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FINAL REPORT

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Terminology and abbreviations

Because many people on the spectrum reject the use of the term ‘disorder’ to describe their experience of autism, the authors of this report have chosen to use the terminology ‘the autism spectrum’, ‘students on the autism spectrum’ and ‘students on the spectrum’ when referring to the conditions described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as ‘autism spectrum disorder’. However, the terminology used by the survey participants around autism spectrum disorder has not been altered in the qualitative data sections and is their chosen wording.

The Cooperative Research Centre for Autism (Autism CRC)

The Cooperative Research Centre for Autism (Autism CRC) is the world’s first national, cooperative research effort focused on autism. Taking a whole of life approach to autism focusing on diagnosis, education and adult life, Autism CRC researchers are working with end-users to provide evidence-based outcomes which can be translated into practical solutions for governments, service providers, education and health professionals, families, and people on the autism spectrum.

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Abstract

The current pilot study evaluated the effects of using a humanoid robot to help develop the social perspective-taking skills of school-age children on the autism spectrum, during story retelling. Storytelling and retelling are activities that occur at school and in family and social situations. Understanding how children on the autism spectrum perceive and react to humanoid robots, and how these robots can help strengthen the story retelling and perspective-taking skills for children on the autism spectrum has significant implications for the planning of more effective group interventions.

Non-autistic children's retelling of stories narrated by a humanoid robot has been previously investigated. This pilot study expands the use of humanoid robots to support the story retelling and social perspective-taking for students on the autism spectrum. Other important strategies considered in this proof-of-concept study to support story retelling included the modelling of the language to be used in the retelling, the use of character and social perspective-taking maps, and the use of the Story Braid to scaffold the retelling. Outcomes of the study include a teacher guide to support schools and teachers interested in using a humanoid robot to support story retelling. This guide can also be used without a humanoid robot, as the retelling of the story and the modelling of the language, can be implemented by the teacher.

1. Introduction

Over the last decade, researchers have explored the use of social robots to support therapy for children on the autism spectrum (Begum, Serna, & Yanco, 2016; Pennisi et al., 2016). The use of humanoid robots, however, is relatively new to schools and most studies with children on the autism spectrum have focused on the development of social skills, communication skills, and encouraging positive social behaviours with the aim of increasing their opportunities for a more independent life (Silvera-Tawil & Roberts-Yates, 2018; Silvera-Tawil, Roberts-Yates, & Bradford, 2018). While these robots have been successfully used in previous research as social story telling agents in robot-assisted therapy for children on the autism spectrum (Vanderborght et al., 2012), further research on the use of social robots for use in classroom activities, such as promoting story retelling and social perspective-taking, needs to be explored.

1.1 Social perspective-taking in children on the autism spectrum

Social perspective-taking refers to the ability to look at a situation from an alternative point of view, so you can understand others' visual perspectives and mental states (i.e., desires, intentions, knowledge, beliefs, intentions, emotions), in order to explain and predict their behaviour (Howlin, Baron-Cohen & Hadwin, 1999). It is associated with a range of common social behaviours, such as empathy, pretence, deception, and persuasion, and is essential for social communication (Howlin et al, 1999). Social perspective-taking is often regarded as an essential skill for successful social interactions and social inclusion.

Perspective taking is the ability to understand a story plot from the point of view of the different story characters implies the mentalising skill to relate the characters' actions with their internal mental states (i.e., perceptions, thought processes, beliefs, intentions, and feelings) (Diehl, Bennetto, & Young, 2006). Mental state language is used as "a conversational device to communicate subjective experience in conversation" (Bang, Burns, & Nadig, 2013; 1732) and narrative retelling requires the ability to understand a character's mental state and perspective.

People on the autism spectrum, however, can experience difficulties in their ability to infer mental states and empathy with others (Baron-Cohen, Leslie, & Frith, 1986). A meta-analysis by Baixauli et al. (2016) found that children on the autism spectrum use significantly fewer mental state terms in their narratives than non-autistic children, and state that there is a need for narrative interventions in this area. Their meta-analysis looked at 24 relevant studies and used internal state language to analyse the narrative performance of children on the autism spectrum.

Retelling a story involves not only understanding the story, but also constructing the retelling so that others can understand it (Diehl et al., 2006). In a study with three non-autistic kindergarten (aged 4-5 years) children at risk for language disorders, visual prompts were used during story time to remind students to listen for each of the respective components of the story (Brown, Garzarek & Donegan, 2014). The prompts consisted of picture cards representing five story grammar components: character, take-off (initiating event), feelings (emotion), action, and landing (consequence). Visual prompts (pictures) were also used by Gabig (2008), to examine the verbal working memory and language ability in 15 school-age (aged 5-7 years) children on the autism spectrum, using a story recall task. Story recall was assessed using a short story script and a series of pictures depicting events from the story. Story retelling ability was measured using the percentage of propositions recalled and utterance length from a retelling of *The Renfrew Bus Story*, which is a test of story recall. The children were asked to retell the story with the aid of the pictures.

Picture prompts were also used in a study by Sella et al. (2015). During 10 sessions across five weeks, children not on the autism spectrum were shown pictures that illustrated the "character, setting, time, problem, actions, and resolution" of a story and were asked questions to prompt their recall (Table 1). Prompts include: "*We are going to listen to a story together. After we listen to the story, you will retell the story to the teddy bear, so pay attention. Can we start?*" After the story was read, the children were asked: "*Did you like the story? Let's hear it once more so we can remember everything. Can we start?*" After the story was re-read a teddy bear was placed on a chair and the children were asked: "*Now, can you tell the story to our friend the teddy bear? He was far away and could not hear the story. Tell him the story, with all the little pieces that you can remember*." The results of the study indicated that using the picture prompts alone did not guarantee an improvement in children's story retelling and further investigation was needed to ascertain if it was children's repeated exposure to the story that resulted in significant change to their retelling performance.

Scaffolds to prompt story retelling were also used by Stirling et al. (2017), who found that story schemas assisted children on the autism spectrum to demonstrate their understanding. After the story was read and re-read to children they were told: "*Now we would like you to retell the story of 'The Three Little Wolves and the Big Bad Pig'* (Trivizas, 2003), *in your own words, using the computer program. We are interested in your own special story, however you want to retell it."* Further prompts were used during the story writing including: *"We're interested in your own special story that you can write, so we can't help with that, but I'm sure you can work out what to do and it*

will be absolutely fine", and "We want you to tell the story of 'The Three Little Wolves and the Big Bad Pig.' As long as you do this, I'm sure whatever you do will be fine".

The study by Sterling et al. (2017) involved 15–20-minute sessions, 2-3 days a week, and involved a baseline 'story-time' reading from a "*typical elementary school narrative storybook*". At the end of the first read of the story, the children were prompted to state if they liked the story and were also given feedback about their participation e.g., "I like how you looked at the pictures while I was reading". During the sessions, the five-story grammar components were taught, and the children were expected to use the targeted components in the session retells. The Test of Narrative Retell (TNR) for Kindergarten Stories (Petersen & Spencer, 2012) was used to provide consistent measure of retell performance and the PPVT-4 (Dunn & Dunn, 2007) was used as a descriptive measure. The study demonstrated that students improved their retelling skills through the narrative retelling and maintained the skills two weeks after the sessions ended.

