A Computer Game-based Approach for Increasing Fluency in the Speech of Autistic Children

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Abstract

Autism is a complex developmental disability that typically appears during the first three years of life. This is the result of a neurological disorder that affects the functioning of human brain. Children diagnosed with autism often are self-absorbed and seem to exist in a private world where they are unable to successfully communicate and interact with others. Sometimes they have difficulties in developing language skills and understanding what others say to them. They also might have difficulties in communicating nonverbally, such as through hand gestures, eye contact, and facial expressions. What actually causes verbal and nonverbal communication difficulties in autism is not yet known, but it is thought that an individual’s brain development was affected either before, during or after birth and thus the communication control centre was somehow impaired. Depending on the individual, the type of communication difficulties experienced will vary. Some individuals with autism can speak fairly fluently while others may not be able to speak at all. In this paper we have described a system that will help an autistic child for increasing his or her fluency in speaking. Besides, we also present results of our experiments using the proposed Gaming Software with the autistic children of Autism Welfare Foundation (AWF) at Dhaka, over the past 3 months.

1. Introduction

Autism is perhaps the most common pervasive developmental disorder. It is a brain disorder that affects multiple areas of development including social interaction creative/imaginative play and verbal and nonverbal communication. Usually a child will begin to show signs of autism by the age of three, including signs that his or her verbal speech is not developing as normal for a child of his or her age. It affects people of every race, ethnic group, and socioeconomic background. Boys are four times more likely to have autism than girls. According to a study by the Centers for Disease Control and Prevention (CDC), autism spectrum disorders were found to affect as many as one out of every 150 8-year-old children.

Not every child with an autism spectrum disorder has a speaking problem. A child’s ability to communicate varies, depending upon his or her intellectual and social development. Some children with autism are unable to speak. Others may have rich vocabularies and are able to talk about specific subjects in great detail. Some children with autism have little or no problem pronouncing words. The majority, however, have difficulty using language effectively, especially when they talk to other people. Many have problems with the meaning and rhythm of words and sentences. They also may be unable to understand body language and the nuances of vocal tones.

Below are some patterns of language use and behaviors that are often found in children with autism.

Repetitive or rigid language: Often, children with autism who can speak will say things that have no meaning or that seem out of context in conversations with others. For example, a child may count from one to five repeatedly. Or a child may continuously repeat words he or she has heard, a condition called echolalia. Immediate echolalia occurs when the child repeats words someone has just said. For example, the child may respond to a question by asking the same question. In delayed echolalia, the child will repeat words heard at an earlier time. The child may say “Do you want something to drink?” whenever he or she asks for a drink. Some children with autism speak in a high-pitched or singsong voice or use robot-like speech. Other children with autism may use stock phrases to start a conversation. For example, a child may say “My name is Tom,” even when he talks with friends or family. Still others may repeat what they hear on television programs or commercials.

Narrow interests and exceptional abilities: Some children may be able to deliver an in-depth monologue about a topic that holds their interest, even though they may not be able to carry on a two-way conversation about the same topic. Others have musical talents or an advanced ability to count and
do math calculations. Approximately 10 percent of children with autism show “savant” skills, or extremely high abilities in specific areas, such as calendar calculation, music, or math.

Uneven language development: Many children with autism develop some speech and language skills, but not to a normal level of ability, and their progress is usually uneven. For example, they may develop a strong vocabulary in a particular area of interest very quickly. Many children have good memories for information just heard or seen. Some children may be able to read words before 5 years of age, but they may not comprehend what they have read. They often do not respond to the speech of others and may not respond to their own names. As a result, children with autism sometimes are mistakenly thought to have a hearing problem.

Poor nonverbal conversation skills: Children with autism often are unable to use gestures—such as pointing to an object—to give meaning to their speech. They often avoid eye contact, which can make them seem rude, uninterested, or inattentive. Without meaningful gestures or the language to communicate, many children with autism become frustrated in their attempts to make their feelings and needs known. They may act out their frustrations through vocal outbursts or other inappropriate behaviors.

