

# Preliminary Observations from Interactions among Ghanaian Autistic Children and Rosye, a Humanoid Robotic Assistive Technology

Rose-Mary Owusuaa Mensah<sup>1</sup>, James Ben Hayfron-Acquah<sup>2</sup>

Ph. D., Scholar<sup>1</sup> and Lecturer<sup>2</sup>

Department of Computer Science

Kwame Nkrumah University of Science and Technology

Kumasi, Ghana

---

## ABSTRACT

*Research aimed at exploring the impact and effectiveness of social robots as assistive technologies in autism diagnosis and treatment have been on the rise. However, many of such studies have been undertaken in the Western world, with a few being done in middle to low income countries. As a result, assessing the impact of cultural differences on the acceptance and effectiveness of treatment plans for children on the autism spectrum is quite difficult. Most of the existing robots being used as assistants in autism therapy are in the prototype stage and not accessible to the public; a few on the market are costly and for developing countries, deploying such robots on a large scale to aid these children is not feasible. We have developed a humanoid robot Rosye as part of an ongoing project to research into how robot interventions could be used as therapy assistants for caregivers of Ghanaian autistic children. In this paper, we present results from a preliminary experiment involving the novel low cost but friendly humanoid robot, Rosye, and some autistic children in Ghana.*

**Key Words:** Autism, Robots, Ghana, Imitation, Joint attention, Africa.

---

## 1. INTRODUCTION

Autism Spectrum Disorder is a complex lifelong neurological and developmental disorder which is characterized by impairments in communication, social interaction and restricted or repetitive behavior [1]. Autism is termed a spectrum disorder because people affected could exhibit different symptoms and the level of severity varies among the individuals. Symptoms of autism are apparent before the age of 3 [2]. The condition lasts throughout an affected person's lifetime. The exact causes of autism are unknown and there currently exists no cure for the disorder. Early signs of autism include: avoiding eye contact, resistance to touch, inability to express or understand emotions, repetitive behaviours and unusual attachment to objects. It is averagely estimated that 1 out of 160 children suffers from autism [3] and the disorder is more common in boys than girls [4].

The epidemiology of autism in developed countries such as United States, United Kingdom, Japan, Canada and Sweden is well documented; however in the middle to low income countries, very little information about the prevalence rates of autism exist. It has been estimated that the number of people who have been diagnosed with autism in the western world is higher than those in the developing and under developed countries [5]. However, research suggests that, there could be more people with autism in the non-Western countries than is being reported [6]. Reasons which are accounting for the low statistics of autism diagnosis in the non-Western countries include cultural beliefs about autism, fear of stigmatisation, lack of skilled personnel to do autism diagnosis and low level of knowledge about the disorder [6].

Currently, there are no medical tests for diagnosing autism. A pediatrician, psychologist or a team comprising of healthcare professionals can diagnose a child with autism by reviewing developmental history of the child, observing the child's behaviour, interviewing his parents or caregivers and also using screening and assessment tools specifically designed to aid in autism diagnosis. Whereas no cure for autism exists, early diagnosis, interventions and treatment plans could help improve the condition of affected people over time. Interventions for managing autism focus on diverse strategies such as behavioural, developmental and medical approaches. Behavioural interventions focus on teaching and enforcing positive behaviours and guiding the child

towards elimination of bad or harmful behaviours. Developmental interventions are geared towards identifying a child's developmental deficits and difficulties and helping them to overcome them; such interventions do not place most emphasis on the child's outward behaviours. Medical interventions are able to help manage some symptoms such as anxiety, hyperactivity, sleep disorders and self-harming behaviours. The recent surge in technology has also paved way for researchers to explore the impact and effectiveness of technological interventions in autism diagnosis and treatment. Technology has become a useful tool in autism management because computing devices have become portable, flexible and can be easily adapted to suit the individual preferences of children on the spectrum. Also, keyboards and touchscreens can make learning easier and enjoyable for individuals with autism who have problems with fine motor skills and find handwriting difficult. Early technological interventions for autism included computer applications, mobile devices, tablets and virtual reality applications. More recently, through artificial intelligence, some robots have been developed to aid in autism therapy.

Some individuals with autism find it overwhelming to interact with humans because of the complex nature of human-human interactions involving gestures, facial expressions, sudden changes in tone of voice and body movements. Robots are more predictable because they can be programmed to behave in a defined way over and over again. Therefore, a special group of robots known as socially assistive robots (SARs) could be potential aids and therapy assistants for health professionals and caregivers of children on the autism spectrum. SARs are designed to help people through social interactions and entertainment. The benefits which could be derived from robots serving as assistants in autism therapy could be enormous. However, research on robots in autism therapy is still in the infant stages. A few of such robotic systems exist; most of the existing ones are either still in the prototype stage and are not available to the public, or they are very costly. Most of the past and ongoing research on robots in autism therapy have been undertaken in the Western world. To the best of our knowledge, there is currently no existing research which focuses on how autistic children on the African continent will respond to the robots. Our research is therefore novel; we have developed a low cost but highly attractive humanoid robot, which is currently being used to conduct experiments involving Ghanaian autistic children and the robot. This paper focuses on the preliminary observations from interactions among Ghanaian autistic children and Rosye, our developed humanoid robotic assistive technology. The paper is structured as follows: Sections 2 and 3 present information about autism in Ghana and literature on robots in imitation and joint attention therapy for autistic children respectively. In sections 4, we discuss the impact of culture on acceptance of technological interventions for autism therapy. Results from the preliminary study are presented in section 5 and the section 6 presents conclusion.

