

Towards an Arabic Language Augmentative and Alternative Communication Application for Autism

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Abstract. In this paper we describe the development and evaluation of an iOS application designed as an augmentative and alternative communication (AAC) tool for individuals with speech and language impairments in Arabic-speaking populations. Formative evaluations carried out in different settings are described with insights obtained from involving users and domain experts in the User-Centered Design approach. Moreover, we summarize experts' reviews on the impact of using the developed application in special education classrooms.

1 Introduction

Verbal communication is essential for an individual's daily interactions with others, as it is the first tie to the world we live in. People with speech and language difficulties often experience barriers in understanding and using verbal language in communication. Speaking well-structured sentences and making themselves understood is a key challenge for them. Language impairments are linked to many disabilities such as Autism Spectrum Disorders and some cerebrovascular accidents such as strokes.

People with language impairments use augmentative and alternative communication (AAC) systems as assistive technology tools to help them in carrying out conversations in daily activities. AAC is a specialized area of the tools (high and low tech) that aim to develop techniques, aids and systems to improve the communication abilities of people with speech and language problems by the supplementation or replacement of natural speech [1].

This paper sheds light on user involvement in the design and development of AAC systems in general, and in the context of learning environments for children in particular. The system presented in this paper, called *Touch-to-Speak*, is a novel contribution to the AAC domain, by offering a portable and configurable AAC application that supports different dialects in the Arabic language as well as Modern Standard Arabic (MSA). This AAC application is envisioned as an assistive technology tool that can facilitate the integration of children with speech and language impairments in learning environments.

2 Background

Recent advances in mobile computing have facilitated rapid growth in AAC applications' design for tablets and mobile phones. Our research has concentrated on developing an Arabic computer-based application to enhance communication skills of people with autism spectrum disorders (ASD), with an emphasis on supporting verbal communication in local dialects as well as Modern Standard Arabic (MSA). Few AAC applications which support the Arabic language exist in the marketplace, and the ones that exist limit verbal communication to MSA despite the dominance of using local dialects in clinical settings for speech and language therapy as well as everyday communication in non-formal settings such as at home, leisure, and in most contexts in schools and at work. Consequently, the demand for AAC applications that support local dialects and have configurable settings for customizing the image-based communication and the spoken dialects has emerged. This is mainly to extend the therapy beyond the clinical settings and to facilitate communication in Arabic-speaking contexts. Anecdotal evidence together with publications in Arabic in the field of assistive technologies have highlighted the lack of AAC technologies supporting individuals with speech and language impairments, particularly in the Arabic language.

Applications for AAC are often Picture Exchange Communication (PECs) based interactive applications designed as communication solutions to help individuals whom experience difficulties in speaking to express their needs using pictures and/or typing coupled with automatically generated spoken dialog. Applications in this domain include Voice4u, TapToTalk, TouchChat, and Proloquo2Go [2]. Typical users for such applications are children or adults with ASD, Down Syndrome, Cerebral Palsy, Apraxia, Traumatic Brain Injury, ALS, Stroke (Aphasia) or other conditions that affect a person's ability to communicate effectively with natural speech.

Selecting the iPad platform for the initial proof-of concept phase for our application was based on the extensive body of research that has demonstrated how portable electronic devices (such as iPads) enhance the learning experience for children (e.g. [3], [4]). Moreover, evidence suggests that direct-manipulation interaction types that are inherent in touch screen interfaces are often easier to use for children in general and those with ASD in particular [5].

3 System Description

Inadequate support for Arabic-based AAC applications has motivated us to build Touch-to-Speak, an AAC application that is developed in the area of assistive technology to support people with communication difficulties. The target population varies in age groups and disabilities, as it includes children with autism and elders with stroke. Therefore, due to the different characteristics and needs of our target users, the application contains two separate interfaces. One interface is designed for children with ASD and is based on PECS adapted to the Arabic-speaking population.

The second interface is designed for individuals with aphasia resulting from stroke, and is based on communication boards used in clinical settings for communicating with stroke patients, which were adapted to the local context and dialects. Figure 1 illustrated the ASD interface.



Fig. 1. Touch-to-Speak's interface for ASD

3.1 Context of Use

This application was designed as a tool to mediate communication between children and individuals in the educational context. Interaction with the AAC application takes place in the middle of conversations that involve a child with autism or an individual who has speech problems. *Touch-To-Speak* will act as a supervised translator that translates a series of pictures to well-structured sentences. When the child needs to say something he/she simply taps a picture and the application will form the sentence and read it out-loud.

The key contribution of *Touch-to-Speak* is providing augmentative and alternative communication for Arabic-speaking populations, which is not available in the market today. Moreover, it is the first Arabic AAC system that includes both local dialects and Modern Standard Arabic (MSA). This is particularly important for educational contexts in which MSA is used for the curriculum but local dialects are used for verbal communication with teachers and peers. As for our contribution to the Assistive Technology field in general, *Touch-to-Speak* adds to the existing research available covering this field. Aside to that, we have developed distinctive key features that are not available in other AAC systems that include:

- Enable creating several accounts to facilitate sharing the application on one iPad.
- Two types of images: photographic and boardmaker. This variation in image representation was included in response to bespoke design requests of speech and language therapists to address the needs of children with autism spectrum disorders who perceive these images differently.

