How can social robots spark collaboration and engagement among people with intellectual disability?

Saminda Sundeepa Balasuriya
Queensland University of Technology
Brisbane QLD Australia
samindasundeepa.balasuriya@hdr.qut.edu.au

Laurianne Sitbon
Queensland University of Technology
Brisbane QLD Australia
l.sitbon@qut.edu.au

Margot Brereton
Queensland University of Technology
Brisbane QLD Australia
m.brereton@qut.edu.au

Stewart Koplick
Endeavour Foundation
s.koplick@endeavour.com.au

ABSTRACT

Social robots have been successfully used in previous research to develop social behaviours among participants with Autism Spectrum Disorder (ASD). Technology has often been found to be a contributing factor to heightened engagement in learning activities, including for people with intellectual disability. This research proposes to build on these two opportunities by exploring the potential of social robots to elicit social interaction, cooperation and engagement among groups of adults with intellectual disability. The study presented here involved observation, semi structured interviews and video analysis of six participants with intellectual disability interacting with a social robot in a series of five weekly workshops. The robot used for this study was Cozmo ©, a small AI toy robot with a vehicular appearance and movement, and animated eyes that it uses to display human emotions. Participants played games with Cozmo and took turns in controlling its movements in small groups. Through an inductive thematic analysis we identified themes of collaboration, competition, positive affect and attitudes of participants as well as the factors that affected their engagement with Cozmo. We detail characteristic behaviours within each theme. The study found that interacting with Cozmo resulted in positive affect, high engagement and collaboration. The aspects of Cozmo that had the most positive impact were the ability to play games with it and its humanlike relatable behaviour.

CCS CONCEPTS

• **Human-centered computing → Human robot interaction (HRI)** → Interaction devices → Social robots

KEYWORDS
Social robot, intellectual disability, social interaction, human robot interaction

ACM Reference format:

Saminda S. Balasuriya, Laurianne Sitbon, Margot Brereton, Stewart Koplick. 2019. How can social robots spark collaboration and engagement among people with intellectual disability. In *Proceedings of ACM OzCHI'19 conference, Perth, Australia, 10 pages*

1 INTRODUCTION

Social robots are becoming increasingly common in today's society. In the past decade they have been brought into education and therapy environments, where a number of studies have been conducted to evaluate their effectiveness [14]. Social robots are being tested in many social situations. There is an opportunity and an urgency to influence their adoption and development in an inclusive manner, which is being recognised with extensive research on how robots can be used to help children with a diagnosis of ASD. [14] stated that preliminary evidence suggests that social robots are mainly beneficial for older people with dementia and children with autism. However, as yet there is yet limited literature on whether they can be beneficial for adults with ASD and intellectual disability.

According to the American Association of Intellectual and Developmental Disabilities (AAIDD), "intellectual disability is a disability characterized by significant limitations in both intellectual functioning and in adaptive behaviour, which covers many everyday social and practical skills", and originates before the age of 18. People with intellectual disability often find it difficult to communicate in a manner that meets most of society's expectations. This has been found to result in less social interactions [28] and less fulfilling relationships [10] than those present in a neurotypical population. However, people with intellectual disabilities still have many capabilities and many wish to develop their abilities to relate socially and to make friends. While day centres of organisations supporting people with intellectual disability try to emphasise group learning and the development of social skills, participants who find it difficult to engage in activities cooperatively miss out on the benefits of learning in small groups [26].

People with intellectual disability have shown interest in using new technology [8]. Past research has looked at how they use various social media platforms to achieve different goals [6], use voice activated interfaces to access information [4], use portable electronic assistive technology to become more independent [12] and engage individually with social robots. [14] pointed out future research should look into how social robots can contribute to group interactions. While there has been ongoing research in this area, much of it has been short term studies with children with ASD where the interactions under investigation were between human and robots. Therefore, the question addressed in the present study is, **how can robots contribute to social interaction, cooperation and engagement among groups of adults with intellectual disability?**

To explore this question, we recruited six neurodiverse adults (2 groups) (including people with ASD, intellectual disability and Down Syndrome) who attend a day centre from the Endeavour Foundation, an Australian Disability Service Organisation (DSO), to undertake a series of 5 weekly workshops with the social robot Cozmo©. The duration of the study was designed to explore beyond the novelty effects of interacting with the robot. Cozmo© was selected for this study for both its affordability (which means it could be used broadly) and its ability to display emotions through an LED display for its eyes and animated movements (ie. Expressing fear, curiosity, excitement, etc.). Previous research in ASD, has shown that robots are an effective way to increase engagement and social interactions in children [19, 42]. This research aimed to extend this investigation to understand their efficacy for supporting engagement and social interaction among adults with intellectual disability. We present a detailed understanding of which aspects of the robot contributed most to the increase in engagement and social interaction as well as the kinds of problems that ensued. The findings of this study will contribute towards the inclusive design of future social robots. By understanding what participants found useful, enjoyable, easy, interesting and challenging, design of future robots can better meet the needs and wants of people with intellectual disabilities.

The rest of the paper is organised as follows. After presenting prior research on social interactions with neurodiverse participants (people with intellectual disability or ASD) and social robots, we detail the methodology and how the workshops were iteratively designed. We then present our findings in relation to collaboration and engagement, and discuss how the robot's design and features may have contributed to our observations, paving the way for future work and future inclusive designs.

2 RELATED WORK

2.1 Neurodiverse Social interactions

Previous research has pointed out that people with intellectual disability often feel lonely and are not included in social situations [28]. Yet, according to the mothers of young adults with intellectual disability, having friends and social opportunities are among the most important aspects of their child's quality of life [25].

Often, research does not look at social inclusion from the perspective of young adults with intellectual disability. In light of this, Merrells, Buchanan and Waters (2019) [29] interviewed ten young adults with intellectual disability to understand social inclusion from their point of view. They stated that they liked being employed as it made them feel like part of the team and attending formal programs were an opportunity to meet other people with disabilities [29]. People with intellectual disability in this study reported feeling boredom when they were alone and preferred the company of others.

Young adults with intellectual disability often find it difficult to initiate and maintain friendships and the majority of their time is spent alone or with family and not with peers [29]. Their social networks consist mostly of family members and support workers, which puts them at a higher risk of loneliness and social isolation [28]. It is important for people with intellectual disability to have relationships with people that have shared life experiences, such as other people with intellectual disability [28]. They find it especially difficult to maintain friendships during transitional periods of their life, for example when they graduate from high school. However, family members and support workers can help people with intellectual disability maintain friendships during these transitional stages of their life [28]. While people with intellectual disability are able to form workplace relationships with co-workers and join in on workplace fun and jokes, these relationships rarely last outside of work hours and are not supportive. Therefore, the person with intellectual disability often has to depend on family and staff for social inclusion [15].

Almost 70% of people with ASD also have some form of intellectual disability [24]. Autism Specturm Disorders are neurodevelopmental conditions characterized by persistent significant impairment in the social-communication domain along with restricted, repetitive patterns of behaviour, interests and activities [1]. People with ASD typically have difficulties maintaining eye contact, understanding non-verbal attentional cues and turn taking during conversations [19]. People with ASD also report negative experiences in social situations and high levels of social isolation [9]. However, research shows that adults with mild ASD preferred the company of others rather than being alone despite feelings of anxiety [9]. Their anxiety arises due to self-awareness of their developing social competences in comparison to other people. This lack of social activity can hamper their learning opportunities. Education research has shown that learning in small groups has many benefits when compared to learning alone [26]. Additionally, social inclusion is critical as continued isolation could lead to mental health conditions such as depression and anxiety [31].