## **2. AUTISM IN GHANA**

Around 1984, a researcher, Sanua [7] sought to find out whether autism existed only in the western world or it was a universal phenomenon. Currently among the research confirming the existence of autism in Africa are Bakare and Munir [8] and Fombonne [9]. In Ghana, a country in West Africa, there are children living with autism. As with many countries on the African continent, people with autism were often given cold shoulders because the populace believed such conditions are caused by multivariate factors such as witchcraft, curse from God and other lesser gods or punishment as a result of what the person or his family member did. Until recently, children born with autism and their parents could be cast out of the society and totally ignored by their families. Although there is no official information on the statistical distribution of autism in Ghana, Rural Integrated Relief Service Ghana (RIRSGH) [10] reports that another institution, Autism In Ghana, estimates that 1 out of 87 children in Ghana under the age of 3 suffers this disorder and as in conformance with other statistics worldwide, the condition is more prevalent in boys than girls. Although there has been an increase in research on autism on the African continent, the prevalence and etiology of autism in this region is still unknown.

The low level of knowledge and awareness about autism in Ghana contributes to the late diagnosis and pursuance of treatment options for affected kids. Decades ago, educational facilities and training centers of children with special needs were virtually non-existent. Today, many autism awareness and training centers have sprang up all over the country. The Government also owns special schools which accommodate children with varying disabilities including autism. Notwithstanding these developments, lack of skilled personnel, inadequate funds and societal attitudes continue to hamper the provision of adequate care to people living with autism in Ghana.

## **3. ROBOTS IN IMITATION AND JOINT ATTENTION THERAPY FOR AUTISTIC CHILDREN**

Imitation involves the ability of a person to mimic the behaviour or actions of another person. Basically, to imitate someone, you need to first of all observe what the person is doing and thereafter, repeat the person's actions. Individuals with autism have difficulty and exhibit deficits in imitation skills [11][12]. The imitation ability of an autistic child is an important goal which has a correlation to the child's language development, joint attention, play and social interaction skills. More so, due to the fact that imitation serves as a learning function and social function in infants [13] when children are taught imitation skills, the tendency for their social skills to improve is also high. There are several ways to teach imitation to children with autism. However, research shows that these children find object imitation easier than imitating a human's facial expression, gestures and sounds [11]. Objects such as scribble markers, lollipops, shake bells, toys and computing devices have been used to teach imitation to autistic children.

Stone et al. [14] reported that two year old autistic children who partook imitation games with an object showed improved development in play skills a year later. More recently, sophisticated devices such as robots are being used in research [15] to play imitation games with children with autism. Observations from such research indicate that autistic children are attracted to mechanical devices and easily interact with robots as compared to humans.

Joint attention (JA) skill refers to the ability of a person to share focus with another person on an object or event [16]. This very important skill begins from 6 to 18 months in infants and as a person develops over the years, JA skills are refined [17]. Forms of JA include eye gaze, pointing to objects, making gestures and turning head to focus on an object. To exhibit joint attention, a child can initiate or respond to a JA task. For example: A child and parent are playing together, and the parent points and says "hello child, look at the sky. The child is able to look up to the sky and says "hello Mum I see the sky. In this scenario, the parent initiated the joint attention task and the child responded to the task. The development of joint attention imparts significantly on language acquisition and socio-cognitive development of children. The joint attention skill in an infant could differ from that of a toddler; more so, even children of the same age could exhibit differences in their skills. The rate of development of JA skills could be influenced by factors including frequency of interaction between child and his caregivers, impairments like deafness and developmental disorders such as autism. Children with autism tend to exhibit deficits and impairments in joint attention [18]. Robots are now being incorporated into therapy sessions aimed at teaching joint attention skills to children with autism [19]. Consequently, robots could be employed as therapy assistants to aid parents, medical personnel and caregivers of children with autism.

#### **4. IMPACT OF CULTURE ON ACCEPTANCE OF TECHNOLOGICAL INTERVENTIONS FOR AUTISM THERAPY**

People have suggested that autism could be caused in children who come from highly intelligent families, by environmental factors and religious beliefs (some people in Africa consider the disorder as a curse from God) but many of these claims have not been verified. Research by Dyches et al. [20] indicates that culture could play a major role in the diagnosis and acceptance of treatment options for people on the autism spectrum. It is well known that autistic behaviour varies among individuals but there is currently limited knowledge on multi-cultural variations in autism manifestation. Behaviours of children which may be considered red flags for autism in one country may be completely normal in other environments. Culture could also influence how autistic children interact with their families and outsiders. Similarly, the acceptance of treatment plans for people with autism by their family and autism care centers could differ based on religious beliefs about the etiology of autism, ethnic backgrounds and other cultural variables [21]. Therefore, it is important to factor in culture when designing technological interventions for autism therapy [22].

