


PAPER

My Voice: An Augmentative and Alternative Communication Android App for Children with Apraxia in Arab Countries

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ABSTRACT

Apraxia of speech (AOS) is a disorder that prevents people from talking. There is a need to develop different augmentative and alternative communication (AAC) tools to help people with AOS express themselves clearly to others. Most mobile apps dedicated to helping people with various disabilities don't support the Arabic language, which makes them less effective for users in Arab countries. We present in this paper My Voice as an Android smartphone app that acts as an AAC tool for AOS children all around the world. In fact, this app has come to fill an obvious gap in this area of research. It supports both Arabic and English languages, allowing the users in Arabia to benefit from its features in a similar way to other users in other parts of the world. Moreover, the proposed app provides a user-friendly dashboard that can be used to convert written sentences into speech. It has three modes of communication, which are "keyboard," "phrases," and "words." These modes give the user the choice to select the most intuitive method for constructing sentences. To evaluate our work, we have tested My Voice by asking a group of potential users to use it for a month and then fill out a 10-question survey. The feedback from the survey was very encouraging. As a future work, we plan to add new languages, present an iOS version, and include artificial intelligence (AI) techniques.

KEYWORDS

apraxia of speech (AOS), augmentative communication, social impact of mobile technologies, facilities of mobile learning

1 INTRODUCTION

Communication is a fundamental aspect of our lives. It shapes human interactions, establishes relationships, and allows people to share thoughts, feelings, and ideas [1]. For most people, communication comes naturally, but for the ones with speech or language difficulties, it can be a real challenge [2, 3]. On the other hand, apraxia of speech (AOS) is a neurogenic disorder that affects the motor programming system [3].

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As a result, augmentative and alternative communication (AAC) tools can be an essential approach to allow people with AOS (especially children) to express their feelings and thoughts clearly [4]. AAC includes all the ways an individual can use to communicate besides talking. Augmentative means to add a supporting communication tool to someone's speech. On the other hand, alternative tools can be used to replace speech completely. In fact, these tools are not merely supplementary; they can be very essential for enabling children to articulate their needs, thoughts, and emotions.

One of the revolutionary innovations that has changed the shape of communication between people was the invention of cell phones. The appearance of these gadgets has literally changed our lives by allowing people to communicate with each other at any time and in any place [5]. Even more, the rise of the smartphone has transferred the communication process into a new level. In fact, this device has become more than just a tool to make phone calls, especially with the advent of its related applications (apps). Figure 1 shows how the popularity of smartphones has increased during the last few years and how it is expected to rise in the near future. This increment in the number of smartphones reflects how these devices have become very important for all people around the world.

As a natural result of their enormous popularity among users, smartphone apps have literally covered all fields of daily life activities. Nowadays, you can easily find an app to help you balance your bank account, pay taxes, check the weather's forecasts, or even communicate with people socially in different ways. As a natural result of that, many apps are developed to make a societal impact by acting as helping tools in different areas of life. The field of higher education, for example, has benefited from having a smart class attendance system such as in [7]. Also, the work in [8] provides college students with an interactive assistant app during the COVID-19 pandemic. Moreover, [9] has presented a cooperative drawing tool for engineering students, which could be a useful tool in long-distance design projects. On the other hand, the educational apps can also be useful for younger ages. In fact, the work in [10] has introduced a new tool to measure the parents' perception of educational apps for kindergarten students. Moreover, another study tries to evaluate the real value of self-proclaimed educational apps for young children [11]. The work in [12], for example, can provide real educational value by merging fun with learning through a virtual reality educational game. In addition to that, autistic children can also use interactive educational apps that are dedicated to teaching them both social skills and different academic subjects [13–15]. On another side, [16] presents an innovative Alzheimer care system to help the users manage their lives independently. Even more, many apps were also produced to help the special needs users, such as [17]. This work presents a tool for arm-disabled users to control a computer device using voice commands only. In addition to that, [18] allows the visually impaired users to detect or read written scripts by converting them into audio records. Finally, [19] helps wheelchair users find accessible buildings in the city of Amman, Jordan.

