

To what extend can a social robot help toddlers with LDD around the age of 2 – 4 with their social interactions during language therapy sessions?

Isabelle van Dijk, Michel Kastelein, Mitchell Temming, Melvin Alomerovic

Hoge school Utrecht

Abstract- In the early stages of children's youth, social interaction is needed to convey their feelings and to develop their social and language skills. Children with a language development disorder (LDD) have trouble with both these conditions. In the research that will be discussed in this paper, the focus is to discover the effects of a social robot on the social interactions between children with LDD. To discover this, an observation will be performed where the social robot will give these children tasks to stimulate cooperation. During the experiment, our participant will interact with a social robot that will give the participant a certain task to perform. While performing this task, the participant will be observed on his/her behaviour and social interaction with other children while performing these tasks. During the observation, a list of specific behavioural findings will be noted. These behavioural findings will be compared with a baseline that has been set before the participant interacts with the social robot. This is how changes in behaviour and changes in social interaction are measured.

I. INTRODUCTION

Language is an essential instrument for forming and continuing all sorts of relationships, such as friendships [1]. Children spend much time with friends and learn from interacting with other children. Especially in the early years of a child, this interaction is important. Difficulties with language development can lead to low-quality friendships and a lack of social interaction, which can eventually lead to being less accepted by your peers and having fewer friends [2]. This impacts the emotional growth of the child, which impacts them for the rest of their lives [3]. Language development disorder (LDD) is a neurobiological developmental disorder where language is processed inefficient in the brain. Children with LDD are less able to distinguish speech sounds [4]. As a result, the child has a particularly high risk of developing other behavioural problems such as aggression, depression, and anxiety [5]. The parents' ignorance about the child's disorder makes the life of the parents more difficult. Simply because the parent does not recognize the child's atypical behavior [6]. Organizations such as the

Nederlandse stichting voor dove en slechthorende kinderen (NSDSK) focusses on this group of children. Main reason for this is that NSDSK tries to improve the social ability of the child before going to school, since school is a place where the children will encounter a lot of social interaction. These children receive special treatment for nine months, during which they spend two to three half-days together. The treatment of LDD takes place in the form of therapy, with a particular focus on linguistic skills. The treatment allows individuals with LDD to maximize their language skills [7]. It is important to start this treatment early because the earlier treatment for LDD is started, the higher the chance the child's social abilities will increase [8]. Friendships and communication skills are necessary to build experience in social interaction [9]. Children spend a lot of time developing their intellectual skills while playing with other children under nurses' and psychologists' supervision [10]. The nurses encourage this. Research has shown that a social robot can also help to stimulate social interaction in children with autism [11]. To support this treatment, we want to look at the effects that social robots have on children with LDD. In addition to a stimulator, a social robot can also be a valuable extension for primary school teachers [12]. This robot stimulates social interaction as well, as it can help with learning. Perhaps a social robot can also help in the treatment of children with LDD, this is the reason for our research. Social robots can help in education to make the monotonous digital learning process tangible for children and can increase their interest and productivity [13]. The main objective of this research will be the discovery if a robot is able to improve interaction between toddlers around the age of 2 – 4, during language therapy sessions. Social interactions will be interpreted as interpersonal relationships between two or more individuals within and/or between groups. We hypothesize that social robots can improve social interactions between toddlers who suffer from LDD. We have based our hypothesis on research that has already been conducted for NSDSK [14]. In this research, the research didn't focus enough on the positive influence a social robot can have on the social interactions of toddlers. Therefore, we plan to further conduct more

research. NSDSK has told us that they will single out the toddlers who are most likely to benefit from our research [14]. The chosen toddlers (aged between two to four years old) that we will conduct our research on will be old enough to understand what a robot is and will be told explicitly that the robot does not serve as a toy, but as a language-learning tool. These kids will be chosen by their supervisors. Since the focus group are young children, we expect them to still see the robot as a toy. Playing is one of the main ways a child learns, it helps to build self-worth and helps them to feel good about themselves. Because playing is fun, children often become absorbed in what they are doing [14]. By introducing these children to a social robot, which they see as a toy but serves as a learning tool, we think we can further improve their sessions and bring them a more fun learning experience. The social robot we use will have written scripts that support the learning goals of the children. The robot will give short instructions to the kid or teach them a word. This is also further discussed in the research design. In order to properly test the progress of the children, an observation list is required; this observation list is divided into several categories. Communication can be divided into verbal and pre-verbal (non-verbal) [15]. These two forms of communication can be divided into control and interaction functions. The difference between these two is that control function is influencing the behavior of another, interaction is regulating one's own behavior. By a function is meant to express or have the intention. So, the following categories are tested: Preverbal Interaction Function, Verbal Interaction Function, Preverbal Representation Function, and Verbal Representation Function. In this paper, we will further discuss our methods, analysis, results, discussion, and conclusion.