2.2 Neurodiverse Social Robotics

Figure 1: Robots used in previous research (left to right: Paro, Nao and Kaspar

People with ASD enjoy interacting with advanced technology [19, 37] with research showing the positive impact of their interest in robots [33, 34]. Previous research has highlighted the importance of intrinsic motivation during interactions between people with autism and robots [23]. It is possible to capitalise on this increased attention towards the robot to teach social skills and gestures more effectively than with another human [23]. People with intellectual disability are motivated to increase their social inclusion and are willing to learn new skills and increase their knowledge in certain areas to this end [2].

However, humanoid robots are often expensive and difficult to operate. Aslam compared an expensive Nao robot (see Figure 1) with a much cheaper Lego Mindstorm robot [3]. Four participants with intellectual disability between the ages of 10 and 16 completed learning tasks with both robots. The results showed that three out of four participants had significantly higher engagement with the Lego robot, but that both robots were equally effective in helping participants achieve their learning goals as there was no significant difference in their percentage error. The measured level of intellectual disability has been found to affect the amount of benefit that can come from robot assisted therapy. Robot assisted therapy was successful for autistic children with mild, moderate and severe intellectual disability but not for those with profound intellectual disability [13]. The authors propose that participants with profound intellectual disability were the least engaged because they had trouble comprehending the stimuli.

The majority of research with robots involves short term studies [11] and so the novelty effect is likely to be a cause for increased interactions. A long term study in a public school in Australia showed that the student's willingness to interact with Nao did not diminish even after 24 months, mainly due to the changes in the programs that the robots were used in [36]. Parents also noted that some skills like turn taking, self-expression, confidence and patience were transferred from the robot interaction to general settings [36]. A month long study where a socially assistive robot was placed in a home with a typically developing five year old and a six year old with ASD revealed that the children would like the robot to stay in their home for a longer period of time [11]. The parents stated that as time went by they became more comfortable with leaving their children to interact with the robot independently.

2.3 Neurodiverse robot interventions to develop social skills

Most of the participants in current research on social robots have been children with ASD or neurotypical children. Robots have successfully mediated interactions among children with autism, and they were found to interact differently with robots than they would with other people [41]. Children with ASD direct speech towards the robot like a typically developing child would to a person [20]. They interact and converse with other people more while engaged with the robot [19, 20]. Kim et al. (2013) [19] conducted a study with a robot condition and an adult condition. In the robot condition the child directed more verbal utterances to the researcher than during the adult scenario. This was only done once per child so the novelty factor of interacting with a robot could have played a major role. However, a study by [37] showed that a social robot was not able to elicit more verbal utterances than a human partner. The children held more eye contact with the robot but for verbal utterances, initiation of joint attention and positive affect, both human partner and robot had similar impact [37].

Social robots have also been able to teach children with ASD and intellectual disability to recognise and produce gestures [40]. The children could then generalise what they learned to different scenarios but were unable to reproduce the gestures appropriately when interacting with a human model.

Wainer, Ferrari, Dautenhahn and Robins (2010) [41] conducted research to understand whether collaborative behaviours among children with ASD can be increased by interacting with a robot in a group setting over an extended period of time. The researchers set up robotics classes where children with ASD programmed Lego NXT robots. The study found that when the children spent more time together they talked about the robot more. Most importantly the study found that the children were able to generalise their collaborative behaviours from the robotics class to other settings like a drawing class [41].

Research has shown that dyadic social interactions between children with autism can be improved by triadic interactions with the children and a robot [42]. Children with ASD playing a copycat game in dyadic scenarios and triadic scenarios showed several behavioural changes after their interaction with the robot KASPAR. In the dyadic play session after the triadic play session, the children showed more positive affect, more instances of speaking while gazing at the other child and more instances of gaze changes between the game and the other child [42]. This study also reported that lessons learned during play with the robot can be carried over to scenarios without the robot.

A humanoid Nao robot was able to improve verbal communication among three students with autism or intellectual disability in a public secondary school in South Australia. The participants were eager to work with Nao and intrinsic interest in the robot helped bring about improvements in their communication [35].

Adolescents with ASD working in pairs with typically developing adolescents in a summer robotics camp showed a reduction in self-reported social anxiety. Their shared interest in robotics helped them engage socially with their partners [16]. Since robots are a preferred reinforcer among people with ASD, using them to enhance social interactions will increase the production of target behaviours as the participants are intrinsically motivated [19].

Robots have also been used to prepare adults with ASD to face job interviews. Young adults with ASD faced a mock job interview with an android robot to increase self-confidence and reduce stress level [21]. Android robots are robots which are extremely humanlike in their appearance. The advantage of this system over a virtual reality mock interview is that the three-dimensional learning experience is a closer representation of the anxiety inducing situation of an actual job interview [21].

The previous research mentioned in this section has focused primarily on children and adolescents with ASD, short term interactions with the robot and human-robot interactions. Our research will look at how interacting with Cozmo affects human-human interaction among adults with intellectual disability over a period of five weeks.

3 METHODOLOGY

The study's methodology chose free and semi-free interactions between robots and participants, as, among the studies reviewed, these interactions they led to the most interesting descriptive observations [34]. The study took place over 5 weeks, where two researchers went to the day centre one day of the week to meet the participants. The research team went through a cycle of planning, implementing and reflecting each week, with an overall direction to get participants from discovery and experimentation with Cozmo towards control. We would plan the different activities that the participants would do with Cozmo, implement them during the session and reflect on the observations of the interactions. The aim was to give the participants a sense of independence to communicate with each other and to do what they wanted by the last session.

3.1 Participants

Six participants in our study were recruited through a day centre of a disability service organisation supporting people with intellectual disability. All participants were identified by the centre as having an intellectual disability, and additionally one was diagnosed with ASD, and another with Down Syndrome. Participants were invited to take part in the study by the centre manager, amongst people who regularly attend the day services where we ran the study on the day of the week that we had set for the study over the 5 weeks. All participants knew one another, from spending time together in other activities in the centre prior to the study.

Table 1 shows the participant details. The participants signed consent forms and agreed to take part in the research. The consent forms are provided in easy to read language and explained verbally to the participants, as set out in the ethical clearance protocol approved by the QUT research ethics office for this research. Five of the six participants were female. There were two groups each week and each group had at least two participants every time. Three of the participants participated every week for the five weeks of the study. Some participants chose to leave the study after some time, and some chose to only join at a later time. P6 decided to leave the study after the second session. To make up for her absence, P3 asked if she could bring P4 in. After obtaining her consent P4, was brought into the study from session three. P5 was only able to attend one session as he had another training program scheduled for that time.

