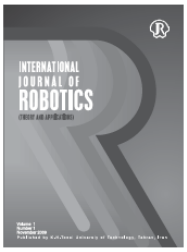

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Exploring Social Robots as a tool for Special Education to teach English to Iranian Kids with Autism

M. Alemi[a,*] and N. Mahboub Basiri[b]

[a] Faculty of Humanities, Islamic Azad University, Tehran-West Branch, Tehran, Iran
[b] Social & Cognitive Robotics Laboratory and Languages and Linguistics Center, Sharif University of Technology, Tehran, Iran

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ABSTRACT

This case study investigates the effects of Robot Assisted Language Learning (RALL) on English vocabulary learning and retention of Iranian children with high-functioning autism. Two groups of three male students (6-10 years old) with high-functioning autism participated in the current study. The humanoid robot NAO was used as a teacher assistant to teach English to the RALL group. Both RALL and non-RALL programs consisted of 12 sessions held within a 2-month period. Using a pre-test, mid-test, immediate post-test, delayed post-test design, this study measured the learning gains of the participants. The RALL group outperformed the non-RALL group in the designed tests which showed the effectiveness of RALL. This was further supported by comparing and contrasting the RALL and non-RALL groups' parents' feedbacks as well as the results obtained from the qualitative analysis of the video records. The findings of this study could be a starting point for a new line of research in second/foreign language education specific to children with autism.

1. Introduction

The word autism has been taken from 'autos', a Greek word meaning 'self', to refer to severe withdrawal. This term, however is not quite accurate, since not all individuals with autism tend to withdraw [1]. Symptoms of autism include having difficulty in talking about personal feelings or understanding feelings of others, lack of eye contact and joint attention, difficulty in communicating or using language, and sensitivity to physical contact [2]. According to the American Psychiatric Association (as cited in [3]), autism is also characterized by restricted and repetitive behaviors along with deficits in social communication.

According to current estimations of the Center for Disease Control and Prevention in 2014 (as cited in [4]), 1 in every 68 individuals suffers from autism which is an increase from 1 in 88 in 2012. This is in line with the statistics available from the U.S. Department of Education indicating a rise in the prevalence rate of autism in schools from 3.29% in 2005 to 7.02% in 2011 [3].

Autism is a spectrum with autistic individuals varying from low- to high-functioning according to their scope of disorders and cognitive skills. Accordingly, the term Autism Spectrum Disorder (ASD) has been adopted as a more accurate terminology to better present the wide range of disorders associated with autism. However, those with high-functioning autism who enjoy average or above average cognitive skills still do not usually perform quite well at school due to their impairments in social cognition which makes them shy away from participating in group works and struggle with cooperation [5]. Due to their distinct deficits, children with ASD have different unique learning styles which should definitely be taken into account by education

*Corresponding author address: Assistant Professor, Islamic Azad University, and Research Associate in SR Lab, Sharif University of Technology
E-mail address: alemi@sharif.edu

system and specifically by teachers. High-functioning autistic children usually make it to mainstream schools with normally-developing peers. However, without the appropriate help and support of the teacher and/or the school staff, children with ASD may have to drop out. Teacher education, therefore, plays an important role in educating students with ASD who with proper trainings have the potential to gain both academically and socially [1].

It has been a decade since robots have made their ways to the real world being used under the title "Socially Assistive Robotics (SAR)". Socially Assistive Robotics' focus is on helping people with social rather than physical interactions [6]. According to [7], the multi-disciplinary field of human-robot interaction (HRI) started in the mid-1990s and early 2000 when researchers from different fields of studies including robotics, psychology, cognitive science, and natural language started working together. Since then, many cross-disciplinary studies have been conducted. One of the important instances of such studies is the group of studies on the use of robots to help individuals with autism. The robots used in the realm of autism research, according to [2], vary in terms of appearance and include humanoid, animal-like, and machine-like robots. There have been lots of studies regarding the application of robots in helping autistic children with imitating, making eye contact, and social interactions. Based on these studies, humanoid robots seem to have a great potential in helping autistic children in overcoming their disorders [2, 8-15]. Previous research has also indicated that high-functioning autistic children are capable of learning a second/foreign language provided that they are granted the opportunity and of course special strategies in teaching [16-19]. The results reported by [20] who used RALL for English learners with autism also supported this claim. Learning a second/foreign language is a fairly complex process even for normally- developing individuals. High-functioning autistic individuals usually do not have severe problems in developing first language, but normally have impaired social cognition which makes communicating hard for them and negatively affects their foreign language learning, since according to Communicative Language Teaching (CLT), as one of the most widely used methods of teaching a second/foreign language around the world, learning a foreign language requires the learners to be engaged in pair and group activities, use the target language, and communicate through it. In other words, high-functioning autistic individuals should be encouraged to communicate with others to be successful in learning a foreign language. Therefore, raising autistic students' Willingness to Communicate (WTC), motivation, and positive attitude seems to be of great importance in foreign language classes. Furthermore, being required to use a foreign language in communicating could make autistics individuals anxious. Accordingly, a learning environment that can lower the anxiety levels of autistic individuals can also contribute to facilitating the foreign language learning process for them. Robots, as tangible interactive objects have given rise to a new system in the realm of second/foreign language learning that is Robot Assisted Language Learning (RALL). According to [21], the origins of research and development of RALL goes back to 2004 mostly in countries where English is considered as a foreign language such as Korea where over 30 English education robots are currently being used in the after-school programs of elementary schools. In the absence of native speakers in such countries, robots with native like pronunciations of the target language seem like a good alternative to make it possible for foreign language learners to be exposed to correct pronunciations of the target language. RALL has turned out to generate much more motivation and interest in normally-developing learners of a foreign language and lower their foreign language class anxiety levels at the same time [21-28]. Therefore, RALL seems to be a potentially good option for the individuals with autism who have been proven to enjoy interacting with robots.