- Customized favorite icon, where the user can choose -based on his personal preferences- one of the available icons as his/her favorite icon.
- Log report, that displays the time and date the user has used the application to facilitate progress tracking of children using these applications.

4 AAC in Learning Contexts

Accessibility of education is important to ensure universal access to individuals regardless of their abilities. However, barriers of communication have prevented some educational contexts from accommodating the needs of children with Autism Spectrum Disorders and consequently from providing them with the opportunity to gain the best out of their educational experience. Several studies (e.g. [6]) observed the effect of using AAC applications in classrooms that included children with Autism spectrum Disorders. The findings of such studies indicated that AAC applications promote student independence, increase his/her engagement, and reduce teaching time, therefore enhance and ease the education process for such students. Nowadays, most available AAC applications in Arabic classrooms are in their traditional form (picture cards) that are cumbersome to use. The fact that Touch-to-Speak is the first Arabic AAC iPad application gives it a potential role in enhancing and easing the education experience in Arabic classrooms.

5 Design Considerations

Touch-to-Speak was iteratively designed by adopting a user- centered design approach, where both Subject Matter Experts (SMEs) and children were involved in requirements' discovery phases as well as the review phases of design prototypes. Testing in design iterations of the system involved cognitive walkthroughs in which scenarios were presented with low-fidelity prototypes depicting the proposed system to SMEs; namely a speech pathologist experienced in working with children with autism and an autism specialist in special education. Feedback was solicited on the general design of the application, the structure, and the flow of the application. In later phases of the project, SMEs were involved in revising the images and spoken dialogue generated by the system. In the final stages of the project, both regular and autistic children were observed while using the application and some design elements were modified according to the problems faced by the majority of the sample.

Personas which are hypothetical characters resembling real people were created during the design process by observing the environment where the system will be applied to keep realistic analysis about its various potential users. These personas were used throughout the development of the application to enhance system's design, usability and functionality in order to meet the needs of the various end users [7].

Table 1 summarizes mapping user requirements to design elements in the application.

Table 1. Mapping user requirements to design elements

User Requirement	Design Element
The application shall to be used by users with unstable hand movement.	<ol style="list-style-type: none"> 1. Spacing between images was measured to offer an optimal distance. 2. The image's audio description will be spoken only once (regardless of how many times it has been tapped).
The application should act as a conversation facilitator.	<ol style="list-style-type: none"> 1. Providing categorized images, structured sentence forming, a favorite list, and quick reply buttons (e.g. thank you, yes and no) that appear on all interfaces. 2. While creating a sentence, each image's audio will be played out immediately after tapping it, without the need to finish structuring the whole sentence. 3. Providing both Modern Standard Arabic (MSA) and local dialects.
The application shall be designed to accommodate the needs of autistic children who have comorbid disorders such as ADHD.	The application provides a distraction-free environment containing static images and uses limited color schemes.
The application needs to be used by autistic children without the need of assistance.	<ol style="list-style-type: none"> 1. Usability with a particular focus on learnability and memorability were key design considerations. 2. The navigation between interfaces was clearly designed and evaluated by SMEs.
The application should assist autistic children with various severity levels.	The system is fully customizable; it gives the user the choice between photographic and digital images.
The application should be understandable.	<ol style="list-style-type: none"> 1. The application allows choosing a customizable favorite icon. 2. Each account is represented by the user's picture to recognize his/her account easily.

6 Formative Evaluations

Touch-to-Speak was examined as a prototype in iterative cycles with SMEs (speech and language therapists, special educational needs teachers and psychiatrists), intended target users, and caregivers of the intended target population. Various tests have indicated that Touch-to-Speak was precise in assisting verbal communication.

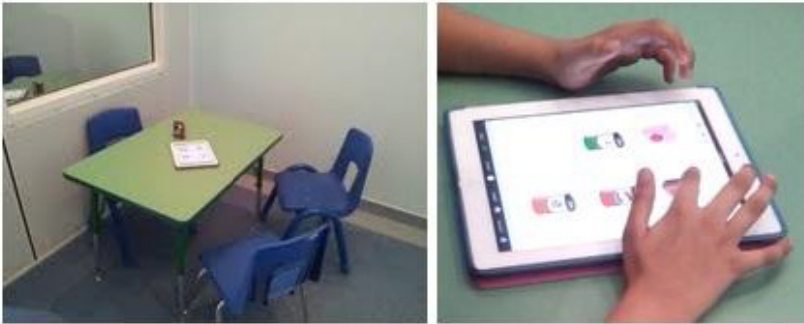


Fig. 2. Usability evaluation

The application was evaluated in terms of functionalities, task-based performance evaluations of users in using the application for communication and subjective satisfaction. User satisfaction was measured with the System Usability Scale (SUS) and resulted with 77.66 percent as an overall score across all SMEs involved in the usability sessions. In the user acceptance testing, the application's functionalities were split into two parts based on the intended users (child with ASD and the administrator) where each part was tested separately. Fourteen ASD SMEs, five typically developing children and two children with ASD were involved in the testing phase. Insights obtained from formative evaluations led to adding features and revising designs in prototypes. A summary is listed in Table 2.