In this vein, several researchers have highlighted that Theory of Mind (ToM) referring to a person's ability to attribute mental states to themselves and others, helps explain why many children on the autism spectrum lack the ability to evaluate the behaviour of other people based on their mental states, such as their goals and emotions (Baron-Cohen et al., 1986). ToM skills are needed to understand the actions of story characters, and to retell the narrative in a way that is comprehensible for the listener (Hilvert et al., 2016). The production of mental state terms describing perception, desire, emotion, and cognition were used by Bang, Burns, and Nadig (2013) to assess a narrative-based program for perspective-taking with pre-adolescents on the autism spectrum. For example, the phrase "drive me crazy and gets on my nerves" was paraphrased as "annoy", an emotion term. The study confirmed results found in the Baixauli et al. (2016) meta-analysis and showed an improvement in the narrative performance of children on the autism spectrum following the program.

A review of social perspective-taking interventions for individuals on the autism spectrum revealed that social perspective-taking can be successfully taught using systematic instructions, group interventions and digital devices such as computers and video games (Southall & Campbell, 2015). In this review, however, the authors noted that despite the effectiveness of these methods, research did not consistently document if individuals were able to generalise their gains in social perspective-taking into real-world with different people.

Table 1: Story retelling scripts used in the literature

Stories	Prompts/Questions	Reference
Frog, Where Are You? by Mayer (1969)	**Inferential questions after the story was read** Why did the boy smile when he heard the croaking sound? Why was the frog sitting proudly with a mother frog?	Diehl et al. (2006)
Miss Nelson Is Missing by Allard (1977) **Harry the Dirty Dog** by Zion (1956) **Too Many Tamales** by Soto (1996) **Thomas' Snowsuit** by Munsch (1989)	**Pre story telling** I am going to read this story to you. I will read it to you twice. After I read the story I am going to ask you to retell the story to me as though you were one of the characters. Then I will ask you to tell me the story again but this time you will be a different character. **Story retelling** I want you to retell the story that I just read to you as if you were Harry the Dirty Dog. Now I want you to retell the very same story but this time you are one of the children. **Further prompts** What happened next? Is there anything more you can tell me about the story?	Dodd et al. (2011)
"16 common early elementary fictional stories"	**Pre story telling** I'm going to tell you a story. Please listen carefully. When I'm done you are going to tell me the same story. Are you ready? **Post story telling** You did a neat job of sitting still and listening to the story. I like how you looked at the pictures while I was reading. Thanks for being good listeners. **Story retelling** Thanks for listening. Now you tell me that same story while talking in this microphone. **Further prompts** It's okay. Just do your best. I can't help you, but you just tell the parts you remember. Are you finished?	Brown et al. (2014) based on Petersen and Spencer (2012)
Peter and the Cat by Leitao & Allan (2003) **A Day at the Movies** by Hilvert et al. (2016)	**Story retelling** Please tell me the story back the best you can. **Further prompts** What happened next? What do you think happened after that?	Hilvert et al. (2016)
"Eight audio stories" Sella et al. (2015)	**Pre story telling** We are going to listen to a story together. After we listen to the story, you will retell the story to the teddy bear, so pay attention. Can we start? **Post story telling** Did you like the story? Let's hear it once more so we can remember everything. Can we start? **Story retelling** Now, can you tell the story to our friend the teddy bear? He was far away and could not hear the story. Tell him the story, with all the little pieces that you can remember.	Sella et al. (2015)
The Three Little Wolves and the Big Bad Pig by Trivizas (2003)	I want you to tell the story of 'The Three Little Wolves and the Big Bad Pig' in your own words. We are interested in your own special story, however you want to retell it… We want you to tell the story of 'The Three Little Wolves and the Big Bad Pig.' As long as you do this, I'm sure whatever you do will be fine.	Stirling et al. (2017)

Using a Narrative Elicitation Task to assess narrative competency, Diehl et al. (2006) found that children on the autism spectrum had difficulty organising events to retell a story. The participants of the study included 17 children on the autism spectrum and 17 non-autistic children matched on age, gender, and language and cognitive abilities. All children were asked to look at a picture book and listen to an audio-recorded narration of the story, ‘‘Frog, Where Are You?’’ (Mayer, 1969). After the children retold the story, they were asked a series of inferential questions about the story (Table 1). The inferential questions involved understanding the narrative—getting the gist of the story—as opposed to simply recalling factual details (Young, Diehl, Morris, Hyman, & Bennetto, 2005).

A narrative-based intervention program for teaching perspective-taking skills to students on the autism spectrum was also investigated by Dodd et al (2011). In this study, a total of 18 students with a diagnosis of ASD (9 -12 years old), received 500 minutes of either a narrative-based intervention focused on teaching perspective-taking (PTI), or a traditional narrative-based language intervention (NBLI) focused on story elements and semantics. Participants were randomly assigned to one of two intervention groups at their respective schools. The program included 30-minute sessions with story books read twice a week for six weeks (Table 1), in groups of five students with one speech language pathologist. Moreau and Fidrych’s (1994) Story Grammar Marker (SGM) provided the framework for the intervention. The Moreau-Rooney and Fidrych (1994) Story Grammar Marker (SGM) provided the framework for the perspective-taking, while the study used criteria to score perspective-taking, from 0 – *Participant failed to provide a story that was told from the perspective of the identified character (e.g., retells story using third person)* to 5 – *Participant used a minimum of four psychological terms (e.g., desire, perception, emotion, emotion–behaviour, cognition).*

In the first session, the selected book was read aloud to the students, and then the story was re-read. The speech language pathologist then modelled retelling the story using SGM. The students were also given an opportunity to retell the story. Each subsequent lesson began with the speech pathologist rereading the selected story. During sessions 2 and 3, each student, with guidance, completed an adapted version of the SGM Character Map. Open-ended and inferential questions were asked about the character (e.g., gender, physical traits, occupation) along with what they could infer about each character (e.g., information that was not explicitly stated). Sessions 4 and 5 provided direct instruction in analysing the story from each character’s perspective utilising the SGM perspective-taking Map. During the last sessions, students were provided with a final opportunity to practise retelling the story from the different characters’ perspectives. Student progress was evaluated with regard to total number of words and total number of psychological

terms used during a retelling activity. The participants who received the PTI demonstrated greater growth in their ability to retell the story from the perspective of different characters compared to those who participated in the NBLI.

Finally, research by Tsunemi et al (2014) presented preliminary evidence of improvements in social perspective-taking in school-age children on the autism spectrum, through intensive experience to narrative in story books read by their parents over a period of 5-6 days. In this study, perspective-taking improved in 16 children (mean age 9yrs) on the autism spectrum. These effects were also confirmed when the children were assessed 4 months later. This study targeted perceptual (visual), cognitive and social perspective-taking assessed using a battery of three tasks: the three-mountain task (Piaget & Inhelder, 1956), the false belief task (secondary level, Perner and Wimmer, 1985) and a role-taking task (Selman, 1980).

1.2 Humanoid robots and storytelling

The appearance, behaviour, and abilities of robots are fundamental during interaction, and have influence on their effectiveness during interventions (Pennisi et al., 2016). Although many different robots have been developed, anthropomorphic shapes with limited expressivity and basic human-like behaviour seem to offer the most promise for therapy and education, providing enhanced generalisation of skills (Duquette, Michaud, & Mercier, 2008; Sartorato, Przybylowski, & Sarko, 2017). Children, however, interact with robots in diverse ways (Peca, Simut, Pintea, Costescu, & Vanderborght, 2014). Understanding how children perceive and react to humanoid robots can help result in more effective planned interactions (Leite et al., 2017).