Considering the facts mentioned above, there seemed to be a gap in the literature, regarding the application of robots as interesting tools to teach a foreign language to high-functioning autistic children. Accordingly, the goal of this study was to probe the effects RALL could have on Iranian high-functioning autistic pupils' English vocabulary learning and retention.

2. Methodology

2.1. Participants

The participants of the RALL group were three high-functioning boys (referred to as S1, S2, and S3, hereafter) who were respectively, 10, 9, and 7 years old with little or no background in English which was proven by the participants' performances in the English pre-test.

Three high-functioning boys (referred to as S4, S5, S6, hereafter) respectively 10, 7, and 6 years old with little or no background in English participated in the non-RALL program. It should be noted that S6 missed three of the 10 teaching sessions (sessions 3, 6 and 10), and failed to participate in the farewell session. Accordingly, the non-RALL group had some attrition through which S6 was technically excluded from data analysis.

2.2. Instruments

2.2.1. Teaching Instruments

2.2.1.1. The Humanoid Robot

The main instrument of the current study was the humanoid robot NAO (the Robocop version) developed

by Aldebaran Robotics (Figure 1) which was renamed to NIMA (a Persian name) to be used in Iranian context. The NAO robot will be referred to as NIMA hereafter. NIMA is a kid-sized programmable humanoid robot weighting 4.3 kilograms with the height of 57.3 centimeters.

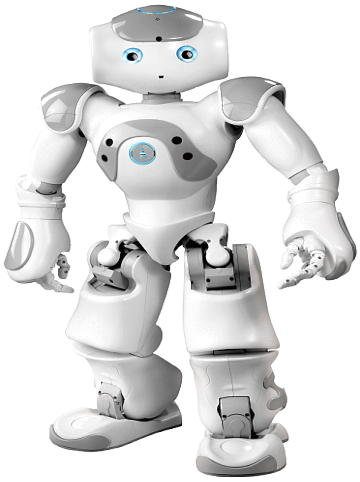

Figure 1. NAO Robot

Choreography is the visual graphical programming language of NIMA which is a user-friendly software. The Choregraphe has a library of predefined behaviors, such as walking, sitting down, standing up, and talking. The creation of desired behaviors and movements on NIMA is possible through programming in this software by mixing the predefined behaviors. In order to develop an action, say a dance, many steps should be taken. This software is equipped with the Webot for NAO simulator. The Webot allows testing the created behavior on a stimulated robot in a 3D environment. This makes it possible to do the programming in the software installed on a computer even without the presence of the robot itself (Figure 2).