Table 2. Formative evaluations

Participant (s)	Insights for Design
<i>Autism SMEs (13)</i> Three sessions; high fidelity prototypes	Understanding context of use; assessing the complexity of the navigation; suggestions for future work.
<i>Speech Pathologist</i> Two session; Requirements discovery and high fidelity prototype	Local dialect usage; configurable spoken dialog; including recorded clips to account for limitations in pronunciation in Arabic TTS engines; visual design features.

Table 2. (Continued)

<p><i>Children with ASD</i> High fidelity prototype and final version</p>	<p>Interaction modes; observations of repetitive clicking was addressed with added control of spoken dialog.</p>
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The testing process of *Touch-to-Speak* has been conducted from another viewpoint that includes enhancing the experience of communication and educational activities in learning contexts. Therefore, the team has visited one of the local intellectual education institutes to conduct interviews with speech pathologists, teachers and a psychiatrist, and test the application with some students with varying disabilities, educational levels and age groups. The following summarizes the points we have concluded from the interviews while the latter is still ongoing.

- The application was perceived by teachers working with children who have cognitive difficulties as a tool that can facilitate expression of thoughts visually for children who lack the ability to eloquently describe their needs verbally; thus it was perceived to offer an opportunity to address the gap between understanding and communicating this understanding in a classroom setting.
- It was perceived as a mediator to accelerate the communication process in an educational setting, which consequently can lead to more effective learning, especially after the student has acquired the basic skills of structuring sentences with the application.
- The application will help the teachers understand their students' needs and feelings, and therefore be able to respond to their needs.
- The time needed for training the student on using *Touch-to-Speak* depends on the student's educational level, severity of the disability and parents' cooperation in supporting the training and adoption process of this AAC application. It is estimated to range from one week to six months.
- Using *Touch-to-Speak* in education was perceived by teachers as facilitating the following:
 - Assessment of the students' understanding by whether or not s/he is participating (using the application).
 - Initial identification of the current educational level the student has reached; hence provide him/her with appropriate material.
 - Increase the chances of the student's participation in class as the application's sounds draws the teacher's attention to the student who has something to share, especially if the class includes children with no verbal communication problems, in that both groups have the chance to participate.
- The application was perceived as a tool to leverage the availability of direct-manipulation technologies that can reduce time, effort and expenses exerted in learning contexts.

- The application was perceived to assist children in different learning levels in both basic skills (e.g. learning colors and numbers) and social interaction (e.g. greeting others).

Among *Touch-to-Speak*'s spectrum of features, SMEs had a great deal of interest in the following features, where they sensed their valuable effect in education as illustrated in Table 3.

Table 3. Features contributing to the educational process

Feature	Effect On Education
Providing two types of images (Photographic and Boardmaker)	<ul style="list-style-type: none"> • Supports both intermediate and advanced level students. • Understandable, clear and expressive images.
Localizing the images to the local culture.	Students would not find any contradiction between what s/he learns and what is in real life.
Playing back the created sentence	Playing back a sentence repeatedly helps students learn faster.
Log report	Helps teachers track and check the child's usage of the application, even outside the classroom without the need of continues observation.
The depth of the sentence (three layers maximum)	Allows a fast and an easy way to learn and form a complete correct sentence. The breadth vs. depth complexity issue was perceived as balanced given the constraints on working memory of children in the target user population.
Adding images by the built-in camera	Having images identical to real life objects facilitates easier recognition and allows students to learn more efficiently and effectively.
Speed of creating a sentence	Has the sufficient time needed for creating and learning a sentence as needed in real life.
Favorite list	Fast access to the sentences that the student should focus on.

7 Conclusion

This paper outlined the key design considerations for developing an AAC application, *Touch-to-Speak* for Arabic-speaking populations. The design process provided insights into requirements for integrating children with speech and language impairments in educational contexts. The application's features of facilitating communication in both Modern Standard Arabic (MSA) and local dialects addresses the communication needs at different levels in educational environments. Furthermore, providing two interfaces, customized accounts, dual-mode for pictures, and customized favorites' list, were key features that were perceived by practitioners and educators as means for improving the user experience in this application, and were derived from iterative cycles of design involving SMEs and intended user populations. *Touch-to-Speak* is envisioned to support the integration of children with speech and language difficulties in mainstream education and to support special education initiatives in Arab-speaking populations.

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