verbal abilities (d330)	*8*	*69%*
Preschool skills	Train or practice skills (d155)	*9*	*65%*
	Follow up instructions (d3102)	*9*	*65%*
	Pose a question/ask for help (d815)	*9*	*65%*
Emotional wellbeing	Having fun, experiencing pleasure (d920)	*10*	*63%*
Play	Develop interest in play (d8808)	*10*	*63%*

[1] The percentages indicate the percentage of participants that indicated that KASPAR "probably" can contribute to that particular objective.

Reflections on scenario's with KASPAR

Professionals clearly saw a benefit for the use of KASPAR for working on specific objectives for children with ASD. The box in Figure 3.6 shows a number of quotes made by the participants in the questionnaire explaining their views of using KASPAR for these children. They clearly consider KASPAR as a tool for the professional, allowing them to use the children's attention for KASPAR in a more fun, predictable, relaxing, yet meaningful manner.

"I think KASPAR can be of benefit, because of its predictability and emotional neutrality, which can prevent overstimulation with non-verbal signs""With the use of KASPAR we can take the role of observer that allows us to see better and reward proper behavior. Without KASPAR we are often in a double role: the mirror, supervisor as well as corrector role, which creates confusion and chaos""Because of KASPAR's consistent and clear way of reacting, a safe environment is created in which a child is more likely to interact and consequently learn compared to a human teacher"

Figure 3.6 Illustrative quotes from professionals in focus groups

They expected that children will feel more comfortable and open, actually more urged to react to KASPAR than to a human. In an activity with KASPAR, the initiative can rest more in the hands of the child who is probably motivated to interact with KASPAR more than with a human being. This causes making contact and subsequent action reaction and learning turn taking behaviour to be easier with the help of KASPAR. If they do react to KASPAR indeed, this openness and willingness to interact can be used to train or teach them skills that are difficult in the interaction with a human. Then from there, depending on the progress of the child, they can work towards transfer from what they learned with KASPAR to a setting with 'real' people. Often professionals mentioned they could see a triangle appearing between them, the child and KASPAR to create shared and joint attention. In this way children could learn to focus and from there continue to learn other things related to communication and social interaction or to play.

In human to human social interaction, often "unpredictable" things can happen (e.g. change of tone of voice or change of volume, use of unexpected gestures, or unclear (non)verbal messages). This can be minimalized with KASPAR because he can be purposefully controlled which creates a safer environment for these children.

For each domain one open question was included in the questionnaire to give participants an opportunity to write down their ideas, moreover some participants also expressed some ideas during the focus groups already. Figure 3.7 shows a number of examples of ideas professionals had in mind for the three highest ranked domains 'communication', 'social interaction', and 'play'.

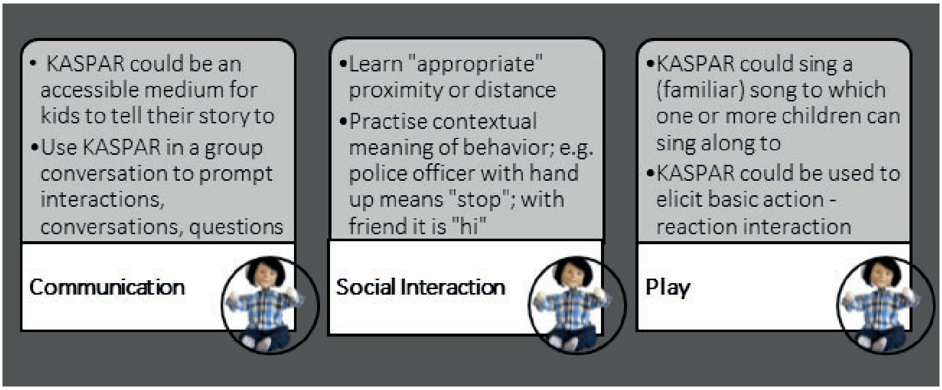

Figure 3.7 Ideas for KASPAR in three main domains

Starting or having a conversation is very challenging for many children with ASD; 'How do I start a conversation', 'how to answer', 'how and where should I look', 'how should I sit' are examples of things they can struggle with. Professionals indicated that maybe for these children KASPAR can provide a safer less intimidating means to practice with and to make some first steps until they feel less anxious and more confident to start practicing with a person. KASPAR could trigger some nice game-like moments, such as 'this is my nose, what is your nose?' or sing a song that is familiar for them. In this way the child can learn imitation, but also turn taking, joint attention for example in a more fun, less stressful manner.

Discussion and conclusions

The results indicate that practitioners expect that the robot KASPAR can meaningfully contribute mainly to three high level domains and more specific objectives for children with autism spectrum disorder. Highest expectations can be observed in the areas that are rather "typical" challenging areas for children with ASD: 'communication', 'social interaction' and 'play'. These results are in line with other studies conducted in the area of robot assisted therapy for children with ASD; the same three domains are the most commonly addressed by different robots studied in peer reviewed literature.[6] Studies often focus on objectives such as imitation, joint attention, collaborative play.[5,6] KASPAR specifically has already been used to address objectives such as making contact, attention, turn taking (behaviour) as well as playing together (collaborative play).[14,23,24,36] When focusing on studies presented in peer reviewed articles, KASPAR has been applied for 12 different objectives.[6] However, also in more indirect areas in which these “typical” ASD difficulties create challenges (such as emotional wellbeing and preschool skills) KASPAR is expected to be able to contribute meaningfully.

Professionals stressed that instead of focusing on the problems these children have, it is important to devote attention to creating a safe and pleasant environment for them so that they can develop towards a (more) independent life by working on the objectives professionals mentioned.

Objectives such as ‘having fun’, ‘experiencing pleasure’, ‘safety’ and ‘rest, relaxation’ contribute to ‘emotional wellbeing’ and many respondents see a role for KASPAR in these areas as well. Moreover, the area of ‘preschool skills’ typically focusses on objectives that enable the children to function in a school environment, a first step towards independent functioning. Objectives such as ‘train or practice skills’, ‘follow up instructions’, ‘pose a question / ask for help’, ‘learn to wait’, ‘execute a task’ and ‘be able to start / stop independently’ are all objectives where respondents could see an added value in using KASPAR in therapy or educational interventions.

There are also a number of objectives in which respondents do not expect an added value of KASPAR such as ‘strengthening of muscles’, ‘domestic skills’, and ‘conflict management’, ‘distinguish main from minor issues’, ‘mobility’ and ‘balance and equilibrium’. These are often the more complex objectives (either cognitively, motoric, physically or emotionally) that might be too difficult (or even impossible) and/or undesirable, to address by means of a robot or for which other interventions are preferred over using a robot.

Since the professionals have not actually worked with robots for children with autism before, we asked for their (educated) opinions and expectations based on a limited exposure with the robot KASPAR during the focus groups. Applied studies and building up more experience with using KASPAR in practice will deliver more applied insight if their expectations indeed match with reality.

Besides this, professionals expectations are not the sole and only predictor of use and adoption of robots in education/therapy settings. Researchers have identified other factors to be of relevance such as user characteristics, contact characteristics, technological considerations as well as organizational capacity.[26] When moving towards more therapeutic scenarios and environments, development of higher levels of robot autonomy would be desirable, for example, to enable the robot to adapt better to the individual needs of the children over time, and supporting professionals using these robots.[40] When focusing on the acceptance of socially assistive robots (SAR), Heerink et al.[41] presented a modification (for a non-specific population) of the "Unified theory of acceptance and use of technology model" (UTAUT model,[42]). This model has been applied in the context of a number studies on SAR.[26] A number of constructs have been suggested to influence whether or not a robot will be used; a few examples of these constructs are: "attitude", "perceived adaptability", "intention to use", "perceived enjoyment", "perceived usefulness", and "trust".[41] These constructs should be taken into account when developing robot-assisted interventions.

Involving end users from the start of the development of KASPAR-based interventions is considered to be a crucial starting point for more pilots and effect studies with KASPAR by professionals. The integration and application of robots in interventions for children with ASD needs/should be based on a user centrered design approach, which is exactly what this study followed.

In the current study the focus was on the robot KASPAR. Similar results, however, may be obtained for any other robotic platform by re-using the same questionnaire (linking to the therapy/educational objectives overview in Figure 3.3 from[6]).

Although this study was done using the KASPAR platform, some overall impressions could be noted that might also apply to other robots for children with ASD as well. The overall characteristic that the professional has some control over KASPAR's behaviour by means of the pre-programmed remote control (in other words the semi-autonomous nature) was considered useful especially for this heterogeneous target group. Human beings are particularly proficient in noting subtle matters such as (changes in) emotions, comfort, stress and 'reading' a certain situation or interaction. The current state of artificial intelligence does not even come close to people's skills and sensitivities. Therefore professionals considered it beneficial that they themselves are present for this task and able to simply choose a reaction of KASPAR. Moreover, the fact that ASD professionals themselves can create new KASPAR scenarios without the need of technical support was found to be a promising characteristic of a robot for ASD therapy and educational purposes in order to optimize the chance of matching the children's diverse needs. Finally, the minimal expressiveness of KASPAR's face while resembling a human was considered to be valuable. In this way the transfer is expected to be better than with a toy or pet robot for example, and yet some facial expressions are possible but not overly realistic as that might increase the burden for the children similar to interacting with humans.

It is important to acknowledge that it is not the intention to use a robot for all objectives. The challenge is to identify wisely for which objectives (and which children) a robot might add value to the existing interventions and practices as well as to understand when a robot shall not be used.

The current work showed that besides identified potential for these rather ‘typical ASD focus areas’, also for other ASD objectives—which might be less obvious for robot developers and less explored by current robotic initiatives - are worthwhile to consider developing robotic interventions for (such as the area of emotional wellbeing, to have fun or experience pleasure for example). Future (applied) research will be focusing on co-creating KASPAR interventions with professionals and other ASD experts (based on the current findings) that will accordingly be tested and used by ASD practitioners in education and/or therapy situations with children with ASD. A meaningful KASPAR intervention does not only provide appropriate and technically stable robotic support, but also ensures practical integration in education and/or care. Aspects such as for what goals the intervention will be applied, who will use it, for which children, where, how often and how long, are all part of the description and orchestration of meaningful interventions. An intervention should contain the robot with its functionalities, but also training for professionals and protocols to embed the robot in the care/education practice.

It will be crucial to learn what requirements should be adhered to in the development of successful robot-based intervention for children with autism spectrum disorder and what the effects are of the application of a robot, such as KASPAR, on both children with ASD as well as on the professionals working with it. By involving professionals and other stakeholders in the creation of these robot assisted interventions, we aim to optimise the fit between their needs as professionals, the needs of the children with ASD and the (robot) interventions that are being created to increase the (social) wellbeing and independence of children with autism. Future work will also deliver a proposed methodology for creating new KASPAR interventions.

3

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Appendix 3.1

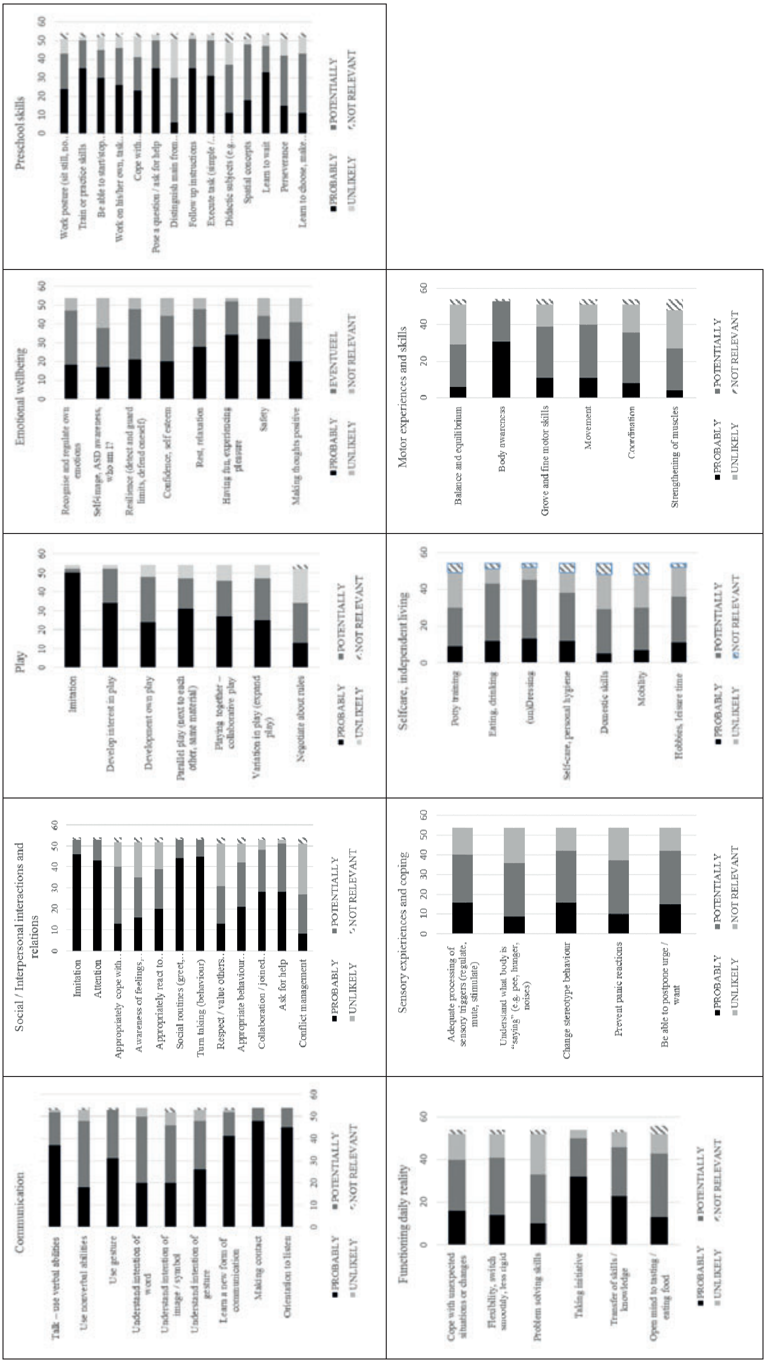

Figure S3.1 Expected role for KASPAR in the nine overall domains (absolute number of people, total n=54)

Chapter 4

Roles, strengths and challenges of using robots in interventions for children with autism spectrum disorder (ASD)

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Abstract

Aim

The aim of this research was to study roles, strengths and challenges of robot-mediated interventions using robot KASPAR for children with autism spectrum disorder (ASD).

Method

Twelve focus group sessions were organized in which 70 ASD care and/or education professionals participated.

Results

Six roles for KASPAR were identified: provoker, reinforcer, trainer, mediator, prompter, and diagnostic information provider. Strengths of KASPAR are related to personalisation possibilities, its playfulness, the action - reaction principle, its neutral expression, consistent and repetitive application of actions, possibilities to vary behaviour in a controlled manner and having an extra hand. Challenges of working with KASPAR were: limited reaction possibilities, possibility of children being scared of KASPAR, difficulties with generalisation or transfer and finally potential dependence on KASPAR.

Introduction

An upcoming intervention area with promising potential for children with autism spectrum disorder (ASD)[1] is robot-assisted therapy (RAT) or robot-mediated intervention (RMI). A number of recent systematic literature reviews have covered the majority of the work related to the use of robots for children with autism.[2-7] However, despite a growing number of human-robot-interaction (HRI) studies for children with autism of which the majority present promising results, advances in robot-mediated interventions have only made minimal progress towards clinical applicability.[2] Begum et al. (2016) summarise a number of important reasons for this; the potential end-users of this technology (i.e. people with ASD, their caregivers, clinicians) are neither aware nor convinced of the role of robots in an ASD intervention;[4,8] many of the robot-based studies for individuals with autism fail to meet criteria commonly used to assess the outcome of an ASD intervention,[9,10] and finally they argue that demonstrating the 'likeability' of robots for children with autism is "not sufficient to formally allow a robot to co-locate and interact with a protected population such as individuals with autism".

When studying robots presented literature, six different roles can be distinguished: "diagnostic agent", "friendly playmate", "behaviour eliciting agent", "social mediator", "social actor", and "personal therapist".[3] The authors came up with these roles based on studies in the literature using robots for this target group. Apparently, as Begum et al. (2016) argue, ASD professionals in practice seem to be unaware of the state of the art as well as the possibilities of robots for this target group.[2] At the same time, robot developers are not always aware of the needs and capacities of children with ASD and those who care for them. This creates a gap that hinders the creation of relevant and effective robot interventions for this target group.

Pennisi et al. (2016) found positive implications in their review that robots might provide therapists and teachers with new means to connect with people with autism in support sessions.[6] They report that participants with ASD showed social behaviour towards robots, showed reduced repetitive and stereotyped behaviours and reported spontaneous use of language in sessions with a robot. In some cases people with ASD show behaviours towards robots that people without autism have towards humans.[6] To benefit from the positive effects of the use of a robot in interventions, higher levels of stimulation (interaction) by the robot are better than lower levels of stimulation. However, despite these positive findings, studies need to better clarify whether gender, intelligence and age of the participants affect the outcome of the intervention and whether any beneficial effects are apparent only during the session or whether they are transferred outside the session as well.

One of the robot platforms that is being applied in research for children with autism is robot KASPAR (see Figure 4.1).[11-14] KASPAR stands for “Kinesics and Synchronization in Personal Assistant Robotics”, and is a semi-autonomous humanoid robot with the size of a sitting infant or toddler and is minimally-expressive.[15]

Figure 4.1 Robot KASPAR

KASPAR is developed at the Adaptive Systems Research Group at the University of Hertfordshire (UK). It uses head, torso, arms and hand movements to make gestures and (limited) facial expressions. Moreover, sound and speech can be used as additional interaction mechanisms. Each arm has 3 degrees of freedom and different parts of its face (e.g. eyes, mouth, eye lids) have separate motors that can be activated. KASPAR sits on a table and cannot stand up or walk away (its legs are not actuated).[15] KASPAR can be controlled by activating its sensors in various body parts (hands, belly, feet, head) and by using a pre-programmed remote control. Using the remote control, professionals can initiate actions of KASPAR using the Wizard of Oz technique (in which the intention is that the child does not notice that the robot is controlled by the professional). New KASPAR behaviour, also called scenarios, can be easily created by using the KASPAR configuration program installed on a laptop.
Research has shown that the use of KASPAR in interventions contributes to learning body awareness, encouraging collaborative skills among children with autism;[14] prolonging children’s attention span;[16] mediating and encouraging children’s social

interaction with other people;[17] and learning about body parts and appropriate physical interaction.[18]

Reviews summarise that often the focus of HRI studies is on skills and behaviours relating to social and communication impairments, but that there are also other relevant target areas in which RMIs are expected to contribute to in a meaningful manner and to be of social significance.[2,5] This question was addressed in a study that intensely involved ASD professionals to better understand to which therapy and educational objectives of children with ASD, robot KASPAR is expected to be able to contribute to.[19] Indeed experts expect most potential for KASPAR in the domains of “communication”, “social interaction and relations”, but also for “play”. Next to this, results indicate that professionals expect KASPAR to have potential for contributing to objectives in domains such as “emotional wellbeing” and “preschool skills”. They particularly see a role for KASPAR in the following top 10 objectives: “imitation in play”, “making contact”, “imitation in social/interpersonal interaction”, “turn-taking behaviour”, “orientation to listen”, “social routines”, “attention”, “learning a new form of communication”, “talk – use verbal abilities”, “train or practice skills”, “follow up instructions”, “pose a question/ask for help”, “having fun, experiencing pleasure”, and “developing interest in play”.[19] These insights on top 10 objectives provide understanding on the objectives that can be targeted by RMI, but not in what manner and hów best to utilize the advantages of robots to complement existing interventions already used in practice.

By intensively involving professionals such as therapists and special needs teachers in the present study, we aim to minimize factors that hinder (clinical relevance and uptake and increase chances for) clinical applicability. As mentioned, currently often professionals working in practice with children with ASD are not aware nor convinced of the role of robots in an ASD intervention. An important element in this is understanding what the potential may be of robots in interventions for children with ASD according to these professionals and in what manner both strengths as well as challenges can be taken into consideration when developing interventions.

The aim of the current study was to gain insight into the potential of the robot KASPAR as contribution to interventions according to practitioners in the field. In short, this study addresses the following research questions:

- What possible roles for KASPAR in an intervention for children with ASD are suggested by professionals
- What strengths and challenges related to KASPAR do they foresee?

Methods

A qualitative study was performed which consisted of focus group sessions[20] with professionals working in the ASD field. The term “professionals” is used to denote practitioners who’s profession it is to work with children with autism in care and/or special education. The aim was to gather insights on relevant aspects with respect to the role KASPAR could have in an ASD intervention and to identify KASPAR’s strengths and challenges related to using KASPAR in practice.

Setting and Participants

A number of organisations in the domain of ASD, in the south of the Netherlands, were approached by the main researcher (CH). If they expressed their interest and willingness to contribute to the study, a contact person from the organisations checked internally if there were professionals that met the inclusion criteria of the study. Additionally, sampling was conducted based on the snowball method keeping in mind a number of inclusion criteria for participating respondents:

- The professional works with children with ASD in their daily practice
- The professional is working at a special school, care organisation or medical day care centre targeted at children with ASD
- Mastering the Dutch language
- Being able to participate in a focus group session during the period of the study.

Procedure

The contact person at each organisation approached colleagues who met the inclusion criteria to invite them for the focus group sessions. The sessions were organised at the premises of the participating organisations. The duration of each session was about 2 hours. Two researchers involved in the study were present during each session; one had the role of session moderator and the other of note taker, observer and transcriber of the sessions afterwards. Before the start of the session, informed consent papers (for making audio recordings and pictures), participant demographic sheets and pens where distributed for each participant. The focus groups started with a short welcome, an explanation of the (goal and nature of the) session and a demonstration of KASPAR to give the participants a better idea of what KASPAR is and what it can do. During the demo KASPAR introduced itself, played a song, and additionally the possibilities were explained and shown (such as the use of sensors, the freedom of movement of the motors, speech, sounds, remote control, as well as the possibility to create personalised new scenarios and the use of additional attributes). Participants were informed that behaviour of KASPAR needs to be programmed in advance and that the operator who is remotely controlling KASPAR during a session, can select a behaviour with or without a corresponding sound or utterance. After the introduction, possible questions were answered and the actual focus group discussion started. The focus group sessions were consistent in terms of structure and main questions that were asked. Examples of questions are: do you see possibilities for using robot KASPAR in your organisation? If so, for what objectives and in what way? Are there any challenges to take into account? We stressed the importance of participants being open and free in their reactions (e.g. that there is no “right” or “wrong” answer or opinion) and that every contribution that people give is valuable.

Participants

A total number of 70 professionals participated during the focus group sessions; 60 were female and 10 were male. All of them were recruited based on their expertise and experience in working with children with ASD (e.g. teaching, providing training or care). The average working experience for the professionals was 13.7 years with a standard deviation of 9.4 years. Table 4.1 summarizes the main characteristics of the participants. All the participants had a positive attitude towards the use of technology in their daily practices. However, none of them had previous knowledge of, or experience in, working with robots for children with autism.

Table 4.1 Demographic characteristics of the participants

Description / Variable	Value (n (%))
Gender	
Male	n=10 (14%)
Female	n=60 (86%)
Total	(N=70)
Number of years working experience with ASD (professionals)	
0-5 years	n=15 (21%)
6-10 years	n=19 (26%)
11-15 years	n=10 (14%)
16-20 years	n=14 (19%)
21-25 years	n=3 (4%)
26-30 years	n=5 (6%)
31-35 years	n=4 (5%)

In total, 22 different organisations were represented by 70 ASD professionals in 12 focus group sessions. For people working for the same organisation the session was organised at their premises (all in The Netherlands). The types of organisations that were represented were: special needs schools, child and youth care organisations, (pedagogical) treatment centres, and medical day care centres. The background of the participants varied; ranging from ASD teachers and assistants at special needs schools, psychologists, speech therapists, occupational therapist, physiotherapist, psychomotor therapist, behavioural therapists, treatment coordinator, to people working in care management.