Considerable research on robotic assistive technologies for autistic patients have been proposed and evaluated; however, studies and research on the role of culture in the acceptance or otherwise of these treatment plans have not been widely explored. A study by Libin and Libin [23] where subjects from America and Japan interacted with a robotic cat indicated that the participants reacted to the robot differently and these variations could include factors such as cultural background. Rudovic et al. [24] also identified variations in levels of engagement and task execution times among two groups of people from different cultures, specifically Asia (Japan) and Europe (Serbia) during their interactions with the robot Nao. Currently, most of the studies on robots in autism therapy have largely been focused on Europe and America. Most of the countries in these continents are developed and far advanced in technology hence the likelihood of the autistic children having prior exposure to computing devices and technological gadgets is high. Therefore such children may readily accept robots. However, in some countries in Africa, autistic children may not be privileged to benefit from high tech gadgets to aid in their therapy and learning process and therefore may or may not react well to robots. Therefore, there is the need for user studies in all continents in order to obtain information about cultural similarities, variations and parameters which could potentially account for acceptance or rejection of robots as partners in autism therapy. Research also needs to throw more light on how pre-exposure to technological gadgets and other robots could influence the acceptance, engagement and learning outcomes of the use of robots in autism therapy. In this paper, we seek to contribute to knowledge by presenting the preliminary outcome of interactions among a humanoid robot, Rosye and some autistic children in Ghana.

#### **5. METHODOLOGY**

##### **5.1 Robotic platform**

A novel humanoid robot, Rosye was used to carry out the research. Rosye is a humanoid robot which has been developed by a research team at the Department of Computer Science at Kwame Nkrumah University of Science and Technology led by Rose-Mary Owusua Mensah, a PhD researcher, in consultation with a robotics expert from industry and some healthcare professionals and caregivers of children with autism. The initial prototype of Rosye, which was used in the experiment, is equipped with accessories such as camera, ultrasonic sensor, led lights and speakers. The robot also has motion functionalities such as hand and head movements. It is also able to move around and through the aid of the ultrasonic sensors, it is able to avoid obstacles. Operating the robot is done via the Wizard-of-Oz approach where the robot is remotely controlled by a person.



**Figure 1: Rosye the humanoid robot**

Ethical approval to carry out this research was granted by the Department of Computer Science, K.N.U.S.T. Also consent forms were also given to the two Autism Centers as well as the parents of the children involved in the study. All the processes involved in the experiment were explained to them and they gave their consent for the research to go on.

*i. Case study*

This preliminary study was conducted in two schools for children with autism in Ghana; Both Centers are privately funded and often rely on the fees paid by parents and the benevolence of philanthropists to run the institutions. In both schools, the children are taken through academics and social skills training, occupational, art and speech therapy as well as independent living skills. At Center A, the experiments were conducted in the Sensory Room. A sensory room is any room which has been filled with materials with varying stimuli such as soft balls, colours, lights to provide a safe environment for children with special needs to interact and explore with minimal risks. At Center B, the sessions took place at their general office.

*ii. Study participants*

In all, fifteen (n=15) children with varying levels of autism participated in the study. Out of this number, three (3) were girls and twelve (12) were boys. The mean age is 12.4 and standard deviation is 2.47. For the purposes of privacy and anonymity, the names of the participants have been pseudonymized.

*iii. Experimental design*

Single subject experimental design was adopted in this study. In this single day experiment, the children took turns to interact with the robot. Each child-robot interaction session took place in the sensory room or the general office depending on the Autism Center. The sensory room had many toys and playful objects which in a way were “distractions” to the experiment. However, in real life deployment, the robot would be used in the classroom and other places where there would also be other objects. Therefore, we sought to determine whether the children would be able to focus on the robot despite the “distractions” in the room. The participants were accompanied by their carers; the presence of the carers provided a familiar environment for the children. There was no fixed time for each child-robot interaction session. As a result, the children were made to interact with the robot as long as he or she felt comfortable and the sessions ended only when all the tasks had been completed. However, sessions were brought to an end when a child became aggressive or felt uncomfortable. The flowchart in figure 1 depicts the various stages involved in each child-robot interaction session. Each child-robot interaction followed a sequence of activities beginning with a quiet phase followed by an introduction, musical interlude, six imitation tasks, musical interlude, five joint attention tasks, musical interlude and finally a conclusion. The robot was remotely controlled by the principal researcher. Before any activity session, the robot informs the child of the tasks to be done and when the task is finished, the robot also prompts the child. This principle adopted by the robot is in line with the protocols used in their classroom sessions where the children are prompted at the beginning and end of each activity session.

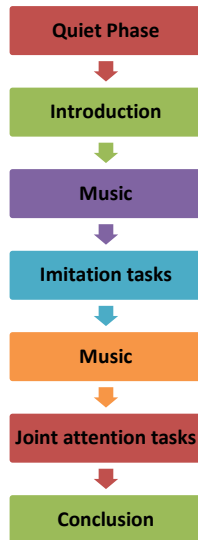


Figure 2 The seven stages involved in each child-robot interaction session

**Stage 1: Quiet Phase**

The robot is off as the child is ushered into the room. We wanted to observe whether the child would draw towards the robot, keep his distance or even express displeasure. The robot remained off for 30 seconds. Then the robot was turned on.

