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THE USE OF NAO ROBOTS IN TEACHING CHILDREN WITH AUTISM

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Abstract:
There is an increasing number of people with autism spectrum disorders (ASD) and therefore different software and hardware solutions are made for them. The effectiveness of any type of treatment is connected to its intensity and interventions based on the use of technology can allow that. The aim of this literature review is to examine the effectiveness of interventions focused on teaching people with ASD with the use of Nao robots. For the literature search, we used Google Scholar, SciIndex and ProQuest search engines. The articles were searched by using keywords: autism, autism spectrum disorders, Nao robots, and humanoid robots. We included articles published in the last 10 years that were original research articles focused on teaching people with ASD certain skills. In the review section, we included eight research. The average effectiveness of these interventions was 40.3%. The reasons for insufficient success are a subjective measurement of intervention success and a low number of sessions. Having in mind that parents of people with ASD often choose interventions that are not scientifically based, we believe it is of great importance to implement research focused on the effectiveness of different treatment modalities, which is also the main significance of this article. Suggestions for future research in this area are discussed, as well as the limitations of this paper.

Keywords: skill acquisition, Nao robots, autism, teaching, technology

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1. Introduction

In a report by World Health Organization (WHO, 2011), it is highlighted that there are more than a million people with some disability and because of the emerging number of people with developmental disabilities (DD), different software and hardware solutions are made for this population (Aresti-Bartolome & Garcia-Zapirain, 2014). The effectiveness of any type of treatment is linked to its intensity and frequency (Boyd *et al*., 2014) and the need for having more intensive treatment in teaching certain skills lead to interventions based on technology use, which enables repetition while teaching certain skill (Goh, Ang & Tan, 2008).

Research implies that people with DD have a preference for using technology in teaching (Hart, 2015) and interactive robots have proven to be a promising tool in working with people with different types of DD (Liu *et al*., 2016), especially autism spectrum disorders (ASD). The emerging of Nao humanoid robots made robotic use in education and research possible (Miskam *et al*., 2014) and robot use in the treatment of people with ASD can improve their education and bring diversity into traditional teaching (Palestra *et al*., 2014). Nao robots can be used in schools, as well as centres for early intervention (Pot, Monceaux, Gelin & Maisonnier, 2009). The biggest advantage of using Nao robots in teaching people with ASD different skills is believed to be an increase in their motivation (Ricks & Colton, 2010) and it was shown that they react positively and have a more proactive approach in their teaching and training sessions, which some authors believe is essential for teaching social initiation (Robins, Dickerson, Stribling & Dautenhahn, 2004).

People with ASD used more eye contact while interacting with a robot in comparison to humans, had a higher frequency of imitation (Chevalier, Isableu, Martin & Tapus, 2015) and showed more willingness to interact with a robot than humans (Taheri, Meghdari, Alemi & Pouretemad, 2017), which can be beneficial in social skills training. The research conducted by Miskam and allies (Miskam *et al*., 2014) conducted with the aim of examining the possibility of using Nao robots in teaching children with ASD emotion recognition showed that children with ASD can successfully be taught new skills while using robots, because all children from the sample were successful in identifying emotions presented to them by the robot with 100% success. The authors of the study state that these results are a good foundation for using robotics in teaching people with ASD.

The aim of this literature review is to examine the effectiveness of interventions that focused on teaching people with ASD with the use of Nao robots.

2. Methodology

For the literature search, we used Google Scholar, SciIndex and ProQuest search engines. The articles written in English and Serbian language were searched, by using keywords: autism, autism spectrum disorders, Nao robots, and humanoid robots. We included

articles published in the last 10 years that were original research articles focused on teaching people with ASD certain skills by using Nao robots.

3. Literature review

Research by Liu *et al*. (2016) focused on using Nao robots to teach motor imitation and following instructions to five eight-year-old children diagnosed with ASD. Teaching sessions were conducted as follows: the child was facing the robot, and the robot gave them the discriminative stimulus 'do this' and performed a skill that the child was supposed to imitate. If the child imitated with success, the robot would provide praise and if not, the robot would provide visual feedback about which joint should be moved in order to successfully perform a skill. The authors found the results defeating. None of the participants could finish the teaching procedure, because of the inability to focus on the robots instructions. The authors of the study explain this issue due to the lack of verbal instructions given by the robot and state that future research should incorporate verbal feedback in combination with visuals because they believe that audio-visual input would lead to greater success. However, we believe that it would be beneficial to examine the attending skills of the children included in the study, which are necessary for this intervention.