Participant	Gender	Age	Diagnosis	Sessions
P1	F	31	Intellectual disability	S1, S2, S3, S4, S5
P2	F	24	Intellectual disability	S1, S2, S3, S4, S5
P3	F	26	Intellectual disability	S1, S2, S3, S4, S5
P4	F	29	Down syndrome	S3, S4, S5
P5	M	24	ASD	S3
P6	F	42	Intellectual disability	S1, S2

Table 1: Participant details

Two support workers (S1 & S2) were also interviewed as part of this study, and we collected their impressions of the sessions in terms of engagement and collaboration. Their perspectives were critical in the absence of other baseline information about the participants' typical level of social interaction and engagement with technology. Both of them said that none of the participants could be said to be close friends with one another.

Finally, one of the education managers of the DSO, who is familiar with the participants, having known some of them for many years, acted as both a participant and researcher in this research, and is a co-author of this paper.

3.2 Apparatus

3.2.1 Video recording devices All sessions were video-recorded primarily using a 180 degrees Kodak Pixpro © camera, or an HTC © 10 camera.

3.2.2 Cozmo. Cozmo (see Figure 2) is an AI toy robot produced by Anki. Cozmo has a visual appearance of a robotic vehicle with animated eyes that it uses to portray emotions. Its eyes, sounds and behaviours give it a cute animated appearance. A pilot study [22] of 16 individuals with ASD between the ages of 10 and 17 showed that most of them preferred cute mascot type robots over android and mechanical looking robots. People with ASD have strong likes and dislikes and if they do not like the robot being used the session may not be successful [22]. That is why we chose a small robot that acts cheerfully and friendly. Cozmo acts autonomously when it is left alone. For example, it explores its surroundings, plays with its cubes and sings songs. It gives the impression that it wants companionship by asking to play games, fist bump and saying the names of people it recognises. Cozmo is promoted as being as a robot with a mind of its own that is able to show emotions. It is not just a passive machine but a side-kick of its owner [39]. Cozmo's facial recognition features allow it to store up to 10 faces with their corresponding names. When Cozmo sees someone that it recognises it will say their name in a cheerful manner.

Figure 2: Cozmo

A smart device must be connected to Cozmo when it is being used. The device can be used to select activities that the user wants to do with the robot. Cozmo comes with 3 built-in games: 1) Quick Tap 2) Keep Away 3) Memory Match. In Quick Tap, each participant, including Cozmo, gets a cube. The cubes change colour and when all three are the same colour the quickest player to tap on their cube gets a point. This rule applies except when all the cubes turn red, in which case tapping the cube results in the other players getting a point. The first player to get five points wins. Keep Away is a game between Cozmo and one player. This game is a test of the player's reflexes and the objective is to prevent Cozmo from tapping on the cube. To do this the player must pull the cube away just before Cozmo can tap it. The player needs to succeed three times before Cozmo taps the cube three times in order to win. In Memory Match, the players are first shown a sequence in which the cubes light up and then have to repeat it by tapping the cubes in the same order. Cozmo also acts as a player in this game. The first player to make three mistakes loses the game.

In addition to these built-in games, the participants played a few other games contributed and shared by other Cozmo owners. Among these games, participants played Wakeup Cozmo and Cube Whack. We chose these games as they required active engagement from the users and could encourage conversation and cooperation among the participants. In Wakeup Cozmo the participants had to place the robot upside down so that it could 'sleep' and then tap on of the cubes to wake it up. When the players tap the cube, Cozmo would react with protests that many of the players in our study found humorous. In Cube Whack, each cube lights up in a different colour, and the participants have to tap in time the cube whose colour corresponds to the colour on Cozmo's back, which changes every second.

Cozmo also has a feeding feature which akin to a virtual pet that needs to be taken care of. The last interaction offered by Cozmo that participants used was the "explorer" mode. In this mode the user can take control of Cozmo and drive it around using controls on the screen of the smart device that is connected to it (similarly to a remote controlled toy car). The controls enable the user to pick up cubes, move Cozmo's head and greet people that it recognises.

3.3 Session design

Each session with Cozmo lasted for about 45 minutes, and the 5 sessions were set one week apart. During the first meeting with the participants, we asked participants if they had interacted with a robot before. None of the participants had interacted with a robot prior to the study. We told them that Cozmo was still sleeping and we would introduce them to the robot shortly. We used its 'meet Cozmo' feature with all the participants. Cozmo's facial recognition software allows it to recognise faces and learn people's names. Once it has scanned the participant's face it makes a 'ding' sound and says the person's name 2 times in a cheerful manner. Name calling is a useful way to get participants' attention and encourage interaction as people want to be distinguished as individuals [18].

Next, we showed participants how to play a game with Cozmo. For the first week we played the 3 built in games that come with Cozmo. During the first play session of each game, one of the researchers would show the participants how to play the game. The subsequent times the participants played the game without interference from the researchers. Games like Memory Match and Cube Whack could be played individually but we invited participants to play them cooperatively. For Memory Match we asked one participant to watch the pattern and tell the other player which cubes to tap. To make Cube Whack more cooperative we gave each participant one cube and placed the third cube between them.

After the second week, we gave the participants more control over what games they wanted to play. We taught them new things to do with Cozmo but it was up to them if they wanted to try the new activities or do the ones they were familiar with. Giving them freedom to do what they wanted showed us what interested participants and how they negotiate what to do. The quality and meaning of the interaction is not fully understood during structured observation [15]. We introduced them to the other code lab games and they experimented to see which games they liked. In the last two session we gave them full control of Cozmo by showing them how to control it on the smart device. The two participants had to decide what they wanted to do, and the researchers only stepped in on request.

We used subtle cognitive probes similar to that used by [19]: we instructed the participants and gave subtle cues to interact when they wait silently for over 10 seconds. Semi structured interviews were conducted before and after each session with the participants.

We conducted participant observations of group interactions of between two to three participants and a robot. Participant observation enabled us to collect qualitative data to develop a holistic understanding of the area of study in a manner that is as objective and accurate as possible given the limitations of the method [5]. The research team conducted a qualitative analysis of what the participants were saying to each other, to Cozmo and to the researchers. We used thematic analysis to analyse, identify and report patterns within the data [7].

4 FINDINGS

4.1 Collaboration and cooperation

Finding	Behaviour
Cooperation	• Verbally helping partner • Receiving help • Demonstrating correct procedure • Coordinating their tasks to win • Teaching their new games • Providing encouragement • Using gestures to help partner
Competitivenes s	• Moving blocks away from partner • Keeping track of score • Commenting on wins and losses • Comments towards Robot • Impatience during turn taking

Table 2: Participant behaviours

The researchers observed many instances of cooperation and competitiveness during the sessions with Cozmo. A list of behaviours frequently shown by participants can be seen in Table 2.

4.1.1 Cooperation during gameplay. Cube whack was the game that elicited the most cooperation from the participants. Participants were seen to comment on what they were observing, ask each other for help, give help, and correct each other, which led to a sense of cooperation. The participants had to work together if they wanted to get a good score. P1 had speech difficulties and sometimes could not be understood by the other participants. She would point at the cube and say the name of the colour when it matched what was on Cozmo's back and would tell P5 not to tap the wrong colours. She would say 'no, no' when he tapped the wrong colour. Participants chose to cooperate with their partners when they had difficulties in the game. P3 asked what colour was on Cozmo's back when she could not see it clearly and P6 replied 'white'. Even when P3 took the cubes away from P6 to have a turn on her own, P6 continued to shout out the colours to help her out.