**Stage 2: Introduction**

The robot turns the LED lights around its eyes and mouth. The robot then speaks for the first time.

**Robot vocal (RV) 1:** “Hello, my name is Rosye. I am a robot and friend of children with autism”.

**Stage 3: Musical Interlude**

At the third stage, the robot asks the child his or her name and tells the child it is going to sing a song. All the songs sung by the robot were popular Ghanaian songs. As the robot is singing, it performs some hand and neck movements.

**RV 2:** What is your name?

**RV 3:** Hello + “*name of child*”, I am going to sing a song for you

**RV 4:** Robot sings a song

**RV 5:** Music time is finished

**Stage 4: Imitation tasks**

After playing the music, the robot leads the child through exercise sessions. Robot raises its left, right and both hands up and down and encourages the child to do same.

**RV 6: It is exercise time!**

**RV 7: Left hand up**

Action: Robot raises its left hand up

**RV 8: Left hand down**

Action: Robot puts its left hand down

**RV 9: Right hand up**

Action: Robot raises its right hand up

**RV 10: Right hand down**

Action: Robot puts its right hand down

**RV 11: Both hands up**

Action: Robot raises both hands up

**RV 12: Both hands down**

Action: Robot puts both hands down

**RV 13: Exercise time is finished**

### **Stage 5: Musical Interlude**

After the imitation tasks, robot plays music while moving its hands and neck

**RV 14:** Robot sings a song

**RV 15:** Music time is finished

### **Stage 6: Joint Attention(JA) tasks**

For all the joint attention tasks, the task is completed when child turns to look at the robot and performs the robot's request. If the child does not respond by the third prompt, task is aborted. The robot also rewards the child for good work done by saying "good job!"

#### **JA task 1**

Just before the joint attention tasks, each child is given a toy to play with. The robot tries to shift the attention of the child from the toy towards the robot. The robot mentions the child's name.

**RV 16:** "Hello *name\_of\_child*"

Robot repeats **RV 16** till the child turns its attention towards the robot or aborts the task when the child does not turn by the third prompt.

#### **JA task 2**

Whereas some of the children have speech, others are nonverbal. We chose to let the robot ask the children the simple question "how are you" because almost all the children are able to respond to this question using speech or sign language.

**RV 17:** "Hello "*name\_of\_child*" how are you"?"

#### **JA task 3**

Robot tries to shift the attention of the child towards a ball on the floor.

**RV 18:** ("*name\_of\_child*"), take the ball

#### **JA task 4**

Robot asks the child to give the ball to it.

**RV 19:** Hi ("*name\_of\_child*"), give me the ball

#### **JA task 5**

Robot asks of a child's name.

**RV 20:** What is your name?

### **Stage 7: Musical Interlude**

After the joint attention tasks, robot plays music while moving its hands and neck

**RV 21:** Robot sings a song

**RV 22:** Music time is finished

### **Stage 8: Conclusion**

Robot tells the child the playtime and interaction session has ended.

**RV 23:** Hello my little friend, we are done for today. You have done so well. Good job. Bye bye

### **Conditions to abort the session**

The child-robot interaction session were brought to an end immediately a child became restless, aggressive or when the carer of the child requested the experimenter to end the session because the child was becoming uncomfortable.

## **6. HYPOTHESIS**

- i. How would the children on the autism spectrum experience the uncanny valley phenomenon?
- ii. Would the humanoid robot, Rosye, be able to engage the Ghanaian autistic children in an imitation game?
- iii. Would Rosye be able to elicit joint attention behaviours from the autistic children?
- iv. Can Rosye persuade an uncooperative autistic child to respond to a task by giving several prompts?

## 7. RESULTS AND DISCUSSIONS

### Quantitative description of children’s behaviour during one-on-one interactions with the robot

Due to the fact that this is the first study where the participants had one on one interaction with the humanoid robot, it is necessary to present the quantitative description of each child’s behaviour during this preliminary study. In future when more trials are conducted, it would be easier to compare the initial reaction of the child towards the robot, to how the child responds to the robot over time. People on the autism spectrum have different needs and preferences, hence we expected that they would not exhibit the same behaviour towards the robot. In all, we analysed 116 minutes 44seconds (1 hour 56 minutes 44 seconds) of video recorded during the preliminary trial. The minimum child-robot session lasted for 2 minutes 53 seconds, maximum duration was 16 minutes 27 seconds and the average interaction time recorded for all the participants was 8 minutes 16 seconds.

### Hypothesis 1: How would the children on the autism spectrum experience the uncanny valley phenomenon?

Autistic children easily concentrate and get stuck on objects of interest. Some children on the autism spectrum are sensitive to touch and therefore they may not like touching objects or also dislike being touched by objects or people. During the interactions involving Rosye and the children, we sought to determine whether the children would like the robot, get close to it and subsequently learn from it. Therefore our experiments were carefully designed to begin with a quiet phase so as to observe the initial reaction of each child upon entry into the room. Specifically, we observed how the children experienced the uncanny valley phenomenon. Although Rosye is a humanoid robot, its features have been selectively designed to reduce its resemblance to human beings. From the video recordings, we present that out of the 15 children, only 1 female child express signs of fear upon seeing the robot for the first time. All the other children did not feel creeped out by the robot; some smiled, touched and hugged the robot. Whereas some of the children were more interested in engaging the robot in the imitation and joint attention games, others found delight in touching various parts of the body.