One of the most commonly used humanoid robot in schools around the world is the NAO (Woo et al., 2021), a small (58cm height) bipedal humanoid robot developed by the SoftBank Robotics Group. As such, a research study investigating storytelling by preschool children not on the spectrum, used the NAO robot (Figure 1) as a teaching assistant (Fridin, 2014). During the first meeting, designed to introduce NAO to the children, the robot started by making a yawning sound and then introduced itself by singing a greeting song. Then, NAO read two well-known stories (Table 1), whilst expressing emotions via body movements, turning of its head, and by its eyes changing colour. The robot asked the children if they knew some of the terms related to the story (e.g., “darker” and “ridicule” in The Ugly Duckling story), gave positive feedback for any answers, and explained what the terms mean. The children were also asked by the robot, what sounds the animals in the story made, and NAO reproduced the animal sounds for the children to hear. Finally,

a cradle song was introduced during “The Ugly Duckling” story, and the game “Simon Says” was used for the children to imitate NAO’s movements while representing the animals in the story.

Figure 1: NAO Robot

Non-autistic preschool children’s’ perceptions of a story, narrated by NAO, were also investigated by Conti, Di Nuovo, Cirasa, and Di Nuovo (2017). The study was conducted in three 15-minute sessions, over a 3-week period. Children in this study were asked to draw the details they were able to recall about the story (Table 2). Drawings were examined to determine how many main elements of the stories (i.e., plot, characters, setting, and theme) were represented by the children. The results from this brief intervention showed a positive effect of using the NAO robot as a storytelling agent.

Table 2: Story telling scripts with a NAO humanoid robot used in the literature.

Stories	Prompts/Questions	Reference
Where is Pluto? by Leah Goldberg **The Ugly Duckling** by Hans Christian Andersen	**After the story** Do you know what ‘darker’ means in terms of the story? What does ‘ridicule’ mean? Explanation…. **Further prompts** Songs, Simon Says	Fridin, 2014
The Ugly Duckling **The Emperor’s New Clothes** by Hans Christian Andersen	**After the story** Draw the details you can recall about the story.	Conti et al., 2017

1.3 Current study

The aim of this study was to develop evidence-based guidelines for teachers on the use of humanoid robots to foster narrative social perspective-taking in children on the autism spectrum. The study had the following specific objectives:

1. To identify and evaluate effective strategies that strengthen story retelling for children on the autism spectrum.
2. To create and apply story retelling scripts (verbal and non-verbal) for appropriate use with humanoid robots with children on the autism spectrum, during sessions facilitated by their teachers.
3. To assess changes in the social perspective-taking ability of children on the autism spectrum, as reflected in their ability to retell a story from different perspectives and the use of mental state language following the story retelling teaching sessions.

The outcomes from this study include a literature review, robot scripts, and a guide for teachers and schools planning to implement humanoid robot-assisted story retelling sessions for supporting story retelling learning activities and social perspective-taking with children on the autism spectrum. The outcomes from this study also address the main research question:

1.4 Research question

What are the potential impacts of using a humanoid robot as a tool to support social perspective-taking with students on the autism spectrum?

2. Research Design

A mixed-method sequential explanatory two-phase design (Creswell, 2009) was used in this study. This two-phase design is useful for gaining an in-depth understanding of quantitative data through the collection of qualitative evidence.

2.1 Research methods

2.1.1 Phase 1

Baseline data was collected via an oral narrative task, individually administered before the story retelling group sessions. The oral narrative task took approximately 20 minutes to complete per child. Following the baseline data collection, the children were involved in six 20–30-minute story-retelling sessions conducted in groups of five children with their teacher. All story-retelling group sessions were video-recorded for transcription and analysis purposes. Finally, the same 20-minute oral narrative task as for the baseline data was individually administered after the story retelling group sessions. Children's oral narrative retellings were collected using an iPad, transcribed verbatim and scored for social perspective-taking and use of internal state language.

2.1.2 Phase 2

Following the final story retelling session and oral narrative tasks, individual semi-structured interviews with the two teachers who delivered the sessions were conducted to ascertain their perceptions of the value of the story retelling sessions, and of the children's ability to transfer their story retelling skills to classroom activities. The teacher interviews included 15 open-ended questions covering themes including the importance and suitability of the story retelling sessions for students on the autism spectrum, their views on the role of teachers as the facilitators, and the impact of the sessions on their students' social and academic skills.

2.2 Participants

The study was conducted in two primary state schools in Queensland. One teacher and five students (aged 9-12 years) from Years 4 and 5 with a verified autism diagnosis, were recruited from each school (Table 3). The participating schools were recruited by the Autism Hub in the Queensland Government Department of Education. The Autism Hub emailed Queensland state schools to raise awareness of the project and inform school principals of project recruitment strategies and timeframes. School principals were asked to reply with an expression of interest. An initial meeting was held with classroom teachers to discuss their potential participation and role in the project. Once teachers' consent was signed, the teachers nominated potential student participants for the study based on formal diagnostic information. Participant information sheets were then sent to parents of the selected students, with an invite for a meeting with the

researchers arranged at the participating schools. The students, their families and carers were all invited to take part in that meeting.

The teacher recruited from School A was a special education teacher, while the teacher from School B was the digital technology teacher for the school. Group A (at School A) worked with the humanoid robot while Group B completed the same story-retelling sessions without the robot. Personal identifiers were used to de-identify all participants for the analysis (Table 3). The student groups were quite similar regarding gender, meaning that all participants across the 2 schools were males except one female student in School A.

Table 3. Student participants

Group	Teacher	Student ID	Age (in months)
Group A	Teacher A	Student 1	118
		Student 2	126
		Student 3	127
		Student 4	129
		Student 5	114
Group B	Teacher B	Student 6	128
		Student 7	118
		Student 8	115
		Student 9	114
		Student 10	114

All participating children were matched on chronological age ($M_{school\ A}$ = 122.80, $M_{school\ B}$ = 117.80), non-verbal intelligence age ($M_{school\ A}$ = 162.00, $M_{school\ B}$ =124.80) and receptive vocabulary ($M_{school\ A}$ = 122.00, $M_{school\ B}$ = 106.60). There were no statistical differences between the two student groups for chronological age [t(8)=1.275, p=0.024], non-verbal ability [t(8)= 1.584, p= 0.172] and receptive vocabulary knowledge [t(8)= 1.069, p=0.109].

Non-verbal ability was assessed using the Test of Non-Verbal Intelligence-4 (TONI-4) by Brown, Sherbenou and Johnsen (2010). The selection of this instrument was based on the following criteria: a) it uses abstract reasoning and figural problem solving to estimate general cognitive ability, b) it does not require use of language or complex motor responses from the administrator or the child, c) it does not contain any pictures or cultural symbols that may afford advantages or

create disadvantages to children from specific cultural groups, d) it is brief (10 minutes long) and e) has been used widely with children on the autism spectrum for research and program evaluation. The TONI-4 yields three normative scores: index scores (quotients), percentile ranks and age equivalents.

The students' receptive vocabulary was assessed using the Peabody Picture Vocabulary Test 5th Edition (PPVT-5) by Dunn (2019). This instrument has been used to assess word knowledge by allowing students to give verbal or non-verbal responses (i.e., pointing) to demonstrate vocabulary knowledge. This test was selected because it is suitable for assessing receptive vocabulary in a wide age range of children and adults (2yrs, 6mo - 90yrs), it is an untimed assessment and has been employed extensively in research with children on the autism spectrum. The PPVT-5 yields standard scores, confidence intervals, percentile ranks, normal curve equivalents, stanines, test-age equivalents, and growth-scale values.

2.3 Ethical considerations

Ethics approval to conduct this study was obtained from:

- Queensland University of Technology (QUT) Human Ethics Research Committee (approval no. 1900000213).
- Queensland Government, Department of Education (File no. 550/27/2213)
- CSIRO reciprocal approval [2019_085_RR]

2.3.1 Participant informed consent

Participating schools, classroom teachers, parents/caregivers and students were provided with an information sheet about the research project outlining the purpose of the study, participation requirements, risks, and benefits of their involvement, as well as contact details for the project team and research ethics office.