Memory Match, Wakeup Cozmo and Quick Tap had similar levels of high collaboration between participants. In addition to the previous aspects of cooperation, here we observed participants encourage each other. Quick Tap was a game that only one player could win, so we were not expecting a high level of collaboration. However, we saw instances where participants helped each other. Winning was not enough, some participants wanted to help their partners succeed as well. When P2 tapped on a wrong occasion, P1 would say 'no' and alert her when she saw the incorrect pattern even though P1 would get a point every time P2 made a mistake.. P4 was not able to get a single point when playing the game and she would put her hands to her face and sighed. P3 noticed this, patted her on the shoulder and said encouraging words to her. P3 then helped her by taking P4's hand and tapping the cube when the sequence was correct.

Some participants had competencies that helped them do certain tasks better than their partners. During Memory Match, we asked one participant to watch the pattern and tell the other which cubes to tap in the correct order. This tweak encouraged collaboration in an otherwise single player game. When P1 and P2 played memory match, P2 volunteered to tap and so P1 watched the pattern. They were able to collaborate and make it to the fifth round. We asked them to reverse roles but this was less successful as P2 was not able to remember the patterns as well as P1. They played Memory Match again in the third session with P1 instructing P2 and made it to the fifth round again.

Groups displayed varying levels of collaboration when playing the same game. P3 and P6 played Wakeup Cozmo more cooperatively than P1 and P2. They would coordinate when to tap the cubes and tap at the same time. P3 would whisper 'ready' and they would tap together. When P3 felt like P6 was not involved enough she gave her all three cubes so that she could wake Cozmo up herself. S2 also said that it was the best he had seen P3 and P6 getting along as they were both dominant personalities. P1 and P2 were more focussed on hitting the cubes in front of them rather than planning a course of action together. However, they also displayed instances of cooperation.

4.1.2 Teaching and sharing information. Participants taught their partners how to do certain things with Cozmo that they knew how to do. For instance, if it was a participant's first time playing with Cozmo or first time playing a certain game, then the more experienced participant would teach the other. All participants except P4 and P5 provided some form of help to the other participant. P5 only attended one session and he was new to Cozmo whereas P1 and P2 were familiar with the robot. Therefore, they were helping him out and he was listening to their instructions. P2 explained the rules of Quick Tap, Cube Whack and Keep Away to P5. P1 has a speech impediment so was not able to explain the rules, but she did help him during the games by pointing at the cubes he needed to engage with or by saying the name of the colour he should be looking for. S1 said that P1 and P2 are usually "not good at sharing" but during our sessions P1 was taking turns and letting other participants play with Cozmo. Session 2 was P1's first time feeding Cozmo. Her partner P2 had done this before and we asked her if she would like to teach P1 how to feed Cozmo. P2 instructed her correctly on how to feed Cozmo but did not look at her. P2 also taught her to play Cube Whack but again did not look in her direction.

S1 said that P3 likes to mentor others and we saw this in our sessions when she was helping and encouraging P4 during the Cozmo games. In the third session P3 decided to bring P4 to join the session because P6 did not want to attend. P3 showed her how to play Quick Tap using gestures and words. She also taught her how to feed Cozmo and play games like Cube Whack. In the fourth session a support worker joined P3 and P4. P3 taught him how to feed Cozmo and the rules of Cube Whack. Even though P4 did not talk much, she also helped the support worker understand the rules by telling him 'we have to hit the colours'. She initiated a "high five" with the support worker when they got six points at Cube Whack.

4.1.3 Competitiveness. The participants expressed many instances of competitiveness when playing with Cozmo. They displayed this verbally and through their actions with Cozmo and their partners. Participants would celebrate when winning and were disappointed when losing. P2 and P3 displayed the most competitive behaviour amongst all the other participants.. During Quick Tap, P3 made verbal utterances when she was losing and celebrated every time she got a point. P2 also liked to dominate the sessions and told P3 to stop tapping on the cubes when she was not meant to. Some participants were unhappy if they felt like their partner had an unfair advantage in a game. For example, when they were playing Cube Whack, P3 was concerned that one cube was closer to P2 than her and she moved it closer to her even though they were on the same team. Both S1 and S2 confirmed that P2 and P3 are usually very competitive and dominant personalities.

P2 displayed many instances of competitiveness and dominance when paired with P1. At the start of session two, when the researchers asked who would want to go first, P2 raised her hand first and P1 pointed at P2, indicating that she wanted her to go first. When they were playing Wakeup Cozmo, P2 was not pleased when P1 hit the cubes on more occasions than she did and asked her to hit them one at a time. P1 continued to hit multiple cubes and so P2 tried to move her hands away from the cube to prevent it.

Some participants would keep track of the scores of their partners and their scores. They would also mention the winners and losers of the game even if they were not taking part. P2 would watch P1 play Keep Away and tell her what the score is and encourage her to improve if she was losing. S1 said that he was not surprised that P2 was always looking at the score as she is usually very competitive. P3 was the only participant to react competitively towards Cozmo's victory celebrations. She would comment by saying things like 'how rude' and stating her annoyance that Cozmo was winning. When Cozmo was winning, she made a fist towards Cozmo in a light-hearted way to signify her annoyance at Cozmo's lead. But she enjoyed the competition with Cozmo and when we turned down the difficulty level she complained that it was too easy. After a game of Cube Whack, she took the cubes away from her partner and started the game on her own. When the researchers asked her why she did that, she said she wanted to see how many points she can get on her own.

4.2 Engagement

4.2.1 Positive affect. We looked at instances when Cozmo caused positive affect among the participants. This is when the participants were smiling or laughing [42]. We found that participants were always amused when Cozmo referred to them by name. They would laugh and gesture towards the robot. Some participants would comment when Cozmo recognised one of the other people in the room. When Cozmo mentioned P5's name, P2 looked at him and said 'Hey P5 Cozmo just said your name!'.

Cozmo's random activities like singing and giving players fist bumps caused positive affect as well. Even though P5 did not talk during any gameplay periods he did comment when Cozmo started singing. P1 found Cozmo's quirky actions funnier than most games. She was laughing when Cozmo suddenly got hiccups and she had to turn it upside down to stop the hiccups. S2 stated that P1 does not usually smile a lot but we saw her smile several times during our sessions and it was uncommon to see her without a smile. Cozmo's vocalisation and speech was another cause of positive affect. When it said goodnight or complained about being woken up, most participants started laughing. His snoring was another point of amusement. P4 found it very amusing when Cozmo flipped over and did a wheelie to get up back again. She smiled while looking at the researcher and said 'that's so cool'.

The actions of other participants towards Cozmo was another reason for positive affect. When P5 pushed Cozmo during a fist bump sequence, P2 was very amused. P2 laughed while watching P1 play Keep Away, she was watching the score and updating P1 on the score. P3 kept saying 'This is so much fun' during P4's first session to encourage P4 to get involved. And after a few minutes P4 said 'this is so good!'. Getting points or winning at games also increased positive affect among participants. They would laugh and sometimes celebrate with a high five. Doing unscripted actions while controlling Cozmo, like dragging a pencil also caused positive affect. According to the support workers P1,P2, P3 and P4 were much more interested when interacting with Cozmo than they are in the normal workshops run by the staff. S1 stated that he had never seen P3 so engaged before.

