Increasing Intelligibility in the Speech of the Autistic Children by an Interactive Computer Game

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Abstract— **Autism is a disorder of neural development which affects about one in every 150 kids on average. One of the major complexities regarding autistic children in social communication is the speech disorder. The problems related to speech disorder fall into different categories and unintelligibility in speech is one of them. Although there is no definite medicine or treatment for autism, doctors, therapists, and special teachers can help kids with autism overcome many difficulties by different physical and psychological therapies. In this paper we have demonstrated our newly developed interactive computer game which will be helpful in increasing intelligibility in the speeches of autistic children and can be used as a therapy besides the traditional approaches. During our five months of intervention with the autistic children of Autism Welfare Foundation (AWF) at Dhaka, we checked the effectiveness of this therapy and got some encouraging results.**

Keywords-autism;e-learning; assistive computing; software

I. INTRODUCTION

Autism spectrum disorders (ASDs) are a group of neuro-developmental disorders characterized by core deficits in three domains: social interaction, communication, and repetitive or stereotypic behavior. People suffering from autism very often demonstrate a poor performance in social interactions. About one third to a half of individuals with autism do not have enough natural skills in their speeches that can meet the necessity of their daily communications. The problem in communication is based largely upon speech and language problem [2].

Although the cause of speech and language problems in autism is unknown, many experts believe that the difficulties are caused by a variety of conditions that occur either before, during or after the birth effecting cerebral development. This interferes with an individual's ability to interpret and interact with the world while communicating. Different types of irregularities in speech communication have been addressed in literature including the followings:

- Non-Response
- Making Low Sounds in Response
- Making Unintelligible Sounds
- Making Delay in Answering Questions
- Answering Incorrectly with Articulate Words
- Difficulties in Making Correct Sentences with words
- Lacking the Sense of Turn Taking

In this paper, we concentrate on the problem of making unintelligible Sounds. The term "intelligibility" refers to the proportion of a speaker's speech that a listener can readily understand. Many of the autistic children suffer from speech unintelligibility. Although they can produce sounds loud enough, the audience cannot get the meaning of those.

Actually, there is no definite treatment for autism. The best we can do is to help the autistic children in making proper social communication being within their limitations. Computer games have recently been proved to be very powerful tools in this regard [11], [12]. By exploiting the interest of the autistic children to get rewards in the games, we have tried to develop their intelligibility skill in speech. In our intervention with 10 children over 5 months at Autism Welfare Foundation at Dhaka, this approach was fruitful. We do not suggest replacing the traditional therapies by our game; rather we recommend introducing our game besides the traditional therapies for the best output.

The paper is organized as follows. Section II discusses related works about Autism Spectrum Disorders (ASDs). We show our interactive e-learning game with its software architecture and hardware & software requirements in Section III. Image selection procedures for our game described in section IV. We also propose an experiment using our game as a module for the speech development of the autistics children in Section V. We conclude with ideas for future works and conclusions in Section VI & Section VII respectively.

II. RELATED WORKS

In the 1960s, *Ivar Lovaas* began teaching children with autism new behaviors through a technique called "applied behavior analysis", in which a behavior is encouraged or

discouraged as it encounters environmental consequences. In short, his technique relies upon using objects, food, and actions as rewards for desired behavior (prompted by a researcher) [9],[13]. Over many trials and sessions, children with autism eventually learn to respond in a predictable fashion by interacting with people in their environment. There are three main drawbacks to this form of treatment:

1. It requires many sessions with trained professionals who are in short supply. This can place a financial burden on the family.

2. Teaching sessions require intense attention and prolonged contact from a practitioner or parent.

3. The child must interact with a human being. One characteristic of ASD is anxious, detached, and "alone" interaction with other individuals [1], [4]. Thus the interaction with a human being, as the primary mode of teaching, might pose some degree of built-in difficulty for the ASD child.

Existing work by researchers has approached ASD from three primary directions. Works by *Abowd* and others have explored the benefits of technology to aid the diagnosis process [3], [6], [7]. This research is crucial, because early detection allows children to begin treatment earlier, allowing them to catch up faster to their non-autistic peers. Further, this work allows us to better understand how to identify autistic characteristics. Although greatly beneficial, this research does not provide a direct method to enhance the education of children with ASD.

Researchers have also explored the effect that technological environments have had on the process of assisting children with autism to learn how to interact with other human beings [5], [15]. This work uses virtual environments, as well as virtual peers, to create situations in which the children with ASD are comfortable. They are then able to learn person-to-person interactions, without the apprehension of having another person in the room. This work, however, primarily has dealt with "high functioning" children, or those who already know how to speak and have a deficit in social interaction. Therefore, it is hoped that principles learned from this body of literature will have the potential to be applied to research targeting children with ASD who have not yet acquired speech.