II. BACKGROUND

Language development disorder (LDD) is a neurobiological developmental disorder where language is processed less well in the brain. Children with LDD

III. METHODS

Participants

For this project there are four children selected to work with the robot Alpha Mini. All the participants are diagnosed with LDD. One girl with the age of 3 years and 11 months, one boy with the age of 3 years and 10 months and 2 boys with the age of 3 years. All children's parents signed an informed-consent form to allow their children to participate in this study. During the experiment we used

experience difficulties understanding language and therefore experience trouble speaking it [1]. Language is an essential instrument for forming and continuing all sorts of relationships, such as friendships [1]. Children spend a lot of time with friends and learn from interacting with other children. Especially in the early years of a child, this interaction is important. Difficulties with language development can lead to low-quality friendships and a lack of social interaction, which can eventually lead to being less accepted by your peers and having fewer friends [3]. This impacts the emotional growth of the child, which impacts them for the rest of their lives [2]. A second complication that the children experience is having less interaction within their social environment, which can lead to missing out on a lot of information.

Children that have been diagnosed with LDD can be admitted to organizations that help children with their language development. Organizations such as the Nederlandse stichting voor dove en slechthorende kinderen (NSDSK). They focus on this group of children because they want to help these children before going to school, where they will encounter a lot of social interaction. These children will get special treatment over the course of nine months, which they will spend two to three dayparts with each other. To support this treatment, we want to look at the effects that social robots have on the children.

Social robots are robots that interact with humans and each other in a socially acceptable fashion, conveying intention in a human-perceptible way, and are empowered to resolve goals with fellow agents, either human or robot [4]. Studies have shown that social robots can have a positive effect on healthcare, hospitality, and other forms of education.

Research have been done on children with autism, where the results on the use of social robots were positive. Children showed interest in the social robots and increased learning gains were shown. With this in mind, we want to expand the direction that this research has taken and want to fill in the gap if the use of social robots with LDD diagnosed children has a positive effect and give organizations such as the NSDSK opportunities for support in a time where it is needed.

candy and after each experiment the children received additional candy to thank them for participating.

Experimental design

The experiments will be conducted in a room where the children will play and talk with the robot. Next to this room is another room with a one-way screen where the researchers will be observing the child. The child will behave as it likes since it cannot see if he/she is being observed. A speech therapist will also be present during the

experiments, she is able to assist the social robot when the children don't listen to the robot or repeat certain words if the child did not hear the robot correctly. Since there are also toys in the room the therapist also makes sure the participants focus on the robot instead of the toys present in the room. The speech therapist will be taking notes as well and will help the researchers by checking out the observation lists the researchers have filled in during the session (see 'materials' for more information on this list). These experiments will take place from 21 November 2022 till 15 December 2022 on every Thursday from 9:00 AM till 11:00 AM. Every session will be a maximum of 30 minutes with the child and robot. It is possible that the interaction will finish earlier than expected. This will leave enough time to run the script in case unexpected situations happen. The robot will have a 1-on-2 session with the children. This can be observed through the one-way screen.



Figure 1: a picture taken from the one-way screen.

The children will enter the room in pairs, with their speech therapist guiding them. A 1-on-2 interaction is chosen to see if there may occur unexpected results. When a social robot is with the children, we hope this will cause them to talk to each other rather than play in silence or only speak to the speech therapist. We have chosen a pair where child 1 is very energetic, he speaks a lot but has a short attention span and does not listen. Child 2 does not speak at all but pays close attention to what instructions he is given. We put these opposite children together on purpose, so the researchers can see if the communication will be affected by the energy of the other child.