From our study, the part of Rosye touched the most was its hands (both left and right) with a total score of 95 times. The second most touched part was its shoulders, 26 times, followed by midsection being touched 25 times. In this work, we use midsection to represent any other part of the robot apart from the specific parts explicitly mentioned. The fourth was the head, touched 24 times followed by the mouth, 12 times touched, neck, touched 6 times and the eyes of the robot had the least touch with a score of 5. In all, the robot was touched 193 times during the 15 child-robot interaction sessions. Based on observations and findings from our research, we present that the effect of the uncanny valley during the Ghanaian-autistic children and robot interaction was minimal. Figure 5 presents an overview of the total number of tasks done per child (both imitation + joint attention) and the total number of times each child touched the robot.

### Hypothesis 2: Would the humanoid robot, Rosye, be able to engage the Ghanaian autistic children in an imitation game?

Autistic children do not like changes to their routine or environment and may not respond well to unfamiliar people or scenarios. As a result, the robot had a very challenging task to the get the attention of the children and to engage them in the imitation game.

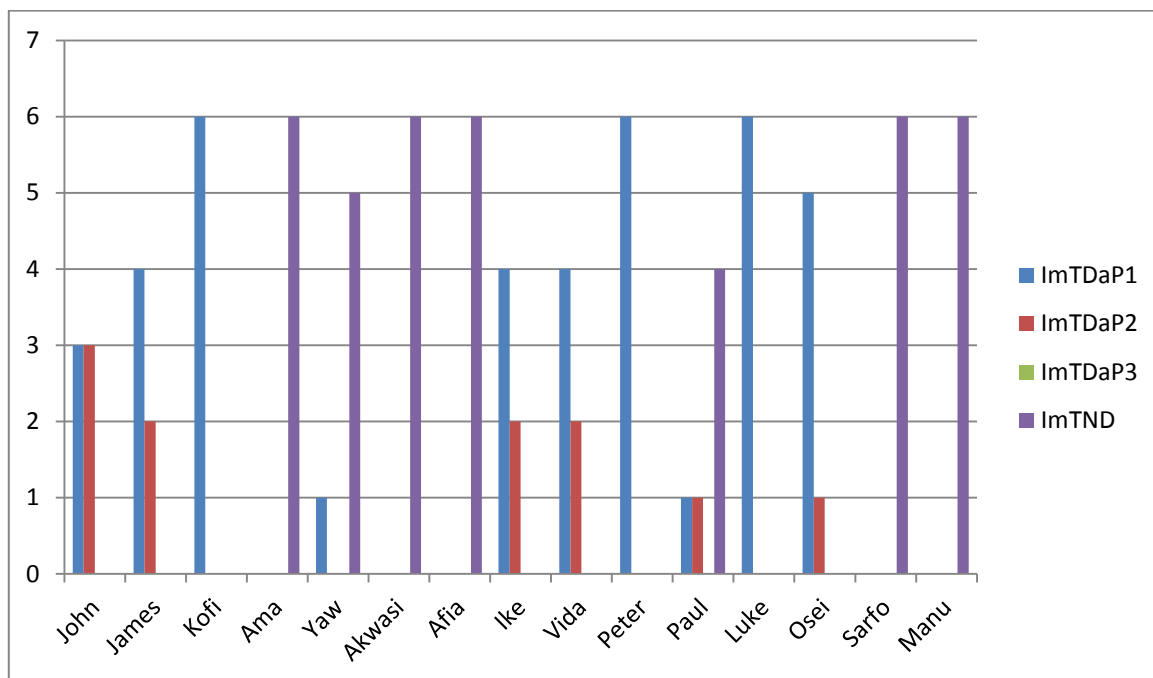


Figure 3 Responses of children to imitation tasks per prompt levels

- ImTDaP1: Imitation tasks done at first prompt
- ImTDaP2: Imitation tasks done at second prompt
- ImTDaP3: Imitation tasks done at third prompt
- ImTND: Imitation task not done

From figure 3, it is observed that 8 out of the 15 autistic children successfully imitated all the 6 actions during the imitation game with the robot. 5 children did not imitate any of the robot’s actions. 1 child imitated only two of the robot’s actions and 1 child imitated just one of the robot’s actions. In all, the robot engaged in 90 imitation tasks with all the children (15 children and 6 imitation games for each child). Out of the 90 tasks, we observe from figure 3 that 40 of the tasks were completed by the children at the first prompt given by the robot, 11 tasks were completed at the second prompt by the robot and the remaining 39 of the tasks were not performed at all. In figure 3, it is interesting to observe that, all the children who performed the imitation tasks did so at either the first or second prompts; none of the children performed an imitation task at the robot’s third prompt. Considering that this research was the children’s first encounter with the unfamiliar humanoid robot Rosye, the results obtained are encouraging; 56.7% of the imitation tasks were successfully completed.