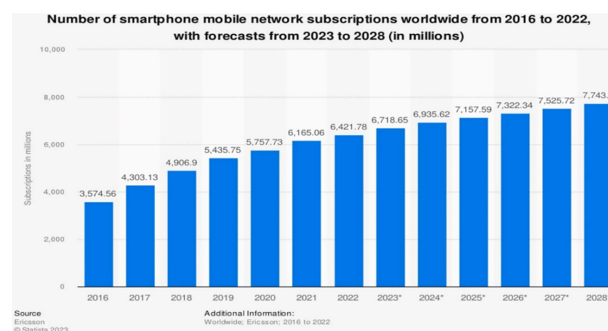


Fig. 1. Smartphone numbers around the world as expected between 2016 and 2028 [6]

In the same context, multiple AAC apps have appeared to provide AOS children with efficient communication tools and to support or even replace normal speech [20]. However, most of the known apps don't support the Arabic language. This may make it a challenge to use them effectively by children inside Arabian countries. This situation creates an obvious gap in this research area, which can prevent millions of potential users from benefiting from AAC techniques due to the language barrier. Motivated by that, we present in this work My Voice as an Android AAC application that aims to help AOS children to express themselves efficiently in both Arabic and English by allowing them to construct written sentences and then play them as audio messages to other people.

In fact, My Voice is more than just a communication tool; it is a transformative solution with a noticeable societal impact on AOS children, their families, and the community in general. Regarding children, My Voice can help them deliver their thoughts and feelings to the world. Moreover, it can build self-confidence in children, help them join the activities they like, and practice the hobbies they enjoy. In other words, children can benefit from My Voice to be active members in the community without feeling excluded. AOS parents, on the other side, can communicate effectively with their children through the app, which allows them to connect stronger with each other and strengthen their family ties. Moreover, the community in general can be more attached together with the existence of My Voice and other societal impact apps. In fact, this type of helping tool can increase the happiness level between the members of the community and raise its general morale. Technically, My Voice allows the users to express themselves through translating written sentences into speech. This is done through a rich dashboard that comes with three modes of communication. Although it is dedicated for AOS children, My Voice can also serve as a valuable tool for AOS adults or even users who can't speak normally for other reasons. Moreover, this app can be useful as a supporting communication tool for all children, especially the shy ones. It is worth mentioning that a preliminary version of this app (My Voice) was presented in [21].

The remaining part of this paper is organized as follows: Section 2 lists a number of similar apps and then compares them with My Voice. After that, Section 3 reviews the software tools and programming languages used in building our app in addition to reviewing the general system design. Following that, Section 4 previews the app's main interfaces and implementation through a run scenario. Next, Section 5 evaluates My Voice by showing the outcomes of an evaluation survey filled out by a group of potential users. Section 6 covers the findings' implications along with the app's limitations. Finally, Section 7 concludes this work.

2 RELATED WORK

In the context of AAC applications, several tools have been developed around the world to help AOS children, with few of them supporting the Arabic language. In this section, we review a number of popular apps in this category and then compare each of them to My Voice AAC.

2.1 Sono Flex application

Sono Flex is an easy-to-use AAC vocabulary app that turns symbols into clear speech. However, this app is only available for iPhone users who have to pay in order to get full access to the included features [20]. In fact, Sono Flex allows using the device camera and photo albums in order to create new personal symbols. Figure 2 shows the home screen for the Sono Flex application.

2.2 CoughDrop application

CoughDrop is a cloud-based AAC app that helps people communicate better [22]. This app is built for individuals who have a hard time speaking. Moreover, it has the ability to work across multiple devices and platforms. Figure 3 shows the home screen for this app where the user can use symbols to express personal needs and feelings.

2.3 TouchChat

TouchChat is a versatile AAC app designed to facilitate communication for individuals with speech impairments. It is available on iOS devices only and offers a comprehensive platform for users to express themselves using a variety of symbols, text, and voice outputs [23]. As we can see in Figure 4, TouchChat supports the Arabic language, which will be a valuable addition for the users in Arabian countries.

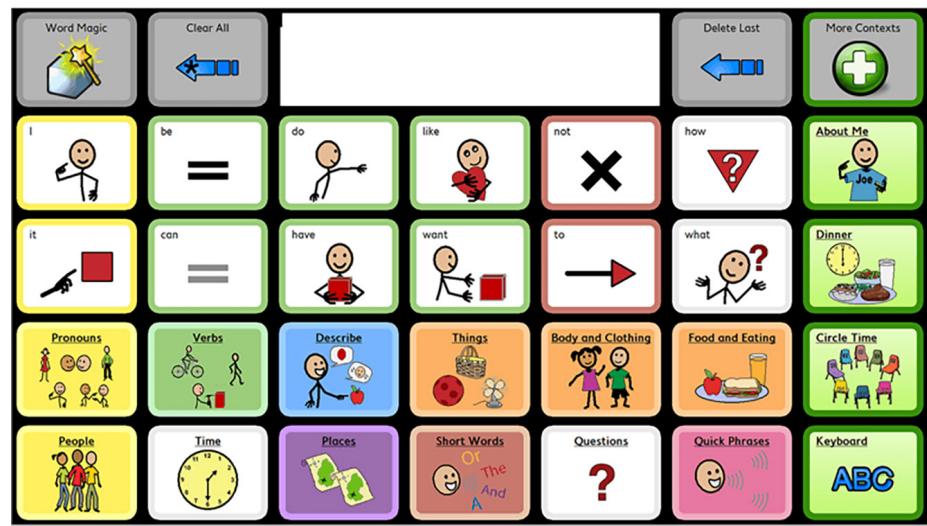


Fig. 2. Sono Flex application home screen [20]