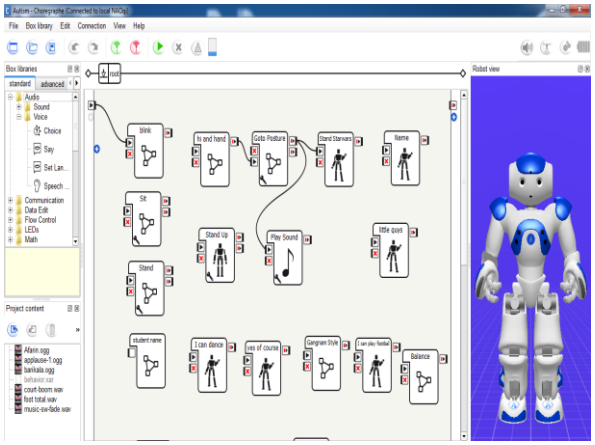

Figure 2. A screenshot of the Choregraphe page

2.2.1.2. The Book

According to the ages and levels of the participants, the fourth edition of LET'S GO 1 by [29] as one of the bestselling primary English textbooks of the world was selected. This book starts with a "Let's remember" chapter which contains the English alphabet, numbers one to ten, as well as some verbs. Due to the performances of the participants on the English pre-test, these three parts were taught within the first three teaching sessions respectively. LET'S GO 1 also contains eight units each with a specific theme starting with a language function such as greeting, requesting, or introducing under the title of "Let's talk". Each unit also consists of two series of vocabulary items with the titles "Let's learn" and "Let's learn more". For each of the next seven sessions, i.e. sessions 4-10, one unit of the book was worked on with the exact same order of the units in the book. Only unit six was eliminated, as seven units were needed for the next seven sessions of the program and also the vocabulary items of unit six seemed the least functional for the students. The first part of each unit, i.e. "Let's talk", and the first group of 6-10 vocabulary items as well as their usages, i.e. "Let's Learn", were worked on during each 45-60-minute teaching session. It is worth mentioning that the students or their parents were not informed about the resource book. This way, the researcher would make sure that all the participants would receive the same amount of opportunity of being exposed to the materials which would only happen during the class hours.

2.2.1.3. Flashcards and Songs

The flashcards of the vocabulary items of the book were also used among other teaching instruments. Two major uses were made of the flashcards in class: First, they would be used in the fast efficient reviews of the pre-taught vocabulary items with the students before teaching new materials. Second, students would get the chance to have face to face interactions with NIMA by using the flashcards.

The related songs from the book were also used to make the learning environment more interesting for the students. For the RALL group, the songs would be uploaded on NIMA. NIMA would play the song as if he was singing it and would dance to it. For the non-RALL group, on the other hand, in absence of NIMA the songs would be played simply by a laptop. The number of playing each song was the same for both groups. Each song would be played 3-4 times. At the first time, the students were asked to just listen. At the next times, they were encouraged to try to sing with the song chorally.

2.2.1.4. Power-point Slides

Each session had at least one power-point slide presentation through which the students would get familiar with the new words for the first time. At some sessions, the previous slides were used within a systematic review. At some other sessions the slides were used in class activities combining the words from different sessions or to visualize the contents of the dialogues of songs for the students.

2.2.1.5. Laptops and Video Projector

Two laptops were used at the RALL program sessions: One to operate NIMA and the other one to be connected to the video projector in order to show power-point slides. One laptop could have also been used for both purposes. Having two separate laptops, however, made it easier for the teacher to go through the slides as she wanted to without making it hard for the operator to do her job. In the non-RALL program, just one laptop was needed to be connected to the video projector and to play the songs which had been uploaded on NIMA in case of the RALL group.

2.2.1.6. English Tests

Four equivalent but not identical English tests, based on the covered book, each with 63 items including matching, multiple choice recognition items, and a few open ended questions to test the simple language functions taught during the course were designed and validated by a group of English teachers: A pre-test, a mid-test, an immediate post-test, and a delayed post-test with the reliability coefficients of Cronbach Alpha of .71, .85, .93, and .91, respectively. The alphabet letters, numbers, vocabulary items, and the language functions in form of simple dialogues between the teacher and the examinee were included in each of the four tests. The vocabulary items were counterbalanced to reduce practice effect. The students were not notified in advance about the exams. The exams were administered as pop-up quizzes. According to [1], individuals with autism may have certain skills or knowledge but fail to use them in a test. Therefore, the teacher would sit with each student, read out each item for him, and mark or write down his answer herself. This was done to make sure all the participants were properly aware of the instructions and that their answers were marked or written down correctly.

2.2.1.7. Video and Audio Recorder

The video records of the program as well as the comprehensive interview with the participants' parents can be considered as complementary sources of data to back up the results of the English tests providing the researchers with deeper insights on the language learning processes of the participants. Each and every teaching session, in both of the RALL and non-RALL programs, were video recorded for further qualitative analysis of the sessions as well as the students' behaviors. Also, at the farewell session, an audio recorder was used to record the interview the researcher had with the participants' mothers. The interview was based on 21 open-ended pre-designed questions including some general questions on the (dis)advantages of the program and the parents' personal comments.

2.2.1.8. Data Collection Procedure

To investigate the effects of RALL on high-functioning autistic children's language learning, the RALL program was administered for a group of three high-functioning children (S1, S2, and S3). The RALL program, which was administered within two months, consisted of 12 sessions in total including 10 teaching sessions (sessions 2-11). At the first session held one week before the program started, the program was introduced to the children and their parents and the pre-test was administered. At teaching sessions held two times a week with each session lasting 45 minutes to one hour, NIMA would just speak English. As recommended by [19] and according to the ages and English knowledge of the participants, the teacher would use Farsi, the participants' mother tongue, to give instructions and would give the translations of the new vocabulary items as well as NIMA's lines. Additionally, a homework assignment was prepared for each session. The students were required to do them at home and bring them back to class the next session. In the middle of the program, i.e. at session 6, a midterm exam was administered. At the last teaching session, i.e. at session 10, an immediate post-test was administered. After two and three weeks following the RALL and non-RALL programs, respectively, a farewell session was held at which the delayed post-test was administered. Furthermore, the parents were interviewed based on some open-ended pre-designed questions on their views of the program. They were asked to talk about the changes, if any, their children had shown throughout the program.