Data collection

The participant demographic forms were filled in and collected on paper and the information was stored in an excel sheet. Audio recordings were made during the 12 focus group sessions and verbatim transcripts were written in Word. Nvivo was used to analyse the verbal material.

Data analysis

To analyse and interpret the content of the qualitative data of the focus groups, conventional content analysis was applied.[21] This entailed that coding categories were derived directly in an inductive manner from the text data rather than from an existing predefined coding scheme. Data triangulation was used to ensure data integrity and validity. Two persons were involved in the collection and analysis of the data (investigator triangulation[22]). Two researchers were independently involved in creating the coding scheme based on the transcripts from the sessions to ensure inter-subjectivity. Both were present during the focus group sessions. In other to reach saturation, two analytical sessions were organised. When all the focus group sessions were transcribed by one researcher, both researchers read two sessions with the goal to identify main themes or codes to create a tentative coding scheme. After this, an analytical session was organised to compare, discuss and align these two coding schemes. The codes were discussed to understand how the data was perceived by both researchers. On a semantic level (the meaning of the data) the coding schemes were very similar, and the best wording (label) for each code was agreed upon. The resulting coding scheme was used by the main researcher to code three more focus group sessions. Subsequently, an additional analytical session with the two researchers was scheduled to finalise the coding scheme to ensure saturation. During the second analytical session some codes were slightly rephrased and finally coding consensus and information saturation was achieved. There was agreement on what code belonged to a certain piece of transcription. The rest of the focus group sessions were then coded by the main researcher using this final coding scheme (see the appendix for the final coding scheme).

Results

Results of the focus groups indicated that six different roles can be distinguished for KASPAR based on the input of the professionals. They argue that depending on the needs and capabilities of the professionals and the training or educational objectives for a child at a certain moment in time, as well as the available other interventions, a certain role for KASPAR may be preferred and chosen. Moreover, rich insight was gathered into the strengths of KASPAR as well as the challenges related to creating robot mediated interventions.

Possible roles for KASPAR

Below, the six roles that professionals envisioned for KASPAR are presented. Professionals indicated that these roles are not mutually exclusive; it may happen that two or more roles apply for a certain task and that another task requires another role. They indicated that the professional shall choose what role(s) are important to reach a certain goal.

Provoker

KASPAR is expected to function as a kind of magnet to (some) children; one that evokes, provokes, elicits, triggers, and stimulates them to engage in interaction. This role was suggested in 6 (of the 12) sessions. KASPAR may remove some barriers that normally prevent these children from feeling free and behaving in certain desired ways. A speech therapist at a special needs school indicated "KASPAR is calm, and manageable for children, he can provoke the children at a safe, calm and step by step manner" (Focus Group (FG) 6, speech therapist 1, special needs school, Female (F), 16 years of working experience with children with ASD). A special needs teacher mentioned "KASPAR might be able to trigger children and give another way of motivation and attention." (FG4, special needs teacher, special needs school, F, 7). Once KASPAR has won the children's attention, "he" can start "working" with them. Professionals highlighted that, currently, often the interaction between a professional and a child is unidirectional; it starts from the professional and stops there when the child does not respond. KASPAR, in their views, may be able to function as a trigger or stimulus that causes initiative from the child. Because KASPAR can always give (the same) reaction, the child might seek contact him-/herself. This creates a safe and predictable atmosphere for the child. KASPAR may stimulate or remove an obstacle so that children might start doing things they normally would not do. A special needs teacher (specialised in physical exercise) indicated that "KASPAR might be able to give a trigger so that the child takes initiative. Because KASPAR will always give a reaction, the child might seek contact." (FG11, special needs teacher, special needs school, Male (M), 17).

Reinforcer

Secondly, professionals indicated that KASPAR can be used to generate success experiences, to positively reinforce the children by giving compliments. "KASPAR can give compliments to the children" (FG9, pedagogical staff, ASD care centre, F, 8). This reinforcer role was suggested in 7 (of the 12) sessions. If needed, the professional can control the robot to deliver a certain reaction. Appropriate behaviour of the child can immediately be rewarded by a (consistent) compliment of the robot, initiated by the professional. In the beginning one may give a positive reinforcement after each instance of appropriate behaviour, and over time this can be given less frequently when the child learns. "We are able to control KASPAR. The reinforcement can be given immediately, or a bit later, or even later after the action. You can give a positive reinforcement after 1 correct action, later after two correct actions...you can play with it" (FG12, special needs teacher, special needs school, F, 14). When a child finishes a task, KASPAR might say "Well done [name of the child], you finished your task". In this way the child experiences moments of joy, and success which are very important for them since often things are difficult, challenging or even impossible for them. If the child does something which is less positive, KASPAR might say in a neutral voice without emotions "try it again". Professionals stressed that it is crucial that children experience success experiences, KASPAR could contribute to these positive moments. "He [child] will always receive the proper reaction. So when he takes initiative, this will be rewarded by KASPAR as an incentive" (FG5, ASD teacher 1, special needs day care centre, F, 17).

Trainer

Thirdly, professionals suggested that KASPAR can be used to repeat certain actions over and over again so that the child can train and practice a (new) skill. "KASPAR could take over a trainer function. I can say it is your turn, or KASPAR says it. I am curious to see if they learn faster if a robot tells it than I" (FG9, trainer, centre for ASD care, F, 4). This role has been suggested in 9 of the 12 sessions. This can be related to a wide and diverse scope of skills, examples are given of imitation skills, following up instructions, learning to cope with proximity, learning to work (independently), understanding appropriate behaviour in different contexts, and solution-oriented behaviour. "Especially with imitation this seems handy; KASPAR can give the example, you can tell the child to look at KASPAR to see how it should be done. Normally I give the examples myself plus I have to instruct the child at the same time" (FG12, speech therapist, medical day care centre, F, 20).

Moreover, a number of special needs teachers suggested that realistic examples from the child's life could be taken to practice with KASPAR in the sessions. Parents could, for example, provide situations of things that occurred, which will be worked with in the sessions so that the child can actually learn from it. In this case, KASPAR can be used in many different situations that make sense in daily life. By explaining for example that proper behaviour can be context dependent. A certain behaviour might mean different things in different contexts. For example, by simply changing KASPAR's clothes into a police uniform, the gesture of holding up one hand would change from waving (what it would be when you see a friend on the street) into a formal stop sign.

Mediator

Additionally, professionals indicated that KASPAR could be used as a medium to enable contact, interaction and communication with the child and another person. This role was mentioned in 8 of the 12 sessions and participants had lively discussions about it. They envisioned that a triangle of joint attention could be established via KASPAR (to a professional, another child or an object). Joint attention is a prerequisite to learn to interact together and KASPAR might help in establishing it. At first, KASPAR has the focus of attention which can be extended to other objects or topics. He can be an attention-, communication- and interaction mediator. Also KASPAR does not always have to be directly or primarily used to actually train certain skills, but he can function as a medium to engage in a moment or activity together as well. It can be a kind of subject of conversation that functions as a bridge to other topics; to support triangulation (involving a person and another person and an object or the robot). "I can imagine this happening with two of those little ones of us. Play a turn taking game together, listen to each other, wait for each other. KASPAR could be the third person taking the lead, for example "hey guys…" (FG9, ASD trainer 1, centre for ASD care, F, 4). Professionals envisioned that it is not always so important what KASPAR does, but that just simply being there would already make a difference. "For me as ASD therapist, there are so many means, but sometimes I cannot find a fit to the needs of the child. We could use KASPAR as another medium. It will not be so much about what he does, but more about that he is there. Then you use KASPAR as a medium for shared activity, or as a conversation topic to reach other topics, together" (FG9, ASD trainer 2, centre for ASD care, F, 8). Moreover, KASPAR could be used to advise the children to talk to the teacher, their mum or dad. Finally, they indicated that children could also use

KASPAR as a voice of their own, to express their wishes or needs if they experience difficulties with this themselves (similar as they do with a speech computer in a sense). An ASD care therapist who supports children and parents with ASD also a mum of two sons with ASD argued (FG7, ASD care therapist, care organisation, F, 18): "It would be wonderful if we could use KASPAR to stimulate or learn solution oriented behaviour. Imagine I am angry, that you can use KASPAR to show what being angry looks like. And that together you can start to think, what would KASPAR do now? Because that is not as scary as when you have to look at yourself. That would be wonderful, if you can use KASPAR as a tool to discuss feelings…that seems less intimidating to me. It could work with other feelings as well. Some children are too happy, what is appropriate and when. KASPAR can mediate in that."

Prompter

A fifth role that was mentioned was that KASPAR might be used to give (concrete, specific and clear unambiguous) instructions or prompts to the children. This role was suggested in 8 of the 12 sessions and participants considered this role of value in practice. They indicated that often children need quite a high level of (physical) proximity to complete a task (on their own). They know, for example, how to perform a certain task, but as soon as they finished that task, they wait and wait. Often they need a person to actually tell them that they need to move on to the next task (which in turn they can perfectly complete themselves again). KASPAR might fulfil that prompting role to give them a little 'hand' to pursue their work. At the end of their task, a KASPAR picto could be used, so that they know they have to interact with KASPAR, who might say "Well done [name child] now you can take the yellow basket and make the next task". In the words of a teacher assistant (FG6, teacher assistant, special needs school, F, 11): "KASPAR can give instructions to the child, go on, well done, please sit down, take the next task, please continue". Or more in general, KASPAR can be used to give instructions or a day/task structure to the children. One example was given by a teacher of a special education school (FG4, special needs teacher, special needs school, F, 25): "When the children arrive at school in the morning, they need to do three things: hang up their coat, put their breadbox in the drawer, and sit at their desk. These are three different things and KASPAR could provide a structure and guidance to complete these step." Or as another participant indicated "KASPAR might be used to plan and organise when there is a range of activities….. "in 5 minutes we will stop and have lunch" (FG8, ASD coach, care organization, M, 20). In this case the dependency of the human might become smaller, and step by step one can work towards a more independent working style (if the dependency of KASPAR of course is gradually decreased as well). If a certain child has sensory difficulties when there are more children around, KASPAR could be placed next to him/her so that more isolated instructions or prompts can be given.

Diagnostic information provider

A sixth and final role that was suggested by the professionals was a diagnostic information provider. By observing how the child interacts with KASPAR, professionals might learn more about the behaviour of the child. This role was brought up by participants in 4 of the 12 sessions. It might provide some diagnostic information that would be difficult to get when the child was interacting with the professional rather than with the robot. From the perspective of a person without autism, KASPAR might look 'clean', awkward, or even 'scary' due to the absence facial expressions and details. For people without autism, facial expressions often provide a sense of safety, security, clarity. For children with autism, this is (completely) different, which might be a reason why they show different reactions and behaviour to KASPAR than to a human being. Professionals expected to be surprised by the children's reactions to KASPAR. This might help professionals to understand the children better and possibly learn them more about their own behaviour towards the children (i.e. "why does the child react in this way to KASPAR and differently to me") and give them more insight in how to improve their behaviour towards the children. So, professionals thought that from observing the child's interaction with KASPAR, professionals might learn about the child on the one hand, and about their own behaviour on the other hand. A number of quotes from participants illustrate this: "KASPAR can help me understand why does this child react this way and another child that way. And what does the child apparently need, also from me. In this way it is a beautiful diagnostic information tool" (FG7, mental health psychologist, ASD care organisation, F, 30); "I do think it works in two directions; it is not just very clear for the child but we [teachers] we will see that KASPAR will provoke reactions that we just cannot provoke. Then you will start to think "why does he [child] do it with KASPAR and not with me? Maybe in this way you will search yourself for better ways of communicating with the child" (FG, special needs teacher,); and "KASPAR can help us to get a better understanding in what a child can actually do" (FG5, ASD teacher 1, special needs day care centre, F, 17).

Strengths of KASPAR

The focus group results indicated that professionals envisioned a number of strengths inherent to KASPAR that could be exploited or utilised in order to optimally complement current ASD practices. Often these strengths are expected to create desirable states of wellbeing for the child such as safety and trust which better enable the child to feel pleasant, motivated and more able to develop to their fullest potential. These characteristics were the following:

1. Personalize and apply in a multifunctional manner; KASPAR can be programmed in a tailored individualised manner to meet every child's needs, wishes, learning objectives, capabilities and preferences. Personalisation is important for children with autism and KASPAR is expected to be able to have an answer to this since new scenarios and KASPAR behaviour can easily be created or fine-tuned. This applied both for the training and educational goals that are relevant for that particular child and will be addressed using the robot, but also to the way these are addressed. KASPAR should look accessible and friendly and children should be able to identify with him. KASPAR is currently a boy, but can be changed into a girl when his hair, clothes and voice is adapted into a female version of the robot.

2. Playful; it is expected that (some) children will enjoy interacting with KASPAR, that they will like it, experience fun, which increases chances for enjoyment, motivation, attention and drive for initiative or exploration. For children with autism this can be a very important positive aspect.

3. Action - reaction; the child is in control; the initiative lies in the hands of the child. Many children with autism are fond of interactive technology such as computers or tablets. One of the underlying causes is, in the eyes of the professional, that the child is in charge of the initiative and control which gives a feeling of predictability and safety. It is expected that the 'action-reaction' mechanism of KASPAR is a strong asset for being a successful tool for children with autism.

4. Neutrality; approachability, lack of "noise" or ambiguous disturbances; due to KASPAR's lack of extreme realistic human facial expressions and emotions he is expected to be more approachable (than humans) for children with autism. It is expected, that in the eyes of the children, KASPAR is thought to be more 'clean', predictable, safe, less distracting, trustable, and less ambiguous and less threatening than a human person would be.

5. Consistent and repetitive application (creates predictability); KASPAR is able to say or do something in exact the same manner for an endless number of times. For humans this is not possible: we will always (unconsciously and unintentionally) vary in some way; our tone of voice, volume, pitch, facial expressions, or speed might alter. For training and practicing purposes this consistent repetition is expected to be extremely beneficial. KASPAR's behaviour and/or reaction can be the same, over and over again. This consistency creates predictability which in turn can create a

feeling of safety for the children (i.e. KASPAR will not perform any unexpected ‘strange’ actions). KASPAR always sits, so they do not have to be ‘afraid’ that he will just get up and move away. Moreover, KASPAR is always there and available, whereas some professionals work part-time, are replaced or are on (sick)leave every now and then which might upset some children. KASPAR might be a stable and constant factor alongside these (changing) professionals.

6. **Vary in a controlled manner**; according to professionals, with KASPAR you have the ability to deliberately chance only some selective and isolated aspects in his reaction or behaviour. Variation or change can be done in a controlled and conscious manner. For humans this might be more challenging since we unconsciously and unintentionally sent numerous messages with our voice, facial expressions, odours, body posture that children sense, perceive and possibly react to. KASPAR is in that sense more focused and selectively controllable when professionals wish to change or vary gradually to work towards transfer and generalisation.

7. **Extra hand**; professionals highlighted that at the moment often professionals occupy a double or triple function. They fulfil multiple roles simultaneously often at a single moment in time in one person; a trainer, an observer, a motivator, a corrector and often a kind of coach. Professionals indicated that this causes a large burden on them and might cause a lack of clarity or maybe even distress or overload for the child. With the use of KASPAR in one of these roles, the professional gets more ‘space’ to focus and or even to take some (physical) distance. For the child it is expected to be less ambiguous.

Challenges related to KASPAR

The results also indicated that professionals envisioned a number of challenges related KASPAR that should be given attention to in order to optimally complement the current ASD practices. These challenges were the following:

1. **Limited reaction possibilities**; according to the professionals, currently, KASPAR has limited mobility capabilities (i.e. he cannot walk, grasp or fetch objects, make fine gestures with his hands or fingers). Since KASPAR is semi-autonomous, a number of pre-defined actions can be programed on the remote control. This means the professional has these and only these reaction possibilities at hand; KASPAR itself has no contextual sensitivity to purposefully react in a situation.

2. **Some children might be scared of KASPAR**; professionals thought that it might very well be that not all children like KASPAR, some children might even experience aversion towards the robot.

3. **Generalisation / transfer**; professionals indicated that KASPAR might be able to train new skills, however, the intention is not to teach the child to optimally and only perfectly behave in the interaction with KASPAR. The goal is that children are able to apply the learned skills also in real live situations. Professionals raised the issue of transfer or generalisation to humans and/or other situations. Also, some professionals were afraid that some children might copy KASPAR in an extreme realistic manner causing them to show 'robotic' behaviour themselves.
4. **Dependence on KASPAR**; it may occur that children with autism have a dependency to some of their teachers or therapists. If a child learns some words with KASPAR as a trainer, coach, or medium in the intervention, professionals wondered if this dependency might shift towards KASPAR. Therefore, attention needs to be devoted to the matter of dependency as well.

Discussion and Conclusion

Results from focus groups with professionals working intensively with children with autism and other stakeholders delivered 6 roles for a robot in the work they do: provoker, reinforcer, trainer, mediator, prompter, and a diagnostic information provider. These roles were defined based on their expertise of what children with ASD need in education and training in order to support their independence in daily life. The roles of the robot were formulated in terms of delivering added value to the already existing work practices and interventions.

Professionals considered the use of robots to be of high potential. In order to achieve this potential, it is crucial that the strong assets of robots (e.g. action-reaction principle, consistent and repetitive application) are carefully implemented in practice while taking into account and utilising the strong characteristics of people (e.g. being able to 'read' the child with autism very well). As a result, they expect that robots can become valuable tools in the hands of professionals.

Results indicated that, depending on the needs of the child and the professional a certain role might be chosen in a certain moment while another role might be needed at another moment in time. Moreover, findings showed that these roles are not mutually exclusive, multiple roles can be applicable or needed for a certain task or activity. Professionals indicated, for example, that for the role of trainer compliments of the reinforcer role are needed as well.

The roles from the ASD professionals are quite similar to those identified in state of the art robotics: "behaviour eliciting agent", "diagnostic agent", "friendly playmate", "social mediator", "social actor", and "personal therapist".[3] On the other hand, when taking a closer look, the roles from the professionals seemed to be more concrete and slightly more intervention oriented when implementing them in a real education or care practice. For example, when looking at the "diagnostic information provider"; the professionals envision a two way interaction, not only to establish information related to the diagnoses of the child's abilities (as suggested in the categorization based on the state of the art of robot literature), but also a feedback mechanism for the professionals to learn and possibly adjust their own behaviour towards the child.

The goal of the study was to get insight into as many different roles that could be envisioned for robot KASPAR in ASD interventions. Since people with autism might have a different perspective or experience, we also invited three adults with ASD in an additional focus group as an extra source of information and to check if their ideas align with what the professionals mentioned. They indeed confirmed the results of the professionals. Moreover, they delivered interesting additional information. They came up with a 7th possible role; a buddy. They argued that KASPAR might say "Hello, my name is KASPAR, I am a little bit different, just like you". So that the child learns it is alright to be different and still be part of the group. This might enable a different connection or relationship, more like a friend rather than a teacher. An adult male with ASD indicated "He [KASPAR] is a friend and does not have a teaching role". If the child then establishes a trust relationship with KASPAR, it might feel safer. KASPAR might be able to 'help' then in difficult cases in which it is hard for the child to express its needs or wishes to a human. KASPAR might fulfil the role to stand next to the child and help to understand what really happened.

More research is needed to systematically and intensively involve people with ASD in the process of researching and developing valuable robot-mediated interventions for children with ASD.

A strength of the present study was intensively involving professionals in the creation of new robot mediated interventions to utility mutual awareness and expertise to better guide robot mediated interventions. Professionals see a strength and advantages of robots for this target group, maybe even more than in other domains were robots are suggested for care (e.g. independent living, service robotics for elderly care as described in for example in.[23] Possibly this is due to the nature and complexity of the disorder, the difficulty of delivering proper care especially as human beings and the open mind that many of these professionals have towards trying out new ways of working with this target group. More robotic appearance and behaviour might be 'better' or preferred in some moments with this target group which is particularly difficult for expressive people. This relates to findings in which children showed more interaction with a 'robot looking man' than with a typical human being.[24]

The potential that was identified using robot KASPAR, can also be applied to many similar other robots that are used in interventions for training or education for children with ASD, as often on an abstract level many robots have similar characteristics. For example, other robots (e.g. Nao as presented in[25,26] can also provide a possibility to personalise the behaviour of a robot to the needs of a specific child, can be playful in the interaction or appearance, and provide a kind of action – reaction mechanism that allows the child to be in control. Depending on the appearance of the robot platform, interaction with a robot can be neutral and approachable for a child with autism. Depending on the implementation (or to some extent the level of autonomy) of the robot, many robots can provide consistent interaction, the option to vary in a controlled manner and provide an extra hand for therapists or teachers. The same holds for the need to pay attention to a number of aspects when working with robots for children with autism; the robot will always have some limitations, for some children or some moments a robot will not be the most optimal choice, prevent dependence on the robot, and take into account matters of generalisation and transfer. The robot shall be an additional tool in the hands of the professionals, not a goal in itself. The aim is to support children in their development so that they can function in the real world with real people, not (only) show great performance in front of a robot.

A limitation of the study could be the snowballing sampling method that was used; due to possible anchoring (not knowing if the sample is an accurate reading of the target population). However, this is a high risk only if only a few people would be included, which is not the case in this study in which a large number diverse professionals (N=70) participated from many different and diverse organisations.

Previous studies already show that professionals have positive expectations of using KASPAR to work on the education and/or training objectives for children with autism; that they see potential for KASPAR for more ASD training and educational objectives than currently proposed in robot studies in peer reviewed literature.[5,19] They clearly can see KASPAR as a tool in the hands of the professional to work on a larger range of objectives. This study contributes to this mission by creating understanding of where the strengths or advantages of robots might be in an intervention for children with autism. By intensively involving professionals we aimed to increase chances for clinical relevance and uptake and overcome typical barriers for robot mediated interventions to reach clinical applicability as stated by Begum et al. (2016) (such as unawareness or lack of believe in the potential of robots by end-users).[2]

The next step will be to co-create and pilot new robot-mediated interventions using these insights as well as the gained awareness and knowledge of the professionals in the field as well as people with autism. Moreover, effort will be given to minimize the reported challenges, for example by co-creating new robot mediated interventions aiming to enhance the robot design and optimize personalised interaction possibilities and dialogues. When truly implementing robots into current practices, also aspects other than the roles, strengths and challenges need to be in place. These can be technical aspects such as technical infrastructure, maintenance effort and costs, as well as stability. Additionally, also many practical requirements need to be taken into account in order to truly implement robot assisted interventions (e.g. a specification of the target group, factors related to the environment, integration into common practices and individualised education/training plans).[27]

4

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Appendix 4.1

This is the final coding scheme used to code the focus group sessions.

Possible roles for KASPAR

- Provoker
- Reinforcer
- Trainer
- Mediator
- Prompter
- Diagnostic information provider

Why could KASPAR work - strengths of KASPAR

- Personalize and apply in multifunctional manner
- Vary in a controlled manner
- Action –reaction
- Playful
- Neutrality
- Consistent and repetitive application
- Extra hand

Why could KASPAR NOT work – challenges related to KASPAR

- Generalisation / Transfer
- Limited reaction possibilities
- Some children might be scared of KASPAR
- Dependence on KASPAR

KASPAR

- Appearance
- Voice or Sound
- Operation of KASPAR
- Behaviour / actions of KASPAR
- KASPAR's Attributes / Toolbox

Target Group

- Specification of target who will probably benefit from KASPAR
- Specification of target who will probably NOT benefit from KASPAR

Environment

Professional

Intervention implementation
Integration in individualised education/therapy plan
Phase in the intervention trajectory
Session characteristics
    individual vs group, spontaneous vs structured, duration
Integration on organisation level and connecting to parents

Chapter 5

How to Implement Robots in Interventions for Children with Autism? A Co-creation Study Involving People with Autism, Parents and Professionals

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Abstract

Aim

The aim of this study was to gain insight into how robots can be practically implemented into current education and therapy interventions for children with autism spectrum disorder (ASD).