**Hypothesis 3: Would Rosye be able to elicit joint attention behaviours from the autistic children?**

Based on the personality and mood, some children on the autism spectrum may not engage in communication or respond to requests from their parents, caregivers and to a more severe extent people they do not know. The robot was programmed to deliver five personalized instructions to each child (by referring to each child by name). Figure 4 presents the responses obtained from the joint attention game.

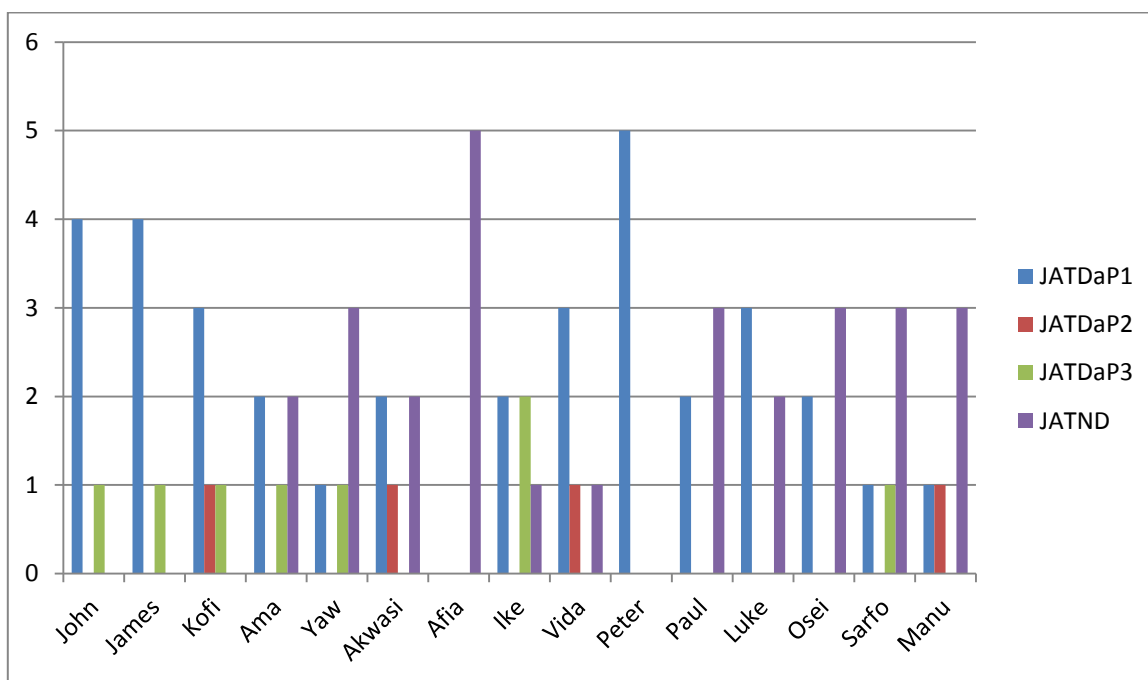


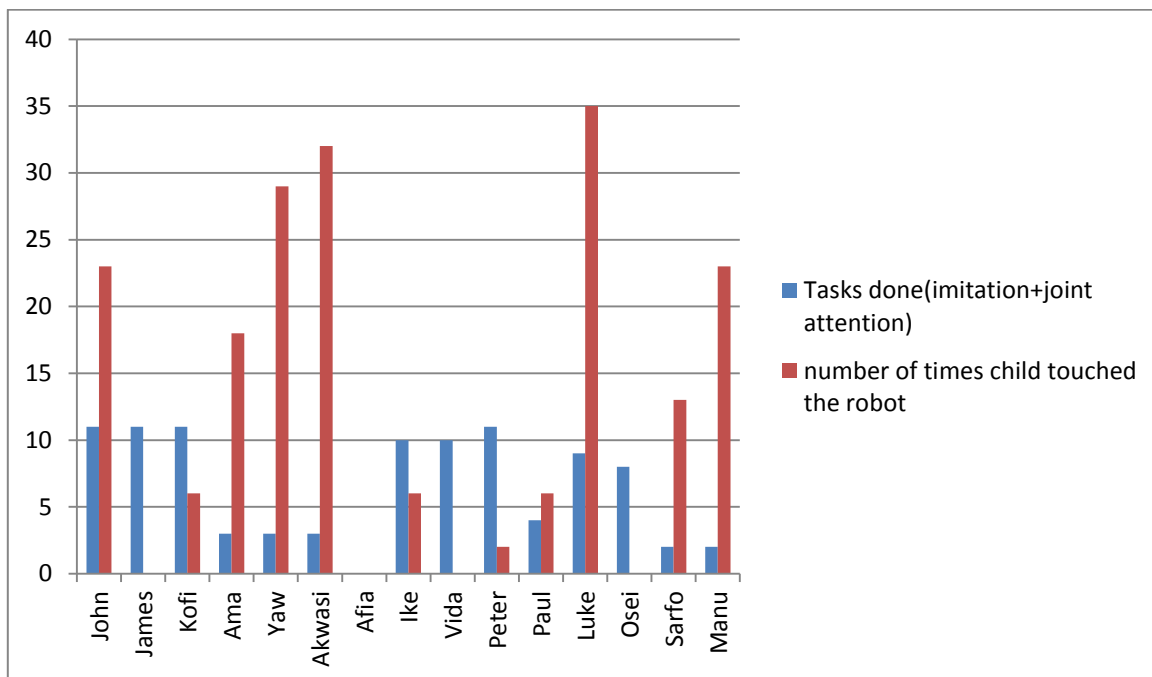
Figure 4 Responses of children to the joint attention tasks per prompt levels