4.2.2 Taking Control of Cozmo. The researchers gave the tablet that was connected to Cozmo over to the participants in their last two sessions. First, we taught them how to use Explorer mode which let the user take control of Cozmo's movements including his arms and head. The participants were very engaged in the tutorial and asked questions. P1, who is not very vocal, also asked questions regarding controlling Cozmo. She asked us 'how to turn right?' and P2 asked if we can still control Cozmo's movements while playing games. P2 volunteered to go first and she held onto the tablet for a long time so P1 tried to tap on the controls while P1 was holding the tablet but she moved it away from P1. P1 asked P2 to give her the tablet twice but was ignored and did not give it to her until we asked her to. P2 was able to figure out how to make Cozmo pickup and stack cubes without our help. S1 stated that he was not surprised that P2 learned to do this without the researchers help. After Explorer mode the participants were free to use the tablet to choose any activity with Cozmo. Participants had difficulty taking turns and wand wanted to choose the next activity by themselves without consulting their partner. Participants found new games that were not shown to them by the research team and learned to play them. During their last session together, P1 and P2 found a game called Colour Shuffle and by listening to Cozmo's instructions, they were able to understand the rules of the game and play it together.

P3 thoroughly enjoyed Explorer mode on Cozmo. She was laughing throughout most of the time she controlled Cozmo. P3 would make Cozmo move to the researchers so that she could see our faces on the tablet. She did not like it when Cozmo was pointed in her direction and covered her face. Initially P3 had trouble steering Cozmo but after a few attempts she mastered it. She would take suggestions from the researchers and execute them, for example when we asked her to push the cubes she drove it into a tower of cubes and made them topple which made her laugh.

4.2.3 Factors that affected engagement. Some participants did not understand the rules of the games and certain games that required participants to recall things from memory was also challenging. Memory Match required the participants to recall a sequence in which the cubes blinked. P1 was the most successful with this and P3 had moderate success. P2, P4 and P6 were not successful at remembering the sequence and correctly telling their partner what cubes to tap. P1 and P2 attempted to play a game called 'Twist, Tap, Roll!' where the participants had to match the action with a colour, but they could not remember which colour corresponded with a particular action. However, they only attempted this game on two occasions and it is possible that they could master it with more practice. P4 was frustrated when she could not understand the rules of the game. There were occasions when she put her hands to head and sighed because she thought that she made a mistake in the game. P3 would console her and help her out and that would usually make her feel better.

There were some difficulties when participants tried to communicate with us and other participants. P1 has a speech impediment so it was difficult for the other participants to understand what she was trying to say at times. She gave 'yes' and 'no' answers but rarely elaborated when probed further. For example, when we asked if she wants to play another game, she said 'yes' but when we asked her which game she wanted to play she said 'don't know'. Cozmo had random events like prompting to play a certain game or getting the hiccups. On one occasion when Cozmo got the hiccups, the app tried to communicate this to the participant via a popup. It wouldn't stop the hiccup sequence until the participant placed the robot upside down. P3 was unsure why this was happening and kept ignoring the pop up and trying to play the game. She did not read it until we told her to.

P6 was the only participant that wanted to leave the study. She did not attend any sessions after day two. The reasons she gave the research team was that she didn't feel like she was learning anything new when engaging with Cozmo. However, there were games where she was laughing and communicating with the other participant. It is possible that she did not understand how to play the games as we noticed that she would often mirror the other participants and only tap on a cube when they did and repeat the phrases that Cozmo or other participants said. According to S2 the reason for P6 not attending after the second session could be because she likes routines and does not like deviating from them. He did state that she looked interested in Cozmo but her vision impairment may have made it difficult for her to see the colours on Cozmo and the cubes. S2 said that Cozmo may not be within P6's field of interest as she was much older than the rest of the participants.

P5 was the only participant with ASD in the study. He did not show as much interest in Cozmo as the research team expected since previous research suggests that people with ASD are interested in technology and robots in particular [33, 34]. He also had trouble understanding the rules of games like Cube Whack and would tap random cubes that did not match the colour that the participants were looking for. He would also look at P2 when she was interacting with Cozmo and try to get her attention. S1 theorised that the presence of P2 may have disrupted P5's attention with Cozmo as he likes P2 a lot. P5 also said he would like to show Cozmo to his mother. He did not attend any further sessions because he was enrolled in another training program at that time. However S2 said that P5 looked interested but it was the normal amount of engagement that he had when he was interested in something.

4.3 Participant attitudes

Throughout the sessions, the researchers asked questions to understand the participant's attitudes and perceptions towards Cozmo.

4.3.1 Projected use of Cozmo. The researchers asked participants about Cozmo's communication skills and if they would like it to talk more. P1 simply said 'yes' and P2 stated that she has seen Cozmo talk to itself a lot when they play games. She also stated that it tells them what colours to tap and alerts them about when to start the game. We asked them if they would like to ask Cozmo any particular question and P2 said that she would like to ask it what it would like to play.

After each session we asked the participants what their favourite Cozmo game was and the answer usually changed every session. P2 said her favourite game was Keep Away during her second session, Cube Whack in the third session and Twist, Turn, Roll in the last session. P1 said Keep Away and Quick Tap on different occasions. The reason for different answers could be that they were choosing the game that they had the most fun with during that session.

We asked participants if they would like to show Cozmo to anyone and P1, P2, P3 and P5 said they would show it to their parents P3 stated on multiple occasions that she had asked her mother to buy her a Cozmo. She said that she wanted to buy one so that she could chase her cats around with Cozmo. P3 said that she wants a big robot that could go to the store to buy doughnuts for her and do her homework. P2 also said that she would like a bigger robot that was about her size. P2 said she would like to show it to her other friends at the learning centre as well. We asked the participants if they could learn anything from interacting with Cozmo. P2 said that they should try learning new and different games and find out how to play them. She also said that with Cozmo she could be artistic and play games as well. P1 said that she can learn math with Cozmo. P3 was using Cozmo says feature to type things that she found challenging to spell and then enjoyed hearing Cozmo saying them out loud.

4.3.2 Anthropomorphising Cozmo. The participants said things that made it sound like they attributed autonomy to Cozmo. When Cozmo was about to fall off the edge of the table P6 scolded Cozmo for going to close to the edge. She said to the robot 'Just wait Cozmo" when it was making noises. During Wakeup Cozmo, Cozmo asked the participants to flip it over if they want to play again and P1 replied with 'yes' instead of doing the action.

Participants attributed feelings and emotions to Cozmo as well. People tend to anthropomorphise robots if they resemble us. Resemblance is achieved by social cues and body languages [30]. Cozmo could display emotions with his animated eyes. Cozmo could also sing, initiate fist bumps, call people by their names, celebrate when it wins and mope when it loses. This made Cozmo feel more relatable to the participants as these were behaviours that most of them were familiar with. When we asked them how Cozmo feels during the Wakeup Cozmo game, P2 stated that Cozmo is feeling angry and sad because they kept waking it up and P1 agreed with her. One of the researchers switched to a different game while P3 was feeding Cozmo and she stated, 'Aww he's not happy now!'. But she also attributed states like hunger to Cozmo when feeding Cozmo. She asked the researchers 'is he feeling hungry?' and was surprised when Cozmo fed on the cubes, 'he took them all in at once!'. P3 also found Cozmo's snoring amusing and stated that it was purring like a cat. She was the most competitive with Cozmo and would comment on how it gloats when it wins and would gloat at Cozmo when she won. When they were playing Wakeup Cozmo, both P6 and P3 were whispering about when they should tap the cubes because they did not want their voices to wake it up.