Materials

For this experiment, the Alpha Mini robot is used to interact with the children. It is programmed with the "Robots in de klas" software [16]. The following script will be used by the robot to stimulate interactions, which is written in Dutch. The experiments are all based on a theme. The themes are 'Sinterklaas' and Christmas. The feast of

Sinterklaas celebrates the name day of Saint Nicholas on 6 December. The feast is celebrated annually with the giving of gifts on St. Nicholas' Eve (5 December) in the Netherlands and on the morning of 6 December. The theme 'Sinterklaas' is from 21 November to 5 December and Christmas is from 6 December till 22 December. When there are two children in the room the robot will have to talk to both, a different approach is needed because the robot must communicate with the children but also make the children communicate with each other. The script used for the 1-on-2 interaction will be listed as an appendix.

The researchers discussed the requirements of the script with the speech therapists Margoke and Nicole. There are a few important points to note that the researchers took into consideration when writing the script for the robot: every sentence must be around four to five words at max.

Otherwise, it will be too complicated for the child to comprehend what the robot said. The script contains the same elements as the TV show Dora the Explorer. This means that the robot will repeat certain questions until the child can understand it and respond. The researchers can make the robot repeat the sentence manually, to give the children as much time to think as possible. Because the robot speaks like Dora the Explorer, the robot also has a playful side and therefore can entertain the child for a long period. Some children that have LDD are also suffering from a phonological disorder [17], and therefore it is important that the robot must repeat the question if necessary.

Every week the child(ren) will be observed, to do this the researchers received an observation list (see appendix for full list). The observation list will measure how well children are able to express their social skills and language. Using the observation lists, the researchers will compare the first measure with the second measure moments using the robot to see how much the child has improved their social skills and the use of language. The list is recommended by the speech therapists and researchers of NSDSK and STAN. The speech therapist and the researchers sat down to see what points of the observation list is applicable to the research. The modified observation list is added to the appendices.

Points of notice:

The researchers decided to control the robot manually. By doing this, the robot can repeat questions and sentences, to prevent long silences if the child does not respond. Also,

there are no issues with touching the robot because the alpha mini is sturdy enough to withstand fall damage to some degree, so it won't be a serious issue in case the child lets it fall over.

Procedure

The participants are all grouped together in the playground prior to the experiment where they would perform their daily activities from their regular treatment. Meanwhile, the researchers are preparing the room for the experiment.

The robot is placed on a small table with two chairs surrounding it. Other attributes which are important when running the script are also placed in advance. 'Pepernoten' are hidden in various spots in the room, from the 6th of December the 'pepernoten' are changed to 'kerstkransjes' due to the theme changing to Christmas. Different toys are placed in the room to build a tower. After preparations are made, the researchers will take place in the hidden room while the speech therapist will pick up the first pair of participants. Upon entering the room, the speech therapist and the children will take a seat. The researchers across the other room separated by the one-way screen will run the script. While the robot and participants interact, the researchers will observe the behaviour of the participants using the observation list (see table 1). The speech therapist takes notes of the participants as well and occasionally aids the social robot when the child does not listen to the robot or is distracted by the toys. After the first session is finished, the speech therapist will bring the two participants back to the playground and get the other pair of participants. The same process will be repeated for the other participants. The experiments will be performed a total of four times.

Analysis

We measured multiple values for each child. All these values are categorized into non-verbal, verbal, non-verbal representation, and verbal representation in order to see where the child might show improvement (see Table 2).

We took the data of the first measure moment (T0) and the last measure moment (T1).

Abbreviation	Definition
PIT0	Non-verbal interaction function measurement 0
VIT0	Verbal interaction function measurement 0
PRT0	Non-verbal representation function measurement 0
VRT0	Verbal representation function measurement 0
PIT1	Non-verbal interaction function measurement 1
VIT1	Verbal interaction function measurement 1
PRT1	Non-verbal representation function measurement 1
VRT1	Verbal representation function measurement 1

Table 1: Abbreviations and definitions

The child has a score based on their performance during the experiment, when the child can express a social skill, they receive a score of 1. When they are barely able to express their social skill and there is room for improvement, they receive a score of 0,5. And lastly, when the child is unable to express a social skill, they receive a score of 0. All the values that belong to a certain category are summed up, for a total of four scores per child per measure moment. These categories are: non-verbal interaction function, verbal interaction function, non-verbal representation function, and lastly verbal representation

function. Afterward, we compare the results with repeated measure Anova, and process the data in SPSS version 29.0.0.0 (241). By using repeated measure Anova, we will be able to measure the improvement in the child's social

skills after the sessions with the robot compared to the first interaction.