Autism typically is diagnosed during a child’s second year and is it continues lifelong, although symptoms may lessen over time. There is no cure for autism, but appropriate treatments can help a child develop life skills to function more independently. In this paper we concentrate into developing the fluency of the autistic children who already have a rich vocabulary but unable to pronounce a complete sentence effectively.

2. Related Work
Autism was first described by Leo Kanner in 1943 (Wing, 1996b)[5]. It is now regarded as part of five disorders, collectively referred to as autism spectrum disorder (ASD) or pervasive development disorder (PDD). The five are autism, Asperger syndrome, pervasive development disorder not otherwise specified (PDD-NOS), Rett syndrome and childhood disintegrative disorder.

Many different behavioral interventions have been developed for children with autism, and they mostly fall under the category of Applied Behavioral Analysis (ABA). This approach generally involves therapists who work intensely, one-on-one with a child for 20 to 40 hours/week. Children are taught skills in a simple step-by-step manner, such as teaching colors one at a time. The sessions usually begin with formal, structured drills, such as learning to point to a color when its name is given; and then, after some time, there is a shift towards generalizing skills to other situations and environments. A study published by Dr. Ivar Lovaas at UCLA [6] involved two years of intensive, 40-hour/week behavioral intervention by trained graduate students working with 19 young autistic children ranging from 35 to 41 months of age. Almost half of the children improved so much that they were indistinguishable from typical children, and these children went on to lead fairly normal lives. Of the other half, most had significant improvements, but a few did not improve much. However, the main drawback of this form of treatment is: The child must interact with a human being. One characteristic of ASD is anxious, detached, and “alone” interaction with other individuals [8], [9]. 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. Sign language and PECS [7] may also be very helpful in developing speech. Speech therapists should work on helping the child to hear hard consonant sounds such as the “c” in cup. It is often helpful if the therapist stretches out and enunciates the consonant sounds.

However the most effective approach to encourage children with ASD to “play,” where playing is mediated through technology [10], [11], [12]. Computer game has proved very powerful tool in this regard [1][2]. Rahman et al [3] have discussed the background of the research in this field and developed a fully computerized game for increasing clarity in the speech of the autistic children. Sharmin et al[4] have tried to eliminate some shortcomings of the Software proposed by Rahman[3] with the help of an human instructor. However, fluency in making a complete sentence with more than one word has not yet been addressed using computer games.

3. Our Contribution
In this section, we introduce our interactive gaming software along with its user interface & architecture. We also discuss our implemented approach for developing the fluency of autistic children of Autism Welfare Foundation (AWF) at Dhaka in this section.

3.1 Introducing Our Gaming Software
Our developed game is an interactive game where an autistic child who has already a rich set of vocabulary but however unable to complete a whole sentence will try to pronounce the name of the object shown in computer screen in an incrementing order of object. The core idea of the game is to simulate a sentence with a help of different object at the same time in computer screen as shown in the Figure 1. However the process of object selection in this simulation is controlled by a human instructor from a remote computer. For example if we want to simulate the sentence,”I eat ice-cream ”, then human
instructor has to select the images of “A man” (in a special case the image of the participant), “ice-cream” and finally “A man eating ice-cream” from our image database sequentially. After the process of selection, the images will be send to the autistic child’s computer through Local Area network & will be displayed in the Graphical User Interface (GUI). If he or she can pronounce the sentence correctly & completely, he or she will receive award (i.e. animated cartoon or any fancy things they love).

In Figure 1, we illustrate a simple example of this game. For example, after initial set up, a user interface will appear at the instructor part as shown in Figure 1(a). Then he will decide which sentence to simulate & select image accordingly from the database. However, there are many predefined simulated sentence in our database, so he or she can select directly that simulated sentence too considering the level of ability of the autistic child. Then this image will be send to the autistic child computer and appeared in Graphical User Interface (GUI) as shown in the Figure 1(b). Besides there is a counter to count how many words of the simulated sentence the autistic child have been able to pronounce within certain time limit (i.e., 10 seconds or 7 seconds) which ultimately helps instructor to decide whether an autistic child is performing better or worse. Depending upon his or her success of pronouncing the whole sentence correctly the score will be saved in our database along with the corresponding difficulty level for future reference.