Method

This qualitative study included focus groups and co-creation sessions. 73 Participants (professionals and adults with ASD) took part in thirteen focus groups to elicit requirements for robot assisted interventions. Additionally, 22 participants (professionals, parents of children with ASD and adults with ASD) generated ideas for interventions using robot KASPAR in three co-creation sessions.

Results

This study resulted in: an overview of requirements concerning the robot, end-user, environment and practical implementation; a template to systematically describe robot interventions in general and for KASPAR in particular; and finally new interventions.

Introduction

Personalised and early therapy and intervention plans are effective in supporting individuals to cope with autism spectrum disorder (ASD) associated symptoms.[1] The call for early empowerment of people with ASD relates to the vision of the World Health Organization (WHO), who recently redefined its meaning of disability as the result of the person's interaction with his environment. They argue that it is "an evolving concept", and "disability results from the interaction between persons with impairments and attitudinal and environmental barriers that hinder their full and effective participation in society on an equal basis with others".[2] They also state that social participation can be improved when the barriers are addressed that hinder people with disabilities in their daily lives. Assistive technologies, when designed and implemented appropriately, and meeting the needs of the user and their environment, are powerful tools to boost independence and improve participation.[2] A variety of assistive applications are suggested for people with ASD, to support them in varies areas of their life, and are implemented in computers, special input devices, virtual environments, avatars, serious games, tele rehabilitation as well as robots.[3] Moreover, an increasing sophistication and transformation can be seen from ASD technology research mainly as theoretical novelties, now growing towards "tools that are better understood, more solidly studied, more nuanced, and more practically relevant".[4] Various publications and studies highlight the potential and state of the art of using robots as assistive tools in interventions for children with ASD.[5-7]

Interacting with robots can be particularly empowering for children with ASD, because it may overcome various barriers experienced in face-to-face interaction with humans. Moreover, robot assisted interventions can be tailored to the needs of the specific child and can be used in an identical manner as often as needed. However, the actual implementation and daily use of robots in practice is still not very common. Begum et al (2016) suggest a roadmap to establish robot-mediated interventions as an evidence based practice (EBP) in the domain of autism, since EBP has become a benchmark in ASD intervention. In order to increase the applicability for clinical practitioners, they propose a number of guidelines, based on a comprehensive review of clinical literature on ASD interventions, for human-robot interaction (HRI) studies on robot-mediated interventions (RMI). These elements are: a clear description of the goal of the intervention, the participants, independent variables with RMI, dependent variables, research design as well as generalization training.[8]

One of the robot platforms used in various (human robot interaction) studies in education/therapy settings is KASPAR ("Kinesics and Synchronization in Personal Assistant Robotics").[9-14] KASPAR is a semi-autonomous minimally invasive humanoid robot developed by the Adaptive Systems Group of the University of Hertfordshire (UK) (see Figure 5.1).

Figure 5.1 Therapy Robot KASPAR

KASPAR allows for several operation modes:

1. automatic behaviour or autonomous control when its sensors (e.g. on KASPAR's head, torso, arms, hands, feet) are activated by the child, as well as
2. as a controlled operating mode used by the accompanying professional or a child by means of a remote control for KASPAR, and/or
3. a combination of both which creates a semi-autonomous mode of KASPAR.

Customisation software allows for the creation of new (personalised) KASPAR scenarios. This customisation software enables users to make new KASPAR poses, behaviour, speech or sounds and scenarios and to fine-tune or personalise existing ones. It can be installed on any regular laptop on which the KASPAR application is running.

Studies indicate that KASPAR can contribute to positive results in the area of increasing body awareness, encouraging collaborative skills;[15] prolonging children's attention span;[16] mediating and encouraging social interaction;[17] and learning appropriate physical interaction.[18]

Professionals see a clear potential for KASPAR for a relative high number of education and/or therapy goals for this target group.[6,14] This applies not only to the more commonly addressed challenging areas such as social interaction and communication, but also in objectives related to preschool skills, play and emotional wellbeing for example.[6,14] Examples are: ‘pose a question’, ‘ask for help’, ‘imitation in play’, ‘making contact’, ‘follow up instructions’ and ‘having fun’.

In order to go beyond “likeability” of robots for children with autism as Begum et al (2016) state it, we decided to intensely involve clinicians and practitioners in the process of actually creating new robot mediated interventions themselves. This facilitates the step from moving from isolated lab human robot interaction (HRI) studies towards feasibility and effect studies, integrated evidence based practice and application of the use of robots in autism interventions that children actually benefit from in their life. This entails not only creating (the contents of) the robot, in this case KASPAR, but especially to better understand hów to embed the robot in interventions in practices of the envisioned end-users.

The aim of the current study was to examine how robot KASPAR can be included in interventions to contribute to reaching therapy and educational goals of professionals for children with ASD as well as to create a template that can be used to create and describe new robot interventions, including the human-robot interaction. This article entails to address the following research questions:

1. What are important requirements regarding the implementation of robots such as KASPAR as tools in an ASD intervention?
2. What are important elements in a robot-mediated intervention description and how should the intervention template look like to enable professionals to create new interventions?

Methods

The qualitative study started with focus group sessions to identify intervention requirements as well as crucial elements of an intervention template, followed by co-creation sessions that applied these insights in order to enable professionals and stakeholders to create new robot interventions for robot KASPAR. The importance of understanding people’s thoughts, drivers, challenges and ideas was the reason for choosing these qualitative methods.

Focus groups

Procedure

The focus groups addressed two main topics:

1. identifying the potential of robot KASPAR and the roles it can take in interventions for children with ASD; and
2. eliciting requirements for robot mediated interventions.

The current paper presents the results of the second topic. The findings regarding the potential and roles of KASPAR are published elsewhere (Huijnen et al. Submitted for publication). Part of those results - possible roles for KASPAR such as for example “provoker”, “reinforcer” or “trainer” - are used in the intervention template that is used in the co-creation sessions which will be discussed later in more detail.

In total, 13 focus group sessions of 2 hours each were organised. Two researchers guided the session; one in the role of moderator and one as a note taker, observer and transcriber of the sessions. Researchers collected informed consent forms for making audio recordings, pictures as well as participant information sheets for gathering demographic information. After a welcome, KASPAR was demonstrated. During this demo, KASPAR greeted the participants, played a song and KASPAR’s possibilities were illustrated in an interactive fashion (e.g. the use of sensors, motors, speech, sounds, the remote control and the option to create new personalised scenarios). After the demo, the discussion on requirements started by asking a general question: what are the requirements of a meaningful KASPAR intervention? People were asked to think about aspects required for a successful implementation of a KASPAR intervention. If participants got stuck in the discussion researchers used prompting. The specific prompts used in the focus groups were: “child”, “professional”, “environment / room / setting”, “KASPAR”, and “school as an entity”.

Setting and Participants

Of the 13 sessions; 12 sessions consisted of a group of professionals and 1 session included individuals with ASD. The professionals work with children with ASD at special needs schools, (youth and child) care organisations, pedagogic organisations, ASD treatment centres and medical day care centres in The Netherlands.

The sessions were conducted at the venues of the organisations and the session with participants with autism took place at a meeting room of the Zuyd University of Applied Sciences. Organising these sessions at the venue of the organisation themselves created a familiar and trusted atmosphere for the participants to facilitate free and open minded discussions. The research team prepared the room in advance, creating a U-shape setup to facilitate interaction between participants and preparing beamer/projection facilities in the front for the demonstration of KASPAR.

The background of the professionals was multidisciplinary: ASD teachers, assistants at special need schools, speech therapists, psychologists, physiotherapist, occupational therapists, psychomotor therapist, treatment coordinator, case managers, behavioural therapists and people working in care management functions. The average work experience was 14 years with a standard deviation of 9.5 years. Table 5.1 presents the characteristics of the 73 participants of the focus group sessions.

Table 5.1 Demographic characteristics of the participants of the focus groups

Description	Value n	(%)
Gender		
Male	13	(18)
Female	60	(82)
Background		
Professional working with children with ASD	70	(97)
Parent of child with ASD	3	(4)
Adult with ASD	3	(4)
Number of years working experience with ASD		
0-5 years	15	(21)
6-10 years	19	(26)
11-15 years	10	(14)
16-20 years	14	(19)
21-25 years	3	(4)
26-30 years	5	(6)
31-35 years	4	(5)

Data collection

The completed participants demographic forms were collected on paper and the data was imported in an excel sheet. Audio recordings were made during the sessions (after obtaining informed consent of the participants). One of the researchers present at the sessions literally transcribed all the data of the 13 sessions in Word files. Subsequently, the software program Nvivo was used to transform the data into written text to be able to start the analysis.

Data analysis

For the analysis of the qualitative data of the focus groups, researchers applied conventional content analysis.[19] This means that coding categories are directly derived from the data of the focus groups in an inductive manner, rather than from an existing predefined coding scheme. To ensure data integrity and validity we used data triangulation. More than one person was involved in the collection and analysis of the data and multiple methods of data collection were used. The two researchers who also accompanied the sessions created the coding scheme based on analysis of the transcripts. Both researchers read two of the sessions in order to identify main labels to come up with a tentative coding scheme. Thus, a code was assigned to a text chunk of any size that represented a single requirement that was mentioned. The collection of these codes resulted in a coding scheme. Subsequently, an analytical session between the two researchers was organised to compare, discuss, fine-tune and align these two coding schemes to make sure the codes were clear, mutually exclusive and that both researchers had the same understanding of each code. In case of difference, discussion was used to reach consensus. The main researcher then used the resulting intermediate coding scheme was to code sessions 3 to 5. Subsequently, the two researchers participated in an additional analytical session to check the work again and the final coding scheme was established and applied to the entire corpus of text by the main researcher.

When all the text was analysed and the requirements were obtained, the two researchers constructed the intervention template based on these requirements and insights of the focus group sessions. This template entails main elements to describe in a robot assisted intervention. The template consists of elements such as: “name of the intervention”, “focus on objectives (select from a given set or choose another one)”, “role(s) of KASPAR”, “goal of the session”, “session characteristics” as well as a schematic representation for the envisioned interaction between the professional, KASPAR and the child. For all the elements and the format of the intervention template we refer to section “Intervention template” and a detailed example in Appendix 5.2.

Co-creation sessions

The aim of the co-creation sessions was to create new robot interventions, incorporating the identified requirements of the focus groups, in a multidisciplinary group of participants.

Procedure

Three co-creation sessions had a duration of 2-3 hours each. After a short welcome, an introduction round to briefly introduce oneself to the others (name, background and current relation to ASD), an explanation of the aim and nature of the session, and a presentation of the intervention template, an interactive live demonstration of KASPAR was given. Participants provided informed consent for making audio recordings during the sessions. After answering questions, participants were asked to think about a certain child with ASD that they have experience with, and to create a meaningful KASPAR intervention using the template. Participants then split up in smaller subgroups to work on a new intervention. The allocation of people to groups was done in a rather organic manner; people seemed to gather around a common theme/idea rather easily;

so the creation of groups happened spontaneously based on the topic for the intervention. In all the subgroups, a researcher was present to guide the brainstorm process and answer potential questions. At the end of the session the subgroups gathered around the big table again and presented their interventions to the entire group in order to receive feedback and suggestions for improvement of everybody. Every group delivered at least 1 new intervention for robot KASPAR based on and written down on the intervention template.

Setting and Participants

The three sessions where organised at an inspiring venue. The session started with a welcome and introduction part in a group setting. After the introduction, people started the group work on different dedicated tables in the same room. The composition of the groups (session 1 n=9; session 2 n=5; session 3 n=8 participants) was multidisciplinary; such as professionals being teachers or ASD therapists/caregivers, individuals with ASD, parents of children with ASD and partners of people with ASD. In total 22 people participated (see Table 5.2 for participant characteristics).

Table 5.2 Demographic characteristics of the participants of the co-creation session

Description/Variables	Value	
	n	(%)
Gender		
Male	8	(36%)
Female	14	(64%)
Background		
Professional working with children with ASD	15	(68%)
Parent of child with ASD	2	(9%)
Partner of person with ASD	1	(4.5%)
Adult with ASD	4	(18%)
Number of years working/experience with ASD		
0-3 years	2	(9%)
3-5 years	1	(4.5%)
5-10 years	6	(27%)
>10 years	13	(59%)

Data collection

During the co-creation sessions, the participants filled in the intervention templates. Researchers collected and digitalised these templates (10 in total) after the session to prepare them for the analysis and further implementation as actual scenarios to be developed in the actual robot.

Data analysis

The person who accompanied that particular subgroup discussion during the session performed the data analysis, not to miss the context and depth of the discussions that took place when creating these interventions. The data analysis was rather straightforward for these interventions since no actual analysis took place on the content of the interventions, but merely an understanding was necessary in order to implement these into the robot platform.

Results

First the requirements for KASPAR mediated interventions and the intervention template are presented and subsequently the new KASPAR interventions made during the co-creation sessions are described.

Requirements for KASPAR mediated interventions

The intention was to elicit factors that are crucial for a meaningful intervention (practical implementation) rather than 'only' understanding technical robot requirements. As a result, the focus groups delivered a number of different categories of requirements for KASPAR mediated interventions. Table 5.3 summarises the overall categories. The following sections present each of these separate categories in more detail.

Table 5.3 Overview of requirement categories for robot assisted interventions

Requirements overview robot assisted interventions
The robot (KASPAR)
Appearance
Voice and sound
Operation of KASPAR
Behaviour and actions of KASPAR
KASPAR's attributed / toolbox
The target group
Specification of the target group who will probably benefit from KASPAR
Specification of the target group who will probably not benefit from KASPAR
Environment
Professional
Intervention implementation and integration into common practices
Integration in individualised education/therapy plan
Integration in organisation, professional levels and connecting to parents
Phase in the intervention trajectory
Session characteristics

The robot KASPAR

This section presents the requirements with respect to various aspects of the robot.

Appearance

KASPAR's looks were important according to professionals. They mentioned that KASPAR needs to look cool. He needs to get a set of cool and nice different clothes suitable for different seasons and weather types. When choosing clothes they mentioned to pay attention to the texture of and prints on the clothes. Some children might get an overload if there are a lot of colours, prints or images on clothes. Moreover, KASPAR needs attributes as well that can boost a cool image that children can identify with, such as a cap (that he could wear backwards) and maybe (sun)glasses. When the lesson in the classroom starts, KASPAR has to take of his cap and sunglasses, just like the children. By changing KASPAR's clothes one can use him in a different context or different role. Some professionals asked if they can change his hairdo and some asked if there is also a girl version of KASPAR.

"*With this hairdo he could be a girl, while he has the voice of a boy."* – Adult with autism, who has a partner and children with autism

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Voice and Sound

A few professionals indicated that for some children it would be good if KASPAR would get the voice of a recognisable person for them (e.g. mum or dad) in the beginning and that KASPAR would then get another voice later. However, more professionals suggested to use an artificial voice from the start. This can be a computerised voice as long if this does not sound too artificial, jerky, canny or robot-like. This voice should be soft in nature and sound friendly not to scare them. The sentences KASPAR utters should be short to increase understanding. The talking speed should be rather slow. If the children make a mistake, or if something does not go as well as hoped, KASPAR should give a positive reaction in a neutral voice, without an angry tone (i.e. "*please try this again*"). If KASPAR will use other sounds than his own voice (e.g. a song), he should always announce this first using his own voice (i.e. "*I will now play a song for you")*.

"Parents imitate unfamiliar sounds as well. What sound does the dog make? Waf, Waf. And the cat? Miauw, miauww…I think KASPAR should indicate that he will produce these sounds."- Adult with autism, who has a partner and children with autism

"Imagine a child goes on a school trip. KASPAR can say "I heard you are going on a school trip, I know some sounds that you will hear there, shall I let you hear them?" - Adult with autism

Many children with autism are sensitive for audio or sound. KASPAR could be used to familiarise them with unusual sounds so that they are better prepared or less scared when they hear the sound in the 'real' situation (i.e. when they go on a trip outside, first time holiday, visit an animal farm, heavy traffic, trains, yelling children, sirens, clock ticking, or sounds with a high pitch). Many professionals mentioned their expectations with respect to the use of all kinds of songs. This will give them joy and might very well stimulate interaction between children, since many children love music and react positively to it.

Operation of KASPAR

Professionals indicated that they need some training to be able to operate KASPAR during the session and to be able to create new scenario's tailored to the specific needs of a child. They indicated that it should not take a lot of time to get KASPAR up and running before a session since they are already very busy with many things in a classroom or therapy setting. Also they expressed relevance for being flexible in changing KASPAR's settings or behaviour when the situation demands improvisation. The behaviour of children can hardly be predicted. It is desirable to be able to fine-tune some KASPAR aspects rather easy and quickly if needed.

Behaviour and actions of KASPAR

Professionals indicated that KASPAR should behave in a consistent, clear, playful and accessible manner of interacting with children. When KASPAR moves his body parts, one can hear a sound of the motors being activated. Professionals expected that this might distract some children. They suggested not to use too much movement and speech at the same time since this might cause an information overload for children. KASPAR should either move or speak first, then do the other thing, so that children only have to pay attention to one aspect at the same time. In this sense, the amount of simultaneous stimuli needs to be limited as much as possible.

Some professionals suggested it would be good if KASPAR could fetch, grasp, manipulate or hold objects. In that case he would be able to make a difference between pinching and caressing a cheek for example. At this moment KASPAR's fingers are fixed, they cannot move separately from each other. It was suggested a number of times that it would be interesting if KASPAR could make gestures and use sign language rather than verbal commands only since quite a share of these children have no or limited verbal skills. KASPAR could then also point to things. Similar as with the use of sounds, KASPAR should not start to move in a very abrupt fast manner as it might scare children. If he was sitting without moving for a while, the start of the movement should be gradual and smooth.

KASPAR's Attributes / Toolbox

Professionals had ideas to integrate KASPAR in other activities or give him objects or tools that they can work with. They mentioned KASPAR could get different attributes such as glasses, or musical instruments and use materials from other methods. For example, by dressing KASPAR up in a police uniform, he gets a different role as when he wears a sporty outfit.

The target group

Specification of the target group who will probably benefit from KASPAR

Obtaining a clear insight on who would be a suitable target group for KASPAR should be learned from ongoing work and experiences according to the professionals. However, quite some of them immediately had particular children in mind when they were thinking about for whom KASPAR could be of added value. These are some examples that give an indication of children they could see benefiting from KASPAR; i.e. children who:

- Have a strong need for proximity and prompting;
- Experience difficulties making contact or are anxious in nature to engage in contact with other people;
- Have difficulties with the unpredictable nature of people and peers in particular;
- Have a kind of urge for 'safe' discovery (and like action-reaction interactions);
- Might have limited verbal skills or (other) difficulties to express themselves with words;
- Have difficulties relating to social-emotional or communicative aspects;
- Feel confident and excited using technology;
- Seem to be in 'their own world';

- Are from around 4 years of age and older (depending on their social and cognitive development). Professionals expected that it is not so much the biological age that defines the KASPAR target group, but rather the socio-communicative-cognitive development of the child;
- Have a cautious attitude and do not (really) engage in interaction with humans;
- Experience problems related to attachment.

Specification of target group who will probably NOT benefit from KASPAR

Some professionals also described children for who KASPAR would probably not be a success in their eyes. Some children (or adolescents) might not consider KASPAR as being "cool" or may be applicable for young(er) children only. For others KASPAR might not be an appropriate choice because of their high activity level, high 'aggression' levels or because they are easily bored.

"*I showed a picture* [of KASPAR] *to my son, who has Asperger who said: "why don't you give me a normal robot that I can use, this is not a real robot but a doll.*"- Adult with autism, who is a professional as well and has a son with autism (Asperger)

Environment

Some professionals saw possibilities of using KASPAR in a group setting, for example in the middle of a classroom where all children sit in a circle around the robot. When they suggested individual sessions, they referred to a quiet, calm and peaceful room where there are very little distracting (sensory) stimuli or triggers outside the classroom.

Professional

Working with KASPAR demands some requirements from the professional (teacher, therapist) according to the participants:

- Professionals need basic instructions on how to operate KASPAR;
- Some (not all) professionals need to know how to make new scenario's using KASPAR's configuration software or how to fine-tune / modify existing ones.

Professionals with varying backgrounds are proposed to be working with KASPAR as he can be used for different therapy and educational objectives. Professions such as a speech therapist, an occupational therapist, a teacher, pedagogical staff, a physiotherapist, a play therapist, psychologist and also parents have all been suggested as potential end-users. It is important that they have knowledge of and are experienced in working with children with autism and that they can see how to move to transfer and generalisation of required knowledge or skills step by step. Several characteristics and skills have been suggested to be important, such as being very alert and aware, knowledgeable about and attentive to the child and understanding how to dynamically control KASPAR in a proper manner, having an open mind to use new technology, having a positive and enthusiastic attitude and nature, seeing opportunities rather than problems in trying new ways of working with these children, feeling confident that they can work with KASPAR, and last but not least, being able to use their professional intuition and creativity. The professionals expected that the person operating KASPAR is a huge determiner of the success of the interaction and thereby of the intervention. It is recommended that over time children work with different, but not too many professionals (after the child feels at ease) in order to stimulate generalisation and transfer.

"*It will depend on what you put in as a teacher or therapist. The success of it is not only dependent on the child, it will actually be a result of various skills of the person operating KASPAR.*" – Teacher at special needs school

"*I think you ask quite a bit of a teacher working with such a vulnerable target group to let go and try something new. We will have to see what the effects are. Being brave to step back a bit in the interaction and put something else in between.*" – Teacher at special needs school

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Intervention implementation and integration into current practices

Integration in the individualised education/therapy plan

Integration was mentioned very often during the sessions as being crucial for a proper implementation of robot-mediated interventions, meaning that KASPAR should not function as a standalone platform, but its use should be integrated in common practices. It is crucial to integrate the work with KASPAR in the overall education/therapy plan of the children. Often schools or care organisations work with an individualised therapy/education/care plan that describes what learning objectives the focus is on for a particular child for the upcoming weeks or months. Based on this personalised plan, education or therapy actions will be taken by professionals. Each child has his/her own plan which is updated regularly. Professionals indicated that when KASPAR is used therapeutically, it has to be part of a conscious decision of knowing for which children KASPAR will be used, what objective(s) to work on, how,

when, where, how long and often, and by whom. This all has to be documented (and introduced, executed, evaluated) in the individualised plan as any other intervention. KASPAR is considered to be simply another means, a tool that professionals have at their disposal that is imbedded in the plan and protocols, not used in an ad hoc manner. It is envisioned that there will be kind of "KASPAR scenario library" (containing varying scenario's, behaviours, sounds) from which can be chosen depending on the needs of the particular child at that moment.
Finally, time is crucial. Professionals stressed the need to give the children the time they need to get used to KASPAR. Changes are difficult for children with autism and they normally take quite some time to accustom to new situations. Time is also required for the professionals who have to learn how to work with KASPAR.

Integration in organisation and professional levels and connecting to parents

Professionals argued that on an organisational or management level a vision needs to be developed and deployed on how to implement and use KASPAR. This plan and strategy prevents KASPAR to be used in an ad hoc manner without relevant effects. This entails aspects such as ensuring proper (internal and external) communication, training, planning, and adequate allocation of resources.
Professionals mentioned it is important to inform parents of the children that will be interacting with KASPAR and maybe even (actively) involve them and ask their feedback or help in optimising the use of KASPAR for their children. Professionals suggested that parents might provide situations that are difficult for their children that can function as training situations in a KASPAR session. Moreover, it was suggested that possibly on a longer term (some) parents might also become users of KASPAR in the home environment. Furthermore, according to professionals it was crucial that there is a kind of feedback and learning loop between and from the professionals who work with KASPAR to the rest of the team to share the experiences and ideas.