To get more valid results, another group of three with high-functioning autism (S4, S5, and S6) was selected to participate in the non-RALL program through which the exact same materials were taught within the exact same number of sessions simply without the assistance of the robot. The non-RALL program also took two months. However, the orientation session was held the day before the program started, and due to the New Year holiday the farewell session, i.e. session 12, was held three weeks after session 11. The agenda of each session, however, was quite the same for both RALL and non-RALL groups. The role NIMA played in the RALL program was played by the teacher herself or in some cases by the camera man, or the students in the non-RALL program. Furthermore, the related songs from the

book which were sung and danced to by NIMA for the RALL group would be played via the laptop for the non-RALL group. At each teaching session, based on the selected book, one or two simple functions, as well as eight to ten vocabulary items were taught. Moreover, a systematic review of the pre-taught vocabulary items was done during each of the next sessions for both groups.

Throughout the RALL program, NIMA played the role of a teacher-assistant with different modes. Below are the different modes of NIMA's assistance in the RALL program as well as instances from different teaching sessions.

- Singing songs and dancing to them

As mentioned earlier, the related songs from the book were uploaded on NIMA. For each song some proper movements in form of a dance would be designed and programmed via the Choreghraphe software. It is also worth mentioning that each of the songs would be sung and danced to by NIMA two to three times. During the first time the students were asked to just listen. During the second and third time, however, they were required to chorally sing with NIMA. The teacher would also give prompts and accompany them while singing.

- Teaching the vocabulary items through power-point slides

Except for the first two teaching sessions at which the English alphabet and numbers were taught, respectively, six to ten vocabulary items from the book with a specific theme were taught at each session. The themes of sessions 3-10 were respectively verbs, things for school (objects), colors, at the store (more objects), family members, gifts (more objects), foods, and Animals. Through this mode, NIMA would look at or point to the power-point slides shown via the video projector and introduce the item, whether a letter, a number, or a picture of a vocabulary item by saying it out 3-4 times with proper gaps between each two times so that the students could repeat after him. The teacher would also encourage the students to repeat. This [slides + NIMA + students' repetition] activity was made use of at all sessions but session 3 in which verbs were taught. To teach verbs, the teacher would ask NIMA "what can you do?" and NIMA would answer with such lines as "I can walk!" Then the teacher would ask the students to use the related positive imperative chorally so that NIMA would act out that verb. NIMA was preprogrammed to act out each of the six verbs of interest (stand up, sit down, raise hand, walk, write, and dance). For example, the students would say "walk!" and NIMA would walk. In other words, NIMA would teach the verbs through Total Physical Response (TPR). In later phases, the students would also cooperate by doing the same actions as NIMA would do (Figure 3).

Figure 3. RALL group practicing the verbs along with NIMA (raising hand in this case)

- Interacting with students individually and chorally

One of the most important features of robots that can be used in English classes is their ability to talk. Students specially the autistic ones find humanoid robots pretty interesting. Accordingly, they would like to interact with them. The researcher had told the students at the orientation session that NIMA could only speak English, so they had to speak English if willing to interact with him. That brought about a great deal of motivation for the RALL group. The verbal interaction between NIMA and the students happened through different class activities.

At session four, for example, based on the selected book, students were supposed to learn to introduce themselves and ask someone else's name. The teacher first had the following conversation with NIMA as a sample for the students:

Teacher: Hello! What's your name?

NIMA: My name is NIMA. What's your name?

Teacher: I'm Nasim (shaking hand with NIMA).

Then the students would come to the board one by one and have the exact same conversation with NIMA with their own names and would shake hands with him (Figure 4).

Figure 4. S1 shaking hands with NIMA

Another kind of choral interaction students had with NIMA was in the activities following NIMA's teaching the new vocabulary via the power-point slides. In the first type of activity, at session four for example, after the vocabulary items were taught, the students would chorally ask NIMA "What's this?" NIMA would look at the slides and then at the students answering with for example "It's a pencil." Then in a following activity, the students and NIMA would change roles. This time NIMA would ask the students and they would answer chorally.