Due the students' age, their parents or guardians made the decisions regarding consent. Following consent, the lead researchers explained to the children the aims of the research and what was involved with their participation. During initial recruitment meetings with the research team, potential participants also received consent forms to sign with the option of returning the signed consent form within two weeks.

The children and their parents/caregivers were also made aware on their participant information sheet that the teachers would be answering questions about the child's participation in the

sessions. The children and parents/caregivers were asked to consent to this, and the students were also asked at the start of all sessions if they still consented to be involved in the research study. Children were also asked to indicate verbal consent before the commencement of each story retelling session. In addition, at the beginning of each session, children were given an opportunity to express their views about the research and their participation to minimise the opportunity of coercion to participate.

2.3.2 Privacy and confidentiality

Individual identifiable data collected on each student to ascertain their eligibility for participation in this project were placed on a secure QUT research server to ensure appropriate ethical storage of electronic data. Paper copies of data were stored in a locked filing cabinet. Codes were used to replace individual identifiable data and all results were de-identified before reporting. During data analysis, only non-identified data was stored in the researcher's password protected personal computers. These data were transferred to the secured QUT server after the analysis was finalised.

2.3.3 Considerations for students

In accordance with ethics procedures protecting the students' rights as participants, the research team took the following actions to accommodate their needs during their participation in the project:

1. The research team prepared an information sheet for the children explaining in plain language the aims and procedures of the research, as well as their rights as participants.
2. Participants were asked to indicate their preferred date and time for the assessments in their school.
3. Prior to the data collection, the researcher who conducted the assessments was available for meetings with each participant and their parents/carers to explain the study in detail and respond to questions regarding the research aims and procedures. In the research briefing meeting, the researcher reminded participants of their right to withdraw at any stage of the study (assessments and sessions) or refuse to respond to any of the assessment tasks.
4. The researchers organised, with the teachers' assistance, the availability of supervised breakout spaces to cater for participants' needs for private spaces, during the assessment and the story retelling sessions.
5. Before the start of the assessments and the sessions, participants were asked for their verbal consent and were reminded of their right to refuse to take part in the study.

2.3 Procedure

Ten children on the autism spectrum (aged 9-12 years), from two mainstream state primary schools were allocated to two equally sized matched groups, with their teachers. Data from the group involved in the robot-assisted sessions (Group A) were collected in September 2019, while data from the control group (Group B) were collected in June 2021. Both groups were involved in a total of six group sessions (15-20 minutes each) over 3 weeks, conducted in a familiar school space. Group sessions for children in Group A, additionally, included the NAO robot to support the sessions.

The study was conducted in two phases. In phase 1 pre-teaching and post-teaching, individual assessments were completed with the children, while in phase 2 interviews were conducted with the teachers to explore their perceptions of the value of the story retelling sessions and the children's ability to transfer their story retelling skills to classroom activities.

2.3.1 Pre-teaching assessment

Each student took part in an individual 15-minute session, in a quiet location in the school. The purpose of the session was for the student to generate an oral retelling of the story 'Harry the Dirty Dog." At the start of this session, the researcher confirmed with the students if they still wanted to participate in the study (verbal consent). Then, the researcher gave a brief overview of the session to students and showed them the iPad used for the audio recording. The researcher followed the script with the instructions below:

I am going to read this story to you. I will read it to you twice. After I read the story, I am going to ask you to retell the story to me as though you were one of the characters. Then I will ask you to tell me the story again but this time you will be a different character.

Perspective-taking 1: ***I want you to retell the story that I just read to you as if you were Harry the Dirty Dog.***

Prompt 1: ***What happened next?***

Prompt 2: ***Is there anything more you can tell me about the story?***

Perspective-taking 2: ***Now I want you to tell me the very same story again but this time you are one of the children.***

Prompt 3: ***What happened next?***

Prompt 4: ***Is there anything more you can tell me about the story?***

2.3.2 Story-retelling sessions

The story-retelling sessions were based on the framework of the Story Grammar Marker (SGM) (Moreau-Rooney & Fidrych, 1994), which provides a structured way of learning the story grammar and creating a story character map by analysing the story from each character's perspective, with teacher guidance (Dodd et al., 2011). Verbal prompts for story retelling, based on Petersen and Spencer (2012), were incorporated into the lesson plans and robot scripts of each session.

The story retelling sessions involved 2 sessions per week, for 3 weeks (Table 4). The six group sessions took place in the school setting as indicated by the classroom teacher. This instructional arrangement is aligned with the Queensland State Schools Improvement Strategy 2021-2025 (https://education.qld.gov.au/curriulums/Documents/state-school-strategy.pdf), and Inclusive Education Policy (https://ppr.qed.qld.gov.au/pp/inclusive-education-policy) which commits to ensuring all students are able to fully participate in learning, supported by adjustment and teaching strategies.

Table 4. Activities across the six sessions of the teaching program.

Session	Activity
Session 1	▪ Robot (or teacher) reads the story. ▪ Robot (or teacher) models retelling the story. ▪ Students retells the story.
Sessions 2 & 3	▪ Robot (or teacher) retells the story. ▪ Students complete the SGM Character Map with teacher (and/or robot) prompting (open ended and inferential questions).
Sessions 4 & 5	▪ Robot (or teacher) retells the story from a different perspective. ▪ Teacher guides students with the SGM perspective-taking Map for retelling the story from other perspectives.
Session 6	▪ Robot (or teacher) re-reads story. ▪ Students retell the story from a different perspective.

The six story retelling sessions were developed specifically for this study based on the SGM. The SGM has been used to support the development of spoken language, literacy, and social perspective-taking in children with autism (Dodd et al, 2011), deafness (Justice, Swanson & Buehler, 2008) and students with English as a Second Language *(*Schoenbrodt, Kerins, & Gesell, 2003).

In addition, a Story Grammar Marker set (Story Braid) was used in the sessions to support students' story retelling. The Story Braid is a three-dimensional, non-linguistic representation of the story narrative structure. It provides a multi-sensory experience helping students make connections between the icons on the actual braid with the "Wh" questions so that they can retell the story by referring to each essential component: Character, Setting, Initiating Event (Kick-off), Internal Response (feelings, emotions), Plan, Attempts, Direct Consequence(s), and Resolution (Moreau & Fidrych, 1994). The Story Braid used in the sessions is shown in Figure 2. The teacher used a large sized Story Braid, and each student used a small-sized Story Braid to help them follow the story and the retelling. The story retelling sessions were designed to allow for flexibility for the teachers so they could redirect or ask further questions, to meet their students' specific needs. Given the importance of story retelling for developing social perspective-taking and internal state language, the scope of the teacher guide could also be widened to younger or older students experiencing difficulties in these areas.

Figure 2. Image of StoryBraid® (MindWing Concepts Inc[1])

[1] https://mindwingconcepts.com/collections/story-grammar-marker/products/teacher-sgm-manipulative

Teacher session guides were developed to support the sessions. The guides outlined the six 20 to 30-minute story-retelling sessions used in the study. A script with questions to be asked by the teacher and/or the robot was also included for each session. Students in Years 4 and 5 are expected to benefit most from this story retelling program. Therefore, the session guides focused on this age group. In specific, the aims of the session guides were aligned with:

- The expected learning outcomes for students at Level 3 (typically by the end of Year 4) in Social Awareness within the Personal and Social Capability learning continuum (ACARA, 2021). These outcomes focus on appreciating diverse perspectives: students can discuss the value of diverse perspectives and describe a point of view that is different from their own.
- The Year 5 achievement standards for English (ACARA, 2021): students will a) describe how events, characters and settings in texts are depicted; b) develop and explain a point of view about a text, selecting information and ideas from a range of resources; c) contribute actively to group discussions, taking into account other perspectives.