"*It will be crucial to have realistic expectations of this* [KASPAR interventions]*, that we see it as a tool and not more than that. This is important because we do not want to present it as thé Holy miracle solution that makes promises but then creates a disappointment*."– ASD therapy expert and coach

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Phase in the intervention trajectory

Participants distinguished between aspects that are important factors in using KASPAR in different phases in the intervention trajectory: training, introduction, session preparation, actual usage and evaluation. They indicated that the person(s) who will work with KASPAR and the children receive a proper training on how to configure, prepare, and use the robot. According to them, part of this training should include a number of hours practice with KASPAR before they are actually going to use it in a session with children. Training should contain a technical component of how to set-up and operate the robot. Besides this, participants suggested that also a social interaction component is crucial for developing a feeling and skill to 'read' the child and being able to provide prompt KASPAR (re)actions. In their view, training and practicing are crucial to be able to create success experiences, both for the children and the professionals.
For the ***introduction*** many professionals suggested to place KASPAR on a table in a room and let the children approach him in their own pace and own preferred way. They compared introducing KASPAR with mastering the art of simplicity in the beginning; exposing a child to a fully equipped and completely extensively programmed robot will probably create adverse effects. Rather, they suggested to dose more interaction / initiative from KASPAR in a slow and step by step way, in a manner that matches the needs of the child. They stressed the importance that the child has the freedom and time to explore KASPAR for him/herself and decides if and how there will be interaction in the first moments. The amount and intensity of the triggers (e.g. sounds, movements, actions, utterances) that KASPAR gives shall be gradually adjusted by the professional according to the needs and capacities of the child. Participants reported that, for some children this might be a matter of some days, while others may need weeks or even months to get familiar and at ease with KASPAR. Others might not like interaction with KASPAR at all, which is fine as well.

"*You can place KASPAR in a room and do nothing, the child will notice him, and you'll see immediately if there is interaction or not…because if he will be introduced formally then you bring in the anxiety factor as well for something unknown, while if you can explore yourself you know best what you want and don't want*" – Adult with ASD

After the introduction and training took place, participants stressed a number of important aspects in preparing for each session. When getting ready for the day the ***session preparation*** will be done in which the professional decides on what objectives (s)he will work on that day with KASPAR for whom and what scenarios are needed.

Fine-tuning and adjusting scenario's will be done during the preparation phase as well, according to the needs of the children that will take part in the KASPAR sessions. Professionals suggested to create and use a dedicated symbol for KASPAR in line with the Picture Exchange Communication System (PECS) method that these children work with in their day structure. The KASPAR symbol would then be placed in the day structure/-programme of the child, so that the child also knows that there will be a session with KASPAR that day and when. Besides this, they stressed that in the planning of the professionals it is assured that also other professionals are available to work with the group of children while a trained KASPAR professional works with one or a small group of children in a dedicated KASPAR session.

During the actual **usage**, conscious experimentation and adaptation will be needed in the views of the participants to learn what works for a particular child and what not once the child received a basic KASPAR training. They expected that the success of the intervention will depend on how the child reacts, but also very heavily on the way the professional is able to control KASPAR in the interaction. Professionals should guide the children through the interaction, build up the sessions in a pace that matches the needs and capabilities of the child, and be attentive to prevent sudden abrupt moves, actions or sounds of KASPAR. Participants expected that the duration of a session will vary per child and possibly also per phase in the intervention. To increase chances for transfer / generalisation, KASPAR should be used in different rooms, according to participants, at different moments and by different people at appropriate times.

Creating (regular) **evaluation** moments is suggested, both with the children to learn more about their experiences as well as with professionals using KASPAR and their management. Possibly one can consider recording some sessions in order to learn from experiences. Moreover, celebration of success moments was expected to be crucial as well.

Session characteristics

Professionals saw possibilities for using KASPAR in different kinds of sessions; **individual** sessions like a 1-1-1 setting (child-KASPAR-professional), a **group** session (in a group interaction in small classroom for example), or in a 2/3-1-1 (2/3 children – KASPAR – professional) setting. With very young children KASPAR might be used in a ritual in a group to start the day; this creates a safe and predictable moment. For a large number of children they expected to be working in individual sessions (since these children have difficulties functioning in group settings).

Another distinction that was made is the degree of structure in the session; it can be a rather free explorative session, semi-structured, or structured. In all three cases,

professionals stressed that if the child is not interested (anymore) in KASPAR, the session will be stopped, persuasion of the child to continue is absolutely out of the question.
With respect to the duration of KASPAR sessions, professionals suggested to make it rather short time frames to match the attention span of the children with autism (i.e. 10-15 minutes, but maximum 30 minutes).

"*I feel very curious, you will have children with whom I want to work very goal oriented, and there are also the kid of which I simply would love to see their reaction.*" – Teacher at special needs school

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Intervention template

Insights gained from the focus groups as well as findings (educational / therapy objectives) from previous work[6] allowed to create the robot mediated intervention template (see Figure 5.2 and Figure 5.3). Important elements that were suggested by the professionals to be included in a robot mediated intervention template are described. Firstly, they indicated that the intervention should have a name and therapy and/or educational objectives will be addressed by this intervention should be selected. Furthermore, one or more roles for KASPAR are chosen (see Figure 5.2).
Subsequently, participants stressed that the goal of the intervention should be clear and adequately described, which is driven by the specific needs of the particular child. Furthermore, they highlighted the importance of creating a detailed characterisation of the child as well as of his/her level of functioning which is needed to get a better idea of the target group for this particular intervention (see Figure 5.3). The session characteristics that were mentioned by the participants in section 0 are then described, a short summary is given, and ways to work towards transfer are outlined and how to measure effects (in 'measurements'). Finally, Figure 5.4 shows how the actual interaction flow between the professional, KASPAR, and the child will go in a stepwise approach for a particular scenario.

<table>
<tr><td colspan="2">Intervention name:</td><td></td></tr>
<tr><td colspan="2">Focus on objective (s):
On which objective(s) does the intervention focus?
Multiple objectives possible</td><td>Role(s) of KASPAR:
Which role(s) does KASPAR have?
Multiple possible</td></tr>
<tr><td></td><td>Imitation in play</td><td>Provoker</td></tr>
<tr><td></td><td>Making contact</td><td>Reinforcer</td></tr>
<tr><td></td><td>Imitation in social/interpersonal interaction and relationships</td><td>Trainer</td></tr>
<tr><td></td><td>Turn taking</td><td>Mediator</td></tr>
<tr><td></td><td>Orientation to listen</td><td>Prompter</td></tr>
<tr><td></td><td>Social routines (greet, say goodbye, introduce)</td><td>Diagnostic information provider</td></tr>
<tr><td></td><td>Attention</td><td>Buddy</td></tr>
<tr><td></td><td>Learn a new form of communication</td><td></td></tr>
<tr><td></td><td>Talk – use verbal abilities</td><td></td></tr>
<tr><td></td><td>Train or practice new skills</td><td></td></tr>
<tr><td></td><td>Follow up instructions</td><td></td></tr>
<tr><td></td><td>Pose a question / ask for help</td><td></td></tr>
<tr><td></td><td>Having fun</td><td></td></tr>
<tr><td></td><td>Develop interest in play</td><td></td></tr>
<tr><td></td><td>Other, namely:</td><td></td></tr>
<tr><td colspan="3"></td></tr>
</table>

Figure 5.2 Template to describe robot mediated intervention – Objectives and Robot roles

<table>
<tr><td colspan="4">Goal of the session:
Starting point is the need for care/education of the child</td></tr>
<tr><td colspan="2" rowspan="4">Characteristics of the target group:
Please describe the child</td><td colspan="2">Level of functioning</td></tr>
<tr><td>High</td><td>Not applicable</td></tr>
<tr><td>Normal</td><td>Specific level</td></tr>
<tr><td>Low</td><td>Multiple levels</td></tr>
<tr><td colspan="4">Session properties</td></tr>
<tr><td>Individual session
Group session

Free
Structured
Semi-Structured</td><td>Duration and frequency</td><td>Who? Describe the professional and their role</td><td>Where? Describe the environment</td></tr>
<tr><td colspan="4">Summary of the intervention</td></tr>
<tr><td>Intervention summary</td><td colspan="2">Options for gradual increase or decrease of difficulty to ensure transfer
Easier:
More difficult:</td><td>Measurements
Reference to literature
Scenario code</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Figure 5.3 Template to describe robot mediated intervention – Intervention description

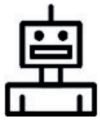
Scenario interaction How does the interaction flow between the professional – robot KASPAR – child?		
Professional	Robot	Child
		
Professional selects ‘gesture imitation’ scenario		
	“Hello John, this is my right arm [while raising the robots right arm], where is yours?”	
		John puts up his right arm
Sees correct imitation behaviour of John and chooses ‘well done’ command		
	“Well done John” [while making a ‘thumbs up’ gesture]	
To be continued ….		John acknowledges and smiles proudly

Figure 5.4 Template to describe robot mediated intervention – Intervention interaction flow

This template is a result created based on the previous focus group findings and used as input for the co-creation sessions in which a number of new KASPAR interventions were made.

Co-created interventions

A total number of 10 new KASPAR mediated interventions were created during the co-creation sessions. Table 5.4 lists all the generated ideas shortly. This paper presents one example in detail (see Appendix 5.2). The ASD objectives overview show the ideas; this is a categorisation of domains of therapy and educational objectives that are important for children with ASD as presented in[6] Appendix 5.1 also presents this overview. The Child and Youth version of the International Classification of Functioning, Disability and Health of the WHO, more commonly known as ICF-CY, functioned as a classification framework.[20]

Table 5.4 Generated KASPAR interventions during co-creation sessions

Intervention idea	Domain
KASPAR helps to learn making eye contact	*Communication*
KASPAR helps to learn how to greet in the morning 1	*Social interaction and interpersonal relations*
KASPAR helps to learn how to greet in the morning 2	
KASPAR helps to learn to greet when entering a room	
KASPAR helps to improve/stimulate a play attitude	*Play*
KASPAR helps with making homework	*Preschool skills*
KASPAR supports with executing a task	
KASPAR helps in self-reflection	*Emotional wellbeing*
KASPAR helps to create peace of mind	
KASPAR helps to be able to have breakfast independently	*Self-care, independent living*
	Sensory experiences and coping
	Functioning in daily reality
	Motor experiences and skills

One example of these intervention ideas is “KASPAR supports with executing a task”. It addresses the therapeutic and educational objectives of “orientation to listen”, “follow up instructions” and “pose a question / ask for help”. KASPAR takes the role of a “provoker”, “reinforcer”, “trainer”, and a “prompter”. The intervention is applied individually in a structured manner. Often, children with ASD experience difficulties with taking initiative and performing tasks independently. In classes, often picto’s (visual symbols part of the PECS method) are used that show an activity/task and these actual activities/tasks are stored in separate baskets. In this intervention KASPAR will help the children to work more independently using this picto/basket system by giving step by step instructions, prompts for working on the task and positive reinforcements to reward their behaviour. The entire intervention (including all the description details and interaction flow presented in the template) can be seen in Appendix 5.2.

Based on the input gathered at the session, the intervention template was further refined (e.g. use of better wording) and also a girl version of robot KASPAR was created since multiple professionals indicated this would be desirable (see Figure 5.5).

Moreover, participants suggested that KASPAR should also be able to give a “thumbs up” to reward children in a non-verbal manner. This was created as well (see Figure 5.6 and Figure 5.7).

Figure 5.5 KASSY (girl version, left) and KASPAR (boy version, right)

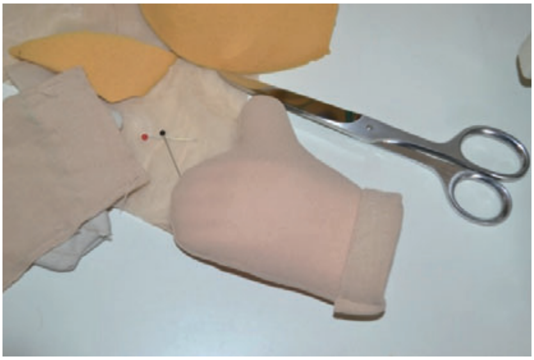


Figure 5.6 Creating KASPAR's thumb

Figure 5.7 Thumb up on hand

Discussion and Conclusion

The aim of this study was to gain understanding on how to implement robots in interventions for children with autism spectrum disorder (ASD). Highlighting a case for the use of robots in interventions for this target group was made decades ago, but actual use is still scarce. We intended to contribute to an increase of awareness and insight on how to actually embed robots in current education and/or therapy practices. The approach was to involve a large number of ASD practitioners and other stakeholders in the field, including people with ASD and parents of children with ASD, in focus groups as well as in co-creation sessions.
Results indicate that besides requirements related to the robot itself such as appearance, the use of voice and sound, the operation, the robot's behaviour and a robots attributes/toolbox, many other factors need to be taken into account. Personalisation to the needs of the individual child at hand is the main message. Keeping that in mind, it is clear that the look and behaviour of the robot is a crucial aspect, but also the role of the professional, the environment, and educational and organisational integration will be key in actual implementation in practice.
These results are in line, yet go beyond other published work on robots for children with autism that often tends to focus on human robot interaction matters. The utmost importance as well as a sense of urgency for robot research to be sensitive and adhere to end-users' requirements and to grow closer towards clinical integration into robot-mediated-interventions has been clearly argued in a number of recent publications.[7,9,21] To date, only few studies are published on systematically eliciting and

describing requirements for robot-assisted interventions and how to actually embed robots in current practices. By intensively involving and co-creating interventions together with professionals and other stakeholders we aimed to increase chances for clinical relevance and uptake and overcome typical barriers for robot mediated interventions to reach clinical applicability as stated by Begum et al. (2016). The contents of the developed intervention template in this study cover (and to some extend expands to) Begum et al's elements to be included in an evidence based practice.

The adoption of this iterative multidisciplinary co-creation approach is expected to contribute to qualitative and meaningful robot interventions. This study provides a tool, the robot intervention template, for systematically developing and implementing new robot interventions and can contribute to an increase in awareness and the creation and uptake of robot assisted interventions for children with autism. It can be used by both professionals, stakeholders and engineers, for many different robot platforms, not only for KASPAR.

Although the study has reached its goals, some limitations should be taken into account. First of all only participants from The Netherlands were included in the study which might hinder generalisability because other countries might have different practices in place regarding care or education for children with ASD. On the other hand, it is expected that when considering the heterogeneous nature of ASD, involving more than 75 participants covers a wide range of knowledge and experiences on ASD. Additionally, ideally, we would have immediately implemented the co-created interventions in KASPAR and would have like to test it in practice rather quickly to evaluate the applicability of these interventions. However, technical implementation of the interventions in the robot, practically training professionals to operate the robot themselves as well as assuring approval of medical/ethical committees is needed before we can actually test these interventions with children with autism.

The heterogeneous nature of ASD causes a demand for different and multiple treatment or interventions for different children. There seems to be consensus that a "one-size-fits-all" solution for all children with ASD does not exist.[22] There is no such thing as "the average disabled person" or "average context".[23] This makes customisable robot-assisted interventions a strong appropriate candidate due to their adaptability and capacities for tailored personalisation. Whether or not a robot intervention will be a success in practice will depend on the dynamic interplay of many (changing) factors, not just on the availability of a stable technical robot platform. This study aimed to shed more light in the relevant aspects of this interplay. Future research entails conducting a pilot and an effect study in which professionals actually use these KASPAR interventions in practice with children with ASD, so that actual effects on both the professionals and children can be assessed.

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Appendix 5.1

ASD Therapy and Educational Objectives Overview

Emotional wellbeing

- Recognise and regulate own emotions
- Self-image - ASD awareness - who am I?
- Resilience (detect and guard limits - defend oneself)
- Confidence - self esteem
- Rest - relaxation
- Having fun - experiencing pleasure
- Safety
- Making thoughts positive

Play

- Imitation
- Develop interest in play
- Development own play
- Parallel play (next to each other SAME MATERIAL)
- Playing together – collaborative play
- Variation in play (expand play)
- Negotiate about rules

Functioning in daily reality

- Cope with unexpected situations or changes
- Flexibility - switch smoothly - less rigid
- Problem solving skills
- Taking initiative
- Transfer of skills / knowledge
- Open mind to tasting / eating food

Social / Interpersonal interactions and relations

- Imitation
- Attention
- Appropriately cope with own anger / sadness /...
- Awareness of feelings wishes behaviour thoughts of others
- Appropriately react to behaviour of others
- Social routines (greet say goodbye introduce)
- Turn taking (behaviour)
- Respect / value others (or things)
- Appropriate behaviour w.r.t. physical proximity / contact or personal space
- Collaboration / joined attention
- Ask for help
- Conflict management

Preschool skills

- Work posture (sit still - no wobbling)
- Train or practice skills
- Be able to start/stop independently
- Work on his/her own - task approach
- Cope with schedule/program
- Pose a question / ask for help
- Distinguish main from minor issues
- Follow up instructions
- Execute task (simple / complex task)
- Didactic subjects (e.g. maths - reading)
- Spatial concepts
- Learn to wait
- Perseverance
- Learn to choose - make decisions

Communication

- Orientation to listen
- Making contact
- Learn a new form of communication
- Understand intention of gesture
- Understand intention of image / symbol
- Understand intention of word
- Use gesture
- Use nonverbal abilities
- Talk – use verbal abilities

Sensory experiences and coping

- Adequate processing of sensory triggers (regulate - mute - stimulate)
- Understand what body is "saying" (e.g. pee - hunger - noises)
- Change stereotype behaviour
- Prevent panic reactions
- Be able to postpone urge / want

Motor experiences and skills

- Balance and equilibrium
- Body awareness
- Grove and fine motor skills
- Movement
- Coordination
- Strengthening of muscles

Self-care - independent living

- Potty training
- Eating - drinking
- (un)Dressing
- Self-care - personal hygiene
- Domestic skills
- Mobility
- Hobbies - leisure time

Appendix 5.2

Detailed intervention idea in template

Objectives and roles of example intervention

Intervention name: Support to learn to execute a task independently	
Focus on objective (s): On which objective(s) does the intervention focus? Multiple objectives possible	**Role(s) of KASPAR:** Which role(s) does KASPAR have? Multiple possible
Imitation in play	**Provoker**
Making contact	**Reinforcer**
Imitation in social/interpersonal interaction and relationships	**Trainer**
Turn taking	Mediator
Orientation to listen	Prompter
Social routines (greet, say goodbye, introduce)	Diagnostic information provider
Attention	Buddy
Learn a new form of communication	
Talk – use verbal abilities	
Train or practice new skills	
Follow up instructions	
Pose a question / ask for help	
Having fun	
Develop interest in play	
Other, namely:	

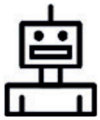
Details of intervention description

<table>
<tr><td colspan="4">Goal of the session: Child is able to execute the sequence and/or the structure of a task</td></tr>
<tr><td colspan="2">Characteristics of the target group:
Children who experience difficulty with maintaining structure when executing a task</td><td colspan="2">Level of functioning
High — Not applicable
Normal — Specific level
Low — Multiple levels</td></tr>
<tr><td colspan="4">Session properties</td></tr>
<tr><td>Individual session
Group session

Free
Structured
Semi-Structured</td><td>Duration: 10-15 minutes
Frequency: whenever a task is given that uses this system</td><td>Teacher trains child to be able to perform the task, then KASPAR takes over the stimulating role</td><td>Train the task in a serene calm room. Work on transfer to a class room.</td></tr>
<tr><td colspan="4">Summary of the intervention</td></tr>
<tr><td colspan="2">Intervention summary

Often children wish ASD have difficulty taking initiative and performing tasks independently. In classes, often picto's are used to show an activity and these are stored in separate baskets. Situation: 3 picto's, 3 baskets with tasks and KASPAR gives instructions about these tasks. The corresponding task with the picto is to be performed. KASPAR reacts positively when the 'ready' basket is filled with the corresponding task. A sensor is placed on the task and the basket.</td><td>Easier: adjust task; practice the task more often (same duration, higher frequency), or adjust environment – practice longer in stimulus free room. Adjust KASPAR;s behaviour; positive reinforcements sooner (i.e. give rewards or compliments).
More difficult: adjust task: gradually decrease KASPAR's support, task with more steps.</td><td>Measurements: ADOS2-communication, social interaction and play
BRIEF – executive functions
IPPA – measurement effectivity of KASPAR
Reference to literature
Scenario code 8.1.1</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Interaction flow between professional - KASPAR - child

Scenario interaction How does the interaction flow between the professional – robot KASPAR – child?		
Professional 	Robot 	Child 
Trains single task with child		
Prepares the room		Enters class and sees picto ‘work’ and takes place at his work desk
Presses: hello	“hello [name child]”	
Presses: work	“you are going to do some tasks. Take the card in front of you” “Take the task from the basket”	
		Takes the card and the corresponding task from the basket
Presses: well done		
	“well done!”	
Presses button: start		
	“[name child] please start with the task”	
		Starts Finishes Child places the completed task in the basket
Presses: next card	“you cleaned up very well, take the next card” ….*repeat until all the tasks are done* KASPAR sensor activates, “you worked very well, high give [raises arm]”	

Chapter 6

Robot KASPAR as mediator in making contact with children with autism

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Submitted

Abstract

Aim

Research findings suggest that robots can enhance interventions targeted at children with autism spectrum disorder. A study was conducted at a special needs school to examine the effect of robot KASPAR on making contact with children with autism.

Method

Nine children between 8 and 12 years of age participated in this mixed methods study with ABAB design. Children participated in 4 sessions, two with KASPAR and two with their teacher (usual care) resulting in total in 36 (video recorded) sessions. Main outcomes were micro behaviours of the children during sessions and teacher reactions based on video recordings.

Results

Results indicated that children showed significantly more non-verbal imitation (p-value= 0.028), touched the robot more often than they touched the teacher (e.g. for a high-five) (p-value=0.012), maintained their attention longer (p-value=0.011), and were less often distracted (p-value=0.021) in the KASPAR sessions compared to the teacher sessions. The children made more positive verbal utterances as a reaction to the teacher than they did to KASPAR (p-value=0.028). A clinically relevant difference was identified in the amount of non-verbal behaviours shown and in the spontaneous use of verbal utterances on initiative of the child, both in favour of the KASPAR condition. As a conclusion, KASPAR was able to make contact with the children and to catch and hold their attention longer and in a more focused manner than the teachers. Moreover, children seemed to be at ease and enjoying the interactions with the robot, which constitute important requirements for further learning and implementation.

Introduction

Children with autism spectrum disorder (ASD) often seem to be in their own world, making no or little contact with the people around them. Their ability to perceive and display social clues and sentiments is impaired.[1] Making sense of complex social-emotional situations, having to decide which piece of information is relevant, can be difficult, overwhelming and even impossible for many of them.[1] The number of children with an autism diagnosis is increasing worldwide.[2,3] About 1 in 68 children is affected, and among boys it is five times more common than among girls. Severity differs per child on the spectrum, ranging from very mild to severe.

The DSM-5 describes the diagnostic criteria of ASD as having persistent impairments in social communication and social interaction across multiple contexts, as well as restricted, repetitive patterns of behaviour, interests or activities.[4] Making and maintaining contact is challenging for children with autism. More specifically they show three main impairments.[4,5] Firstly, "deficits in social-emotional reciprocity, ranging from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interest, emotions or affect; to failure to initiate or respond to social interactions".[4] Secondly, "deficits in nonverbal communicative behaviours used in social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication".[4] And finally they have "deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behaviour to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers".[4]

Autism cannot be cured; the focus of intervention programs is on improving a child's functioning in daily life, coping and improving quality of life. Children with ASD benefit from early and personalised interventions.[5] Mostly children with ASD live at home and attend special schools and possibly receive additional interventions (from specialised care organisations). Research findings indicate that technology and robots more specifically can be effective support tools for children with autism.[6-8] Robots have been applied in several different challenging ASD domains: communication, social interaction, play, but also areas such as sensory experiences and practicing preschool skills.[9]

Although it might sound contradictory to use a robot for teaching communication or social interaction skills, the application of robots may have a number of advantages for children with ASD.[10-12] Interacting with a robot can be easier than interacting with a person, since it may be less complex, more predictable and more appealing. Compared

to children with typical development, children with autism are often more intrinsically motivated or interested by non-social activities, (mechanical) objects and devices.[1] Moreover, robots can be applied in a controlled manner, which decreases the risk of stressful situations. Compared to humans, robots are better in endless repetitions and variations can be made in a conscious and controlled manner.[13,14] Children who showed positive effects in the interactions with a robot continued their gains beyond the intervention period.[10]
One of the robot platforms that has been used in field studies is KASPAR.[15-17] KASPAR Figure 6.1) is a semi-autonomous humanoid robot developed by the Adaptive Systems Group of the University of Hertfordshire.[18] It uses minimal facial expressions, body movements and gestures, as well as speech, music and other sounds to engage children in social interaction. KASPAR's actions can be initiated either by activating one of its sensors (in the hands, on the feet, belly, head and/or arms); or by means of tele-operation using a remote control or a wirelessly connected laptop.

