# Assistive systems for children with dyslexia and autism

by

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# Assistive systems for children with dyslexia and autism

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## ABSTRACT

Autism and dyslexia are both developmental disorders of neural origin. As we still do not understand the neural basis of these disorders fully, technology can take two approaches in helping those affected. The first is to compensate externally for a known difficulty and the other is to achieve the same function using a completely different means. To demonstrate the first option, we are developing a system to compensate for the auditory processing difficulties in case of dyslexia and to demonstrate the second option we propose a system for autism where we remove the need for traditional languages and instead use pictures for communication.

## Categories and Subject Descriptors

K.4.2 [**Computers and Society**]: Social Issues—*Assistive technologies for persons with disabilities*

## General Terms

Design, Human Factors

## Keywords

Dyslexia, Clear Speech, Autism, Alternative and Augmentative Communication

## 1. INTRODUCTION

In our work we consider two developmental disorders that affect the faculty of language - autism and dyslexia. In dyslexia only reading is affected whereas in autism multiple aspects of development such as language, social communication are affected. For dyslexia, based on the hypothesis that auditory processing deficits could lead to reading difficulty we propose a system that could perform speech modification and hence compensate for those deficits. For Autism, we propose an Alternative and Augmentative Communication (AAC) device where two way communication can be achieved by using pictures instead of language.

## 2. DYSLEXIA AND AUDITORY PROCESSING

Developmental dyslexia is an unexpected difficulty in reading in children and adults who otherwise possess adequate intelligence and motivation. The prevalence rate is estimated to be between 5% to 10% in school age children. Dyslexia can be comorbid with language difficulties, writing and mathematics disorders. Though the exact cause of dyslexia is still a matter of debate [8] there is consensus that a significant proportion of these children have difficulties in auditory perception and these auditory difficulties might be causal to their reading difficulties.

The problems in auditory perception include difficulties in backward masking, temporal order judgement, and perceiving amplitude and frequency modulations [10, 11]. This creates difficulty in discriminating speech sounds, for instance the difference between two acoustically close phonemes like /ba/ and /da/ and hence leads to a poor representation of phonemes. Since reading is a grapheme to phoneme correspondence task, this poor representation translates to difficulties in reading.

### 2.1 Speech modification for dyslexia

The above points lead us to the following fundamental research question: can we modify speech in such a way that it improves intelligibility for children with dyslexia? A closely related subquestion is will this modification vary across languages which becomes more relevant in the Indian context as an Indian child is typically exposed to at least two to three languages and the language spoken at the school and home are different.

### 2.2 Clear speech and other related work

There exists some evidence [2, 5] that speech modification could aid children with dyslexia. Fast ForWord [5] uses speech modification as intervention for children with language learning impairments. Recent psychoacoustic studies show that a particular style of speech known as clear speech enhances intelligibility for children with dyslexia [2] and more generally for those who have difficulties in hearing [6]. Clear Speech is defined as the style of speech that results when one attempts to make his/her speech more intelligible. Speakers resort to clear speech when they think listeners do not have the knowledge of language or have some hearing impairments or the background is noisy. There is no clear consensus on the right set of features that differentiate clear speech from conversational speech. Some of the

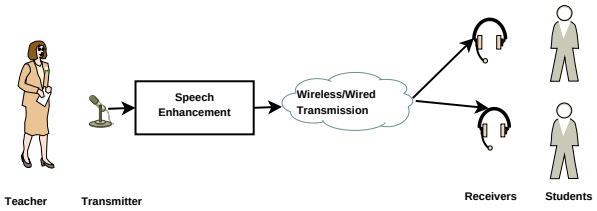


**Figure 1: Assistive listening device in a classroom for children with dyslexia.**

proposed features are - increased consonant-vowel ratio, increased vowel space, slower rate of speaking, increased pitch range, lesser coarticulation and salient stop releases [3, 7].

Though the effectiveness of clear speech in general is known, there are no studies on dyslexic children which would inform us quantitatively about the intelligibility advantage that each of the above features offer. Studies on clear speech production in Indian languages is also absent. Hence, we propose to determine the relative merits of features of clear speech in the dyslexic context and their variability across multiple Indian languages. Specifically, we propose to study this problem, via auditory discrimination studies, for three Indian languages (Hindi, Tamil, Telugu). The goal is to identify the right features which offer most intelligibility advantage for children with dyslexia.

### 2.3 Proposed Solution

Once the appropriate feature set is identified, we propose to develop a system to generate clear speech from normal speech in real-time that can be utilised in different applications. Two exemplar applications are: (i) an assistive listening device and (ii) a tool to create audio books. An assistive listening device as shown in Fig.1 would help students to gain better auditory discrimination in the class room environment. A system with text to speech capabilities on the other hand would allow teachers to create audio books with clear speech, for their students. Our hypothesis is that both these systems would help children acquire better phonemic representations and hence better reading skills.