A few participants made comments about Cozmo being connected to the phone or being controlled by us. During her first session P3 stated that Cozmo was connected to the researcher's phone when she observed me bringing it online. This indicates that they were aware that Cozmo was not fully autonomous even though at times they spoke to it like a pet. Smart technologies need to hide their technological interiors to appear smart and if they are too transparent we see them as passive machines instead of independent and smart companions [39].

We asked all the participants if they thought Cozmo had a gender and if they did, what was it. All of them said that Cozmo was a boy. They said his voice was that of a boy and always used male pronouns when referring to Cozmo. Anki's marketing material uses the word 'guy' indicating that the developers had a gender in mind for the robot [39].

5 DISCUSSION

The research team observed many instances of participant collaboration and cooperation. Past research has showed that reinforcers that lead to intrinsic motivation result in improvements in social engagement [32]. It is possible that Cozmo was a reinforcer that promoted intrinsic motivation, so it encouraged more social interactions. This included instances where participants helped each other, took turns, shared information and taught the other participant how to play a game. Their shared intrinsic interest in the robot may have helped facilitate an increase in communication between the participants [16].

Our observations showed that positive affect occurred mostly when the participants were playing a game with Cozmo, when Cozmo displayed relatable behaviour or when they were watching others engage with Cozmo. Understanding how robots like Cozmo can improve positive affect can be useful to help relieve people with disabilities that have been through stressful situations. Research conducted with children with typical development showed that a social robot can improve positive mood after moderate psychological stress [14].

Some of the games that were played with Cozmo, like Quick Tap, did not require any communication between the participants. But they did speak to each other during and after the games. Other games like Memory Match and Cube Whack were played in such a way that communication was necessary. Learning how to play a game could also lead to social interactions as the participants communicated to ask questions or to teach their partner. Sometimes they did not require the researcher's help to figure things out as they learnt together. Watching others play with Cozmo was another point of interaction. Participants would laugh, comment on the score or provide advice to the person that was playing. Previous research has shown that when children with ASD spent more time with the robot, their collaboration increased [41]. However, if they were not involved in the game after some time they would become agitated and want to play.

A robot's emotive facial expressions coupled with human like behaviours can encourage people that interact with them to develop emotional bonds with them [30]. Cozmo's singing, initiation of fist bumps, snoring, celebrating, name calling and talking to the participants made participants interact with it more and cause positive affect. They would often comment on his activity with their partners or smile and laugh while looking at them. Name calling is a useful way to get participants' attention and encourage interaction as people want to be distinguished as individuals [18]. Robots have been successful in facilitating spontaneous conversation and verbal participation among students with autism and intellectual disability [36]. Participants stated that they liked talking to Cozmo and the researchers observed that participants liked talking about Cozmo with each other.

Dyadic interactions between children improved after triadic interactions with a robot [42]. The support worker interviews in our study suggested that participants communicated and collaborated more in the presence of Cozmo. They stated that some participants showed far greater levels of engagement that they usually do in other activities carried out in the learning centre.

People with intellectual disability can improve on tasks that require memory if they are taught continuously and are given the opportunity to rehearse their learnings [27]. We observed that participants were able to learn new games on their own or to build on lessons taught by the researchers. Games that required remembering colours and patterns were challenging for some participants. When they initially had trouble with a particular game or task, they were able to improve in subsequent attempts.

Attitudes towards Cozmo were positive and most of the participants wanted to engage with Cozmo outside of the sessions. They mentioned that they want to show Cozmo to their families. This is not surprising as for most people with intellectual disability their social network consists mostly of their family [28]. Other participants mentioned that they want to a larger version of Cozmo to run daily errands for them or to engage in fun family activities like playing with their pets. This shows that they want more engagement from Cozmo and for the robot to perform a wider range of social activities. Previous research suggested that participants with ASD should initially be familiarised with visually simple robots before moving onto android robots that look similar to humans [23]. Future research should look at how people with intellectual disability interact with more humanoid robots.

In our research we observed many instances of participants attributing human characteristics to Cozmo. They would comment on how Cozmo was feeling based on what Cozmo said or did. Anki describes Cozmo as 'almost human' and 'self-aware' and designed the robot to display human-like emotions to develop a social bond with the user [39]. People, children in particular, attribute human characteristics to robots [38]. In previous research children attributed mental states to robots and young adults have attributed more moral accountability to robots than to other machines [17]. Children with ASD have also been observed directing speech towards robots like a typically developing child would to a person [20]. This is in line with what was observed with the participants in this study.

The main reason for having multiple sessions was to see if the novelty factor of using Cozmo would ware off and the participants would lose interest. A limitation of many previous studies was that the participants had a single interaction with the robot [14, 19, 37]. The novelty effect of the robot may have caused exaggerated positive results and if the participants could interact with the robot on more occasions the researchers may have seen diminishing results. In our study participants showed more instances of positive affect as they got to know Cozmo and its games better. Participants like P3 and P4 who were sceptical on the first try became increasingly engaged in the following sessions. Participants were also very eager to come into the sessions and always walked in on time when the researchers came to the centre. This is similar to [36] where the children's interest in the robot did not diminish with long term exposure. Just like that study we also introduced variations in what can be done with the robot.

The research team has identified a few areas for possible future research. Research can investigate how robots can facilitate group learning among participants with intellectual disability. Some of the participants suggested that they would like to involve Cozmo in their learning routines. Another area to look at would be to include people with intellectual disabilities in the design of social robots. Participants in our study said that they wanted to interact with larger robots. Several participants in our study said they would like it if the robot would speak more. They may also be more willing to learn from a robot teacher and be less anxious about making mistakes as previous research has indicated that people perceive robots as non-judgemental [14].

6 CONCLUSION

Previous research on use of social robots to elicit social interaction and engagement has mainly focussed on children with ASD. This research looked at how social robots can be beneficial for adults with intellectual disability engaging in social interactions. Social interaction included instances of participants teaching each other how to play with Cozmo, cooperating to win a game and engaging in conversation about Cozmo. As found in prior studies with participants with ASD, participants with intellectual disability were also interested in interacting with robots. Their intrinsic motivation to play with Cozmo was able to be leveraged to encourage social interactions between the participants. Through Cozmo we were able to see participants take turns, collaborate to win games, share knowledge on how to do certain things with Cozmo and laugh at things that they found funny.

Cozmo's ability to play games and his relatable behaviour were found to be the main reasons for participants engaging with each other and Cozmo. We conclude that the participants' engagement with each other increased with the introduction of Cozmo. This finding was confirmed by the support workers that watched footage of the sessions. We also saw an increase in engagement in most of the participants' last session when compared with the first session, which suggests that the novelty factor of Cozmo was not the reason for interacting with it. We conclude that social robots can be used to motivate people with intellectual disability to take part in social or group activities.