Figure 6.1 Robot KASPAR

In The Netherlands, research has been conducted to get more insight into the practical potential of KASPAR. Professionals working with children with ASD expected an added value of KASPAR interventions with respect to reaching therapy and educational goals.[19] Making contact was one of the objectives to which they indicated that KASPAR could contribute to. For making contact, studies using for example the robot Keepon[20] and KASPAR[15] indicated that children showed spontaneous interactions during the interaction with the robot. Making contact is a basis that is required for all children in all socio-emotional, communicative and learning situations as can also be seen in the DSM-5 criteria as described for ASD.[4] Since making contact is a prerequisite for being able to work on any other goal according to professionals, it was chosen as the main focus of the present study. If there is no contact between the robot and the child, no other meaningful interaction can take place. In order to be able to make contact, attention is needed. Children with autism often have difficulties and challenges with focusing and/or maintaining (social) attention.[5] It is crucial that the child has attention for the robot on the one hand and makes contact with it on the other hand. So far, we have not seen any study focusing on attention and making contact behaviours, comparing a robot and a teacher.

Aim and research question of the study

The aim of this study was to examine to what extent KASPAR can elicit attention and make contact with children with ASD. The study had the following research question: what is the effect of KASPAR in reaching the goal of making contact for children with autism spectrum disorder compared to care as usual?

Participants and Methods

Study design

The study had a quantitative-qualitative mixed methods design. The quantitative part had a ABAB quasi-experimental design with a within-subject comparison. The qualitative part consisted of semi-structured video recall interviews with special needs teachers who took also part in the quantitative part of the study.

Setting and participants

The setting of the study was a special needs school in The Netherlands where children with autism receive their education. The children and the teachers who work on a day-to-day basis with these children took part in the study. For the children, a number of inclusion criteria were formulated: having a diagnosis of ASD, aged between 6 and 12, the child can potentially benefit from an intervention in the area of making contact, and understanding the Dutch language. Exclusion criteria were: deafness, blindness and extreme physical aggression. For the teachers, no explicit criteria were formulated except for the fact that they needed to know the child.

Conditions: Intervention and control

The study entailed two conditions: the intervention “KASPAR condition” (K) and the control “Teacher condition” (T), the latter resembling current educational practice. The interaction between the child and the teacher functioned as a baseline to see possible differences between how children behave with a robot compared to with a person. Both conditions aimed to work towards the same goal: making contact. Both the KASPAR and Teacher intervention were co-created with an experienced ASD professional (ASD therapist and coach for children with over 20 years of working experience). As a result, the interventions were practice based, taking into account the needs and capacities of the children as much as possible. Both interventions used techniques of well-established ways of working in this domain, like the use of structure, repetition, clarity and positive reinforcements for the child.

KASPAR condition

In the KASPAR condition, KASPAR was used in a semi-autonomous manner. This means that the main researcher (CH) tele-operated KASPAR. Only the sensors at KASPARs feet were activated; KASPAR would laugh and say “that is funny” in Dutch if the child would touch its feet. The making contact intervention entailed actions such as KASPAR greeting the child and introducing himself, waving, playing peekaboo, clapping, asking questions and giving high-fives. A complete description of KASPAR’s intervention is given in Appendix 6.1.

Teacher condition

In the teacher condition KASPAR was not used. The intervention was carried out by the day-to-day teacher of the child at hand. The teachers were given instructions on the nature of the session with similar contact making actions as in the KASPAR condition (e.g. greeting the child, asking questions, waving; see Appendix 6.1). The teachers were free on how to engage with the child during the session as long as their goal was making contact, based on the general instructions given before the start of the session.

Variables and measurements

Primary outcome

The primary outcome of this study is the quantitative operationalisation of making contact. The goal making contact is a ‘small’ goal for which it was expected that within a short time frame observable and measurable behaviour of the child could be seen. To assess whether or not there was contact between the child and KASPAR or the teacher, a number of relevant behaviour indicators were selected. This was done in close cooperation with the experienced ASD professional based on the clinically applied “framework for basic communication”[21] and the method “video interaction analysis”.[22] This analytical framework allows the researcher to closely analyse the interactions between a child and the interaction partner on micro level. The micro behaviours make clear how the child behaves in the context of the goal of making contact, and can be categorised in non-verbal and verbal behaviours (see Table 6.1).

Table 6.1 Micro behaviours of making contact

Making Contact	
Non-verbal behaviours	Verbal behaviours
Increase of physical proximity	Positive verbal utterance on initiative child
Decrease of physical proximity	Negative verbal utterance on initiative child
- Touch	Positive verbal utterance as reaction to KASPAR / Teacher
Positive expression face/body	Verbal imitation
- Smile	Negative verbal utterance as reaction to KASPAR / Teacher
- Non-verbal imitation	
Negative expression face/body	

All the micro behaviours mentioned in Table 6.1, also the negative expressions or utterances were considered as indications of making contact. A negative expression (such as a frown) or a negative utterance (such as “No, I will not do that”) were considered positive as they are expressions of contact, which can be seen as positive in itself for a child with autism. Besides counting the frequency of occurrence of these non-verbal and verbal micro behaviours during the sessions, the duration of each session was measured as well as the frequency of decrease of attention and the percentage of time of focused attention. To measure these quantitative outcomes, video recordings were made of the entire sessions in both conditions. These recordings were viewed and analysed afterwards by the main researcher (CH) and the ASD professional (HV), independently from each other.

Secondary outcome

The secondary outcome was the opinion of the teachers (who conducted the Teacher sessions) with respect to the goal of making contact. All the KASPAR and teacher sessions of the child(ren) that were accompanied by a particular teacher were viewed entirely together with the main researcher and the teacher. All 36 sessions were viewed. Teachers were asked whether the robot or the teacher established contact with the child and if they saw any remarkable things in the interaction. This qualitative reflection was carried out to understand why the children behaved as they did and to gain more insight into the factors that were important in (not) reaching the goal.

Additional measurements

Relevant demographic data of the children (age, gender, ASD diagnosis, intelligence quotient (IQ), social development and level of independence) and of the teachers (gender, age, education, years of working experience) were collected. The intelligence (IQ) was measured at the special needs school using either the WPSSI-III-NL test[23] or the WISC-III scale[24] as indicated in Table 6.2. Their emotional development and level of independence/autonomy was measured using the "Sociale Redzaamheid schaal" (SRZ) (social independence scale), a measurement instrument often used in the Netherlands for this target group.[25] For this study the scores of two subscales were included; the subscale to measure social abilities and the subscale to measure level of independence. A score of 3 or less on the social abilities subscale resembles a severe to deep intellectual disability; a score of 4 to 6 resembles a mild to severe intellectual disability; a score of 7 to 8 resembles a mild intellectual disability; a score of 9+ resembles a small to mild intellectual disability. With respect to the independence subscale, a score of 5 or less resembles a severe intellectual disability; a score of 6 a mild to severe intellectual disability; a score of 7 indicates a limited intellectual disability and a score of 8 indicates a small intellectual disability.[25]

Procedure

Teachers at the special needs schools were asked to make a selection of children who met the inclusion and exclusion criteria. Parents of these children were approached by the teacher and asked for permission to include their child in the study by giving informed consent. Explanation about participation was provided by a written letter and questions were answered either face to face or by telephone contact.

Two pilot sessions with KASPAR were conducted with two children with ASD from the same school to fine-tune the intervention condition, the procedure and to verify if the study protocol was correct and complete before the start of the actual study. Small adjustments were made to the KASPAR intervention as well as to the operationalization of the making contact micro behaviours.

During four subsequent weeks, sessions took take place on a weekly basis for each child. The planned session duration was approximately 10 minutes. The type of the condition KASPAR (K) or Teacher (T) differed every other week, resulting in two KASPAR sessions and two Teacher sessions for each child (ABAB) over a period of four weeks. In close dialogue with the teachers at the school a fixed day and time slot was chosen for

the KASPAR and teacher sessions with the children. All the sessions took place in the same stimuli free and quiet room at the school of the children. Children would take place at a chair in front of a table, with either KASPAR on the table in front of them, or the teacher on the other side of the table in front of them. In a corner of the room a video camera was installed to record the sessions. During all sessions a researcher was present, in the KASPAR sessions to control KASPAR and in the Teacher sessions as an observant. Teachers would accompany the children to the room and would make sure they felt at ease when starting the sessions.
The study was registered at The Netherlands National Trial Register (NTR) with number TC 6781. Ethical approval was obtained from the Medical Ethics Committee Zuyderland, one of the Dutch official ethical commissions, with number ID 17-N-147.

Data analysis

Per child we collected 4 video recorded session observations as well as 1 video recall interview. For the quantitative part, the pre-defined micro behaviours (Table 6.1) were used for the analysis (coding) of the sessions by the two assessors. A dialogue based coding of the videos was applied using regular analytical sessions to reach consensus with respect to the coding scheme (the list of micro-behaviours); whether both assessors use the same code for a certain behaviour. The mental map that both assessors had on the coding scheme (their idea/interpretation of certain behaviour) was fine-tuned in these analytical sessions. A long session in which a child showed a lot of micro-behaviours was coded independently by both assessors, and then the first analytical session took place. Difficult parts in the sessions were highlighted during the coding process. The structure and nature of the codes was discussed, fine-tuned and the highlighted parts were discussed together. This procedure was repeated four times until agreement was reached. Finally at the end when all 36 sessions were coded, a last analytical session took place to discuss remarkable moments in the sessions. These could be occurrences that the assessors did not expect to happen, or when one of them asked for a second opinion to be sure about how to code that particular behaviour. When all the sessions were coded, statistical analysis was then performed to compare the results from the KASPAR sessions with the Teacher sessions. A two tailed test of the Wilcoxon signed-rank test for paired samples was used. Significance and effect sizes were calculated to indicate the magnitude of the difference found. Alpha was 0.05. Effect size r was calculated using the Rosenthal formula: $r = Z/\sqrt{N}$.[27] A small effect size would be 0.1; a medium effect size 0.3 and 0.5 is a large effect size.[27]
For the qualitative data analysis inductive content analysis[26] (coding derived directly from the data) was used of the video recordings of the KASPAR/Teacher sessions and

the verbatim transcripts of the video recall interviews. This was a rather straightforward process due to the limited number of questions asked during the interviews (e.g. is the goal of making contact reached in your opinion, do you see any remarkable things in the behaviour of this child).

Results

Eleven children were selected and invited, 9 of which took part in the study. One boy decided to turn around and walk away when he entered the room for the first KASPAR session. The teacher talked to him, but he did not want to participate so we respected his choice and he was brought back to the classroom. Another boy did not want to participate at forehand without having seen KASPAR. The 9 other children participated in all the sessions. Table 6.2 shows their demographic characteristics and level of functioning. All the children had a diagnosis of ASD. Alongside autism, these children had some level of intellectual disability as can be seen in the relative low IQ scores.

Table 6.2 Demographic information children

Child	Age (years)	Gender (m/f)	IQ score (WISC-III) (45 to152)	Social development (SRZ) (3- to 9+)	Independence (SRZ) (3- to 9+)
1	11	m	54	no data	no data
2	9	m	55 *[1]	3	5
3	12	m	49	6	6
4	8	f	55 *[1]	6	6
5	8	m	45	6	6
6	10	m	49	8	8
7	11	m	51	8	8
8	11	m	61	9	7
9	12	m	73	8	8

The information about the participating teachers is presented in Table 6.3. All of them had a background in and were specialised in providing education for children with special needs, such as autism. On average they had 15.2 years of working experience with children with ASD and 12.3 years of experience on this special needs school.

[1] IQ measured using WPSSI–III scale with a range of possible scores between 55 and 145

Table 6.3 Demographic information teachers

Teacher	Participated in the study with child number	Education	Gender (M/F)	Work experience with ASD children (in years)	Employment special needs school (in years)	Age (in years)
1	9	Teacher college for primary education	M	19	13	37
2	4 and 7	Teacher college for primary education; Master of special needs in education in progress	F	1.5	1.5	23
3	1 and 8	Nursery class teacher; Special needs education	F	40	40	61
4	2	Teacher college for primary education; Master of special needs in education	F	12	1	35
5	3	Teacher college for primary education; Master of special needs in education	F	3	2	33
6	6	Academy for pedagogy; Special needs education	F	18	18	57
7	5	Teacher college for primary education; Special needs education	F	12	7	42
8	8	Teacher college for primary education; Orthopedagogics	F	16	16	56

Quantitative outcomes

In total 18 KASPAR sessions took place (nine children with each two sessions) as well as 18 Teacher sessions. Figure 6.2 visualises the frequencies of the total non-verbal, total verbal and total (T) micro-behaviours indicating making contact during the two KASPAR (K1 and K2) and two Teacher sessions (T1 and T2). Figure 6.3 visualises the total frequencies of various the non-verbal micro behaviours for the two KASPAR (K Total) sessions and the two Teacher (T Total) sessions. Figure 6.4 graphically presents the total frequencies of the verbal micro behaviours for the two KASPAR (K Total) sessions and the two Teacher (T Total) sessions. Table 6.4 presents the frequencies of the non-verbal and verbal micro-behaviours in numbers as well as the corresponding p-values. The total number of non-verbal behaviours as well as the total number of behaviours show a difference between the KASPAR and Teacher sessions as can be seen in Figure 6.2. Children showed more non-verbal and total behaviours in the KASPAR sessions than in the Teacher sessions. These differences are not statistically significant (p-value: 0,086 for non-verbal behaviours and 0,139 for the total number of behaviours). The total number of verbal behaviours was similar in the KASPAR and Teacher sessions as presented in Figure 6.2 and Figure 6.3. When zooming in on the various micro behaviours within these non-verbal and verbal behaviours, for some behaviours KASPAR and the Teacher elicited similar number of behaviours and for others a difference was seen as presented in Figure 6.3 (non-verbal behaviours) and Figure 6.4 (verbal behaviours).

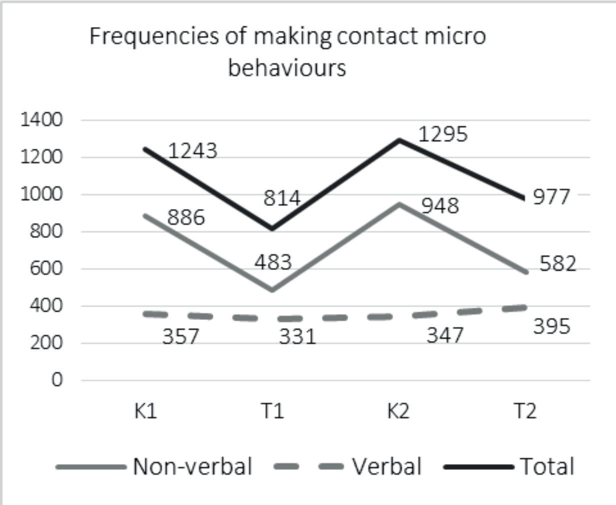

Figure 6.2 Frequencies of total contact making behaviours in conditions K and T

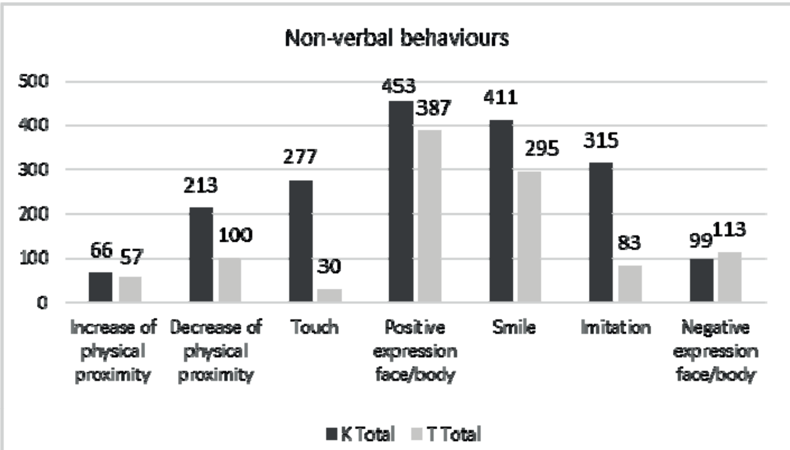

Figure 6.3 Frequencies of non-verbal micro behaviours

Figure 6.3 graphically shows that children moved towards KASPAR more than towards the teacher (decrease of physical proximity) although this was not a significant effect.

They touched KASPAR significantly more often (e.g. for a high five) than the teacher (p-value= 0,012, effect size: 0.405). Furthermore, children showed significantly more “non-verbal imitation” in the KASPAR sessions than in the Teacher condition (p-value=0.028, effect size: 0.589). For all the other non-verbal micro behaviours the results for the KASPAR and teacher session are about the same (Figure 6.3) with no significant differences between the child’s behaviour in the KASPAR condition versus the Teacher condition (see Figure 6.4).

Table 6.4 Frequencies of making contact micro behaviours and P value

Non-verbal behaviours	K1	T1	K2	T2	K Total	T Total	P value
Increase of physical proximity	33	21	33	36	66	57	1
Decrease of physical proximity	120	50	93	50	213	100	0,086
-Touch	103	17	174	13	277	30	**0,012**
Positive expression face/body	232	163	221	224	453	387	0,314
-Smile	201	152	210	143	411	295	0,314
-Non-verbal imitation	137	37	178	46	315	83	**0,028**
Negative expression face/body	60	43	39	70	99	113	0,674
Total Non-verbal	**886**	**483**	**948**	**582**	**1834**	**1065**	0,086
Verbal behaviours	K1	T1	K2	T2	K Total	T Total	P value
Positive verbal utterance on initiative child	121	12	114	37	235	49	0,235
Negative verbal utterance on initiative child	16	2	13	9	29	11	0,497
Positive verbal utterance as reaction	169	284	155	312	324	596	**0,028**
-Verbal imitation	25	17	44	14	69	31	0,122
Negative verbal utterance as reaction	26	16	21	23	47	39	0,726
Total Verbal	**357**	**331**	**347**	**395**	**704**	**726**	0,26
Total Non-Verbal and Verbal	**1243**	**814**	**1295**	**977**	**2538**	**1791**	0,139

Figure 6.4 graphically shows the frequencies for the verbal micro-behaviours in both conditions. It shows that children made more positive verbal utterances on their *own initiative* to KASPAR than to the teacher. These are the cases that the child started a conversation with/to KASPAR or the teacher spontaneously. This is not a significant difference (p-value=0.235). When looking into the frequency that a child made a “positive verbal utterance as a *reaction* to KASPAR/Teacher” a significant effect was found in favour of the Teacher condition (p-value=0.028, effect size is 0.517). Children made more positive verbal utterances as reactions to the teacher than they did to KASPAR. For the other micro behaviours no significant differences were found.

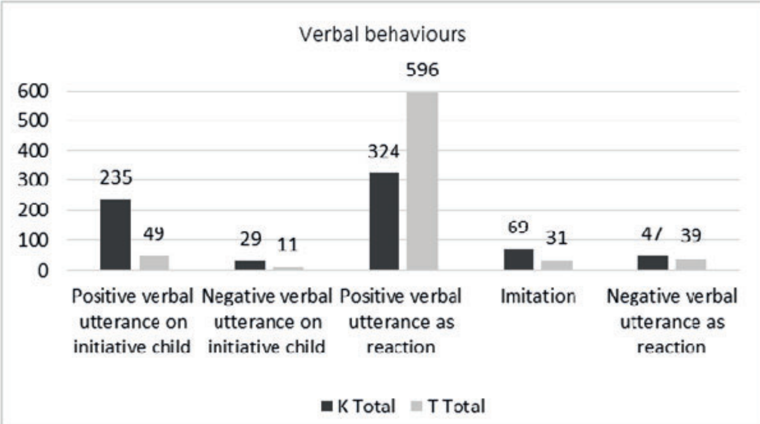

Figure 6.4 Frequencies of verbal micro behaviours

6

“Decrease of attention” was significantly different as well between the KASPAR and Teacher conditions; children lost their attention more often in the teacher sessions than during the KASPAR sessions (p-value=0,021, effect size is 0.405) as can be seen in Table 6.5. The duration of the sessions with KASPAR was significantly higher than those with the teacher (p-value=0,011, effect size is 0.545). In the KASPAR sessions children showed less often signs of a decrease of attention compared to the Teacher sessions. Children were more and longer concentrated with KASPAR than with the teacher.

Moreover, the average number of times that children lost their attention remained the same between the two KASPAR sessions (6 times during each session on average, see Table 6.5); indicating that KASPAR remained as interesting to them. However, children were more often distracted in the second teacher session than they were in the first teacher session (11 times on average during the first session versus 19 times in the second session, see Table 6.5.

Table 6.5 Attention metrics

	K1	T1	K2	T2
Average session duration (in minutes)	9:04	4:55	8:23	5:16
% Of the time focused attention	96	86	93	84
Average frequency decrease of attention	6	11	6	19

Qualitative results

One of the children (a boy) made minimal contact in the KASPAR session according to the teacher. For the other 8 of the 9 children, all of the four sessions, were considered to have reached the goal of "making contact". Teachers mentioned that both KASPAR and the teacher were able to establish contact with the child. No remarkable or stressful situations occurred prior or during the sessions (that might have influenced the child's behaviour). The teachers all recognised the behaviour of the children as part of the child that they are. Most teachers mentioned the high level of concentration the children had during the KASPAR sessions. They were surprised about the positive effect that KASPAR had on them in terms of engagement and focused and directed attention. Some of the questions that KASPAR asked were too difficult or too open for a number of children. For example the robot asked "what is your hobby?", some children did not understand the meaning of the word hobby. Or the question "can you tell me something?" was too open and abstract for some children. Professionals mentioned that they saw that the children were focused on answering KASPAR, but that they did not understand some of the questions.

Table 6.6 presents a number of quotes of both children and teachers and some impressions from stills of the KASPAR sessions can be seen in Figure 6.5.