The third approach seeks to encourage children with ASD to "play," where playing is mediated through technology [8], [10], [14]. By creating technological methods of interaction (visual displays and physical robots), play and comfortable interactions can be garnered from children with autism. There is a feeling of "safety" by having the main form of interaction occur with non-humans. Further, these devices allow the child, rather than a third party, to be in control of the interactions. This research has much potential. To date, however, it has not focused on encouraging more communication-based activities, such as speech and human-to-human interaction

III. EXPERIMENTAL INTERACTIVE GAME

In this section we present the overview of our interactive game, the architecture of the game, and our implementation procedure with software and hardware requirements.

A. Overview of the Interactive Game

The game we developed is an interactive e-learning game in which an autistic child who makes unintelligible sounds will try to produce clear words to communicate to the computer. The basic idea of this game is very simple. Various kinds of interesting pictures appear in the Graphical User Interface (GUI) as shown in the Figure 1(a) one by one and the autistic child who can pronounce the name of the picture clearly and loudly can score and win the game. As a result the autistic child will try to make clear and loud pronunciation to win the game which in turn helps them to overcome their unintelligibility problem. While selecting images we emphasized on the familiarity of the objects to the autistic children. We also set the word for each of these images based on their familiarity to avoid the possible problem regarding synonyms. Besides, there are provision for extending this game for others language and themes.

In Fig. 1 we illustrate a simple example of this game. For example, after running the game, the Main game window [Shown in Fig. 1(a)] will come. We must make sure the microphone is ready. The Speech Recognition engine is automatically started. Now the speech engine is ready to detect desired word as shown in the figure. There is a timer which keeps track of time. Every image is given some fixed time to be uttered. After this time the uttered word is matched with the correct word. If the word is correctly pronounced the student will get point and in this way the game proceeds. If the word does not match with the word specified in the XML grammar file, she will not get any point and next image will be shown. There is a set of images and the game concludes if all the images are successfully uttered. Finally after winning the game a dialogue window will come as shown in the Fig. 1(c) and it also makes sound "¨Wow, you won!"

B. The Architecture of the game

The core of the game consists of the following part.

(a) Speech Engine at the back end for speech recognition.
(b) XML grammar files containing the grammar of the specific words.
(c) Graphical User Interface at the front end for communication.

We used images of common objects collected from internet. We used the default pronunciations of Microsoft's SDK as standard, but we kept provisions for adding words of different styles.

(a)Main Game Scene 1 (b)Main Game Scence 2 (c)Winning Stage

Figure 1: An example of the interactive game

Fig. 2 represents the Data flow diagram of our interactive game. At first, when the game is executed cycle [shown in Fig. 2]. At the beginning a GUI appears with specific image. Next an autistic child with microphone makes voice or pronounces the name of the picture [shown in Fig. 1(b)] which passes through the microphone to the *Speech Engine*. When times out the last saved word of the child is passed to an internal procedure that converts it as text. Now this word is passed to the *grammar checker function* which in turn calls another internal procedure that
loads the *XML Grammar File* from directory. Then this XML *Grammar File* is parsed for that specific word. Finally another image is loaded from the directory by another internal procedure which is shown in *Graphical User Interface (GUI).* And in this way the data flow continues in the game.

To implement *Speech Engine* for speech recognition we have used *Microsoft Speech Engine for English Speech SDK 5.1, Microsoft .NET Framework 3.5.* We have used Microsoft visual studio 2008 for graphical user interface (GUI) purpose. For Operating System we have used *Microsoft Windows XP service pack 2.*

For testing purpose we have used Intel Pentium 4 processor having 2.66 GHz, 1 GB of memory and 80 GB hard disk.

IV. IMAGE SELECTION

In the overview section of our game we have said that in case of image selection, we selected those targeted for a number of autistic children. This is because, according to our last five months of intervention with the autistic children of Autism Welfare foundation (AWF) at Dhaka, we observed that many autistics children were very aggressively selective. They did not want to understand or realize anything that did not match with their mentality or imaginary world. For example, consider a sessional class for teaching alphabet. For teaching a normal child we can easily say, "A" for "Apple". But for an autistics child it might not be effective if he or she do not like fruits. Since these behavioral patterns vary from one autistics child to another, we might need to say "A" for "Aero plane" for some of them. Similarly for an autistic child who likes sports we have to say "B" for "Ball".

Considering diversity in behavioral patterns, we also made a separate section in our game. Before an autistic child start playing the game, his or her teacher will select a specific pattern (i.e. underwater sea life, vehicles or fruits) from our game according to the taste of that child. Here we considered that the teacher knew the background of the children because he or she could easily know this information from the parents of the children.