## 3. AUTISM AND COMMUNICATION

A second problem that we are investigating is an assistive system for children with autism. Autism affects 1 in 1000 children. The language and communication skills of children with autism (CWA) vary widely. Some children have no functional communication, some are echohalic with extremely limited comprehension and some children do develop language but cannot understand abstractions such as idioms, metaphors and stories [9]. They also have difficulty in abstraction and generalization but are excellent visual thinkers.

### 3.1 Picture based communication system for autism

Language is an abstract symbol system. Therefore a fundamental question that arises is, will a lesser abstract system such as pictures aid in improving communication for children with autism. Such a system would take advantage of their visual thinking abilities as well. A related issue is identifcation of the most appropriate set of pictures for this system.

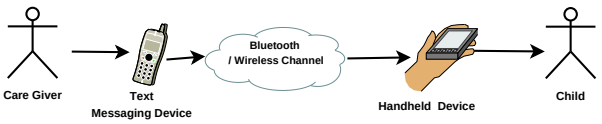


**Figure 2: Receptive communication. The child's handheld performs a text to picture conversion.**

### 3.2 Related Work

Augmentative and Alternative Communication (AAC) devices such as PECS and VOCA have been used with children with autism [4] where children can choose pictures to construct sentences. Historically, these devices were developed for children with severe speech and motor impairments (SSMI), who had difficulty with speaking and signing (expressive comunication) but not with understanding other's speech (receptive communication). However in the case of autism there are difficulties with both expressive and receptive communication [1]. Thus, the current devices do not offer a complete solution to the communication problem as they assist only in expressive communication but not in receptive communication. The input modality in these devices is not visual as a result of which the autistic child has to comprehend the language of the care giver to communicate with her/him. In our work, we propose to develop an AAC that addresses this lacuna.

### 3.3 Proposed Solution

The features of the assistive communication device we propose are

**Two way communication:** The AAC should aid in both expressive and receptive communication. Hence, we aim to build a device that could convert language to pictures and pictures to language and thus complete the communication loop.

The communication chain is as shown in Fig.2 and 3. At the care giver's end a device enables sending text messages to the child. At the child's end, a second device receives this message and converts the text into pictures. To enable expressive communication, this device would present the child with a set of pictures. They can choose the pictures that would describe their needs. An appropriate sentence would be constructed and would be synthesized using a text to speech system and spoken back to the care giver.

The device with the child consists of the following components

- a set of pictures that are intuitive to the child and helps them express their ideas in a day to day communication scenario
- a text to picture converter - that converts the incoming text to appropriate pictures

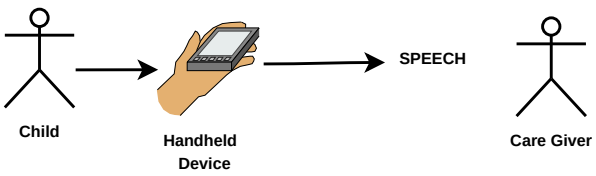


**Figure 3: Expressive communication. Here, the child's handheld performs a picture to speech conversion.**

- a picture to text converter, that constructs an appropriate sentence from the pictures chosen by the child and
- a text to speech converter that speaks out the above sentence to the care giver.

**Intuitive symbol set :** Historically AAC systems were developed for children who had severe speech and motor impairments. In this case, the pictures served as an alternative way to express a concept. These children can easily understand the relation between the picture and the concept. So even a weak visual relationship between the objects and pictures might suffice. However, in case of a child with autism, due to their difficulty with abstraction and generalization, the pictures need to have a strong resemblance to their referents. The more relevant these pictures are to the child's culture and environment, the easier it is for them to use the system.

Current AACs use pictures derived from sources such as Picture Communication Symbols (PCS) which were designed for western culture. These pictures might not be intuitive to a child in the Indian context. Also, the existing symbol sets were initially conceived to be used in static cards. So, the representation for actions (e.g., go, come etc.) is abstract. In our work, we plan to use a symbol set that suits the Indian culture. Also, since this system will reside in a handheld device, we propose to use animations to represent actions.

## 4. EVALUATION

The AAC would be evaluated in a child - care giver scenario. The parameters for evaluation would be based on the improvement in number of times the child initiates the communication, the increase in comprehension. To be specific, we will measure if the vocabulary of the child improves when using the device and their mean utterance length (average length of sentence) improves.

## 5. STATUS OF RESEARCH

We have evaluated the intelligibility advantage of reduced rate of speaking on four children with reading difficulties. They were chosen from a local school and had been assessed by a clinical psychologist. These children were played some sample words in both normal and slowed down form (50% reduction in rate of speaking) and asked to spell these words. The results indicated an improvement in their performance. A controlled study with a larger population is being planned.

## 6. ABOUT THE AUTHOR

I am a second year Ph.D. student in Center for IT in Education, International Institute of Information Technology, Hyderabad, India. My research interests are the neuroscience underpinning developmental disorders and assistive system design. In particular, I am working on assistive systems for children with autism and dyslexia for my thesis.

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