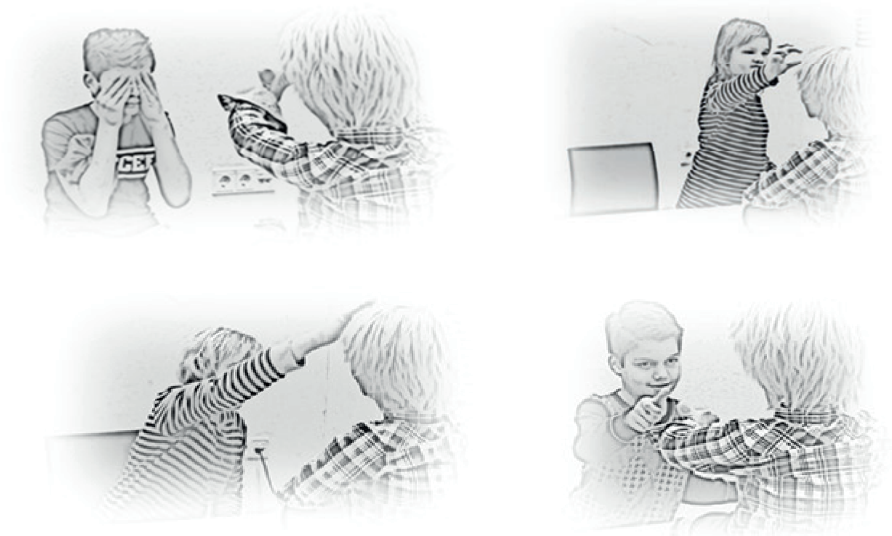

Figure 6.5 Impressions of KASPAR sessions

Table 6.6 Quotes of the children interacting with KASPAR and quotes of the teachers

Quotes **children** during the pilot sessions	Quotes **Teachers** during the video recall interviews
Child 4 (girl) before the KASPAR session *"i am looking forward to it enormously. When may I work with KASPAR again?"* KASPAR*: "do you have a favourite animal?* Girl*: 'my favourite animal is a panda bear and a dolphin. And what is yours?...and robot, I would like to tell you a number of things, because I have to return to the class in some minutes. May I stroke your hair please, don't be afraid okay?"* Girl*: "robot, what is your favourite colour?"* KASPAR*: "I am not so sure to be honest"* Girl*: "no? maybe pink, or purple, or blue, you may choose yourself."* Child 8 (boy): *when he enters the room and sees KASPAR he says "ohw what scary eyes, …. Ooops I hope he did not hear this" … "Shall we shake our hands, such as 'hello I am KASPAR the robot' and I am [name child] a human"* KASPAR*: "can you tell me something?'"* Boy*: "about what?[pause] KASPAR you are the most lovely robot that I know"* KASPAR*: "you make a lovely wink"* Boy*: "you can wink very well too...shall we become friends?"* Boy 9 in the session with the teacher: *"KASPAR gives a high five three times and when he felt it properly he says thank you to me. I have to tell KASPAR that we also have programming lessons in the class. KASPAR always says "wow super cool" and then he makes this movement."*	About child 1 (boy): *"he is very concentrated, answers all KASPAR's questions, and he tickles KASPAR to get a reaction"* About child 2 (boy): *"KASPAR gets his full and total attention. Only sometimes his questions are too difficult for him to answer"* About child 2 (boy): *"there is interaction with the teacher, he asks attention but then does not know how to deal with it and then acts in a distracted and 'strange' way"* About child 4 (girl): *"she shows interaction with KASPAR in the typical enthusiastic way that she does it in a free situation. With the teacher she has contact, but shows less initiative and only strictly answers questions of the teacher.* About child 5 (boy): *this is too difficult for him. On the one hand with respect to the difficulty words that are used and on the other hand in terms of too little actions that are happening. The movements of KASPAR are too slow. He needs more non-verbal interaction. Words such as "hobby" and "farewell" are words that do not fit in his imaginary world. No, there is no contact".* About child 6 (boy): "*KASPAR absolutely makes contact, in action-reaction and in focus, there is imitation and the boy responds in an adequate manner to KASPAR and looks at him in a fascinating way very focused. I am jealous on the focus that he gives to KASPAR. KASPAR has to do much less to deserve his attention than I. … I also see a certain tension, but the focus is good. "* About child (8) (boy): *"He even gives compliments to KASPAR. Wonderful. He is very enthusiastic. He even shows reciprocity in contact as well as sincere interest in KASPAR." "with the teacher he is more quiet, shows less eye contact, only responds to questions does not react spontaneously, there is not enthusiastic with the teacher".* About child 9 (boy): *"KASPAR radiates a kind of calmness over him".*

Discussion

This study aimed to examine to what extent KASPAR can contribute to the goal of making contact with children with ASD compared to care as usual. An ABAB pilot study was conducted at a special education school in which 9 children participated in two

KASPAR sessions and two teacher sessions. Results indicated that KASPAR is able to make contact with children and to attract and hold their attention. The KASPAR intervention showed statistically significant effects on a number of micro behaviours (touch, non-verbal imitation, and attention) and the Teacher condition on one behaviour (verbal utterances as reaction to the teacher). The effect sizes range from relative large (0.405) to very large (0.589).

Even though not all micro-behaviours reached a difference that was statistically significant, a number of the differences are considered to be of clear clinical relevance for children with autism. Results indicated that KASPAR elicits more behaviour in total. When looking at the videos of the sessions clinically relevant differences could be identified in the intensity and nature of the interaction of the children in the KASPAR sessions versus the teacher sessions. Robot KASPAR also elicits more non-verbal behaviour of the children than the teacher. This is a remarkable and interesting finding since children with autism tend to show impairments in the use and understanding of non-verbal communication. Even more so because the repertoire of behaviours that KASPAR utilised in the sessions was rather limited and restricted compared to the repertoire that the teachers had at their disposal as a human being. Children with autism are often described as having impaired non-verbal communication skills. For people without autism, a large share of the communication we do as humans consists of non-verbal communication. In this study the children did show a high number of non-verbal micro behaviours, they seemed to be free to behave in the interaction with KASPAR.

Results also indicated that children showed more signs of contact making behaviour on their own initiative with true interest and reciprocal interaction with the robot compared to the teacher. Children seemed to be more engaged and motivated in the sessions with the robot compared to the sessions with the teacher. Qualitative results confirmed this. For a target group that “normally” shows deficits with communication and social interaction these are important observations. When looking at the frequencies it can be seen that children also show more positive verbal utterances on their own initiative in the KASPAR sessions. When analysing the behaviours we counted the number of instances that a certain micro behaviour occurred, not the duration that this micro behaviour lasted nor the content or semantics (the meaning) of the reactions. One of the most striking or remarkable impressions according to the professionals was that the children started to talk so much and so long on their own initiative to KASPAR and that they were telling KASPAR whole stories, and asking him all sorts of questions. They seemed sincerely interested in getting to know KASPAR better in their own personal ways and on their own initiative. The reactions (answers) to the teachers, on the other hand, were more of a closed nature (yes or no). They seemed more interested in engaging in a dialogue with KASPAR on their own initiative than with the teacher. This was also confirmed by the teachers in the video recall interviews. Possibly this was because of the novelty of a robot, however, at the same time, children with autism often have difficulties with new situations or new interactions. Another reason might be that they felt more at ease with the robot due to its lack of emotions and facial expressions.

When focusing on the verbal utterances that the children made as a reaction to KASPAR or the teacher another interesting phenomenon happened. The speed of reaction and dialogue of the teacher was much higher than the reactions from and with KASPAR. The teachers would hardly/not leave any silences or short breaks in the dialogue. Children answered these questions mostly with short answers: yes or no and hardly any reciprocal utterances towards the Teacher. In the KASPAR sessions, it sometimes took the researcher longer time to find the appropriate KASPAR command in the user interface. Therefore, the speed of the dialogue with KASPAR was much slower compared to with the teacher. Unexpectedly, this seemed to have a positive effect on the conversation dynamics in the sense that there was more time and calmness for the children to react and to take initiative on their behalf.

The KASPAR sessions had a longer duration and at the same time less instances in which that children lost their attention. Children were more concentrated in the KASPAR sessions compared to the Teacher sessions. This was confirmed by teachers, who argued for example: “KASPAR” requires less effort to engage the children than the teacher”, “he is so focused on KASPAR all the time” and “KASPAR needs to do much less to deserve this attention than a teacher needs to do”.

Knowing that children with ASD are often reported to be unable to use gestures or show other non-verbal conversation skills to give meaning to their speech or interaction, it is quite remarkable that children in this study showed so many reciprocal, non-verbal and communicative behaviours towards KASPAR (and spoke so often on their own initiative). Pennisi et al. (2016) found similar positive results in their review. They reported that participants with ASD showed social behaviour towards robots, showed reduced repetitive and stereotyped behaviours and reported spontaneous use of language in sessions with a robot. In some cases people with ASD showed behaviours towards robots that people without autism have towards humans.[28] Increased engagement, increased levels of attention and novel social behaviours such as joint attention and spontaneous imitation have also been found in other studies where robots were part of the interaction.[8,29,30]

With respect to methodological considerations, a strong point of the study is that we applied mixed methods to analyse the data with different methods (behaviour analysis of children and video recall interviews with teachers). Both the quantitative and qualitative results point in the same direction and confirm each other. Another strong point is the involvement of ASD professionals in an iterative manner in setting up and executing the study, which increases chances of designing a clinically relevant robot-mediated intervention. If robots are indeed to be used in future interventions for children with autism, it is crucial that these fit to current practices and are adopted by the professionals who will apply them. Since professionals were continuously part of the research and design process, they were pro-actively thinking along on how to optimally create a robot-mediated intervention.

A potential weak point of the study is that in this study, KASPAR had the same instructions and commands for all the children in both sessions. To be able to start this study and to be able to compare between children this was a pragmatic decision. However, for some children some instructions where too difficult (e.g. the question “what is your hobby?” could not be answered by two boys, better would have been “what do you like to do?”). On the other hand, for two other boys, KASPAR was (too) predictable in the second session. For them, if true learning would be the goal, KASPAR would need a different scenario (including different instructions) in the second session. Personalisation and tailored interventions seems to be crucial. Another weak point of this study is the relatively short duration of four weeks, consisting of two KASPAR and two teacher sessions. Possibly, children reacted to KASPAR in such a positive way because it was new to them.

During this study we counted the frequency of occurrence of a number of micro-behaviours for making contact. A recommendation for future research would be to also study the semantics, or meaning, and the duration of these behaviours. In the present study, children often expressed true interest towards the robot and showed signs of reciprocal interaction for in a rather long dialogue (e.g. they gave the robots compliments, asked returning questions after KASPAR asked them something, or praised the robot for its appreciated character or for its “beautiful and soft hair”). This occurred more often and in a more engaging manner than they did in the teachers sessions, which we did not expect to see. It would be very interesting to get more insights into this phenomenon and to learn how we can utilise this in interventions for these children. Another recommendation would be to involve more children in a longer duration study and to address other objectives besides making contact. Including more children would be interesting in order to learn how to better personalise and tailor the interventions. A longer duration of the study, meaning also more sessions, would be needed to analyse whether these effects also remain after a longer period of time and to investigate whether children show a transfer from KASPAR to people. The ultimate aim is to learn children new skills that they can and will apply in the interaction with other people, not just during the moments of interaction with KASPAR. Achieving transfer or generalisation of learned skills are true challenges when working with children with autism. Continuous tailored interventions would be a next step in the study of using robots for children with autism in practice.

In summary, this study showed that the minimally expressive robot KASPAR does conquer children's attention more than the teacher does and that it does establish contact with children with autism spectrum disorder. This is considered to be a valuable and necessary basis for meaningful interaction and future interventions in practice for these children.

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Appendix 6.1

KASPAR’s “making contact” intervention

Hummen
Hi!
Mmmm
Hello, I am robot KASPAR!
Come here, and sit on the chair
You do not have to be afraid of me, I do no harm
I am robot KASPAR, what’s your name?
Please say it again
Well done
Wow!
Super cool
Thank you!
Hah that is funny

You make a lovely wink
Nodded well
You are good at waving
You make a cool high five!
Ohhhh … wow, you told this very well
Sorry?
Yes
No
I have to think about this
Please say it again
Robots cannot do that
See what I can do
And I can do this
Can you do something that I cannot do?
Can you tell me something?
Can you do that too?

Kiekeboe!
Wink eye - without sound
Nod yes - without sound
Blink eyes
Hatsjoe!
Wave
Laugh - hahaha
Oops, now I need to yawn – yawn
Clap in hands with sound
Eyes left right
It’s great that I know you now, I give you a high five
High five
KASPAR raises his hand and says Hi, can you say hi to me?
Do you have a favourite animal?
What is your hobby?
With whom do you live in a house?
You participated very well
Now we will stop. You are finished.
See you next time
Bye bye

Instructions teachers “making contact”

Instructions regarding teacher sessions of Making contact

The goal of this session of approximately 10 minutes is to make contact with the child.
Please do this using the behaviours below.
You are free to choose the sequence and to turn it into action in your own way.

1. Greet / say hello
2. Blink eyes
3. Nod yes
4. Kiekeboe (covering eyes)
5. Hatsjoe (Sneeze)
6. Wave
7. Laugh
8. Yawn
9. Clap hands
10. High five
11. Ask the child to do or tell something
12. Close / wrap up

Chapter 7

Discussion

Main findings

The aim of the research presented in this dissertation was to examine the potential of robot-mediated interventions (RMI) in practices for children with autism spectrum disorder (ASD), in particular robot KASPAR. To date, only limited attention has been devoted in the literature to how robots can best be integrated in educational and therapeutic protocols and settings.[1] Successful integration of robots in school settings depends amongst other factors on teacher's views and acceptance.[2] The goal of this dissertation was to learn more about the possibilities of robots for children with ASD in a systematic manner and to create a basis of knowledge on how to apply RMI, by intensively involving practitioners such as teachers and therapists. In order to identify the potential of robot-mediated interventions for this target group, it is important to understand what objectives professionals work on with children with autism and to learn if and how robots could contribute meaningfully to these objectives. Several studies have been conducted to address these aspects.

We started with a focus group study including nine sessions in which professionals (e.g. special need teachers, occupational therapists, psychologists) participated to identify important therapy and educational objectives for children with ASD. This resulted in an overview of 74 objectives in 9 domains of the International Classification of Functioning for Child and Youth (ICF-CY). This overview presents goals that are important for children with autism and can function as a guide to create awareness or a common language, for example, when robot-mediated interventions are developed (irrespective of the chosen/selected robot platform or technology).

The second study consisted of a systematic review of the literature providing the state of the art of robots for children with autism. The robots found in the literature were mapped to the objectives overview from the focus groups. This gave insight into what objectives were or may be targeted by state of the art robots. In total, 14 robots addressed 24 of these objectives in 8 domains. Most of the robots in the studies found were prototypes used in a tele-operated mode. One of these robots is the humanoid robot KASPAR. It addressed the most different objectives (n=12). Based on both the positive results described in the literature, the promising characteristics, and functionalities of this platform (e.g. customisability, accessibility, reasonable affordability) KASPAR was used as the robot to be studied.

The third study aimed to answer the question: to which objectives for children with autism can robot KASPAR contribute according to professionals? An online questionnaire was completed by 54 professionals (e.g. therapists, special needs teachers, psychologists) working with children with autism. The results of this study indicated that KASPAR is expected to be able to contribute to many different objectives. The majority of the professionals indicated to expect KASPAR to be useful for working on imitation in play, making contact, turn taking, orientation to listen, social routines, attention, and learning a new form of communication.

The fourth study focused on the question how robots can be integrated into current autism practices. It addressed the roles that could be assigned to robots in interventions for children with autism, and strengths and challenges of the current robot KASPAR platform to take into account. Professionals identified six roles for KASPAR: provoker, reinforcer, trainer, mediator, prompter and diagnostic information provider. Participating adults with autism mentioned an additional role of a buddy. Expected strengths of KASPAR are related to personalisation possibilities, its playfulness, the action-reaction principle, its neutrality, consistent and repetitive application of action, possibilities to vary behaviour in a controlled manner and having an extra support for the professionals. Professionals also identified aspects to take into consideration or challenges to take into account. They mentioned that KASPAR currently has rather limited reaction possibilities, some children might be scared of KASPAR, and professionals had questions related to the generalisation or transfer of learned skills with KASPAR and mentioned that a potential dependence on KASPAR might develop if children become attached to the robot.

In this qualitative study professionals and adults with ASD also took part to elicit requirements for robot mediated interventions. Additionally, professionals, parents of children with ASD and adults with ASD generated ideas for new KASPAR interventions in three co-creation sessions. This study resulted in an overview of requirements concerning the robot, the children, environment and conditions related to practical implementation, and a template to systematically describe robot interventions in general and for KASPAR in particular was created. Additionally, a number of new KASPAR interventions were created.

Finally, a fifth study was an ABAB designed study aimed at making contact was conducted in a special school ('De Parkschool') in The Netherlands. It was a mixed method study aimed at getting more insights into the interaction of children in sessions with KASPAR (phase A) compared to sessions with only the teacher (phase B). Micro-behaviours of the children (quantitative) were analysed based on video recorded sessions with KASPAR. Additionally, video recall interviews were held with professionals (qualitative). Nine children between 8 and 12 years old participated in 4 sessions, two with KASPAR and two with their teacher. Children reacted positively and freely to KASPAR, they made contact both verbally and non-verbally, showed initiative, had more and longer focused attention with KASPAR than with the teacher and seemed to be at ease with and enjoying the interactions with the robot. Involved teachers were positively surprised by the interactions between the children and KASPAR and the continued focused attention that they had with the robot. Significant differences were found between the KASPAR and teacher condition: children touched the robot more often, showed more non-verbal imitation with the robot and had longer and more focused attention with the robot. The children made more positive verbal utterances as a reaction to the teacher than they did to KASPAR. Clinically relevant was also the finding that the children made more positive verbal utterances on their own initiative to the robot than to the teachers. This study showed that KASPAR can contribute to the objective of making contact for children with autism.

Besides answers to the research questions, a number of interesting additional insights were found while conducting the studies described above. Firstly, an almost immediate and automatic positive first reaction of professionals to the potential use of robots for children with autism occurred from the moment when we first approached professionals in the field during the first study throughout the years lasting to and even after the study. During the first focus groups, most professionals almost immediately started to talk about possibilities they envisioned and had a certain child in mind that might benefit from interacting with a robot. They had a very open and constructive mind-set. A number of other studies also reported positive attitudes of pre-school and elementary school teachers towards the use of robots in (psycho)therapy and education and that they accepted a human-like robot to serve as an interactive tool in the teaching process.[2-4] One reason to explain this open and positive attitude of ASD professionals is that especially in their work with children with autism, by nature, they have to be open, flexible and try new things. Another reason might be that they realise that children with autism particularly experience difficulties with (certain) human characteristics which are likely to be absent in robots like emotions, hidden or contradictory meanings in non-verbal and verbal messages, and unpredictability. And, finally, a reason could be because they were so intensively involved in co-developing the robot-mediated interventions. In this way they could shape and influence the actual behaviour and application of the robot intervention.

Another interesting additional insight was that most of the children who participated in sessions with KASPAR were very enthusiastic, had a lot of fun and were engaged in pro-active social interaction with the robot. For children without autism, this might not be so remarkable and more natural, but for children with autism this is special. They visibly opened up in the moments with KASPAR, interacted freely, smiled and used spontaneous and enthusiastic language to and with KASPAR. What they said and how they interacted with KASPAR showed real interest in KASPAR and in a number of cases even expressions of appreciation were made (e.g. “shall we be friends?, “you are the nicest robot that I know”, “what is your favourite colour?”, “your hair is so soft and beautiful”, “shall I teach you how to walk?”, “ow he looks a bit scary, …. oops I hope he did not hear this”). After the sessions they often talked about KASPAR with their parents, teachers or peers at school, and they asked when they would see KASPAR again. They were more enthusiastic than we expected, and they showed behaviour that does not typically occur in children with autism, e.g. showing social and emotional reciprocity towards the interaction partner, use and understanding of non-verbal communication, and the use of spontaneous language.[5]

A third insight that we as researchers, but also professionals and other stakeholders did not expect, was related to an increased awareness of the human way of approaching children with autism, and the problems that may cause for children with autism. KASPAR is a tool to bring methods and strategies (e.g. based on elements of TEACCH framework) about what works best for children with autism into practice, e.g. clarity, repetition, structure, and no unpredictable changes. In a robot the characteristics of the 'desired' way to approach children with ASD can be more easily implemented and consistently controlled than in human behaviour. The robot is programmed using relatively simple commands and repetitive instructions, it uses simple verbal messages, neutral expressions and tone of voice, all alternated with short breaks. Human behaviour is per definition more confusing for a child with autism due to the mix of verbal and nonverbal triggers and stimuli that people use automatically and cannot be turned off. Observing the human-robot interaction made some involved professionals more aware about their own human-child interaction. Moreover, the robot allows the person (a teacher, therapist or parent) who is normally part of the interaction with the child to take more distance.

Critical Reflections

The research presented in this dissertation studied the use of robots in education and care for children with autism. This is a relatively new field of research for which an established theoretical framework, a solid body of knowledge or systematic approaches to guide practical implementation are not available yet. Studies conducted to date are often explorative in nature and technically oriented, describing a single robot platform mostly in a prototype phase, and/or used in a study for one isolated task. Diehl et al. (2012) argue that many of the studies have methodological limitations (e.g. sample sizes and appropriateness of control conditions/groups) and do not focus on the clinical or practical application of the technology, but more on technology development.[1] In our studies, we adopted a rather pragmatic approach including involvement of practitioners in order to optimise chances for applicability of the robot in practice. The results described in this dissertation are in line, and go beyond findings in the existing literature on robot-mediated interventions in terms of results delivered as well as in terms of the participatory approach and co-creation with professionals from real world contexts. Findings are in line with earlier studies which reported that children with autism showed 'desired' behaviour and were motivated during the interaction with a robot.[1,6,7] Before actually talking about a robot with practitioners, we were interested in their focus on objectives for children with autism irrespective of any intervention. We considered this a necessary starting point in both literature and practice: a solid basis for developing future robot-mediated interactions. Many of the publications in this area are rather technical in nature and focus on the development of robots.[1,6] The resulting objectives overview can be applied in the context of different kinds of interventions, by different (technical) organisations, and for various technologies and thus also robots. Previous studies on the exploration of robot-mediated autism interventions have more often been directed at clinical therapy settings rather than on educational settings in which children with autism might also benefit from this upcoming intervention domain.[8] Therefore, the studies in this dissertation also had a focus on educational objectives and contexts and explicitly involved practitioners from schools in order to value their professional knowledge and situated nature of experiences and to place them in the centre of inquiry together with other stakeholders. We considered the professionals and stakeholders as "experts" in co-creating new interventions rather than only vehicles for delivering interventions that have proven to be effective in research.[9]

The studies described in this dissertation delivered a number of findings specifically related to the use of robot KASPAR, and a number of findings that are not platform dependent and are more generalizable. The objectives overview, the questionnaire to match the objectives to any robot, and the intervention template can be used as tools to systematically think about how to apply any robot platform in practice (e.g. specification of the target group, appropriate selection of objectives, session properties and choice of scenario). Other results are also expected to be more generalizable such as the roles, strengths and challenges to take into account when applying robots in practice. Many other robots (may) possess similar characteristics or strengths that might create similar effects for children with autism. Characteristics such as predictability, playfulness, neutrality, action-reaction principle, consistent and repetitive application of actions, being able to vary behaviour in a controlled manner and having an extra hand for the professional can be designed and implemented in other robot platforms as well. Also the potential weaknesses found are not necessarily KASPAR specific. Therefore, we expect these results to be applicable and valuable for other RMI developers too.

From the last study it was clear that conducting research with this target group is rather challenging due to the heterogeneous nature of the disorder and therefore large differences in the population with respect to symptoms of the ASD but also in terms of variations in developmental and cognitive capacities and behavioural problems. Providing support for these children calls for a highly individual and personalised approach. Moreover, because of the nature of the autism disorder, it is a rather vulnerable and 'difficult' population to conduct research with. Children with autism can be oversensitive to (new) stimuli and triggers, show great need/importance for structure and predictability and tend to show a resistance to change.[10] In other words, when professionals try new things, they have to get it (as) right as quickly as possible. Involvement and consultation of many professionals and other stakeholders in all the studies that we conducted was one way we aimed to achieve this. This was a challenging task, since settings of special education and therapy for children with ASD have limited resources in terms of time, money, availability of children with ASD and professionals to participate in studies. However, it is a worthwhile effort that hopefully leads to innovations that are better suited to what current ASD practice needs. Since this is such a new area, it takes a considerable amount of time to understand the child, select the objectives to focus on, co-create, program and implement an appropriate robot scenario and to prepare and create an comfortable setting to conduct the session with the child. Especially the co-creation and subsequently programming of the behaviour of the robot (e.g. movements, spoken words, tone of voice) currently requires quite some efforts since there is no existing set of scenarios to choose from.