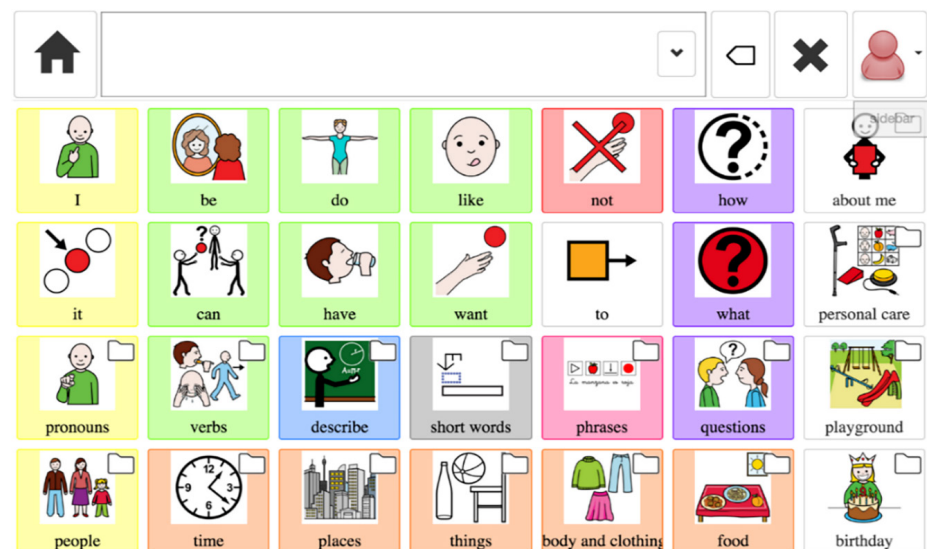


Fig. 3. CoughDrop application home screen [22]

2.4 Voice4u AAC

Voice4u AAC is an app with a different approach than the previously mentioned ones. It mainly allows the users to select the favorite photos in their phones, turn them into icons, and record a voice message on each icon to express personal needs and ideas [24]. In fact, the app can easily carry around 1000 icons. Moreover, the user can easily build a daily or even a weekly schedule using the icons. Figure 5 shows the home screen of Voice4u.



Fig. 4. TouchChat home screen [23]

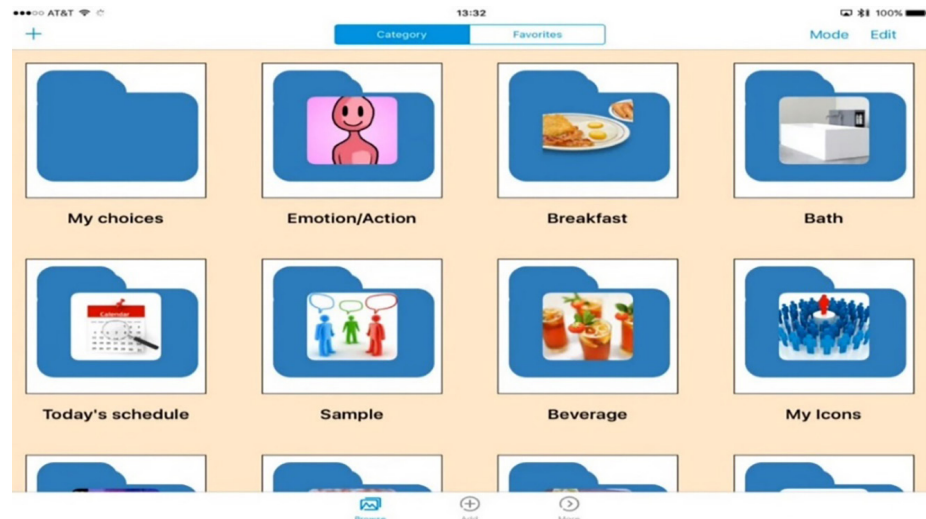


Fig. 5. Voice4u app home screen [24]