### 3.2 The Core Components of the game
The core of the gaming software consists of the following part.

1. Java Socket-based networking technology for connecting two computers.
2. Swing Component of Java for the design of the front end.
3. MySQL Database for storing images and scores.

Some of the interesting feature of our newly developed game are (a) Completely platform independent (i.e., compatible in all kind of operating system provided the compatible JDK is available), (b) Very easily extensible image database with click & update option etc.

### 3.3 Our Implemented Approach & Result
During our 3 months of intervention, we used our gaming software in an incrementing manner of the difficulty level of the sentence (i.e. 2 words sentence or 3 words sentence etc) to improve the fluency level of the autistic children. We not only increased the difficulty level of the sentence but also set some certain time limit to pronounce the sentence correctly & completely.

#### 3.3.1 Experimental Setup
In figure 2 we have illustrated the experimental setup that was used for improving the fluency in the speech of the autistic children.

#### 3.3.2 Sequentially Moving Images: For increasing fluency in the speech
Since our main concentration is to develop the fluency of the autistic children, we had tried make our gaming software as versatile as possible. Along with other features discussed earlier, one of interesting feature is, the image are movable from...
right to left of the screen. We introduce this feature considering the fact that, this will give the autistic child more exciting gaming environment which in turn helps them to pronounce the complete sentence more quickly. In table 1, data were collected by this movable picture first with one movable image, then two, then three etc.

![Figure 2](image-url)  
**Figure 2:** An overview of the experimental setup.

### 3.3.3 Observed Result

We have said that we concentrated only on those autistic children who had already a rich set of vocabulary. But in order to measure how effective our implemented approach, we had taught them new vocabulary using both tradition PECS method [7] and our gaming software. In figure 3 we have illustrated the result obtained during the above mentioned process. In the figure 3, you will notice that the points in the curve for Manual Picture Method is always either above or on the every point of the curve of our proposed method which eventually illustrates the power of gaming environment for learning world quickly & efficiently.

Our approach consisted of the following strategies.

1. Initially a single word appears in the screen.
2. Then a simulated sentence consists of two words.
3. Then a simulated sentence consists of three words.
4. And in this way continue.

Besides we maintained also data regarding the time taken by the autistic child to pronounce the words along with data of number of the word they actually pronounce of the sentence. In Table 1 we illustrated a fraction of our data collected by our gaming software.

In table 1, if we go from left to right in any row, we will notice that the time limit for pronouncing the word of the sentence is reducing. And if we go from top to bottom in any column, we will observe that the difficulty level of the sentence is increasing. So the leftmost top cell is the easiest & the rightmost bottom cell is the hard most. In any cell the √ marks indicate that the autistic child was able to pronounce the word of the corresponding row within certain time limit in that column. Similarly the X mark the autistic child was unable to pronounce the word of the corresponding row within certain time limit in that column.

![Figure 3](image-url)  
**Figure 3:** Comparison between two learning methods indicate that the autistic child was able to pronounce the word of the corresponding row within certain time limit in that column. Similarly the X mark the autistic child was unable to pronounce the word of the corresponding row within certain time limit in that column.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>10 seconds</td>
<td>Ball</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7 seconds</td>
<td>Book</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5 seconds</td>
<td>Tree</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Computer+TV</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Umbrella+Bicycle</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Cat + Dog + Lion</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Mango+Banana+Apple</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Table 1.** Time taken by the autistic children at different levels of difficulty of the sentences.
Moreover, there is a provision for generating different kinds of reports (i.e. individual performance analysis in terms of difficulty level, per week, month etc). These report generated by our gaming software help the instructor to analyze an autistic child more closely & effectively.

4. Future Works
In future, we have a plan to implement this game in Mobile Platform so that it will also become widespread among middle & lower class people.

5. Conclusion
For autistic children, improving verbal communication is a realistic goal of treatment. Parents can increase a child’s chance of reaching this goal by paying attention to his or her language development early on. With the help of our developed system, they can maintain constant improvement map of their children from very early stages of their life.

6. References
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