As mentioned earlier, the flash cards of the selected book were also used in different activities. At sessions 4, 5, 6, and 10 after the vocabulary items were taught and practiced chorally by the two types of activities explained above, students would have the chance to have individual face to face interaction and practice with NIMA using the flash cards of the newly taught vocabulary items. Each of the students was randomly given two flash cards. Each student then would come to the board standing in front of NIMA, showing him the card, and asking him the above mentioned questions, i.e. "What's this?", "what color is this?", or "how many markers?" NIMA would answer them, sometimes making mistakes on purpose. Upon receiving NIMA's answer, the student would give NIMA a feedback. If NIMA's answer was right, the student would say "Yes!" and if it was wrong, he would say "No!" and would say the correct answer to NIMA. NIMA would then repeat the correct answer as if he had noticed the feedback given to him (Figure 5).

Figure 5. S2 asking NIMA "what's this?"

- Playing games

Game-based instruction is a quite helpful way of engaging young students in class. A humanoid robot like NIMA with its toy-like shape could be considered as a very good tool in applying game-based instruction. The researcher tried to include some games in the syllabus and almost in all of them NIMA was kind of involved. Some games had winners who would be applauded by NIMA. This kept the students even more engaged in the tasks assigned to them.

As an instance, at session three, when six verbs were supposed to be taught, some TPR games were played in class. After the verbs were taught by NIMA through a TPR activity, the teacher would say each of the verbs and the students were required to act upon hearing the verbs. NIMA's role in this game was being a cheer leader. Yet another game was that NIMA would act out the verbs randomly and the students had to say the associated verb. In another game, NIMA would say a verb and the students had to do it if NIMA would raise his hand. If not, the students were required not to do what NIMA was asking them to. Such TPR games were made use of again during some of the next sessions in form of a review.

- Giving feedbacks

During the games and practices, NIMA would applaud the students for giving correct answers or for winning the games. The applause was through clapping while the sound of clapping was also being played, through saying "hooray!", or by using some Farsi applause such as "Afarin!" and "Barikalla!" which were uploaded on NIMA. The teacher told the students that NIMA had learned some Farsi words to be better able to applaud them. The students enjoyed NIMA's applause specially the ones given in their mother tongue pretty much. They would laugh out loud upon receiving them and seemed to be motivated for giving the correct answers.

In some other cases, when the students gave the wrong answers, NIMA would correct them and vice versa. NIMA's correction did not seem to embarrass the students as in some other cases NIMA would make mistakes and they would correct him.

- Making mistakes on purpose

As was mentioned in some previous examples, when engaged in games and practices, NIMA was programmed to make mistakes on purpose to first, give this chance to the students to realize that it was ok to make mistakes. Second, the students knew that NIMA's answers were not always right so they had to pay attention to what he had to say and to notice his mistakes.

3. Results

The current study tried to answer the following research question: What is the effect of RALL on high-functioning autistic children's English vocabulary learning and retention?

To answer this research question, four equivalent but not identical English tests were administered at different points during the program to tap into the participants' gradual learning gains. The RALL group participants' performances on the above mentioned tests are presented in Figure 6 in terms of their scores (the number of correct answers) out of 63.

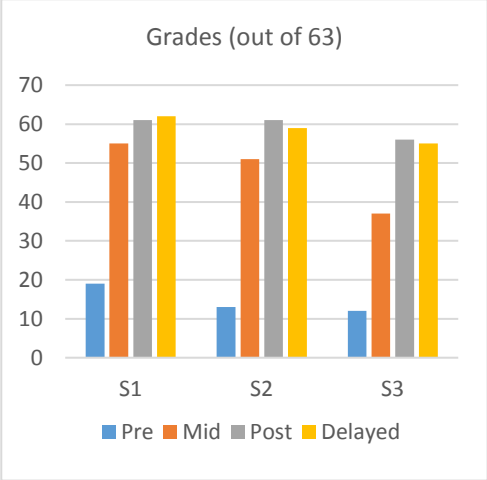

Figure 6. RALL group scores of English tests

The RALL group showed great improvements during the program. According to the scores of the RALL group in the delayed post-test, retention also happened.

The non-RALL group's scores are also presented in Figure 7. The non-RALL group also had learning gains throughout the program. S6's scores of immediate and delayed post-tests were not included as he quit attending the sessions. S6 did take the mid-test, but his performance was not good enough. Additionally, based on the researcher's observations, S6 learning gains were quite low. This may have had with the fact that he missed some sessions and did not show up at the farewell session.