The sessions attended by each student is shown in Table 5. Across the two groups, students attended 3-6 sessions.

Table 5: Sessions attended by students

Groups	Teachers	Students	Sessions attended					
			1	2	3	4	5	6
Group A – with robot	Teacher A	Student 1	x	x	x	x	x	x
		Student 2	x	x	x	x	x	x
		Student 3	x	x	x	x	x	x
		Student 4	x	-	x	x	x	x
		Student 5	x	x	-	x	-	-
Group B – without robot	Teacher B	Student 6	-	x	x	x	-	-
		Student 7	x	x	x	x	x	x
		Student 8	x	x	x	x	x	x
		Student 9	x	x	x	x	x	-
		Student 10	x	-	-	x	-	x

NB: Student 5 left halfway through Session 3 and did not complete the Story Character Map.

2.3.3 Post-teaching assessment

On the next school day after the completion of the 6 story-retelling sessions, all students participated in individual sessions in a quiet location in their school, with the same researcher as before the sessions were conducted. The same oral narrative story-retelling task was administered to all students. Due to COVID-19 restrictions, follow-up assessments were completed only with four students in School B, four weeks after the completion of the sessions to assess maintenance of their social perspective-taking and internal state language use.

2.3.4 Teacher interviews

This phase involved collecting qualitative data from teachers to evaluate the validity of the story retelling sessions and transfer of children's story retelling skills, as well as Teacher A's perception of the NAO robot. The teachers of the participating students attended individual (20-30 minute) semi-structured interviews following the completion of Phase 1. Example questions include, "*What strategies did you use during the story-retelling sessions to support students' story-retelling*? and *What do you perceive as concerns that may arise with using this humanoid robot to help students on the autism spectrum develop story-retelling skills*? (Appendix A). Both interviews were conducted in a private space on each school site and teachers consented to the recording of the interviews. The teacher interviews were audio-recorded, transcribed, and thematic analysis was employed to examine the teachers' views.

2.4 Data analysis

Data from the robot-assisted sessions (Group A) and the teacher interview for Teacher A was collected in September 2019, while data from the control group (Group B) and Teacher B was collected in June 2021. Children's narrative retellings before and after the sessions were evaluated for perspective-taking and use of internal state language. Each narrative language sample was evaluated in regard to the perspective-taking score and total number of internal language terms used. Additionally, all story retelling sessions were video recorded to collect and analyse students' narratives in the story retelling tasks. The teacher interviews were also recorded and transcribed, and a thematic analysis was used to generate themes. Thematic analysis involves an examination of data to generate relevant themes (Braun & Clarke, 2006).

2.4.1 Social perspective-taking skills

Following Dodd et al (2011, p.26), two members of the research team compared their independent scorings of each story retelling from each student using the scoring criteria for perspective-taking score as outlined in Table 6. Any discrepancies between the scorings were discussed and resolved. Each student had provided two retellings in each story-retelling session with the researcher. The final score was calculated by adding the scorings from each retelling and dividing the sum by 2.

Table 6 Perspective-taking scoring criteria

Scoring	Criteria
0	Participant failed to provide a story that was told from the perspective of the identified character (e.g., retells story using third person).
1	Participant provided “some” reference to the character’s perspective, such as using a quote
2	Participant demonstrated emerging role taking as evidenced by his or her reference and correct use of personal pronouns
3	Participant referenced the target character’s actions and perceptions or any of the two psychological terms: desire, perception, emotion, emotion-behaviour, or cognition
4	Participant used two or more of psychological terms from the following categories: desire, emotion-behaviour, emotion, or cognition
5	Participant used a minimum of four psychological terms (e.g.., desire, perception, emotion, emotion-behaviour, cognition), two of which must have been from the cognition category

2.4.2 Internal state language

Following Dodd et al (2011, p.27), the use of internal state language was coded in each story retelling as presented in Table 7. Two members of the research team and a research assistant independently coded the story retellings using the table below and met to discuss disagreements

and reach consensus on the number of mental state terms for each student before and after the teaching program.

Table 7. Examples of psychological terms per category of mental state

Mental State	Psychological Terms
Desire	Need, want, beg
Perception	See, hear, feel, look
Emotion-behaviour	Cry, laugh, scream
Emotion	Sad, surprised
Cognition	Forget, wonder, remember, know, think
Other	Like

2.4.3 Thematic analysis

A thematic analysis was completed for all interviews. This analysis involved the repeated reading of the data to generate themes related to the semi-structured interviews conducted with the teachers. Themes relevant to the interview questions were coded first, using a deductive approach, then other common recurring themes were identified. A constant comparative method was used to discover the themes using inductive analysis (Glaser & Strauss, 1967).

3. Findings

3.1 Social perspective-taking

The social perspective-taking scores for each student before and after the teaching program are presented in Table 8 (and in Appendices B & C). The comparison between the groups revealed

interesting similarities as well as some differences. On average, students in both groups increased their social perspective-taking score. Students in School B (without the Robot) achieved greater progress than the group in School A. While three students in School A (with the Robot) and four students in School B (without the Robot) improved, one student in both groups (Student 3 in School A and Student 8 in School B) regressed in their social perspective-taking. In addition, the two students who had the lowest scores out of the total number of students in both schools (both students were from School B) before the sessions, showed improvement in their social perspective-taking. In fact, the pre-teaching scores for students in School B were overall lower than the scores in Group A. With lower scores at the start, the opportunities to improve their scores were greater to students in School A.

Notably only one student (School A) across the two groups did not make any progress, which could be explained by their lack of interest in participating during the sessions. This student also missed the last two sessions, which were focused on social perspective-taking. On the other hand, the two students (Student 3 and Student 8) who decreased their social perspective-taking scores after the teaching program, had attended all sessions. A potential reason for this finding could be a lack of concentration during the post-assessment sessions. Out of all students in the study, two students achieved the highest social perspective-taking score following the teaching sessions (School A, with the Robot): both students had attended 5-6 sessions.

Nevertheless, full attendance of the teaching program was not associated with progress in social perspective-taking for both groups. Three (out of the four) students who attended more than five sessions in School A showed progress in their social perspective-taking. Three students in School B achieved considerable progress in their social perspective-taking, and only two of them had attended more than five sessions. Further analysis of active engagement in each student in the video-recorded sessions they attended could reveal aspects of the teaching process that may have impacted students' progress in social perspective-taking.

Given the small group size, the significance of the observed group differences was assessed using the non-parametric Mann-Whitney test which did not reveal any significant group differences in social perspective-taking before (School A Mdn=6.80, School B Mdn= 4.20, U=6, p=0.22) and after (School A Mdn= 5.20, School B Mdn = 5.80, U=14, p=0.841) the teaching program.

Table 8. Pre- and post-teaching social perspective-taking for students in schools A and B.