- JATDP1: Joint Attention tasks done at first prompt
- JATDP2: Joint Attention tasks done at second prompt
- JATDP3: Joint Attention tasks done at third prompt
- JATND: Joint Attention task not done

From figure 4, we observe that 4 out of the 15 children performed all the 5 joint attention tasks, 2 of them did 4 tasks, 3 of them did 3 tasks, 5 of them did 2 tasks and only 1 child did not do any of the joint attention tasks. Comparing to the imitation tasks, we observe that the number of children who did not do any of the joint attention tasks is lesser (1 child) than the number that did not do any of the imitation tasks (5 children). The robot instructed the children to do a total of 75 joint attention tasks (15 children and 5 tasks per child). Out of the 75 tasks, 35 of them were successfully performed by the children at the robot’s first prompt, 4 tasks were completed at the second prompt and 8 tasks were completed at the third prompt; unlike the imitation game where no tasks were performed at the third prompt. The number of JA tasks which were not performed was 28.

Data from our research shows that 13 of the children responded (by either turning to face the robot, walking towards the robot or saying “yes” or “hi”) when robot called each child by name. The second most executed task was “how are you” to which there were 12 responses. The tasks “what is your name” and “take the ball” all had 8 responses and the task with the least response was “give me the ball”. Perhaps due to the fact that their carers call the children by their names and ask each child “how are you”?, during their “Good morning” assembly sessions at school, they were familiar with the first two tasks and that could possibly account for the high responses. As some of the children are non-verbal, the decrease in responses to “what is your name” is not surprising. More so, the tasks involving taking the ball and giving it to the robot are unfamiliar to the children and that could account for the low responses.





**Figure 5** Number of tasks completed successfully (maximum points achievable=11) vrs number of times child touched the robot (child could touch the robot limitlessly)

From figure 6, we observe interesting results. Some children who achieved lesser scores during the imitation and joint attention games touched the robot more times than those children who had higher scores during the games. More specifically, one child, James who performed all the 11 tasks correctly did not touch any part of the robot during his session with the robot. Three of the children who also performed all the 11 tasks correctly touched the robot a lesser times (6, 2 and 23 times (a higher score)). Some of the children who scored less during the games touched the robot severally (18, 19, 32, 6, 0, 6, 35, 0, 13, 23 times). 1 child, Afia neither touched the robot nor engaged in the imitation game; this was the child who was scared of the robot. We therefore argue that most of these children are not scared of the robot Rosye and the uncanny valley effect had minimal impact due to the fact that they touched Rosye multiple times during the interaction sessions.

**Hypothesis 4: Can Rosye persuade an uncooperative autistic child to respond to a task by giving several prompts?**

The experimental script for the interaction sessions was designed to permit the robot to give 3 prompts for each task; if a child does not initially respond the robot’s request, the robot repeats the same request for at most 3 times. The task is aborted if a child does not respond by the third prompt. From figure 4, it is observed that some of the tasks were successfully done at the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> prompts. For the joint attention module, 46.7% of the tasks were done at first prompt, 14.6% were done at the second prompt and 10.7% were done at the third prompt. From figure 3, all the imitation tasks successfully done by the children were completed at the 1<sup>st</sup> or 2<sup>nd</sup> prompt. 44.4% of the imitation tasks were done at the first prompt and 12.2% of the tasks were done at the second prompt.

**Table 1: General overview of results from the experiment**

Tasks	Total number of task done per prompt			Total number of task done for all three prompts	Total number of tasks not done
	1st prompt	2 <sup>nd</sup> prompt	3 <sup>rd</sup> prompt		
<b>Imitation</b>	40	11	0	51	39
<b>Joint attention</b>	35	4	8	47	28

From table 1, the total number of tasks done for the imitation and joint attention are higher than the total number of tasks not done. 56.7% of the imitation tasks were successfully done by the children whereas the percentage of imitation tasks not done was 43.3%. For the joint attention tasks, 62.7% were successfully completed while 37.3% of the tasks were not done. This implies that the children showed interest in engaging with the robot although it was their first encounter with it. The robot was also able to get some of the “uncooperating” children to respond to its requests by repeating each task three times. The repetitive capabilities of the robot therefore makes it a beneficial assistive technology for caregivers of children with autism who may get tired or frustrated repeating instructions to the children multiple times.

## 8. CONCLUSION

This research has provided information on how autistic children in Ghana, a country in West Africa have responded to a novel humanoid robot Rosye. Results from our study have indicated that the robot was able to engage some of the autistic children in imitation and joint attention games and also succeeded in persuading some children to perform the robot's requests by giving several prompts. Almost all the children were not scared or creeped out by the humanlike appearance of Rosye. These Ghanaian autistic children have shown interest, responded to and tolerated Rosye well and the results from our research are encouraging. However, considering the nature of the children on the autism spectrum, their reaction to the robot may change over time; a child who showed much interest in the robot upon seeing it for the first time may or may not like it at a different encounter with the same robot. On the other hand, a child who previously did not engage much with the robot could tend to like it as time goes on. This research has presented results from the preliminary one day encounter of some autistic children with Rosye. We are currently engaged in more trials to investigate how these children will respond to Rosye over time. Results of this experiment will therefore be a basis to aid in investigating and making comparisons on the responses and engagement levels of the children to the robot over time. Evidence from this study also serves as a contribution to knowledge in research on robots in autism therapy, majority of which have been done in the developed countries.