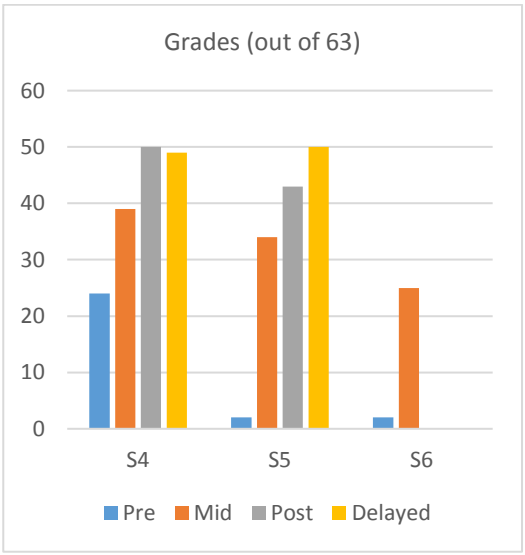

Figure 7. Non-RALL group scores of English tests

The mean scores of each of the RALL and non-RALL groups are compared in Figure 8.

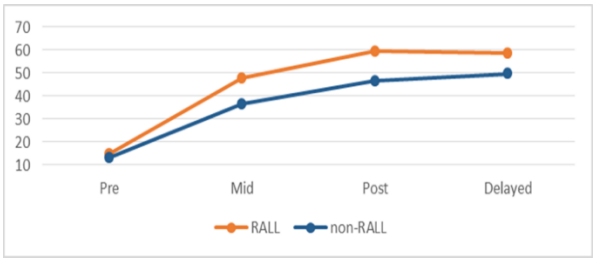

Figure 8. RALL and non-RALL group mean scores

S6 was eliminated from this analysis due the above mentioned reasons. Figure 8 clearly suggests that the RALL group out-performed the non-RALL group in terms of the English tests scores.

The participants' mothers' feedbacks on their children's English learning processes for both RALL and non-RALL groups were as follows.

RALL group

S1 had attended English classes for three semesters about 3 years ago. But as his mother mentioned, even though he got good grades in exams, retention had not happened. This was also clear in his performance in the pre-test. However, he learned a lot through the RALL program since he loved NIMA and the teaching program was game-based with fun activities. At home, he would greet his older brother in English. The previous English classes he had attended were more rigid and less fun. She said: "as he was learning English quite well because of the game-based instructions, now his teacher at school is also trying to use the same method for him in other participants such as writing." However, she suggested that even adopting game-based instruction without the presence of a robot would not seem to be as effective as the RALL program was, for S1 was "literally in love with robots!" S1's mother suggested that S1 did his English homework without asking for help, something that would not happen about his school homework. Among the teaching sessions, S1 liked the birthday session the most. NIMA's speaking in English and his applause in Farsi were the most interesting things about NIMA for him.

S2 was attending private school, so he had English lessons at first and second grades, but as his mother put "he never learned a thing, as he used to find those classes quite boring. But after attending 4 or 5 sessions of the RALL program, he asked me to take him to English classes so that he could perform even better in the RALL program." However, his mother did not do that, meaning that the only English class he was attending at the time was the RALL class. Regarding the homework assignments, S2's mom would remind him of his English homework and he would do them smoothly. The difference S2's mother felt between the RALL program and other educational programs was the happy friendly environment of the classes and the presence of the robot

as S2's favorite technology which made the classes pretty exciting for him to attend. The most interesting thing about NIMA for S2 was that in his view NIMA was teaching the children English and would learn Farsi from them. This made the program quite exciting for him. She felt the program gave him the feeling that he could be successful even at school. His self-confidence had increased a lot. He would obey the rules more often and he would take his lessons more seriously than before. In S2's mother's view, the most important feature of a robot was that the children would find him easy to communicate with, even though she did not know why this was the case. S2 would practice his English learnings with his older sister who also knew some English. His sister was surprised by his learning gains implying that "S2 seems to be learning English better than I do!" S2's mother herself had experienced positive feelings during the program as she was assured that her son had the ability to learn well.

S3, as his mother said, had no background in English. He just knew some letters or numbers, but he did not know the order of them or even the right pronunciations. He had not attended English classes before, and was not attending any other English class during the period the RALL program was being administered. S3 was very cooperative regarding doing his homework. The most interesting features of NIMA for S3 were his movements and the games he played.

Non-RALL group

The use of English sentences in class caused anxiety for S5. He could pick up the vocabulary items easily, but he would feel anxious when he was required to repeat or produce an English sentence. S5, according to his mother, generally had high levels of anxiety. She said: "when he is in a context in which he cannot make sense of some items, he feels very anxious and this affects his performance negatively." S5 liked the birthday session the most even though it was not NIMA's birthday. At the non-RALL program the birthday session was administered by having a birthday party for NIMA's operator who at that session attended the English class. S5 also liked the session in which he learned the English vocabulary of animals, as he was very interested in animals.