Students	Sessions attended	Pre-Teaching	Post-Teaching	Outcome
School A				
Student 1	6	1	2	Increase
Student 2	6	4	5	Increase
Student 3	6	2.5	1	Decrease
Student 4	5	2.5	5	Increase
Student 5	3	1	1	No progress
School B				
Student 6	3	1	4	Increase
Student 7	6	0	3	Increase
Student 8	6	2.5	2	Decrease
Student 9	5	0	2	Increase
Student 10	3	2	4.5	Increase

3.2 Internal state language use

As shown in Table 9 there were very small group differences before the teaching program in the mean number of mental state terms. A Mann-Whitney test indicated that the use of mental state terms was the same for students in both schools before (School A Mdn= 6, School B Mdn= 5, U= 10, p= .69) and after (School A Mdn= 4.80, School B Mdn= 6.20, U= 16, p= .55) the teaching program. In addition, a Wilcoxon Signed-ranks test indicated that there were no significant differences between the pre-and the post-assessment in the use of internal state language in School A (Pre Mdn=13, Post Mdn=13.6, z=0.365, p=0.71) and School B (Pre Mdn=11, Post Mdn = 15, z = 0.68, p= 0.50). Therefore, no significant statistical differences were observed within and across schools in internal state language use.

Table 9. Mean rank of mental state terms used by each group before and after the teaching program.

Phase	School A	School B
PRE- Teaching	6	5
POST- Teaching	4.80	6.20

The use of mental state terms for each student in their story retellings across the two phases is presented in Table 9. An important group finding was observed in the level of improvement in the use of internal state language in the story retellings: students in School B used more (ranging from 3 to 12) mental state terms compared with students in School A (ranging from 1 to 4) after the teaching program (Table 10). Three students in School A and four students in School B used more mental state terms after the teaching program. However, one student in each group (Student 1 and Student 8) used fewer mental state terms after the sessions and one student (Student 3) used the same number of mental state terms before and after the teaching program. Two of these students (Students 3 and 8), were the same students that decreased in their perspective-taking scores). Some similarities were observed between the groups in the use of terms referring to specific mental states. Students' total use of terms for each mental state category before and after the teaching program is presented in Table 10. It is interesting to note that students in both schools used mostly terms to describe perceptions and cognitive states of the story characters, whereas

terms describing emotional behaviours were the least used across the two assessment phases. These findings provide evidence of advanced mentalising skills (attributing cognitive states to story characters) and lack of attention to the characters' emotional behaviours in their story retellings.

Table 10. Total number of terms used by students in both schools for each mental state category.

	Phase	Desire	Perception	Emotion-behaviour	Emotion	Cognition
School A	PRE	3	23	2	13	20
	POST	9	19	1	3	25
School B	PRE	9	20	3	5	13
	POST	6	36	7	6	14
Total		27	98	13	27	72

The use of terms for each category of mental state by each student across the two assessment phases is presented in Tables 11 and 12. The tables note the greater increase (Student 6 and 7) and decrease (Student 8) in the number of terms used in School B, with only marginal changes to all students in School A. No correlations were observed between the number of sessions attended and changes to the number of mental state terms used in both assessment sessions. Analysis of the conversations occurring between the teachers and the students in the sessions could assist in the interpretation of these interesting group and individual differences. In specific, the teachers' use of prompting questions about the characters' mental states and their conversational exchanges with the students in sessions 2-6 across the two groups could offer valuable insights into the scaffolding strategies applied by the teachers, the students' responses and comments and their use of the Story Braid to aid their story retelling. Notably, students in School B used more internal state terms and showed greater improvement in their social perspective-taking compared with students in School A. This finding indicates a link between social perspective-taking and use of

mental state language as a positive outcome from the teaching program which did not involve the robot.

Table 11. Number of mental state terms used by each student in School A before and after the teaching program.

ID	Phase	Desire	Perception	Emotion-behaviour	Emotion	Cognition	Other	Total	Difference
School A									
S1	Pre	2	3	0	0	1	1	7	-5
	Post	2	0	0	0	0	0	2	
S2	Pre	0	10	0	7	6	0	23	+3
	Post	1	10	0	1	8	6	26	
S3	Pre	0	0	0	0	2	1	3	0
	Post	1	0	0	0	2	0	3	
S4	Pre	0	9	2	3	5	1	20	+1
	Post	3	3	1	1	9	4	21	
S5	Pre	1	1	0	3	6	1	12	+4
	Post	2	6	0	1	6	1	16	

Table 12. Number of mental state terms used by each student in School B before and after the teaching program.

ID	Phase	Desire	Perception	Emotion-behaviour	Emotion	Cognition	Other	Total	Difference
School B									
S6	Pre	2	10	0	1	1	1	15	+12
	Post	2	12	4	1	4	4	27	
S7	Pre	5	2	1	1	4	2	15	+12
	Post	1	18	1	1	6	0	27	
S8	Pre	2	5	1	3	6	2	19	-15
	Post	0	1	0	0	2	1	4	
S9	Pre	0	1	1	0	2	0	4	+4
	Post	1	4	0	2	0	1	8	
S10	Pre	0	2	0	0	0	0	2	+7
	Post	2	1	2	2	2	0	9	

3.3 Teachers' perspectives of story retelling sessions

The main themes that emerged regarding the use of the humanoid robot from Teacher A included: a) first impressions, b) expectations, and c) interest and engagement. Further codes were developed regarding the story-retelling sessions, as the interview transcripts were compared to discover recurring themes from both teachers. The following themes emerged from the inductive analysis from both interview transcripts: a) modelling and repetition, b) retelling strategies and c) perspective-taking and character mapping. Selected excerpts from the interviews are included to highlight each theme.

Humanoid Robot

Teacher A (Table 3) had experience in special education, but did not have prior robotics experience, and "didn't have any experience with programming". Teacher A, however, responded positively toward the use of the humanoid robot and described the first impression of the robot as "probably a bit bigger than I'd pictured" but was "fun and exciting and engaging. I like that he changed colours and could move his arms and all that sort of stuff". It was interesting to note that this teacher used the pronoun 'he' in the interview and during the story retelling sessions, even though the teacher had discussed with the students about the robot being neither a boy nor a girl.

When asked if the robot met their expectations, the teacher commented that "he looks like a robot and the talking and the flashing eyes… is what I thought the robot would do" but initially had expected that the robot "'would be doing a lot more in the lessons or there would be a lot more interactions with 'he' and the kids". The teacher noted that their initial expectations of the robot were unrealistic and was more "like in my fantasy world of robots", but they had "learnt about the robot along the way" and "now I realise why 'he' can't" do everything. Teacher A also stated that they had enjoyed the experience working with the robot and liked how the robot "was programmed for the questions the kids could ask and 'he' would answer".

The uniqueness of using a humanoid robot was mentioned by the teacher as a reason that the students were engaged with the story retelling sessions, "I think that they were probably listening a bit better when the robot was reading the story" rather than "teachers just doing it day after day". The teacher commented that the students "probably don't feel like they're learning and that's probably a good thing" and that the students "perceive the robot to be fun, not work". When asked to discuss the students' experience with the robot, the teacher stated, "I think what 'he' taught them was to ask questions and be curious". Following each story-retelling session, the students were encouraged to ask questions about the robot and were able to program the robot to achieve basic

tasks e.g., move forward and ask a question. The teacher also noted that while the robot was useful for the story-retelling sessions, the students were also “interested in the sessions afterwards about how you program ‘him’ and their reactions to what ‘he’ could do, like lying down and standing up and that sort of thing”.

Teacher A suggested using the robot in different lessons would help keep students engaged: “we might use if for English and then we might use it for Maths and then we might use if for PE or whatever, just so it’s difference settings”. Using the robot “to program it for lessons for a class” so the students “can see why the limitations are there” was also discussed by the teacher as a way to “keep them engaged”. The teacher further suggested that students could be “programming it for the class and for the other kids sort of benefiting on the other end”. Using the robot as a teaching tool in “a small group activity” was also seen as useful for “kids who are really struggling … the repetition that the robot has would be good for them”. The teacher stated that the robot helped keep the students interested in attending the story retelling sessions, “I know that if I had called them down for me and a Story Braid every day they would have been bored”.