Another challenge with respect to working with and conducting research with children with autism is the aspect of generalisation or transfer. In other words, being able to apply and generalise the learned skills or knowledge to other areas, people or domains than in which it was learned. This is difficult to achieve in children with autism, because they have a rather rigid and different way of information processing and learning compared to children without autism.[10] Also, children with autism receive often more than one intervention at any point in time, making it difficult to separate out an effect and attribute this to one intervention.[9] In the short term study that we conducted, we only focused on the behaviour of the child in the moment of the interaction, not after a longer period of time. The micro behaviours that we were interested in, making contact in the moment, did not ask for transfer measurement. In future research, when focusing on other objectives, this is an aspect that should be taken into account.

Methodological reflections

During the iterative research process we aimed to involve different stakeholders, such as teachers, therapists, parents of children with autism as well as people with autism themselves to increase changes for acceptability and clinical validity. People with autism often had very original different ideas and suggestions on what the robot could potentially do and how it should behave. For example they suggested to use KASPAR to take away possible prejudices or to learn how to have a conversation. For example, to help understanding the level of detail when answering the question what they had for dinner yesterday. That they would not answer “I had 35 peas and 3.5 potatoes”. Although adults with autism participated in several phases of the research (e.g. focus groups, co-creation sessions) unfortunately, the number of people with autism that we managed to involve was rather limited due to practical and availability reasons. In future studies, it would be worthwhile involving more adults with autism as well as children with autism if possible to also include their viewpoint and experiences since especially they can have a fresh perspective on the matter.

During the study with the children, KASPAR was used in a semi-autonomous mode (a combination of the activation of its sensors and actuators and by remote control by the researcher). Many of the reported robot studies used a Wizard of Oz approach (remote control) as also found in the systematic review.[11] One of the advantages is that the person controlling the robot can read and understand the reaction of the child and choose the appropriate robot reaction. Current state of the art robotics is not able to fulfil this nuanced task as good as humans can. A disadvantage of this operating mode is that it increases the workload for professionals (someone needs to control the robot). Another, potential disadvantage is that the style of the Wizard, the person that controls the robot, determines the behaviour of the robot. In this way, there is some element of subjectivity or personal touch of a human, in deciding the behaviour of the robot. At the same time this can be an advantage as well since education and care can be delivered in a personalised manner, tailored to what that certain child needs.

During the sessions in the study, relatively long breaks between reactions were seen from KASPAR's side. This was caused because the researcher controlling the robot, sometimes had to think about and then find the appropriate reaction/button on the user interface. During the sessions, the experimenter felt that these breaks or silences (no action of the robot), were too long. However, when analysing the micro behaviours of the child afterwards and conducting the interviews with the professionals, this turned out to be very pleasant for the children with autism. It is very difficult to predict what would work best and how children will react to certain interactions from the robot. Actually trying things out, in practice, with real children with ASD, is the best way to learn.

Implications

For children with ASD

Studies in this dissertation build up more knowledge and experiences on hów to actually use robots in robot-mediated interventions for children with ASD. Robots might become tools in the hands of teachers, therapists or parents to provide an alternative way to engage children with autism. In the literature[1,6] as well as in our study it is clear that many (but not all) children are intrinsically motivated and challenged to engage in the interaction with a robot. Besides the fun and pleasure element they seem to experience, they learn new skills while interacting with it. This might imply that they learn new social or communicative skills in a manner that is more appealing for them. Hopefully they make the transfer of the learned skills to the interaction with people. As an intermediate step KASPAR might function as a mediator between different children with autism or between a child with autism and an adult so that they learn in a challenging and fun manner to engage with each other.

For practice of education and therapy for children with ASD

At this moment, KASPAR is still in a prototype phase and not commercially available. Besides aspects such as certification and compliance to safety regulations, the prototype needs an improved, stable and more user friendly user interface to create new and more scenario's, training for professionals needs to be in place, and accessible (technical) support has to be arranged. Also the mind-set and availability of professionals has to be ready to use robots as new tools in their work. Ideally, one would wait with applying KASPAR regularly in practice until the robot has reached a certain (higher) level of maturity. On the other hand, it is expected and likely that even using this technical version of the prototype it can add value to practice. Even more so because, the more than 100 professionals and stakeholders that were part of the research and process, created enabling conditions and mind-sets at their organisations who are now enthusiastic and ready to actually "do it". Once a KASPAR scenario or intervention is developed, it is easy and fast to apply, and although KASPAR is still in a prototype phase, it could already be applied in practice. It is important that the person who will work with KASPAR in practice, is trained and experienced and feels comfortable in controlling the robot.

Besides using the robot already to work on therapy or educational objectives, it can also be useful as a research instrument, or diagnostic information provider as suggested by several professionals during the focus groups. Because the instruction of the robot is standard and always the same, it can function as a tool to observe how children react to certain stimuli or triggers. Possibly it can help understanding and modifying 'difficult' or challenging child behaviour better (e.g. as part of applied behavioural analysis). A disadvantage is that the user interface to create new scenario's is not very user friendly at the moment (cumbersome, but not difficult) and rather time consuming for people working in practice to make sure that the right commands are created to fit the individual needs of the child.

For robot developers

Children with autism need highly individualised/tailored and personalised interventions. This is also true for robot-mediated interventions. There is no 'one size fits all' in this domain.[12] Different objectives, needs, capabilities, sensitivities, and preferences need to be taken into account in order to achieve personalisation. For robot developers this means that they have to enable people in the field, who know the children well, to adjust the behaviour of the robot and to create and organise new scenario's in an easy and time efficient manner. One of the elements in the current prototype that could benefit from improvement, for example, is the manner in which KASPARs speech can be created and generated along with its movements. An advantage of using a computerised voice compared to a person speaking, is that it is always the same and highly controllable in terms of spoken words, but also tone of voice or speed. At this moment an external commercial text to speech generator is used to create sound (.wav) files with KASPAR's words or sentences. This has to be integrated in the KASPAR application in advance to the sessions with the children. Preparation is crucial and on the fly improvisations are not possible currently, except for the already recorded vocabulary or sentences. A disadvantage is that the professional might not be as free as desired to improvise in the moment. On the other hand, an advantage can be that the human factor is limited in this case which increases predictability. If it would be possible to create new KASPAR's speech in real-time, more human characteristics and 'errors' can be made as well. Maybe, next versions of robot systems can take this into account and create different levels of freedom, that can be chosen depending on the needs and capabilities of both professional and child in a certain session.

The current version of the prototype has probably not reached the optimal look and feel yet related to the design and appearance of the head and the expressiveness it allows. For example, the eye balls are far back into the eyes now which tends to create dark holes depending on the viewing angle. Having said this, there might be need for only limited further increase of expressiveness of the humanoid characteristics. People without autism tend to derive meaning and some sense of security or clarity from seeing facial expressions. For children with autism, however, the same expressions are more likely to be a source of ambiguity and stress. Many people without autism who see KASPAR for the first time say that it looks scary or it resembles 'Chucky' (from the movie). The uncanny valley theory describes the phenomenon about humanoid objects (such as KASPAR), which appear almost but not exactly like a human, can elicit uncanny, or strangely familiar, feelings of eeriness and revulsion.[13] The uncanny valley might look different for children with ASD,[14] which may imply that further increasing the expressiveness of humanoid characteristics of the robot should be done with care. Also the design of KASPAR's hands could possibly be improved. During the second round of focus groups several professionals mentioned that they could see value that KASPAR's hands and fingers would get more degrees of freedom enabling the robot to use gestures and signs or even sign language with are important and appropriate for many children with autism.

Only few studies reported used autonomously functioning robots in this domain.[15] Although Thill et al. (2013) call for a more autonomous behaviour of robots rather than remote controlled robots,[15] this will some more research and consideration. It might be supporting to have more autonomy and intelligence in a number of areas, although a fully autonomously operating robot might be a bridge too far for this target group. The current prototype of KASPAR used pre-recorded words, sentences or sounds which can be triggered using the commands on the user interface. This only allows for a certain vocabulary in the dialogue. Possibly, smarter conversational applications can be build, dedicated for this target group, to enable a more interesting and rich dialogue in real time. At the same time, this introduces a certain level of unpredictability, which might work adverse for these children. Also, more intelligence in the robot might work well with respect to creating new interventions. Certain guidelines or even rules for the robots behaviour can be programmed, based on existing knowledge from other interventions and current practices. For example, when it comes to how to approach the children: the robot could be programmed to always start the first interaction with a soft sound not to scare the children with a sudden expression, always start a sentence with the child's name to catch the attention and use repetitive short expressions. Moreover, certain levels of difficulty could be implemented to take into account different capacities and needs of different children, but also to be able to adjust the robot behaviour when a child learns certain skills and develops. More and more technologies are suggested in this area such as machine learning techniques and emotion recognition. However, with the current state of technologies and artificial intelligence, for current practices a semi-autonomous mode of robot control is likely to be the best option to ensure an optimal interaction between the child and the robot.

Recommendations

For further research

Our approach was practice-oriented and pragmatic in nature, in the sense that we aimed to align everything that we did optimally to the needs of the professionals and the children as well as current practices. Interventions for these children demand considerations on micro level and a highly individualised approach and support. At the time of writing, there is no theoretical framework on the application of robot-mediated interventions for children with autism. Future research would be interesting and valuable in this area to guide RMI research and development also from a theoretical point of view. Ideally this theoretical framework would be created by a collaboration of experts in the area of education or therapy for children with ASD, together with people with more technical expertise such as robotics.

The results described in the ABAB study of this dissertation are explorative in nature. Nevertheless, the results give clear indications for promising effects relating to making contact which ask for continuation and further elaboration addressing more objectives that are important for children with autism. It is preferable to involve (more) people with autism in future studies and potentially also in the development of new robot scenario's. This could be part of student's education, for example, where students from different disciplines (e.g. engineering, industrial design, occupational therapy, special education) collaborate.

A longitudinal study, for example, using a multiple single case (ABAB) design would be suggested in which for each specific child the relevant objective(s) would be addressed by an appropriate personalised robot-mediated intervention. Both qualitative and quantitative measurements would be taken. Methodologies need to be close to both (understanding and describing) the complexities and contradictions of the disorder while also actually measuring the effects of the intervention under study. The goal would be to involve a larger population to create a more solid knowledge base, to also know more about other objectives, to measure long(er) term effects and to address the matter of transfer. Corresponding behaviour of the child could be measured, and the opinions and experiences of professionals, parents and the participating children would be analysed (if the latter is possible with regard to the children's capacity to express themselves verbally or nonverbally). Professionals, parents of children with autism and people with autism would be in the co-designer seat for creating robot-mediated interaction scenario's. Results from our studies can function as a starting point (e.g. the objectives overview and the intervention template can be used as a guide).

Policy

At this moment in The Netherlands there are no policies in place for the use of robot-mediated interventions in practice. Considering the promising positive results reported about this new area of support it would be advisable to make sure policies are created so that ASD care and/or education delivered by means of robot-mediated interventions are indeed considered as 'regular' care or education and will be reimbursed by regular funding mechanisms from the government. First steps in that direction would be to stimulate and enable continued multi-centre and multidisciplinary applied research in this domain, development and implementation of innovations such as robot-mediated interactions which builds up a larger body of evidence, to create structures for reimbursement for use in practice and home settings, to embed examples of innovative interventions in education of ASD professionals and possibly in the hands of parents in home environments and to help schools and therapy contexts to prepare their organisation and professionals for the implementation of robot-mediated interventions.

General conclusion

The application of robot-mediated interventions is considered a promising direction to augment or complement autism therapy and (special) education. These interventions are likely to have a place in the broad scala of interventions for children with ASD. They are expected to become valuable empowering tools in the hands of professionals. This is mainly due to the way in which they seem to support professionals and engage children, attract their attention, increase their responsiveness and motivation to take part in (reciprocal) interaction. However, needless to say, robots are not the solution for all needs, and not for all children, as any other intervention in this domain. Moreover, as Steve Jobs said: "technology alone is not enough". Having a working robot is (just) one element that needs to be in place in other for robot-mediated interventions to actually contribute to the lives of children with autism. Acceptance and adoption by teachers and/or therapists is crucial, as well as integration of the robot into current educational or therapy plans, and environmental and organisational aspects need to be arranged. In order to increase the chances of creating meaningful innovations and uptake in practice, we involved professionals, parents of children with autism and people with autism as much as possible in the different studies. Expectations and the motivation of professionals, parents of children with autism as well as the adults with autism were positive. Moreover, throughout the years of their involvement in this research, they became more and more (pro) active to participate in (future) collaboration and to co-create and bring meaningful robot-mediated interventions to children with autism. Robots might be one of tomorrow's tools of ASD professionals helping children with autism learn, develop, cope and also importantly, to have fun. In order to realise this, there is still some work to be done.

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Summary

Summary

Chapter 1

The first chapter introduces the topic of this dissertation: the potential of robot-mediated interventions (RMI) in educational and therapy practices for children with autism spectrum disorder (ASD). Autism is a complex pervasive developmental disorder characterised by impairments in social interaction, communication and restricted, repetitive patterns of behaviour, interests, or activities. Children with autism often show difficulties with approaching people, social-emotional reciprocity, non-verbal communication behaviours, and developing, maintaining and understanding relationships. The use of robots for children with autism is suggested as a promising direction to augment or complement autism therapy and (special) education. Robots allow for playful action-reaction interactions, can be controlled and applied in a consistent and repetitive manner tailored to the needs and preferences of a specific child, and can be neutral in their expressiveness which all together creates a certain predictability and approachability for children. To date, only limited attention has been devoted in the literature to hów robots can best be integrated in educational and therapeutic protocols and settings.

The goal of the studies presented in this dissertation was to learn more about the possibilities of robots for children with ASD in a systematic manner and to create a basis of knowledge on how to apply RMI, by intensively involving practitioners such as teachers and therapists. In order to identify the potential of robot-mediated interventions for this target group, it is important to understand what objectives professionals work on with children with autism and to learn if and how robots could contribute meaningfully to these objectives. Several studies have been conducted to address these aspects and to increase the chances of creating meaningful innovations and uptake in practice, professionals, parents of children with autism, adults and children with autism were involved throughout the studies. Robot KASPAR was used as the robot platform for which interventions were co-designed and tested in the context of (special) education. The questions guiding the research were:

1. What are objectives that professionals work on in practice with children with autism and what is the state of the art of robotics targeting these objectives?
2. To which objectives for children with autism can robot KASPAR contribute according to professionals?
3. What roles are possible for robots in interventions for children with autism, and what are strengths and challenges to take into account?
4. How can robots be practically implemented into current practices? What are important requirements to take into account?
5. What is the effect of a KASPAR-mediated intervention on making contact with children with autism?

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Chapter 2

In order to address the first research question focus group sessions were held and a systematic literature study was conducted. Various professionals (e.g. special needs teachers, occupational therapists, psychologists) participated in the focus group study, which delivered an objectives overview that presents the goals that are important for children with autism. It seems that professionals work on a broad variety of therapy or educational goals for the children with this heterogeneous disorder. In total 74 objectives were identified in 9 different domains of the International Classification of Functioning for Child and Youth (ICF-CY). Professionals indicated that all objectives are relevant for children on the spectrum, but that not all objectives are urgent to focus on for a particular child at any given moment. The systematic review of the literature provided the state of the art of robots for children with autism. The robots found in the literature were mapped to the objectives overview from the focus groups. This gave insight into what objectives were or may be targeted by (state of the art) robots. In total 14 robots were found which together addressed 24 of the objectives, in 8 domains. Most of the identified robots were still in a prototype phase, addressed only a few of the objectives for children with autism and were used in a tele-operated manner. One of the identified robots that was used for the largest number of objectives and showed positive results in the literature was robot KASPAR.

Chapter 3

In order to gain understanding about the objectives KASPAR can contribute to according to professionals, a questionnaire was completed by professionals (e.g. therapists, special needs teachers, psychologists) working with children with autism in The Netherlands. The results of this second study indicated that KASPAR is expected to be able to contribute to many different objectives in a number of domains. The majority of the professionals indicated to expect KASPAR to be useful for working on imitation in play, making contact, turn taking, orientation to listen, social routines, attention, developing interest in play, and learning a new form of communication. These are objectives in the ICF-CY domains of communication, social interaction and relations, and play. Also in other domains, such as preschool skills and emotional wellbeing, it is expected that KASPAR can contribute to objectives such as training or practicing skills, following up instructions, asking for help or having fun and experiencing pleasure. Professionals also identified objectives to which they think KASPAR can probably not contribute, such as mobility. Professionals stressed the importance of devoting attention to creating a pleasant and motivating environment for the children so that they feel free and can develop.

Chapter 4

The third study focused on the question how robots can be integrated into current autism practices. A focus group study was conducted in which various stakeholders and professionals participated to answer the third and fourth research question. Chapter 4 presents the findings on possible roles, strengths and challenges of using robots for children with autism. Professionals and other stakeholders identified six roles for KASPAR: provoker, reinforcer, trainer, mediator, prompter and diagnostic information provider. Participating adults with autism mentioned an additional role of a buddy. Expected strengths of KASPAR are related to personalisation possibilities, its playfulness, the action-reaction principle, its neutrality, consistent and repetitive application of action, possibilities to vary behaviour in a controlled manner and having an extra support for the professionals. Next to strengths, also challenges or aspects to be taken into account were identified. These are: KASPAR currently has rather limited reaction possibilities, some children might be scared of KASPAR, questions related to the generalisation or transfer of learned skills with KASPAR and a potential dependence on KASPAR might develop if children become attached to the robot.

Chapter 5

The focus group study mentioned in chapter 4 also addressed the question how can robots be practically implemented into current practices and what important requirements should be taken into account. This resulted in an overview of requirements concerning the robot, the children, environment and conditions related to practical implementation, and a template to systematically describe robot interventions in general and for KASPAR in particular was created. These are presented in chapter 5. Additionally, professionals, parents of children with ASD and adults with ASD generated ideas for new KASPAR interventions in a number of co-creation sessions. This delivered more insights into the question how robots can be practically implemented into current practices and what important requirements are to take into account.

Chapter 6

In order to learn more about what the effect would be of a KASPAR intervention on children with autism, a study was conducted in practice. This was an ABAB designed study aimed at making contact conducted in a special school in The Netherlands. The study aimed at getting more insights into the interaction of children in sessions with KASPAR (phase A) compared to sessions with only the teacher (phase B). Micro-behaviours of the children were analysed based on video recorded sessions with KASPAR. Additionally, video recall interviews were held with professionals. Children reacted positively and freely to KASPAR, they made contact both verbally and nonverbally, showed initiative, had more and longer focused attention with KASPAR than with the teacher and seemed to be at ease with and enjoying the interactions with the robot. Involved teachers were positively surprised by the interactions between the children and KASPAR and the continued focused attention that they had with the robot. Significant differences were found between the KASPAR and teacher condition: children touched the robot more often, showed more non-verbal imitation with the robot and had longer and more focused attention with the robot. The children made more positive verbal utterances as a reaction to the teacher than they did to KASPAR. Clinically relevant was also the finding that the children made more positive verbal utterances on their own initiative to the robot than to the teachers. This study showed that KASPAR can contribute to the objective of making contact for children with autism.

Chapter 7

This dissertation concludes with a general discussion presenting the main findings, a number of additional insights that were gained during these studies, critical reflections on the conducted studies and methodological reflections. Furthermore, a number of implications are given: implications for children with autism, for practitioners in education and therapy for children with autism and for robot developers. Finally, chapter 7 gives a number of recommendations for further research and policy. It concludes that the application of robot-mediated interventions can be considered a promising direction to augment or complement autism therapy and (special) education. This is mainly due to the way in which they seem to support professionals and engage children, attract their attention, and increase their responsiveness and motivation to take part in (reciprocal) interaction. However, needless to say, robots are not the solution for all needs, and not for all children, as any other intervention in this domain. Robots might be one of tomorrow's tools of ASD professionals helping children with autism learn, develop, cope and also importantly, to have fun. In order to make this happen, there is still some work to be done for people with various disciplines, backgrounds and experiences, to actually utilize this potential in practice.

Nederlandse samenvatting

Nederlandse samenvatting

Hoofdstuk 1

Het eerste hoofdstuk introduceert het onderwerp van dit proefschrift: het potentieel van robot-gebaseerde interventies in het speciaal onderwijs en bij therapie voor kinderen met autisme spectrum stoornis (ASS). Autisme is een complexe ontwikkelingsstoornis die gekarakteriseerd wordt door beperkingen op het gebied van sociale interactie en communicatie en een beperkt interesse- en gedragsrepertoire. Kinderen met autisme hebben vaak moeite om mensen te benaderen. Non-verbale communicatie, sociaal-emotionele wederkerigheid, en het ontwikkelen, onderhouden en begrijpen van relaties is vaak een uitdaging voor hen of zelfs onmogelijk. Het gebruik van robots voor kinderen met autisme wordt gezien als een veelbelovende wijze om begeleiding van kinderen binnen het (speciaal) onderwijs en therapie te ondersteunen of stimuleren. Het sterke 'actie-reactie' karakter van robots lokt op een spelenderwijze interacties uit bij de kinderen. Bovendien kan robotgedrag exact voorgeprogrammeerd worden. Robots kunnen op een consistente wijze toegepast worden, gebruikmakend van eindeloze herhalingen, toegespitst op de behoeften en voorkeuren van een specifiek kind en kunnen uiterst neutraal zijn in hun non-verbale expressies. Hierdoor is het mogelijk een bepaalde mate van voorspelbaarheid en laagdrempeligheid voor de kinderen te creëren. Tot op heden is er echter nog weinig bekend over hoé robots geïntegreerd kunnen worden in het onderwijs en de therapie voor kinderen met autisme.

Het doel van de studies beschreven in dit proefschrift was om op een systematische wijze meer te leren over de mogelijkheden van robots voor kinderen met ASS en om door middel van intensieve samenwerking met professionals (basis)kennis op te doen over hoe robot-gebaseerde interventies toegepast kunnen worden in de praktijk. Om het potentieel van robots in interventies voor deze doelgroep te kunnen identificeren is het allereerst van belang om te begrijpen aan welke doelen voor kinderen met autisme professionals werken en om vervolgens te leren of en hoe robots daar een betekenisvolle bijdrage aan kunnen leveren. Verschillende studies zijn uitgevoerd gericht om inzicht te krijgen in deze aspecten. Om de kans op het maken van betekenisvolle innovaties die daadwerkelijk door de praktijk omarmd worden te vergroten, zijn professionals intensief betrokken in het proces, maar ook ouders van kinderen met autisme, volwassenen met autisme en kinderen met autisme. Robot KASPAR is gebruikt als platform waarvoor door middel van multidisciplinaire samenwerking interventies zijn ontworpen en getest in de context van speciaal onderwijs. De onderzoeksvragen waren als volgt:

1. Aan welke doelen werken professionals in de praktijk met kinderen met autisme en wat is de state-of-the-art met betrekking tot robotica gericht op deze doelen?

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2. Aan welke doelen voor kinderen met autisme kan robot KASPAR volgens professionals een bijdrage leveren?
3. Welke rollen zijn mogelijk voor robots in interventies voor kinderen met autisme en met welke sterke punten en aandachtsgebieden met betrekking tot het gebruik van robotica moeten we rekening houden?
4. Hoe kunnen robots toegepast worden in de praktijk? Wat zijn belangrijke randvoorwaarden waaraan voldaan dient te worden?
5. Wat is het effect van een KASPAR interventie op het maken van contact met kinderen met autisme?