IV. RESULTS

The most useful table is the Test within subject contrast. This is because the table suggests that the robot affects the non-verbal representation function. The other functions are not affected by the robot since the **sigma returns greater than 0.005**.

Source	Time			
Measure	pin	vin	pr	vr
Tijd	Level 1 vs. Level 2	Level 1 vs. Level 2	Level 1 vs. Level 2	Level 1 vs. Level 2
Time III Sum of Squares	1000	9000	25000	20250
df	1	1	1	1
Mean Square	1000	9000	25000	20250
F	2000	4154	75000	5400
Sig	.252	.134	.003	.103

Table 2: Test within subject contrast

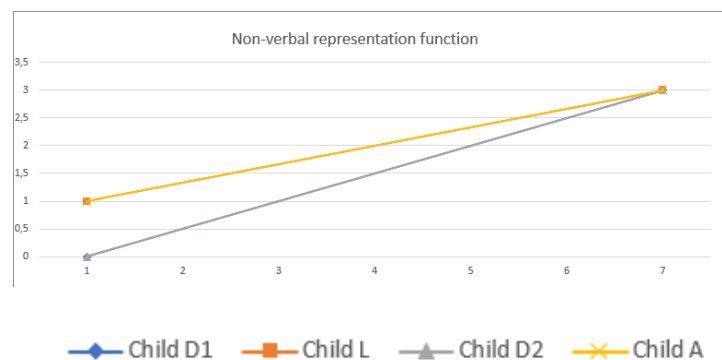


Figure 3: Grow of non-verbal representation function per child

Based on the repeated measure ANOVA could be concluded that the interaction with the alpha mini and children did not influence PI ($F = 2.00$, $p = 0.252$). The same could be conducted on VI ($F = 4.154$, $p = 0.134$) and VR ($F = 5.40$, $p = 0.103$). Pr has a different effect ($F = 75.00$, $p = 0.003$); the robot influences non-verbal communication in a positive way. Based on other research, our results seem to be correct. Their results were that children were more expressive in their non-verbal behavior when playing with the robot than when they were playing alone, but less expressive than when playing with a friend. [18] The robot makes the child produce non-verbal behavior. In our research, the robot

improved the non-verbal representation between the children.

V. DISCUSSION

The outcomes of the research have given insight into the effects of using a social robot during speech therapy sessions. The results show that there is a positive effect on the non-verbal representation of the children. Other than this we can see small changes in other functionalities, but these changes differ between the children. Therefore, we can conclude that a social robot can be used to help toddlers with LDD around the age of 2 – 4 with their social interactions during language therapy sessions. However, the results should be interpreted with caution due to the limitation in the number of children and the amount of acquired data. For these tests, we used only four children, in pairs that were often switched up. This low number of test subjects makes it difficult to conclude if the findings are true for all children or for only these four children. Another weakness of this research is that the time between tests differs for each session. Therefore, other things could influence the outcomes of the experiments. Lastly, the absence of a control group provides a good comparison with normal speech therapy sessions. The results of the tests show growth in social functionality with the children, but not a side-to-side comparison of this growth and the growth during the normal speech sessions. This absence goes hand in hand with the low number of test subjects. In Future research, the number of children that participate in the experiment should be larger so more data can be acquired. The control group should be present to make a good comparison. Different directions with this research can be to look at the growth in language knowledge. At the NSDSK, the children are tested on their knowledge of words and the making of sentences. Future research can make a comparison between normal language therapy sessions and therapy sessions using a social robot.