The main concern the teacher noted was a possible “disengagement” of students, as they wanted the robot “to do something different every time” and changes in little things might be needed to keep them interested “like the eyes that they noticed, and the head movements and stuff”. The teacher noted keeping students focused as a limitation as the students “were so excited about ‘him’ [the robot], they just wanted him to do everything” and they expected “more and more and more” and wanted to know “what else can ‘he’ do?”. According to Teacher A, there is a need for teachers to be “controlling their [students] expectations of what it can do”. The mispronunciation of some words by the robot, due to the programming, was noted as a limitation by the teacher who also commented that the students “were probably listening a bit better when the robot was reading the story because ‘he’s’ not pronouncing everything perfectly correct”.

In relation to the story-retelling sessions, Teacher A perceived using the robot as important for the sessions. Using the robot as a teaching tool for the repeated reading of the story was seen as important for students who were struggling. The repetition that the robot provided kept the students interested in the story. The teacher stated students were engaged with the sessions as they were having fun and did not realise they were working. While the teacher’s initial expectations were seen as unrealistic, they learnt about humanoid robots and what they could do during the story-retelling sessions. Other areas the teacher felt the robot could assist with included English, Mathematics, and Physical Education. Programming the robot for lessons in other classes was another way the teacher suggested that students could use the robot. The teacher discussed this would keep students engaged with the use of the robot. Disengagement with the humanoid robot was

highlighted as a concern and students' expectations of the robot. These expectations were seen as needing to be managed by the teacher. The mispronunciation of some words, due to programming, was also noted as a limitation, however, this was also noted as keeping students engaged as they were “listening a bit better”

Story-retelling sessions

When asked what ways students’ story-retelling skills were supported by the story-retelling sessions, both teachers indicated that the repeated reading of the story was helpful as well as modelling the answers to questions. Teacher A stated that the “modelling of the language to be used” had increased the students’ ability to retell the story from a character’s perspective and “modelling hearing myself or the robot modelling what the answers look like, I think was really helpful and the repetition”. Modelling by peers was also noted by Teacher A as a strategy for students who were “struggling a bit” and “by not putting him [the student] first and him listening to somebody else say it first” helped some students retell the story. Teacher B also mentioned that “the multiple reads of the same text cemented what it was about. They [students] became familiar with the text very quickly”.

Teacher A stated that using a variety of strategies was important during the story-retelling sessions “of sometimes the book, sometimes the robot, sometimes me, sometimes the Story Braid, and that sort of thing so changing it up, yeah, all the time was a good strategy”. Teacher B mentioned the Story Braids were effective for comprehension as the students retold the story: “they knew what each part was, they felt if, and they would feel it while they were doing it”. Teacher A also stated that the Story Braids helped students retell the story and they also gave them “something to fiddle with that we’re actually talking about” and “it just shows that kids can play, fiddle, and listen and engage in that sort of thing. So, yeah, I think the Story Braid was my learning of the year”.

Both teachers agreed that the Story Braids would transfer the most easily into a classroom context. Teacher A stated that they “would just have one for everybody every time you’re doing sort of narrative work and that sort of thing” and that “the kids who don’t need it would slowly just stop using one and those that rely on it could keep using it”. Students using the Story Braids for retelling stories in the classroom context was also discussed by Teacher B, who stated the students were “familiar with the story beads” and that they would be asking other teachers in the school “would they like the story beads” for story retelling, “because the kids are familiar with it, they know how to do it”. Teacher A, compared using the robot to using the Story Braids, stating that while they were “miles apart in terms of strategies … I think the Story Braid is so effective” and the robot was mainly “there for the interest and engagement”.

The perspective-taking and character maps were also discussed by Teacher B as helpful for students to retell the story from a character's perspective, as they "could see the two sides, especially doing the two characters… they could see the same progression of the story on two different sides of the sheet". Teacher A stated that it helped to have the robot to prompt students when "they get stuck writing it down" but some students were "writing exactly what the robot said" and if the sessions had gone for longer the students should have become "less reliant on the robot" for their answers.

As students completed the character and perspective-taking maps, both teachers encouraged students to look at the pictures from the storybook. Teacher B stated it was important for students to "see what they [the characters'] were wearing, and they can associate with the behaviours". Teacher B further stated, "going back and talking about the story, how it all unfolded" was important for encouraging perspective-taking and students needed "the visual clues, with going back, looking at the pictures, then doing the different perspectives". Using visuals was also a strategy that Teacher A focused on when discussing the strategies used for story retelling stating, "the visuals were excellent".

Teacher B discussed the modelled responses (scripts) that were given to the teachers, to help scaffold the sessions, as one reason the "group went well" and stated that "I think it was just the guided, the modelled response. Just so we know how much you expect from the children". Teacher B suggested that while "I think the group, the activities were really good. The group went well", by making the groups smaller the sessions would be "more focused. They're not waiting for someone else to finish their turn". Teacher A, however, saw students working in the group as beneficial for "hearing each other's" retelling of the story. Including further sessions on retelling the story from a character who isn't a main character in the story, was discussed by Teacher A who stated that children "kind of wanted to, I think do that one, but then don't think they can do it".

In summary, both teachers discussed the repeated reading of the story as helpful for students for their story retellings. The students quickly became familiar with the story. The teachers reported that the repeated reading of the story and the questions by the teacher and/or the robot modelled the language students could use for their retellings and helped their ability to retell the story from a character's perspective. Hearing other students retell the story was also noted as important for students who were struggling. Using a variety of strategies was also highlighted, including the repeated reading of the story, scaffolding students' answers with the character and perspective-taking maps, and using the Story Braids. Both teachers agreed that the Story Braids were the most effective strategy and would transfer most easily into a classroom context. The perspective-taking and character maps were also seen as helpful for students as they helped prompt them when they

were retelling the story from a character's perspective. The teacher guide scaffolded the sessions for the teachers and while the session guides and scripts were seen as beneficial, an additional session was suggested, retelling the story from a character who is not the main character in the story.

4. Summary of Key Findings

This pilot study expands understanding about the use of humanoid robots for supporting story-retelling for children on the autism spectrum. The study developed teacher session scripts for supporting the teachers conducting the story-retelling sessions. These guides scaffolded the sessions, as well as the use of the Story Braids and character and perspective maps. In addition, robot scripts were developed to help model the language to be used in the student retellings. These scripts were also used by the teacher without the robot.

While social perspective-taking and use of internal state language did not seem to change after the teaching programs across the two groups, individual student differences were observed in both schools. The lack of significant change in the students' social perspective-taking and use of internal state language indicates that the use (or lack of use) of the robot did not contribute to the improvement of these skills in both groups. However, the assessment of these skills was based on a single brief narrative story-retelling task which may have posed inherent limitations to students' performance. Additional story-retelling tasks could generate richer narrative data on these skills and could assist in the interpretation of any group differences. Another plausible interpretation of the lack of any significant changes in the students' targeted skills is the short length of the teaching program. The findings of this proof-of-concept study have indicated that 6 sessions may have not been sufficient for any significant group changes to be observed immediately after the end of the teaching program. This explanation is supported by the fact that only half of the students across the two schools attended all teaching sessions. With these considerations in mind, it would be meaningful to collect data 4-6 weeks after the completion of the teaching program in order to evaluate whether students had maintained the targeted skills.