## REFERENCES

- [1] Cabibihan, J.-J., Javed, H., Marcelo, A., & Aljunied, S. (2013). Why Robots? A Survey on the Roles and Benefits of Social Robots for the Therapy of Children with Autism. *International Journal of Social Robotics*, 5(4), 593-618
- [2] CDC, C. f. (2014). *Autism Spectrum disorder, data and statistics*.
- [3] World\_Health\_Organisation. (2017, April 4). *Autism spectrum disorders*. Retrieved August 26, 2018, from WorldHealth Organisation: <http://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders>
- [4] Christensen, B. J., Van Naarden Braun, K., Bilder, D., J., C., Constantino, J., Daniels, J., et al. (2016). Prevalence and Characteristics of Autism Spectrum Disorder Among Children Aged 8 Years--Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States. *Errata, MMWR Surveill Summ*. 65(SS-3) , 1-23.
- [5] Uwaezuoke, N. S. (2015). Autism Spectrum Disorder in Children: The Disparities between the Developed and Developing Countries. *Autism Open Access* 5:152 .
- [6] Missigman, S. (2017, August 24). *Autism in Developing Countries*. Retrieved September 1, 2018, from The Borgn Project: <https://borgenproject.org/autism-in-developing-countries/>
- [7] Sanua, V. (1984). Is infantile autism a universal phenomenon? An open question. *Int J Soc Psychiatry* 30(3) , 163-177
- [8] Bakare, M., & Munir, K. (2011). Autism spectrum disorders (ASD) in Africa: a perspective. *African Journal of Psychiatry* , 208-210.
- [9] Fombonne, E. (2003). Epidemiological surveys of autism and other pervasive developmental disorders: an update. *J Autism Dev*, 33 , 365 – 382.
- [10] RIRSGH, R. I.-G. *The Autism Project for Ghana*.
- [11] Ingersoll, B. (2008). The Social Role of Imitation in Autism: Implications for the treatment of imitation deficits. *21(2)* , 107–119.
- [12] Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Auriol, D., & Cox, A. (2003). Predicting language outcomes in infants with autism and pervasive developmental disorder. *International Journal of Languages and Communication disorders* 38(3) , 265-285.
- [13] Ingersoll, B. (2007). Teaching Imitation to Children with Autism: A focus on social reciprocity. *SLP- ABA* 2(3)
- [14] Stone, W. L., Ousley, O. Y., & Littleford, C. D. (1997). Motor imitation in young children with autism: What's the object? *Journal of Abnormal Child Psychology*, 25 , 475–485
- [15] Duquette, A., Michaud, F., & Mercier, H. (2008). Exploring the use of a mobile robot as an imitation agent with children with low-functioning autism. *Autonomous robots* 24(2) , 147–157.
- [16] Adamson, L. (1995). *Communication development during infancy*. Madison, WI: Brown and Benchmark Publishers.
- [17] Lisa, S., Mundy, P., & Mastergeorge, A. M. (2015). Joint Attention in Preschool Children: Is it a Meaningful Measure? *International Journal of School and cognitive psychology* 2:120 .
- [18] Gernsbacher, M. A., Stevenson, J. L., Khandakar, S., & Goldsmith, H. H. (2008). Why Does Joint Attention Look Atypical in Autism? *Child Development Perspectives* 2(1) , 38–45.
- [19] Zachary, E. W., Zheng, Z., Swanson, A. R., Bekele, E., Zhang, L., Crittendon, J. A., et al. (2015). Can Robotic Interaction Improve Joint Attention Skills? *J Autism Dev Disord*. Nov; 45(11) , 3726–3734

- [20] Dyches, T., Wilder, L., Sudweeks, R., Obiakor, F., & Algozzine, B. (2004). Multicultural issues in autism. *Journal of Autism and Developmental Disorders*, 34 , 211-222
- [21] Ennis-Cole, D., Durodoye, B. A., & Harris, H. L. (2013). The Impact of Culture on Autism Diagnosis and Treatment: Considerations for Counselors and other Professionals. *The Family Journal: Counseling and Therapy for Couples and Family* 00(0) , 1-9
- [22] Cascio, M. A. (2015). Cross-cultural autism studies, neurodiversity, and conceptualizations of autism. *Cult. Med. Psychiatry* 39 , 207–212
- [23] Libin, A., & Libin, E. (2004). Person-robot interactions from the robopsychologists' point of view: the robotic psychology and robototherapy approach. *Proc. IEEE* 92 , 1789–1803.
- [24] Rudovic, O., Lee, J., Mascarell-Maricic, L., Schuller, B. W., & Picard, R. W. (2017). Measuring Engagement in Robot-Assisted Autism Therapy: A Cross-Cultural Study. *Frontiers in Robots and AI* .