ACKNOWLEDGMENTS

This research is supported by the Australian Research Council under grant LP160100800, jointly with Endeavour Foundation. We acknowledge the time and dedication of our participants, as well as the staff of the sites we visited.

REFERENCES

[1] American Psychiatric Association. 2013. Diagnostic and Statistical Manual of Mental Disorders : Dsm-5 (Fifth edition.). American Psychiatric Publishing, Arlington, VA.

[2] Suzanne Abbott and Roy McConkey. 2006. The Barriers to Social Inclusion as Perceived by People with Intellectual Disabilities. Journal of Intellectual Disabilities 10, 3, 275-287. http://dx.doi.org/10.1177/1744629506067618

[3] S. Aslam, P. J. Standen, N. Shopland, A. Burton and D. Brown. 2016. A Comparison of Humanoid and Non-Humanoid Robots in Supporting the Learning of Pupils with Severe Intellectual Disabilities. In Proceedings of 2016 International Conference on Interactive Technologies and Games (ITAG). 7-12. http://dx.doi.org/10.1109/iTAG.2016.9

[4] Saminda Sundeepa Balasuriya, Laurianne Sitbon, Andrew A. Bayor, Maria Hoogstrate and Margot Brereton. 2018. Use of Voice Activated Interfaces by People with Intellectual Disability. In Proceedings of OzCHI'18. ACM, 102-112. http://dx.doi.org/10.1145/3292147.3292161

[5] B. Kawulich Barbara. 2005. Participant Observation as a Data Collection Method. Forum: Qualitative Social Research 6, 2.

[6] Andrew Bayor, Filip Bircanin, Laurianne Sitbon, Bernd Ploderer, Stewart Koplick and Margot Brereton. 2018. Characterizing Participation across Social Media Sites Amongst Young Adults with Intellectual Disability. In Proceedings of OzCHI'18. ACM, 113-122. http://dx.org/10.1145/3292147.3292167

[7] Virginia Braun and Victoria Clarke. 2006. Using Thematic Analysis in Psychology. Qualitative Research in Psychology 3, 2, 77-101. http://dx.doi.org/10.1191/1478088706qp063oa

[8] Allison C. Carey, Mark G. Friedman and Diane Nelson Bryen. 2005. Use of Electronic Technologies by People with Intellectual Disabilities 43, 5, 322-333. http://dx.doi.org/10.1352/0047-6765(2005)43[322:Uoetbp]2.0.Co;2

[9] Yu-Wei Chen, Anita Bundy, Reinie Cordier, Yi-Ling Chien and Stewart Einfeld. 2016. The Experience of Social Participation in Everyday Contexts among Individuals with Autism Spectrum Disorders: An Experience Sampling Study. Journal of Autism and Developmental Disorders 46, 4, 1403-1414. http://dx.doi.org/10.1007/s10803-015-2682-4

[10] Fullwood Chris, Wesson Caroline and Chadwick Darren. 2013. Internet Access by People with Intellectual Disabilities: Inequalities and Opportunities. Future Internet 5, 3, 376-397. http://dx.doi.org/10.3390/fi5030376

[11] C. Clabaugh, D. Becerra, E. Deng, G. Ragusa and M. Matari. 2018. Month Long, In-Home Case Study of a Socially Assistive Robot for Children with Autism Spectrum Disorder. In Proceedings of HRI '18. ACM, 87-88,

[12] James C. Collins and Lana Collet-Klingenberg. 2018. Portable Electronic Assistive Technology to Improve Vocational Task Completion in Young Adults with an Intellectual Disability: A Review of the Literature. Journal of Intellectual Disabilities 22, 3, 213-232. http://dx.doi.org/10.1177/1744629516689336

[13] Daniela Conti, Grazia Trubia, Serafino Buono, Santo Di Nuovo and Alessandro Di Nuovo. 2018. Evaluation of a Robot-Assisted Therapy for Children with Autism and Intellectual Disability. In Proceedings of Towards Autonomous Robotic Systems. Springer International Publishing, 405-415.

[14] Molly Crossman, Alan Kazdin and Elizabeth Kitt. 2018. The Influence of a Socially Assistive Robot on Mood, Anxiety, and Arousal in Children. Professional Psychology : Research and Practice 49, 1, 48. http://dx.doi.org/10.1037/pro0000177

[15] Andrew Jahoda, Jeremy Kemp, Sheila Riddell and Pauline Banks. 2008. Feelings About Work: A Review of the Socio-Emotional Impact of Supported Employment on People with Intellectual Disabilities. Journal of Applied Research in Intellectual Disabilities 21, 1, 1-18. http://dx.doi.org/10.1111/j.1468-3148.2007.00365.x

[16] Juhi Kaboski, Joshua Diehl, Jane Beriont, Charles Crowell, Michael Villano, Kristin Wier and Karen Tang. 2015. Brief Report: A Pilot Summer Robotics Camp to Reduce Social Anxiety and Improve Social/Vocational Skills in Adolescents with Asd. Journal of Autism and Developmental Disorders 45, 12, 3862-3869. http://dx.doi.org/10.1007/s10803-014-2153-3

[17] Peter H. Kahn, Heather E. Gary and Solace Shen. 2013. Children's Social Relationships with Current and near-Future Robots. Child Development Perspectives 7, 1, 32-37. http://dx.doi.org/10.1111/cdep.12011

[18] T. Kanda, R. Sato, N. Saiwaki and H. Ishiguro. 2007. A Two-Month Field Trial in an Elementary School for Long-Term Human–Robot Interaction. Robotics, IEEE Transactions on 23, 5, 962-971. http://dx.doi.org/10.1109/TRO.2007.904904

[19] Elizabeth S. Kim, Lauren D. Berkovits, Emily P. Bernier, Dan Leyzberg, Frederick Shic, Rhea Paul and Brian Scassellati. 2013. Social Robots as Embedded Reinforcers of Social Behavior in Children with Autism. Journal of Autism and Developmental Disorders 43, 5, 1038-1049. http://dx.doi.org/10.1007/s10803-012-1645-2

[20] H. Kozima, M. P. Michalowski and C. Nakagawa. 2009. Keepon: A Playful Robot for Research, Therapy, and Entertainment. International Journal of Social Robotics 1, 1, 3-18. http://dx.doi.org/10.1007/s12369-008-0009-8

[21] H. Kumazaki, Z. Warren, B. A. Corbett, Y. Yoshikawa, Y. Matsumoto, H. Higashida, T. Yuhi, T. Ikeda, H. Ishiguro and M. Kikuchi. 2017. Android Robot-Mediated Mock Job Interview Sessions for Young Adults with Autism Spectrum Disorder: A Pilot Study. Frontiers in Psychiatry 8, <xocs:firstpage xmlns:xocs=""/>. http://dx.doi.org/10.3389/fpsyt.2017.00169