The examination of individual students' social perspective-taking and use of internal state language before and after the teaching program has revealed changes worthy of further analysis. It would be interesting to conduct a micro-analysis to explore the verbal interactions among the students in each group and the teachers' responses as well as the students' engagement in the teaching sessions. Teachers used the teaching scripts to guide and support students in their narrative story-

retelling and the completion of character and perspective-taking maps. However, the spontaneous teacher-student and peer interactions in the sessions may reveal the reasons for individual student's learning pace and their performance in the narrative story-retelling tasks post the teaching program. A comparison of the repertoire of teaching strategies (e.g., modelling, explicit instruction, peer learning, formative feedback, use of visual supports) employed by teachers in both schools across the sessions could offer insights into the observed differences between individual students in the targeted skills.

The teachers used a variety of strategies, and the Story Braids were seen as the most effective for transferring to a classroom context. The character and perspective maps helped the students to retell the story for a character's perspective. The robot was seen as a tool to keep students engaged with the repeated reading of the story and to help model the language to be used in the retelling. Disengagement with the robot over time was discussed by Teacher A and the need for further research on the use of the humanoid robot in other learning areas, for children on the autism spectrum (English, Mathematics, Physical Education and Digital Technologies).

Key findings of this pilot study aimed to evaluate the effects of a humanoid robot on the story retelling skills and the social perspective-taking of children on the autism spectrum, are as follows:

- No significant changes were observed in students' social perspective-taking following the completion of the teaching program in both groups.
- No significant changes were found in students' use of internal state language after the teaching program in both groups.
- The expectations teachers have about using a humanoid robot need to be addressed prior to commencing using the robot in the classroom. Students' expectations also need to be managed.
- The robot helped keep students engaged with the repeated reading of the story.
- The teacher guide and session scripts were seen as important for helping scaffold the story retelling sessions. The scripts, and the robot, helped model the language needed for the retellings.
- The character and perspective-taking maps were considered as beneficial for scaffolding students' retelling of the story from a character's perspective.
- The Story Braids were the most effective strategy used and were seen as the easiest to transfer to a classroom context.

5. Limitations

While these results suggest that the story retelling sessions implemented in this study have the potential to improve the student's social perspective-taking skills, it is difficult to make comparative conclusions between the two groups, and the potential impact of the robot. Limitations of this pilot study include:

- The delay in the recruitment of School B due to restrictions caused by the COVID 19 pandemic. This also caused delays in the recruitment of teachers and students for the study.
- The small sample size, of two groups of 5 students, from two different schools, limits the ability to generalise the results. Further research would need to explore if the results from this study can be replicated.
- The teachers also present a limited data set but do show a representation of their perceptions after being involved in this study.
- Two different teachers, with different skills, conducted the sessions in each school. As such, it is difficult to identify the impact the different teaching styles could have had on the outcomes.
- The lack of follow up data to evaluate whether students' social perspective-taking and use of internal state language have been maintained after the completion of the teaching program. This phase has not been implemented as planned, due to COVID-19 restrictions on school operations.

6. Implications

6.1 Implications for Future Research

This study can inform the use of humanoid robots for narrative story retelling with students on the autism spectrum. Further research on social perspective-taking and internal state language with children on the autism spectrum through group teaching programs delivered by teachers is required to uncover the learning process for individual students and how they engage with their teacher and their peers in these sessions. Further studies are also necessary to explore the variety of strategies used by the teachers in the story retelling sessions, including the story retelling

session guides and scripts. The effectiveness of the teacher session guides and scripts could also be examined in other curriculum contexts and on a larger scale.

6.2 Implications for Future Practice

Implications for future practice include:

- Making the session guides and scripts, developed for this study, available for teachers and schools, interested in using humanoid robots for supporting story retelling with children on the autism spectrum.
- Providing guidelines applied in this study, to teachers and school staff interested in the use of visual supports (such as the Story Braid) to scaffold story-retelling covering key parts of the story structure for small group instruction.
- Providing exemplars of activities and rubrics for evaluating the individual use of internal state language in story retelling and written activities (e.g., character and perspective-taking maps).
- Professional Development (PD) for teachers to discuss expectations and to provide an overview of the teacher guide, scripts, and strategies used in the story retelling sessions.

7. Key Recommendations

Not only will this study contribute to existing practices in the fields of autism education and educational robotics, but it also has implications for future research and practice. Developing teacher capacity to use assistive technologies (in this case educational robots) and the use of guides and scripts will expand teachers' existing practices for supporting students on the spectrum in their story-telling and social understanding.

This study has generated new knowledge on the use of humanoid robots for story retelling and social perspective-taking skills with students on the spectrum. It also contributes to the research about the use of NAO Robot with children on the autism spectrum and can be used to inform future research into additional attributes of the robot that could contribute to improved learning and generalisation of skills.

Despite the fact that teachers in both groups were provided with scripts, it would be interesting to explore their spontaneous use of mental state language in their references to the story characters' mental states and the instances of positive and corrective feedback to help every student in their

group complete the perspective-taking maps for the story characters and retell the story using the Story Braid.

Project findings can guide participating schools and teachers using humanoid robots to supporting story retelling with children on the autism spectrum. Other teachers, and students on the spectrum, might also benefit.

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Appendix A: Semi-structured interview questions

1. What were your first impressions of the humanoid robot?
2. Did the robot meet your expectations? If so, how? If not, why not?
3. What do you think the students' experiences with the humanoid robot taught them?
4. What do you think are the positive and negative aspects of using the humanoid robot?
5. What do you perceive as concerns that may arise with using this humanoid robot to help students on the autism spectrum develop story-retelling skills?
6. Would you use this robot as a teaching tool? What would you need to facilitate using the humanoid robot (other than the robot)?
7. In what ways do you think students' story-retelling skills were supported by the story-retelling sessions?
8. What strategies did you use during the story retelling sessions to support students' story retelling?
9. Do you think that the story-retelling sessions increased students' ability to re-tell stories from another character's perspective?
10. How do you think the learning from the story-retelling sessions supported the transfer of these skills to the classroom setting?
11. How do you think this type of intervention can be improved to increase the benefits for students on the autism spectrum?
12. Is there anything else you would like to add?

Thank you.

Appendix B: School A -Social perspective-taking scores

Detailed pre- and post-teaching social perspective-taking scores for students in School A.

School A							
ID	**PRE Retelling 1**	**PRE Retelling 2**	**PRE Average**	**POST Retelling 1**	**POST Retelling 2**	**POST Average**	**Outcome**
Student 1	1	1	1	2	0	2	Increase
Student 2	5	3	4	5	5	5	Increase
Student 3	3	2	2.5	0	2	1	Decrease
Student 4	1	4	2.5	5	5	5	Increase
Student 5	1	1	1	1	1	1	No progress
Mean Score			2.2			2.8	Increase
SD			1.12			1.83	

Appendix C: School B -Social perspective-taking scores

Detailed pre- and post-teaching social perspective-taking scores for students in School B.

School B							
ID	**PRE-Teaching Retelling 1**	**PRE-Teaching Retelling 2**	**PRE-Teaching Average**	**POST-Teaching Retelling 1**	**POST-Teaching Retelling 2**	**POST-Teaching Average**	**Outcome**
Student 6	1	1	1	5	3	4	Increase
Student 7	0	0	0	3	3	3	Increase
Student 8	5	0	2.5	2	2	2	Decrease
Student 9	0	0	0	4	0	2	Increase
Student 10	4	0	2	5	4	4.5	Increase
Mean Score			1.1			3.1	Increase
SD			1.01			1.02	

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Our values

Inclusion

Working together with those with the lived experience of autism in all we do

Innovation

New solutions for long term challenges

Evidence

Guided by evidence-based research and peer review

Independence

Maintaining autonomy and integrity

Cooperation

Bringing benefits to our partners; capturing opportunities they cannot capture alone

Australian Government
Department of Industry, Science, Energy and Resources

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