VII. ACKNOWLEDGMENT

REFERENCES

- [1] G. Lindsay, "The relationship between speech, language and communication needs (SLCN) and behavioural, emotional and social difficulties (BESD) Evaluation of evidence-based parenting programmes View project PGCE Plus View project," 2012, doi: 10.13140/2.1.2540.6721.
- [2] L. Dickstein-Fischer and G. S. Fischer, "Combining psychological and engineering approaches to utilizing social robots with children with Autism," in 2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Aug. 2014, pp. 792–795. doi: 10.1109/EMBC.2014.6943710.
- [3] I. Way, P. Yelsma, A. M. van Meter, and C. Black-Pond, "Understanding Alexithymia and Language Skills in Children: Implications for Assessment and Intervention," *Language, Speech, and Hearing Services in Schools*, vol. 38, no. 2, pp. 128–139, Apr. 2007, doi: 10.1044/0161-1461(2007/013).
- [4]: P. Tallala, N. Gaabb, Dynamic auditory processing, musical experience and language development, July 2006 , from https://www.sciencedirect.com/science/article/pii/S0166223606001147?casa_token=PQQ-dbvAAjYAAAAA:IZPIULHVVDWEfM1ix4BqSigsOCaCi4wUvRIH1QwSJS8_jZutDmogytIgennB8NHjQttgXmzlg
- [5]: U. Willinger, E. Brunner, G. Diendorfer-Radner, J. Sams, U. Sirsch, B. Eisenwort, Behaviour in Children with Language Development Disorders, October 1, 2003 from <https://journals.sagepub.com/doi/abs/10.1177/070674370304800907>
- [6]: Sapti, Faria Fairoz, Behaviors in children with language developmental disorders: its social impact on the parents in Bangladeshi context , 2018-12-05 , from <http://dspace.bracu.ac.bd/xmlui/handle/10361/11760>
- [7]: E. Armstrong, Language disorder: A functional linguistic perspective, Received 28 Aug 2003, Accepted 16 Dec 2003, Published online: 09 Jul 2009, from https://www.tandfonline.com/doi/abs/10.1080/02699200410001698599?casa_token=rgd6SzGqOuwAAAAA:QtzkptgktaHgG63DhLibyhKQ_HOU8t-xwsRouj7VZws6N31EsuqCjT3s0Tz4CfccRR7ixj5YeXqG
- [8] NSDSK, "NSDSK TOS Behandelmethode," 2021.
- [9]: Why Social Interaction is Important For Young Children , January 19, 2018, from <https://www.ybrecdc.org/child-care-maple-grove/why-social-interaction-is-important-for-young-children/#:~:text=Social%20interaction%20is%20important%20for%20kids.,develop%20these%20important%20life%20skills.>
- [10]: Nasli Bakir Zina Ibtisse, Language Developmental Delay and Speech
- [11]: J. Kanero, V. Geçkin, C. Oranç, E. Mamus, A. C. Küntay, T. Göksun, Social Robots for Early Language Learning: Current Evidence and Future Directions, 08 January 2018, from <https://srcd.onlinelibrary.wiley.com/doi/full/10.1111/cdep.12277>
- [12]: M. Smakman, P. Vogt, E. A. Konijn, Moral considerations on social robots in education: A multi-stakeholder perspective , 2020 from

<https://research.vu.nl/en/publications/moral-considerations-on-social-robots-in-education-a-multi-stakeholder-analysis>

[13] Gupta, Jain: Challenges of Robot Assisted Teaching in Education Domain. 2021. Retrieved October 3rd, 2022.

[14] De Jong, C. Children and social robots: Towards a better understanding of their acceptance of a new technology. (2022, 12 July).

<https://dare.uva.nl/search?identifier=136cf1ba-40a5-4270-bc86-03bf1654135c>.

[15] M. Noterdaeme, K. Mildenerger, F. Minow & H. lief, "The frequent co-occurrence of verbal and non-verbal, in particular neuromotor, deficits in developmentally impaired children put an additional burden on the development of these children and should be diagnosed as early as possible." 2002,

[http://link.springer.com/article/10.1007/s00787-002-0285-](http://link.springer.com/article/10.1007/s00787-002-0285-z)

[z](#)

[16] Eight Media. (z.d.). Robots in het onderwijs: de moreel verantwoorde inzet van robots assistenten | Hogeschool Utrecht.

<https://www.hu.nl/onderzoek/projecten/robots-in-het-onderwijs-de-moreel-verantwoorde-inzet-van-robots-assistenten>

[17] Wat is een TOS/ Taalontwikkelingsstoornis? (z.d.). NSDSK - Specialist voor taal en gehoor. Geraadpleegd op 17 oktober 2022, van <https://www.nsdsk.nl/wat-is-een-tos>

[18] S. Shahid, E. Krahmer, M. Swerts, "Child-robot interaction across cultures: How does playing a game with a social robot compare to playing a game alone or with a friend?" November 2014, from:

<https://www.sciencedirect.com/science/article/abs/pii/S0747563214004178?via%3Dihub>