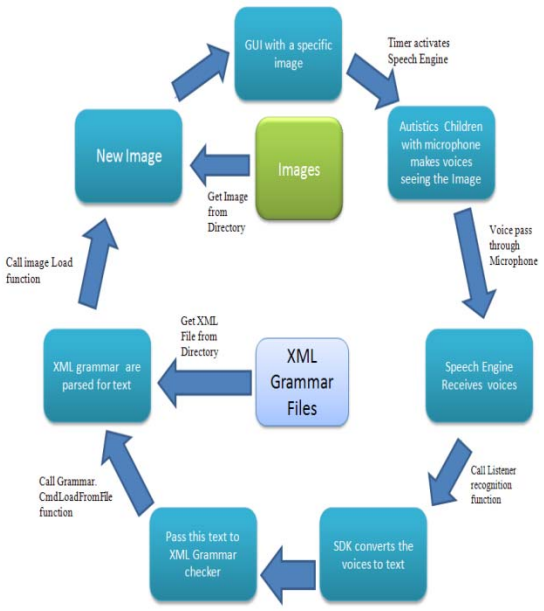

Figure 2: Data Flow Diagram

V. EXPERIMENTS

For autistic children those who made unintelligible sound, we have found that following level-wise experiment is very effective. Since in "*English Language*" most of the words are mono-syllabic, di-syllabic or tri-syllabic we divided the experiment into three distinctive sessions which we called levels.

Level-1: [Mono-syllabic words with unlimited number of attempts]

We started our experiment with mono-syllabic words. At this early stage of the experiment an autistic child would get unlimited opportunity to pronounce the word correctly. No matter how many attempts they took, they would get rewards. The results are shown in Fig. 3.

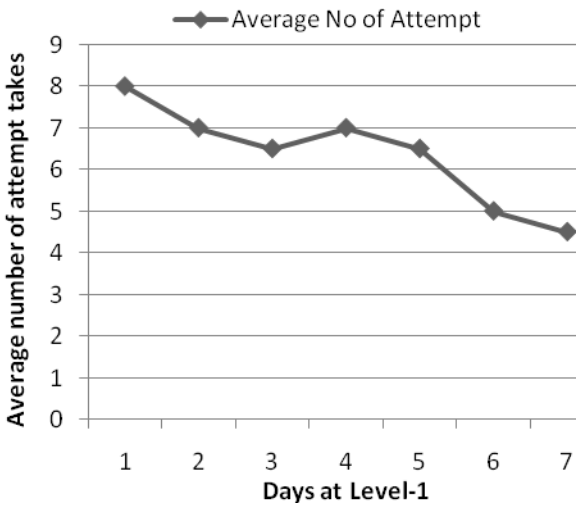

Figure 3: Average Number of attempt takes

Level-2: [Mono-syllabic & Di-syllabic words with fixed number of attempts]

After successfully completing the level-1 experiment these autistics children were taught to pronounce both mono-syllabic & di-syllabic words. However at this stage of the experiment they would get only a fixed number of chances. If they could do it within the limits it was considered as a success otherwise it was failure.

Level-3: [Mono, Di and tri-syllabic words with fast response]

Since at this stage, the autistics children were familiar with both mono and di-syllabic words, so we tried to increase the speed of their speech. For computing the effectiveness we counted how fast an autistics children response with the image and correctly.

Based on this analytical reports [shown in Fig. 3, 4 & 5] generated by our software a teacher decides which child is making improvement or who needs further assistance.

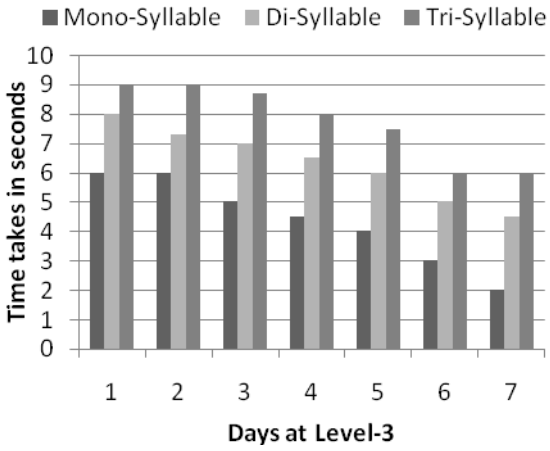

Figure 4: An autistics child's promptness at Level-3

VI. FUTURE WORK

The future works of this game include using free & sophisticated graphics toolkit like *OpenGL*. We are also interested to include the introduction of Artificial Intelligence so that it can dynamically update the XML grammar file and picture from the environment. It might extract emotional data from the facial expression of the children.