S4's performance at schools, according to his mother, was quite weak. According to her, the reason was his avoidance from participating in group works. The game-based instructions used in the English classes, according to his mother, helped his learning process, because it allowed him to trust the teacher and learn better accordingly. S4's mother would not practice the newly taught vocabulary items with him at home. He would do his homework spontaneously and if needed, he would ask his mother for help in doing his homework. S4 was attending another English class while he was attending the non-RALL sessions. Apparently he would not compare the two of them, but his mother believed he liked the non-RALL program better than the English classes at the institute. S4's mother believed using the robot at the English teaching sessions could bring about much more motivation in her child, as autistic children enjoy robots.

The qualitative analysis of the video records showed that the TPR technique could bring about some energy to the non-RALL class, involve the students, and make them laugh. But when it came to the verb "dance", S4 sat down. During the practices at the next sessions, however, he danced. The RALL class at session three was more energetic with the students being engaged in acting out the verbs along with NIMA.

At session five, when a human played NIMA's role in RALL group for the non-RALL group in practicing verbs or two-by-two interactions making intentional mistakes, the non-RALL group seemed more engaged. It can be hypothesized that the presence of a human assistant with the roles NIMA played could also make learning process easier for autistic children. In other words, robots may seem like to be the best option, but a young human assistant making intentional mistakes for the students to correct can be the second best choice.

At session eight, when the RALL group was taught how to ask NIMA's age, out of curiosity to know his name, they participated quite well trying to ask NIMA how old he was and later to tell their own ages in English when NIMA asked them how old they were. However, in equivalent situations when S6 was asked to answer questions, he would usually say: "I don't know!" or "it is hard!" showing less willingness to cooperate.

4. Discussion

In line with the studies conducted by [16-20], the results of this study indicated that high-functioning autistic children do have the ability to learn a second/foreign language. Autistic children, as big fans of technological tools, could benefit from using technology in education and robots can be considered as the newest most interesting technology that can be applied for children with autism in education in general and in teaching a foreign language in specific.

As mentioned earlier, according to [18], high-functioning autistic pupils may need special strategies to be engaged in language classes such as routine greetings, and a specific order of seats. The researcher tried to use such strategies and they turned out to be helpful in keeping the participants engaged. Using a highly technological tool like a humanoid robot could be considered as the most obvious way of using engagement strategies specific to autistic children. As another teaching strategy, using Farsi in class, in line with [19], could lower the burden for the participants and allow them to make connections between the new

vocabulary items or functions and the ones they already knew. As [11] suggested the presence of a robot providing applause and hints can lead to great learning gains. The positive results of RALL on language learning and retention of children with autism could be associated to the fact that the presence of a robot made using Asher's Total Physical response (TPR) approach, Schmit's noticing theory, and Swain's pushed out put hypothesis more feasible in language classes. TPR which refers to listening and acting by giving physical responses [30] was used in teaching verbs for both RALL and non-RALL groups. However, the presence of the robot made it a lot more fun for the RALL group to participate in the TPR activities compared to the non-RALL group. On the other hand, based on Schmit's noticing theory, explicit knowledge and focal attention play important roles in language learning. The presence of NIMA in RALL group classes and the feedbacks given by it made the students really excited and made them laugh out loud and show willingness to communicate. This was in line with the findings of [25]. The focal attention they paid to NIMA's lines could be a clear manifestation of Schmit's noticing theory. Moreover, Swian's output hypothesis states that when language learners use the language and have output, learning happens through consciousness raising, hypothesis testing, and reflecting [31]. This means that when producing output in target language, language learners consciously pay attention to the newly taught items, find out if they are using them correctly when they receive feedbacks, and reflect on their learnings. In line with [10, 27], NIMA was efficient in eliciting utterances through real life scenarios and Swain's hypothesis was applied accordingly. For instance, when teaching the vocabulary items of family members, the RALL group had to ask NIMA to introduce his family members, pictures of different robots shown in the power-point slides. Since RALL group participants were really interested in hearing NIMA talk, they would produce output in target language more often and better compared with non-RALL group.

In the interviews, the participants' mothers were also asked about the probable disadvantages of the program. Their feedbacks are presented below.

RALL group

The disadvantage S1's mother pointed out was that when the program was finished, it might affect the children's emotions negatively. She said so because during the two-week interval when S1 was not seeing NIMA, he had missed him. At one point during the interview, S3's mother pointed out one general disadvantage of technology: "technology is the reason why our children have the problems they do in the first place." By saying so she was trying to refer to the hypothesis that autism is a disorder caused by the use of technology in the modern world.

Non-RALL group

In S5's mother's opinion, the disadvantage of the program was the use of English sentences in class which were hard for S5 to digest. He would pick up the vocabulary items easily, but he would feel anxious when he was required to repeat or produce an English sentence, especially a long one.

A disadvantage, according to S4's mother, was that he liked to have the English book based on which he was being taught to be able to study at home. Despite these few disadvantages, the overall results obtained from the current study indicated the effectiveness of humanoid robots for autistic pupils. When asked about the general advantage(s) of the program, the RALL group participants' mothers pointed out the following advantages.