Hoofdstuk 2

Om de eerste onderzoeksvraag te beantwoorden zijn in de eerste studie focusgroep sessies georganiseerd en is een systematische literatuurstudie uitgevoerd. Verschillende professionals (zoals leerkrachten uit het speciaal onderwijs, ergotherapeuten, psychologen) hebben deelgenomen aan deze studie. Het resultaat was een overzicht van doelen waaraan professionals werken die relevant zijn voor kinderen met autisme. Het blijkt dat professionals aan een grote variatie aan therapie- en onderwijsdoelen werken voor kinderen met deze heterogene stoornis. In totaal werden 74 doelen geïdentificeerd passend binnen 9 verschillende domeinen van de "International Classification of Functioning for Child and Youth" (ICF-CY). Professionals gaven aan dat al deze doelen relevant zijn voor kinderen op het spectrum, maar dat niet alle doelen urgent zijn voor alle kinderen op elk tijdstip. De systematische literatuurstudie leverde de "state of the art" robots op voor kinderen met autisme. De gevonden robots uit de literatuur werden gekoppeld aan het doelenoverzicht uit de focusgroep studie. Dit heeft geleid tot inzicht in de doelen waarop "state of the art" robots zich richten. Er werden 14 robots gevonden in de literatuur welke samen 24 van de doelen adresseerden, die passen binnen 8 domeinen. De meeste robots verkeerden in een prototype fase, en adresseerden slechts een paar van de doelen voor kinderen met autisme en werden gebruikt middels bediening op afstand. Robot KASPAR was één van deze robots die werd ingezet voor het grootste aantal doelen en waarvan positieve resultaten in de literatuur werden beschreven.

Hoofdstuk 3

Om inzicht te krijgen in de doelen waaraan KASPAR volgens professionals wellicht een bijdrage zou kunnen leveren, is er een online vragenlijst ingevuld door professionals in Nederland die met kinderen met autisme werken (zoals therapeuten, speciaal onderwijs leerkrachten, psychologen). De resultaten van deze tweede studie toonden aan dat verwacht wordt dat KASPAR een waardevolle bijdrage zou kunnen leveren aan veel verschillende doelen binnen een aantal domeinen. De meerderheid van de professionals gaf aan te verwachten dat KASPAR geschikt zou kunnen zijn voor doelen als imitatie in spel, contact maken, beurtgedrag, luistergerichtheid, sociale routines, aandacht, interesse in spel ontwikkelen en het aanleren van een nieuwe communicatievorm. Dit zijn doelen die vallen binnen de ICF-CY domeinen communicatie, sociale interactie en relaties en spel. Bovendien dacht men dat KASPAR een bijdrage zou kunnen leveren in domeinen zoals voorschoolse vaardigheden en emotioneel welbevinden. KASPAR zou in hun ogen kunnen bijdragen aan het behalen van doelen zoals het trainen of oefenen van vaardigheden, opvolgen van instructies, hulp vragen of lol maken en plezier ervaren. Professionals identificeerden ook doelen waarvan ze dachten dat KASPAR daar waarschijnlijk geen bijdrage aan zou kunnen leveren, zoals mobiliteit. Ze benadrukten het belang van het hebben van aandacht voor het creëren van een plezierige motiverende omgeving voor de kinderen waarin ze zich vrij voelen en zich kunnen ontwikkelen.

Hoofdstuk 4

De derde studie richtte zich op de vraag hoe robots geïmplementeerd kunnen worden in huidige autisme onderwijs- en therapie settings. Een focusgroep studie met verschillende stakeholders en professionals is uitgevoerd om de derde en vierde onderzoeksvraag te beantwoorden. Hoofdstuk 4 beschrijft verschillende rollen die KASPAR zou kunnen vervullen, sterke punten die benut kunnen worden en aandachtsgebieden rondom het gebruik van robots voor kinderen met autisme. Professionals en andere stakeholders identificeerden zes mogelijke rollen voor KASPAR: stimulator, beloner, trainer, mediator, aanspoorder en diagnostisch hulpmiddel. Een zevende rol, een maatje, werd genoemd door volwassenen met autisme die deelnamen. Verwachte sterke punten van KASPAR hebben te maken met mogelijkheden voor: personalisatie, speelsheid, actie-reactie principe, neutraliteit, consistente en herhaaldelijke handelingen, mogelijkheden om gedrag op een gecontroleerde wijze te variëren en het hebben van extra ondersteuning voor professionals. Naast deze sterke punten, werden ook aandachtsgebieden benoemd. KASPAR heeft op dit moment relatief beperkte actie-reactie mogelijkheden, kinderen kunnen bang zijn voor KASPAR, vragen rondom generalisatie of transfer van geleerde vaardigheden met KASPAR en er zou een mogelijke afhankelijkheid van KASPAR kunnen optreden wanneer kinderen te zeer gehecht zouden raken aan de robot.

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Hoofdstuk 5

De focusgroep studie adresseerde ook de vraag hoe robots geïmplementeerd kunnen worden in praktijk situaties en aan welke belangrijke randvoorwaarden dan voldaan moet worden volgens professionals. Dit resulteerde in een overzicht van randvoorwaarden gerelateerd aan de robot, de kinderen, de omgeving en aspecten rondom praktische implementatie. Bovendien is er een interventiesjabloon ontwikkeld dat handvatten biedt om op een systematische wijze robot interventies (en specifiek voor KASPAR) te beschrijven. Dit is beschreven in hoofdstuk 5. Bovendien zijn er tijdens een aantal co-creatie sessies met professionals, ouders van kinderen met autisme en volwassenen met autisme een aantal nieuwe ideeën bedacht en uitgewerkt voor KASPAR interventies. Dit leverde meer inzicht op over hoe robots praktisch ingebed kunnen worden in huidige praktijken en waar rekening mee dient te worden gehouden.

Hoofdstuk 6

Om het effect van een KASPAR interventie op kinderen met autisme te onderzoeken is een effect studie uitgevoerd in de praktijk. Deze studie bestond uit een ABAB design waarin het effect van KASPAR op contact maken werd onderzocht en is uitgevoerd bij een school voor speciaal onderwijs in Nederland. In de studie werd meer inzicht verkregen in de interactie van kinderen tijdens de sessies met KASPAR (fase A) vergeleken met de sessies met een begeleider (fase B). Micro gedragingen van de kinderen werden geanalyseerd aan de hand van opgenomen video beelden. Bovendien werden achteraf interviews aan de hand van de opgenomen video's gehouden met de begeleiders. Kinderen reageerden overwegend positief en open op KASPAR, ze maakten op non-verbale maar ook op verbale manier contact met KASPAR, namen initiatief en hadden langere gerichte aandacht tijdens de KAPSAR sessies dan met de begeleider, waren op hun gemak met KASPAR en hadden plezier tijdens de interacties met de robot. Betrokken begeleiders waren positief verrast over de interacties tussen de kinderen en KASPAR en de aanhoudende gerichte aandacht die kinderen toonden voor de robot. Significante verschillen werden gevonden tussen de KASPAR en begeleider conditie: kinderen raakten de robot vaker aan, lieten meer non-verbale imitatie zien met de robot en toonden langere en meer gerichte aandacht voor de robot vergeleken met de begeleider. De kinderen deden meer positieve verbale uitspraken als reactie op de begeleider dan ze deden als reactie op KASPAR. Klinisch relevant is het resultaat dat de kinderen meer positieve verbale uitspraken deden naar de robot vanuit hun eigen initiatief dan dat ze deden naar de begeleider. Deze studie toonde aan dat KASPAR een significante en relevante bijdrage kan leveren aan het maken van contact met kinderen met autisme.

Hoofdstuk 7

Het laatste hoofdstuk van dit proefschrift beschrijft een algemene discussie die de belangrijkste resultaten presenteert en een aantal additionele inzichten weergeeft die verworven zijn tijdens de studies. Verder worden een aantal kritische en methodologische reflecties beschreven en een aantal implicaties benoemd. Dit zijn implicaties voor kinderen met autisme, voor professionals in de onderwijs- en therapiepraktijk en voor ontwikkelaars van robots. Tenslotte worden in hoofdstuk 7 een aantal aanbevelingen gedaan voor verder onderzoek en beleid. Het sluit af met de conclusie dat de toepassing van robot-gebaseerde interventies beschouwd kan worden als een veelbelovende richting om therapie en speciaal onderwijs voor kinderen met autisme aan te vullen of verrijken. Dit heeft met name te maken met de manier waarop professionals ondersteund kunnen worden door de inzet van robots en de manier waarop kinderen geboeid worden, aandacht hebben, reageren en gemotiveerd raken om (wederzijdse) interactie aan te gaan. Echter, vanzelfsprekend zijn robots niet de oplossing voor alle behoeften en niet voor alle kinderen, zoals alle interventies in dit vakgebied. Robots kunnen één van de tools worden in de handen van autisme professionals om kinderen te helpen ontwikkelen, om te gaan met ‘hun’ autisme, en niet onbelangrijk, plezier te hebben. Om dit te kunnen bereiken en het potentieel van robots te kunnen benutten, is er nog wat (samen)werk aan de winkel voor mensen met verschillende achtergronden en ervaringen.

Valorisation

Valorisation

The research described in this dissertation was part of a larger research project called 'Social robots in care'. It was funded by the RAAK-PRO program of 'Stichting Innovatie Alliantie' of the Dutch Ministry of Education, Culture and Science (project number RAAK PRO-4-10). It focused on the practical application of three robot platforms (ZORA, PARO and KASPAR) for three target groups (children with physical disabilities, older people with dementia and children with autism spectrum disorder respectively). This thesis is part of the subproject studying interventions using KASPAR for children with autism. The studies conducted in this dissertation describe the potential and practical application of robot-mediated interventions (RMI) in practices for children with autism spectrum disorder (ASD), in particular robot KASPAR.

The use of robots is considered a promising direction to augment education or therapy practices for children with autism. However, to date, not much is known (in literature nor practice) about hów to integrate robots in educational and therapeutic protocols and settings. Successful integration of robots in school settings requires teachers' acceptance and adoption. Therefore we intensively involved professionals and other stakeholders throughout the research. For the outcomes of the research to be of real value, publishing in scientific peer reviewed journals is not sufficient to reach all relevant stakeholders. Besides the scientific community, also daily practice, educational settings and the general public may benefit from the lessons learned. This valorisation chapter describes the impact of the research findings on education, practice and society.

Valorisation can be seen as the process of value creation from knowledge, by making knowledge available or suitable for societal use and to make it appropriate for translation into products, services, processes and new commercial activities. In this project no commercial products or services have been delivered. We used a robot that was and is in prototype stage and contributed to the improvement of that prototype (new KASPAR scenarios have been developed, new requirements were elicited and practical insights were delivered). The valorisation of the results has largely been done throughout the conduction of and communication about the research itself. The intensive involvement of different target groups and numerous dissemination activities for various audiences created valuable insights on the application of robot-mediated interventions for different populations, which will be described in more detail. These populations are the general public, professionals and other stakeholders working in practice with children with autism, children with autism, students from different educations, and researchers and robot developers.

General public

For the general public this project contributed to the awareness and discussion on the use of robots in care or education. This was done by opening up the dialogue on this topic and sharing insights gathered so far. A number of concrete results and activities have been delivered. An accessible book is published and shared on the application of social robots in care: “Sociale robots in de zorg: van experiment tot zorgpraktijk” (ISBN 978-90-77901-90-8). A number of dissemination activities targeted at the general public have been undertaken, for example: contribution to the Futurum event, Rabobank member’s only event, demonstration and presentation for the "Zorginnovatiewinkel” by the Ministery of Health, Sport and Science, KASPAR was included in a book on old and new technology created by the CUBE museum, Parcours of Arts and Science (PAS) event by the University of Maastricht, demonstrations and presentation at the “Showroom van nu” and “Lunchen met robots” by the Ministry of Health, Sports and Science in The Hague and many more. The project also received quite some media attention. We were invited and interviewed four times by L1; twice for their TV programme Avondgasten and for radio and television news. Also we participated in a number of other television programmes of RTL 4 and RTL 5. A short movie was made for Heerlen Smart City Smart Services. Moreover, a 2Doc documentary for NPO2 was made by director Sander Burger called “Scenario’s voor een normaal leven” (Scenarios for a normal life). The goal of the documentary was to raise (public) awareness about autism and a potential role for a robot for children with autism. A boy called Jonathan is the main character in the documentary. Recordings were made of him at school, at home and during sessions with KASPAR. The documentary was broadcasted on national Dutch television, shown in the cinema “Filmhuis de Domijnen” for three (sold out) days, and can still be viewed online (also a version with English subtitles is available from the producers “Hollandse Helden”). The documentary received a lot of attention in the media and reached many people in the general public in the Netherlands. Interviews were given for local radio/television news channels (L1, OmroepStart Geleen). National and local newspapers and TV guides published about it (e.g. Trouw, De Volkskrant, NRC, De Limburger, VPRO gids). Also we were invited for the live TV program “Tijd voor Max” at prime time, with 1 million viewers (the day before the documentary was broadcasted). Articles have been written for/by the University of Maastricht, Hallo Limburg, Brigthlands, Zuyd Hogeschool. Radio interviews were given for “Omroep Start Geleen”, L1 and the VPRO guide. The documentary and the media attention that was generated afterwards resulted in quite some interest from parents of children with autism and professionals working in practice. Also, from people in our network we heard that parents of children with autism started to communicate in a KASPAR kind of way with their children and it delivered positive results. We heard often that viewing KASPAR at work with Jonathan, made people more aware of their own behaviour and they tried to be more “neutral” in the interactions with their children with autism. We are approached by several events, organisations, parents and professionals of children with autism with the question if we are willing to think about continuing this work.

Professionals and other stakeholders working with children with autism

The studies conducted demonstrate that there is potential in the use of robots for children with autism and that professionals are keen on and motivated for co-creating new robot-mediated interventions. Practical knowledge was gathered on how to create and apply robots in real life settings for children with autism. This is a new field of knowledge. Our approach was innovative in the sense that a large number professionals from many organisations were involved in an intensive manner. All these professionals have contributed without any kind of financial incentive. Professionals and other stakeholders (parents of children with autism, children and adults with autism, children with autism, and partners of people with autism) collaborated in focus group sessions and co-creation sessions. Often it was mentioned by participants that talking about their work and sharing experiences with peers gave them more insights and reflection about their own work. Together they were constructing the new upcoming field of robot-mediated interventions. Many of them expressed that they highly valued this involvement. Often people introduced the researchers to their colleagues at other organisations, stimulating their peers to participate in the research too. Besides the participation and voice that professionals and other stakeholders had in the research, also about hundred presentations, demonstrations and workshops have been given at special schools, (health)care organisations, (autism) interest organisations, and government bodies in this area. Some examples are presentations/demonstrations/workshops for organisations such as Meander, Adelante, Radar, Koraalgroep, Dutch Association for Autism (Nederlandse Vereniging voor Autisme), Vivium, De Parkschool, Stichting Mee, and Horizon. Also activities for national and local government bodies have been organised such as the Dutch Ministry of Health, Welfare and Sport, the Province of Limburg, and management of the municipality Parkstad Limburg).

Children with autism

Children with autism are considered as a ‘population’ that would hopefully benefit in the future from interactions with robots at school, in therapy settings or maybe even at home. Jonathan (the boy from the documentary) and (most of) the children who participated in the effect study visibly opened up and enjoyed the KASPAR sessions. Some of them also asked for KASPAR later on or called KASPAR their friend. Moreover, next to this element of fun, also positive effects were seen in their behaviour with respect to making contact and attention. Other studies report similar positive outcomes about the effects of robots for children with autism.

Education

The insights and knowledge gathered through this research are incorporated in various teaching activities of students from different disciplines and new educational content has been developed. Presentations, demonstrations, lectures, workshops have been given to students in the fields of occupational therapy, speech therapy, ICT, (healthcare) engineering, iArts, communication and multimedia design, psychology, advanced nursing, engineering students and even to primary school pupils. Multiple (applied) Universities have been involved: Maastricht University, Tilburg University, Delft University, Technical University of The Hague, Technical University of Eindhoven, Applied University of Windesheim, Applied and Technical Universities of Aachen (Germany), Applied University of Hasselt (Belgium), Jazan Applied University (Saoudi Arabia), Tokyo Metropolitan University (Japan), Linköping University (Sweden), ZorgTechniek Limburg, and German occupational therapy faculty. A number of students have participated thoroughly in the project which resulted in four theses. Two psychology students from Maastricht University contributed, a philosophy student from Tilburg University, a group of three occupational therapy students from Zuyd University of Applied Sciences, and a communication and multimedia Design student from Zuyd University of Applied Sciences.

Researchers and robot developers

For researchers and robot developers the practical insights on RMI gained from the professionals and other stakeholders are of value. For example:

- the objectives overview that shows important goals for children with autism;
- possible roles for robots;
- practical requirements;
- the intervention template that guides RMI developers when creating new robot-mediated interventions;
- the development of a number of co-created KASPAR scenarios.

Four articles addressing these findings have been published in international peer reviewed journals and an additional fifth article is under review. Also a short commentary is published in the International Journal of Neurorehabilitation. The work with KASPAR was also communicated in and with help of the LUDI network. This is a network enabling exchange of knowledge and experience. Specifically the aim is to promote international exchange of knowledge and expertise in the area of supporting play for children with disabilities. LUDI supported a Short Term Scientific Mission (STSM) exchange visit to the University of Hertfordshire. Findings and experiences on working with KASPAR for children with autism were shared during this exchange visit. Various presentations and demonstrations have been given at conferences and other events and several articles have been written for non-scientific readers.

Current status and outlook

The KASPAR robot that was used in the studies in this dissertation is a prototype developed by the University of Hertfordshire in the UK. It is not yet commercially available, however commercialisation plans and actions are being put in place at the moment. It is the aim to have KASPAR available on the market in the next few years.

Although this thesis did not deliver new products or services, it can be said that new insight were created on the potential of robot-mediated interventions for children with autism. A large share of these insights are not KASPAR specific and apply also when working with other robot platforms for children with autism. Currently, still regular requests are being made for presentations, demonstrations or new research activities. As a conclusion, it seems worthwhile to continue efforts investigating and co-creating this area towards practical implementation in current practices.

Dankwoord

Dankwoord

Het einde van dit promotietraject komt in zicht. Ik kan het eigenlijk niet geloven, want er is nog zoveel te doen, nog zoveel vragen, nog zoveel enthousiasme, nog zo veel zin om met dit veelbelovende werk en deze prachtige mensen door te gaan. Toch voel ik me tegelijkertijd heel blij dat er ietsje meer ruimte gaat komen. Het dankwoord schrijven. Hoe vaak heb ik dit uitgesteld omdat ik er nooit klaar voor was om er écht aan te beginnen. Het is haast onmogelijk om iedereen bij naam te noemen die er voor mij was, inhoudelijk of persoonlijk, ver weg of dichtbij, kortstondig of langdurig. Bedankt iedereen die onbaatzuchtig en onvoorwaardelijk dichtbij is gebleven in een tijd dat ik mijn sociale leven toch wel even in de diepvries moest bewaren om wat balletjes in de lucht te houden als frisse alleenstaande mama.

Wat heb ik toch geboft dat Gert Jan Gelderblom me in een Heerlense supermarkt aansprak een vijftal jaar geleden. “Claire, ik weet dat je lekker bezig bent bij Smart Homes en ik wil je daar ook niet wegkapen. Maar … we hebben een project dat eigenlijk op jouw lijf geschreven is … mag ik je wat meer vertellen erover …?”. Niet lang daarna vond het ‘sollicitatie gesprek’ plaats bij Luc de Witte thuis in de achtertuin in het zonnetje. Een promotieproject: Luc promotor, Gert Jan co-promotor. Kunnen robots iets betekenen voor kinderen met autisme? Meteen leek het alsof mijn bloed een soort van prikkellimonade was geworden; een opwekkende tinteling stroomde door mijn aders. Ik was geraakt, in mijn hart en hoofd. En wilde dan ook heel graag aan deze uitdaging beginnen. Oké, ik moet die verdediging nog maar even zien te doen ... maar … als jullie me nu zouden vragen nog een promotietraject te starten rondom dit thema, zou ik meteen ja zeggen en voorstellen morgen door te pakken. Gert Jan, veel te vroeg ben jij van ons heen gegaan. Nog regelmatig hebben we het over je, natuurlijk op ZAP, maar ook vaak op heel onverwachte momenten met collega’s in het werkveld, en dat zal ook altijd wel zo blijven. Ik ben je dankbaar dat je me toen toch aansprak ondanks je aarzeling.

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D

Luc de Witte, mijn promotor, jij doet je naam eer aan. Altijd het licht en het goede zien. Als ik weer eens een ideetje had en het jou voorhield, zei je "Ja, leuk, doen!". Er is altijd een weg te maken in jouw ogen, ookal (en soms denk ik wel eens, het liefst) waar er nog geen glad bewandeld pad ligt. Vooral doen waar je overtuiging ligt en dan stap voor stap doorgaan. Je wist me altijd het gevoel te geven dat ik dit "gewoon" kon. Ons overleg in december 2017 in Maastricht, vlak voor het afronden van mijn proefschrift zal ik nooit vergeten waarin je zei: "Claire, als ik jou een dag in dat hoekje van dit cafeetje zet, staat de discussie. En daarna nog een dagje voor de introductie." Ik heb wat langer in die figuurlijke hoek doorgebracht, maar de rode draad van je strekking klopte (alweer). Niet te moeilijk maken, gewoon beginnen, doorgaan en vooral afmaken. Het is gelukt. Ook de ruimte die je continue, volgens mij op een haast natuurlijke wijze, gaf aan me heeft me enorm goed gedaan. Als ik even vast zat in het schrijfproces vertelde je dat jij in op een dergelijk moment even piano gaat spelen. Ja! In plaats van druk te zetten in zo'n haperend moment geef jij vrijheid en ruimte. Wat een kracht. Wat je zei kwam binnen als ook *mijn* waarheid en ik ging spontaan grasmaaien, in de tuin werken of wandelen. Voordat ik het wist kwam mijn gedachtestroom weer op gang en kwam de vaart er weer in.

Lieve Dr. Renéeke (nu nog van den Heuvel ☺). Mijn steun en toeverlaat op ZAP en maatje in het Sociale robots in de zorg project. De meest attente en opmerkzame persoon van Sjummert, én omstreken! Toen ik je leerde kennen en je achternaam hoorde dacht ik, dit zit goed, kan niet anders. Bij Smart Homes had ik namelijk ook een collega die Van den Heuvel heette. Collega Herjan werd een vriend. Net als bij hem ontwikkelden wij ook een vriendschap vanuit het collega's zijn. Jij was al een half jaartje bezig toen ik bij Zuyd kwam werken en bent een paar maanden geleden gepromoveerd. Naast de vele momenten die we samen beleefden als we weer eens op pad mochten voor een *(ik kan het niet laten het woord ook maar even te noemen* ☺) circus optreden met onze robotvriendjes, heb jij me enorm geholpen in de wereld van brieven en formulieren rondom promoveren. Samenwerken met jou voelde niet als werken, maar meer als samen zijn. Ik ben blij dat je achter me zal staan als paranimf en hopelijk mag jij ook een stelling oplezen net zoals ik dat bij jouw promotie mocht doen ☺.

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Curriculum Vitae

CV

About the author

After getting her VWO diploma, Claire Huijnen (1977, Heerlen) studied Psychology at the University of Maastricht (1996-2000) and continued her education at the Technical University of Eindhoven in the area of User System Interaction and Technological Design (2000-2002). She worked on various user driven innovations for organisations as Philips Research, Vodafone Group Research, Smart Homes and Zuyd University of Applied Sciences. Since 2008 she has been actively involved in several (inter)national projects in the area of social robotics for several user groups and domains (e.g. children with autism, older people with mild cognitive impairment or dementia, and independent living for elderly). Currently, she works as a senior researcher on assistive technology in care, for the faculty of Health of Zuyd University of Applied Sciences and for the Centre of Expertise for Innovative Care and Technology (EIZT) in Heerlen (NL). Her passion lies in co-creating user driven innovations; making technology work for and with people in real life. The research and collaboration journey on studying the potential of robots for children with autism was (is) extremely rewarding, both emotionally and intellectually for her.

CV

List of publications

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This dissertation describes the potential of using robots in interventions for children with autism spectrum disorder. Although it may sound counterintuitive to use a robot to teach children with autism new social or communicative skills, robots dó seem to possess a number of characteristics that can enable professionals to create promising and motivating learning experiences for these children. What these characteristics are and how the potential of robot-mediated interventions (using humanoid robot KASPAR in particular) can be used in educational and therapy practices for children with autism can be read in this dissertation.