VII. CONCLUSION

To date, Very little research has been reported on using technology to teach low functioning children with ASD to learn to vocalize or speak. However, the field of augmentative and alternative communication embraces technology primarily as a medium of communication and

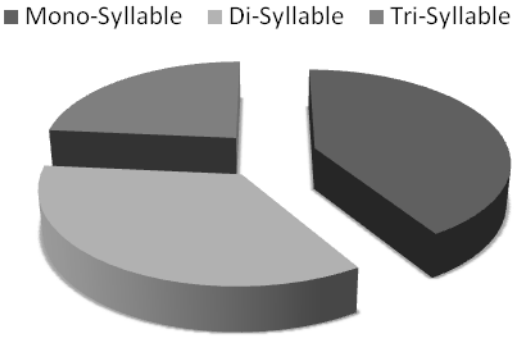

Figure 5: An overall performance of autistics children

not as often as a method of instruction. If we can encourage vocalization at the age of 3, a pivotal age for children with ASD, this could lead to an increased communicative ability, which makes not only the child's life easier,

but also increases their chances of functioning in the world around them.

ACKNOWLEDGEMENTS

We acknowledge the contribution of Bangladesh University of Engineering and Technology (BUET) [16] for this research with all sorts of supports.

REFERENCES

[1] C. B. Baskett, "The effect of live interactive video on the communicative behavior in children with autism", University of North Carolina at Chapel Hill, Chapel Hill, 1996.

[2] Center for Disease Control and Prevention, CDC. Autism Information Center, DD, NCBDDD, CDC, Atlanta, April 25, 2007

[3] Hayes, G. R., Abowd, G.D., et al. "Designing Capture Applications to Support the Education of Children with Autism," Proc. International conference on ubiquitous computing, Nottingham, vol. 3205, pp. 161-178

[4] L. Kanner, "Autistic Disturbances of Affective Contact," in Kanner, L. ed. Nervous Child 2, V.H. Winston, 1943, pp.217-250.

[5] S. J. Kerr, H. R. Neale, and S. V. G. Cobb, "Virtual environments for social skill training: the importance of scaffolding,"Proc. The fifth international ACM conference on Assistive technologies, ACM Press, Edinburgh, Scotland, 2002.

[6] J. A Kientz, G. D. Abowd, et al. "Grow and know: understanding record-keeping needs for tracking the development of young children,"Proc. SIGCHI conference on Human factors in computing systems, ACM Press, San Jose, California, USA, 2007.

[7] J. A Kientz, G. R. Hayes, G. D. Abowd and R. E. Grinter, "From the war room to the living room: decision support for home-based therapy teams,"Proc. The 2006 20th anniversary conference on Computer supported cooperative work, ACM Press, Banff, Alberta, Canada, 2006.

[8] J. F. Lehman, "Toward the use of speech and natural language technology in intervention for a language-disordered population," Proc. The third international ACM conference on Assistive technologies, ACM Press, Marina del Rey, California, United States, 1998.

[9] I. I. Lovaas, "The Autistic Child". John Wiley & Sons, Inc, New York, 1977.

[10] F. Michaud and C. Théberge-Turmel, "Mobile robotic toys and autism," in Dautenhahn, K. ed. Socially Intelligent Agents - Creating Relationships with Computers and Robots, Springer, 2002, pp.125-132.

[11] M. E. Hoque, "Analysis of Speech Properties of Neurotypicals and Individuals Diagnosed with Autism and Down Syndrome,"Proc. 10th ACM conference on Computers and Accessibility (ASSETS), Halifax, Nova Scotia, October, 2008.

[12] M. E. Hoque, J. K. Lane, R. elKaliouby, M. Goodwin and R. W. Picard, "Exploring Speech Therapy Games with Children on the Autism Spectrum," Proc. InterSpeech, Brighton, UK, September, 2009.

[13] M. H. Charlop-Christy, M. Carpenter, L. Le, L. A. LeBlanc and K. Kellet, "Using the picture exchange communication system (PECS) with children with autism: assessment of PECS acquisition, speech, social communicative behavior, and problem behavior," Journal of Applied Behavior Analysis, 2002 Fall; 35(3):pp. 213–231.

[14] N. Parés, A. Carreras, et al. "Promotion of creative activity in children with severe autism through visuals in an interactive multisensory environment,"Proc. The 2005 conference on Interaction design and children, ACM Press, Boulder, Colorado, 2005.

[15] A. Tartaro,"Storytelling with a virtual peer as an intervention for children with autism," SIGACCESS Access. Comput. (84):pp.42-44.

[16] Bangladesh University of Engineering and Technology (BUET) [http://www.buet.ac.bc]