Another research conducted with a similar goal was research implemented by Iranian authors (Taheri, Meghdari & Mahoor, 2020) that compared the effectiveness of teaching imitation skills by robots and by therapists. The experimental group that was taught by the robot consisted of eight participants, and both the experimental and control group were taught 10 motor skills that included entire body movements. Results showed that in 10 sessions, participants learned 50% of those modelled movements.

Research conducted by Suzuki & Lee (2016) with the aim of examining the possibility of teaching five children with ASD, of an average age of 13.4 years-old, skills of body part identification on others showed the possibility of using Nao robots in this domain as well. Robots had cameras and sensors that detected touch. Upon entering a room, the robot would give a child a verbal demand to touch one of his body parts and the child's reaction was noted. The robot taught the children from the sample identification of five body parts. Results show that the first participant mastered showing only two body parts out of five (40%), three participants could identify successfully only one body part that was taught (20%) and one participant mastered all five taught body parts, which represents 100% success. This implies that the average success rate was 32%. The authors state that these low results are because there was only one teaching session, but they imply that all children included in the sample showed interest in interacting with the robot. However, we believe that these results are not satisfying because there were not any prompts provided by the robot, also baseline was not performed, therefore it is uncertain if that one participant that mastered the skillfully already knew those modelled body parts or not.

Music can be used in working with children with DD in different ways (Kern, Rivera, Chandler & Humpal, 2013) and teaching different music skills is believed to be a foundation for social and communication skills (Geretsegger, Holck, Bieleninik & Gold, 2016; Kim, Wigram & Gold, 2008). Having that in mind, Iranian authors (Taheria, Meghdaria, Alemia & Pouretemade, 2019) conducted a research focused on teaching children rhythm perception. The sample included four six year-old children diagnosed with ASD and the inclusion criteria for the participants were that they have the prerequisite listener skills, motor imitation of simple motor movements and no prior musical education. They were taught to play the drums and xylophone, because they are believed to improve eye-hand coordination and rhythm perception. The robot was programmed to detect the correctness of played notes and give feedback if the note was played incorrectly or verbal praise if it was played correctly. Each session lasted about 20-30 minutes. The authors made a detailed teaching plan, where they planned on teaching participants successively more difficult tasks through different activities each week. They made nine phases; each with a duration of one week. The training would start with color matching and the final phase would include playing short melodies. Results showed that all children from the sample successfully mastered color matching, however, only one participant (20%) could complete the teaching plan and play a melody. Authors explain this as needing too much time to complete the first phase, which resulted in a lack of time for the following phases. Even though the primary aim of the study was not completed, progress was noted in all participants in the area of rhythm reproduction, with an average of 12% progress. Also, each participant had better results in the areas of motor imitation and joint attention probes.

Research (Chevalier *et al*., 2016) that focused on the possibilities of using Nao robots in teaching joint attention skills and matching skills to a sample of 11 children diagnosed with ASD, the average age of 11.9 years-old was conducted in a daycare center for children and teenagers with DD. The sample was divided into three groups, based on their baseline level of visual abilities. The first group consisted of five participants that had the best results on baseline assessment, the second group consisted of four participants with moderate abilities and the final group consisted of two children with low average baseline scores. For the purpose of research, they designed the game of stimulus matching that incorporated having joint attention prerequisite abilities. The game had three different levels, that matched previously assessed visual abilities and all levels had 15 matching pairs. Results showed that there was no statistically significant improvement among the participants after the intervention was implemented.

The research (Beer, Boren & Liles, 2016) was conducted with the aim of examining the effectiveness of the use of the Nao robot as a teaching tool for therapists that perform musical therapy with children with DD, focused on four children with ASD, with the average age of 13 years-old. The participants received musical therapy by the robot for a total duration of six weeks. The teaching procedure consisted of robots demonstrating eight different dance moves, which they had to imitate and every one of those moves was performed to a certain melody and combined with other movements, therefore the total

dance consisted of 39 movements. Baseline data showed that children can successfully imitate only 12 movements on average (32%), while in the posttest they successfully imitated 21 movements on average (53.84%), which represents a success rate of 21.84% in six weeks. In concluding remarks, the authors state that prompts given by the musical therapists during teaching sessions decreased and that they believe that if they continued with the training there would be even more improvement. However, since the musical therapists were the ones that prompted the children's movements, we would like to note that robots functioned only as modelling prompts, while response prompts were given by humans.

Newer research (Suzuki, Lee & Rudovic, 2020) was conducted with the aim of teaching eight children with ASD dancing skills, which consisted of teaching naming body parts and memorizing the sequence of movements through motor imitation. The authors measured intervention results in several domains. First, they measured participants' listening skills in a way of following instructions given by the robot. Results showed that there was no statistically significant improvement when comparing baseline and posttest results. The same refers to dancing skills or memorizing a sequence of movements because they could not replicate the moves when given the instruction. After that, they compared naming body parts results, which showed that there was a statistically significant improvement in this domain.