[22] Hirokazu Kumazaki, Zachary Warren, Taro Muramatsu, Yuichiro Yoshikawa, Yoshio Matsumoto, Masutomo Miyao, Mitsuko Nakano, Sakae Mizushima, Yujin Wakita, Hiroshi Ishiguro, Masaru Mimura, Yoshio Minabe and Mitsuru Kikuchi. 2017. A Pilot Study for Robot Appearance Preferences among High-Functioning Individuals with Autism Spectrum Disorder: Implications for Therapeutic Use.(Research Article)(Report). PLoS ONE 12, 10, e0186581. http://dx.doi.org/10.1371/journal.pone.0186581

[23] Hirokazu Kumazaki, Zachary Warren, Amy Swanson, Yuichiro Yoshikawa, Yoshio Matsumoto, Hideyuki Takahashi, Nilanjan Sarkar, Hiroshi Ishiguro, Masaru Mimura, Yoshio Minabe and Mitsuru Kikuchi. 2018. Can Robotic Systems Promote Self-Disclosure in Adolescents with Autism Spectrum Disorder? A Pilot Study.(Report). Frontiers in Psychiatry 9. http://dx.doi.org/10.3389/fpsyt.2018.00036

[24] G. La Malfa, S. Lassi, M. Bertelli, R. Salvini and G. F. Placidi. 2004. Autism and Intellectual Disability: A Study of Prevalence on a Sample of the Italian Population. Journal of Intellectual Disability Research 48, 3, 262-267. http://dx.doi.org/10.1111/j.1365-2788.2003.00567.x

[25] Laura Lee Mcintyre, Bonnie R. Kraemer, Jan Blacher and Susan Simmerman. 2004. Quality of Life for Young Adults with Severe Intellectual Disability: Mothers' Thoughts and Reflections. Journal of Intellectual and Developmental Disability 29, 2, 131-146. http://dx.doi.org/10.1080/13668250410001709485

[26] Iolanda Leite, Marissa McCoy, Monika Lohani, Daniel Ullman, Nicole Salomons, Charlene Stokes, Susan Rivers and Brian Scassellati. 2015. Emotional Storytelling in the Classroom: Individual Versus Group Interaction between Children and Robots. In Proceedings of HRI '15. ACM, 75-82. http://dx.doi.org/10.1145/2696454.2696481

[27] Hefziba Lifshitz, Esther Kilberg and Eli Vakil. 2016. Working Memory Studies among Individuals with Intellectual Disability: An Integrative Research Review. Research in Developmental Disabilities 59, C, 147-165. http://dx.doi.org/10.1016/j.ridd.2016.08.001

[28] Keith R. McVilly, Roger J. Stancliffe, Trevor R. Parmenter and Rosanne M. Burton-Smith. 2006. "I Get by with a Little Help from My Friends": Adults with Intellectual Disability Discuss Loneliness. Journal of Applied Research in Intellectual Disabilities 19, 2, 191-203. http://dx.doi.org/10.1111/j.1468-3148.2005.00261.x

[29] Jessica Merrells, Angus Buchanan and Rebecca Waters. 2019. "We Feel Left Out": Experiences of Social Inclusion from the Perspective of Young Adults with Intellectual Disability. Journal of Intellectual & Developmental Disability 44, 1, 13-22. http://dx.doi.org/10.3109/13668250.2017.1310822

[30] Marco Nørskov. 2016. Social Robots : Boundaries, Potential, Challenges. Taylor and Francis, Florence.

[31] G. I. Orsmond, P. T. Shattuck, B. P. Cooper, P. R. Sterzing and K. A. Anderson. 2013. Social Participation among Young Adults with an Autism Spectrum Disorder. Journal of Autism and Developmental Disorders 43, 11, 1-10. http://dx.doi.org/10.1007/s10803-013-1833-8

[32] Rhea Paul. 2008. Interventions to Improve Communication in Autism. Child and Adolescent Psychiatric Clinics of North America 17, 4, 835-856. http://dx.doi.org/10.1016/j.chc.2008.06.011

[33] Valentina Pennazio. 2017. Social Robotics to Help Children with Autism in Their Interactions through Imitation. Research on Education and Media 9, 1, 10-16. http://dx.doi.org/10.1515/rem-2017-0003

[34] Paola Pennisi, Alessandro Tonacci, Gennaro Tartarisco, Lucia Billeci, Liliana Ruta, Sebastiano Gangemi and Giovanni Pioggia. 2016. Autism and Social Robotics: A Systematic Review. Autism Research 9, 2, 165-183. http://dx.doi.org/10.1002/aur.1527

[35] D. Silvera-Tawil, D. Bradford and C. Roberts-Yates. 2018. Talk to Me: The Role of Human-Robot Interaction in Improving Verbal Communication Skills in Students with Autism or Intellectual Disability. In Proceedings of 2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN). 1-6. http://dx.doi.org/10.1109/ROMAN.2018.8525698

[36] D. Silvera-Tawil and C. R. Yates. 2018. Socially-Assistive Robots to Enhance Learning for Secondary Students with Intellectual Disabilities and Autism. In Proceedings of 2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN). 838-843. http://dx.doi.org/10.1109/ROMAN.2018.8525743

[37] Ramona E. Simut, Johan Vanderfaeillie, Andreea Peca, Greet Van de Perre and Bram Vanderborght. 2016. Children with Autism Spectrum Disorders Make a Fruit Salad with Probo, the Social Robot: An Interaction Study. Journal of Autism and Developmental Disorders 46, 1, 113-126. http://dx.doi.org/10.1007/s10803-015-2556-9

[38] Claudia Sinoo, Sylvia van Der Pal, Olivier A. Blanson Henkemans, Anouk Keizer, Bert P. B. Bierman, Rosemarijn Looije and Mark A. Neerincx. 2018.

Friendship with a Robot: Children's Perception of Similarity between a Robot's Physical and Virtual Embodiment That Supports Diabetes Self-Management. Patient Education and Counseling 101, 7, 1248-1255. http://dx.doi.org/10.1016/j.pec.2018.02.008

[39] Jörgen Skågeby. 2018. "Well-Behaved Robots Rarely Make History": Coactive Technologies and Partner Relations.

[40] Wing-Chee So, Miranda Kit-Yi Wong, Carrie Ka-Yee Lam, Wan-Yi Lam, Anthony Tsz-Fung Chui, Tsz-Lok Lee, Hoi-Man Ng, Chun-Hung Chan and Daniel Chun-Wing Fok. 2018. Using a Social Robot to Teach Gestural Recognition and Production in Children with Autism Spectrum Disorders. Disability and Rehabilitation: Assistive Technology 13, 6, 527-539. http://dx.doi.org/10.1080/17483107.2017.1344886

[41] Joshua Wainer, Ester Ferrari, Kerstin Dautenhahn and Ben Robins. 2010. The Effectiveness of Using a Robotics Class to Foster Collaboration among Groups of Children with Autism in an Exploratory Study. Personal and Ubiquitous Computing 14, 5, 445-455. http://dx.doi.org/10.1007/s00779-009-0266-z

[42] Joshua Wainer, Ben Robins, Farshid Amirabdollahian and Kerstin Dautenhahn. 2014. Using the Humanoid Robot Kaspar to Autonomously Play Triadic Games and Facilitate Collaborative Play among Children with Autism. Autonomous Mental Development, IEEE Transactions on 6, 3, 183-199. http://dx.doi.org/10.1109/TAMD.2014.2303116