S1's mother stated that the RALL program made his son happy and even improved his performance at school. The advantage of the program in S2's mother's view was that the program improved S2's self-confidence; he believed more in himself, as he was valued, applauded, and paid attention to within the RALL program. S2's mother herself had experienced positive feelings during the program as she was assured that her son had the ability to learn well.

S1 and S2's mothers both suggested the researcher to transform the good results of the program to CEDRA implying that applying robots in their therapeutic sessions would highly improve the quality of the classes and their effects on the children. They elaborated on the fact that the therapeutic programs were quite costly and their effects were not as one would expect.

The general advantage of the program based on S3's mother's claims was the fact that it was a technology-based program. According to her, the new generation is quite interested in technology ranging from computer games to robots as the most interesting technological tool for kids. She thought the technology can come to help children with autism with their speech issues. She said: "autistic children are drowned in their own world of thoughts. Drawing their attention to what we want them to learn is not easy. Using technology as a new technique to address this issue was the main advantage of the program." She also emphasized the importance of the human-like appearance of the robot to make the therapeutic items more authentic. She claimed that even she herself was not bored with the program, even though she had to arrange the time and make it to the program. The environment was quite positive and energetic. She would feel good when finding her child to be improving. As she put it: "Parents always want the best things to happen for their children. By having my child take part in this program, I feel relieved knowing that I am doing my best for him. I have no regrets. I am doing my best for him."

5. Conclusion

The results of this study, in line with previous research, showed that the presence of the robot in the English classes could bring about a great deal of motivation and positive attitude toward English learning in the RALL group. They also found it easier to communicate in class and experienced lower anxiety levels. Affecting some of the most important affective factors in language learning, RALL could turn the foreign language learning classroom into a fun and interesting environment especially for autistic children as big fans of technological tools. This was further supported by the fact that the RALL group outperformed the non-RALL group in terms of language learning and retention.

The effectiveness of using robots may be brought under question by the claim that the obtained results could be just due to the newness of the applied technology and that they would fade away as the children become accustomed to it and take it for granted. However, this could take a pretty long time to happen especially with young children who can play with the same toys for years and still enjoy playing with them. Additionally, robots have many different features which could be made use of to keep the learning environment interesting in the long run. This was the case in the RALL program, since session ten, as the last teaching session, was one of the most energetic sessions of the RALL program. This showed that to the end of the program the students kept their high motivations and interest in NIMA. It is also important to remember that using new technologies is an inevitable aspect of education, because the new generation has new needs and new expectations from their education environment and keeping up with their expectations is the only way to keep them motivated and satisfied. Robots perceived as the next generation of technology penetrating human's life will inevitably find their ways into education as personal computers did many years ago. Doing research on how to use robots in education and their (dis)advantages, therefore, seems to be of great importance.

The findings of this study as an inter-disciplinary research involving robotics, TEFL, and cognitive sciences, could be a starting point for a whole new line of research in our country, Iran. To date, these kinds of studies involving researchers from various backgrounds and disciplines have not received the proper attention. It is important to let individuals from other fields of study intervene and make some efforts to make use of robots for social problems. The results of this study could be helpful for high-functioning autistic pupils, their language teachers, and centers of treatment of autism as well. Additionally, due to the exploratory nature of this study, some new insights were obtained about autistic children, their communication patterns, and also their language learning process in absence/presence of a robot in the language class which can be useful in turn.

To obtain results with higher external validity, further research could be an experimental research with bigger number of participants in each of the RALL and non-RALL groups. Using the treatment for an intact class of a mainstream school with both normally developing and autistic students could be a more authentic setting which can better tap into the challenges both students with autism and their teachers may face in real life and the potential solutions.

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Biography

Minoo Alemi received her Ph.D. in Applied Linguistics from Allameh Tabataba'i University (ATU) in 2012. She is currently Assistant Professor and Division Head of Applied Linguistics (TEFL) at Islamic Azad University, Tehran-West Branch. She is also an Adjunct Research Associate of the Social & Cognitive Robotics Laboratory at Sharif University of Technology. She is the founder of Robot-Assisted Language Learning (RALL) in Iran which she achieved as a post-doctoral research associate in Sharif University of Technology. Her areas of interest include discourse analysis, interlanguage pragmatics, materials development, technology-based education, social robotics, and RALL. She has been the author of over 75 papers and books in ELT and Social Robotics. She is on the editorial board of various international humanities and applied linguistics journals and conferences, including the prestigious British Journal of Educational Technology (BJET).

Nasim Mahboub Basiri is a graduate student of Applied Linguistics (TEFL) at Sharif University of Technology. Her areas of interest include RALL, special education, technology-based education, and psycholinguistics