The research that used the Nao robot in the treatment of stereotypy (Luthffi Idzar, Syamimi, Hanafiah, Fazah Akhtar & Nur Ismarrubie, 2012) in six children with ASD and ID ranged from mild to average. Sessions were conducted in a way that a robot played children's favourite songs and danced to them with prearranged steps, which lead to stereotypy reduction. Each child interacted with a robot for 15 minutes and the duration of stereotypy was measured before and during the intervention. Almost all children from the sample had stereotypy reduction, except for one participant, whose stereotypy increased due to interaction with the robot. In concluding remarks, the authors highlight that this research shows that the Nao robot can be used in a school setting in order to enhance the social participation of children with ASD, since stereotypy can disable successful integration in the school environment. However, we believe that the noted reduction of stereotypy was because the children were engaged in other activities during that interaction, therefore the results are misleading. It would be methodologically better if authors measured stereotypy after the interaction.

The Literature review about the effectiveness of all interventions is listed in the review section and is given in Table 1.

Table 1: The literature review of the effectiveness of the use of Nao robots in teaching people with ASD

Reference	Sample	Average number of sessions	Treatment area	Treatment effectiveness
Liu *et al*., 2016	Five children with an average age of eight years old	One session	Motor imitation and following instructions	0%
Taheri, Meghdari & Mahoor, 2020	Eight participants, age was not specified	10 sessions	Motor imitation	50%
Suzuki & Lee, 2016	Five children with an average age of 13.4 years-old	One session	Body parts identification	32%
Taheria, Meghdaria, Alemia & Pouretemade, 2019	Four six-year-old children	63 sessions	Color matching and rhythm perception	Color matching 100% Rhythm perception 12%
Chevalier *et al*., 2016	Eleven children with an average age of 11.9 years-old	One session	Matching to sample and joint attention	Statistically significant improvement was not detected
Beer, Boren & Liles, 2016	Four children with an average age of 13 years-old	42 sessions	Dance skills through motor imitation	21.84%
Suzuki, Lee & Rudovic, 2020	Eight children, age not specified	Three sessions	Dance skills through following instructions and naming body parts	Statistically significant improvement was detected only in naming body parts
Luthffi Idzar, Syamimi, Hanafiah, Fazah Akhtar & Nur Ismarrubie, 2012	Six children, age not specified	One session in total duration of 15 minutes	Reducing stereotypy	66.6%

4. Conclusions and Recommendations

The literature review consisted of eight research articles, that were focused on teaching motor imitation skills, following instructions, body parts identification, rhythm perception, matching to sample, color matching, dance moves, joint attention and reducing stereotypy. The overall sample in all research articles included 51 participants, however, in the majority of the articles age of the participants was not mentioned. In 14 sessions on average, the overall success of these interventions was 40.3%, which implies that the use of Nao robots in the treatment of people with ASD is not sufficient.

We believe that the major limitation of these articles was the use of subjective measurement instruments, meaning that the majority of authors measured participants' satisfaction with the teaching process and measuring satisfaction is considered to be not objective (Kohn, LeBlanc & Mortola, 1994; Lenker, Scherer, Fuhrer, Jutai & DeRuyter, 2005; Wuolle *et al*., 1999). Another limitation refers to conducting only one session in

order to determine procedure effectiveness, which is the insufficient time frame needed for people with ASD to master a certain skill.

Even though it was stated in the methodological part that we searched articles published in Serbian and English language, we have to highlight that none of the articles published in Serbian was found. Therefore, we believe that more researchers from our region should focus on researching this kind of topic, which is our recommendation. We believe that regular classrooms, as well as schools for educating children with DD should own some form of technological advancements, in order to be able to use them in treatment. Having in mind that parents of children with ASD primarily choose to take their children to treatment modalities that have no scientifically proven benefits (Arsić *et al.*, 2021), we believe it is of great value for experts who work with children with ASD, as well as scientists from our region to have these types of technological advancements, in order to examine if they could be used effectively in treatment or not.

In conclusion, we give recommend future implementation of research that focuses on using Nao robots in teaching different skills to children with ASD, as well as other types of DD. However, we recommend implementing baseline assessment and posttests, as well as maintenance and generalization sessions, in order to know if the progress potentially made was because of the use of robots, or if it was contributed by different factors. We believe research conducted with the aim of examining intervention effectiveness should have adequate experimental control, in order to eliminate prejudice or exaggeration about certain types of treatment.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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