2.5 Critical analytics of related work

As useful as the early mentioned apps are, each of them may have fatal limitations. As a result, these gaps may affect the apps' popularity and the numbers

of their users especially in Arabian counties. Table 1 compares My Voice with the early mentioned related apps based on a number of important features. As we can notice, each of these apps lacks one or more important features. Sono Flex, for example, is dedicated to iOS phones only and doesn't support the Arabic language. It also requires paying fees to benefit from all the features included. On the other hand, CoughDrop and Voice4u support both iOS and Android phones. However, they don't support the Arabic language, they are not free, and they don't provide built-in keyboards. TouchChat, is an AAC app that supports both Arabic and English languages, which makes it a possible choice for Arabic users. However, it is an iOS app. This excludes all the Android users in Arabian countries. Moreover, it is also a paid app. This may prevent many potential users from installing it due to financial reasons. In conclusion, My Voice was built to fill an obvious gap by providing a free app with both Arabic and English interfaces for Android phone' users in Arabian countries and other parts of the world. Moreover, our work distinguishes itself with a combination of useful features, such as the self-definition message that introduces the user to other people just by pressing a single button.

Table 1. Related work apps comparison with My Voice

Feature	Sono Flex	CoughDrop	TouchChat	Voice4u	My Voice AAC
Personal account customization	Available	Available	Available	Available	Available
Self-definition message	Not available	Not available	Not available	Not available	Available
Languages support	English	English and German	English and Arabic	English	English and Arabic
Text to Speech support	Available	Available	Available	Available	Available
Built in keyboard	Available	Not available	Available	Not available	Available
Cost	Free/Paid	Subscription	Paid	Paid	Free
Platform Availability	iOS	iOS/Android	iOS	iOS/Android	Android

3 SOFTWARE TOOLS AND SYSTEM DESIGN

3.1 Software tools

In order to build My Voice, we have adopted a number of software tools and programming languages known for both efficiency and sustainability. First of all, we have selected Android Studio as our integrated development environment (IDE). Android Studio is considered the official IDE for Google's Android operating system and its related apps [25–28]. It was originally built by JetBrains' IntelliJ IDEA and was essentially intended for Android applications design and development [29, 30]. However, it is also available for download on other operating systems, such as Windows, Mac OS, and Linux [31–33]. In fact, Android Studio is a very powerful tool that has enabled us to develop our app quickly and easily, with an obvious ability for future expansion to other operating systems.

Furthermore, the Android Virtual Device (AVD) manager is an interface that is launched inside Android Studio [34, 35]. Each AVD is an emulator configuration

that simulates a physical Android device [36]. This made it possible for us to test My Voice in a variety of configurations to represent different physical Android devices. Moreover, Text-to-Speech (TTS) is a package inside Android Studio that converts the written text into spoken language [37]. Interestingly, it supports both English and Arabic languages, which allows the users to hear the words instead of reading them [38–40]. In the context of our work, TTS played a significant role in providing a voice for the users who have speech or communication difficulties.

On the other hand, JAVA is a popular programming language that can be used in web applications and services, web development, data science, artificial intelligence (AI), and even smartphone app' development [41]. In fact, it is considered the most popular object-oriented programming language regarding its security features [42, 43]. Moreover, it is considered the official language for applications development [44]. Interestingly, the majority of Android applications around the world were built using this language. Hence, using Java to develop My Voice was the natural decision for us to make.

Finally, we used Firebase to build our backend services. Firebase provides a number of essential security services for any Android application [45–48]. We also utilized Cloud Firestore as our NoSQL database and Firebase Storage for reliable data storage, management, and retrieval [49–50]. Even more, Cloud Firestore is a flexible, scalable database that is suitable for mobile, web, and even server development processes [51]. Naturally, Cloud Firestore has served as our primary database solution. It acted as the central hub for storing diverse datasets, ensuring efficient data organization, allowing easy accessibility, and adding scalability to meet our application's demands. Finally, we relied on Firebase Authentication for its robust user authentication capabilities and secure access to the app's features and data [52–54].

3.2 System design

As mentioned earlier, My Voice AAC offers a range of services designed to enhance communication for children with AOS. Figure 6 shows the overall hierarchy of the app and how different features are distributed over its sections. As we can notice from the figure, any user has to get an account in order to log into the app's home page. The reason for that is to give the user the privilege of customizing a personal account with personal preferences and defined word or phrase symbols and categories. Upon reaching the home page, we can find four main sections to select from. "Settings" is a standard section that includes the app's information screen, a log-out button, a language selection button, and a dark mode enabling button. On the other hand, the "Words and phrases" section leads to a wide range of categories that represent groups of word symbols and phrase symbols that can be used for communication through the dashboard. In addition to the existing categories, the users will be able to add new categories to their accounts and fill them with new word and phrase symbols. Moreover, the user can edit or even delete the previously added categories or symbols. The "Dashboard" section is the core of My Voice and represents the main communication method with other people. Finally, the "My profile" section allows the user to edit and view personal information in addition to preparing an introductory "About me" message.

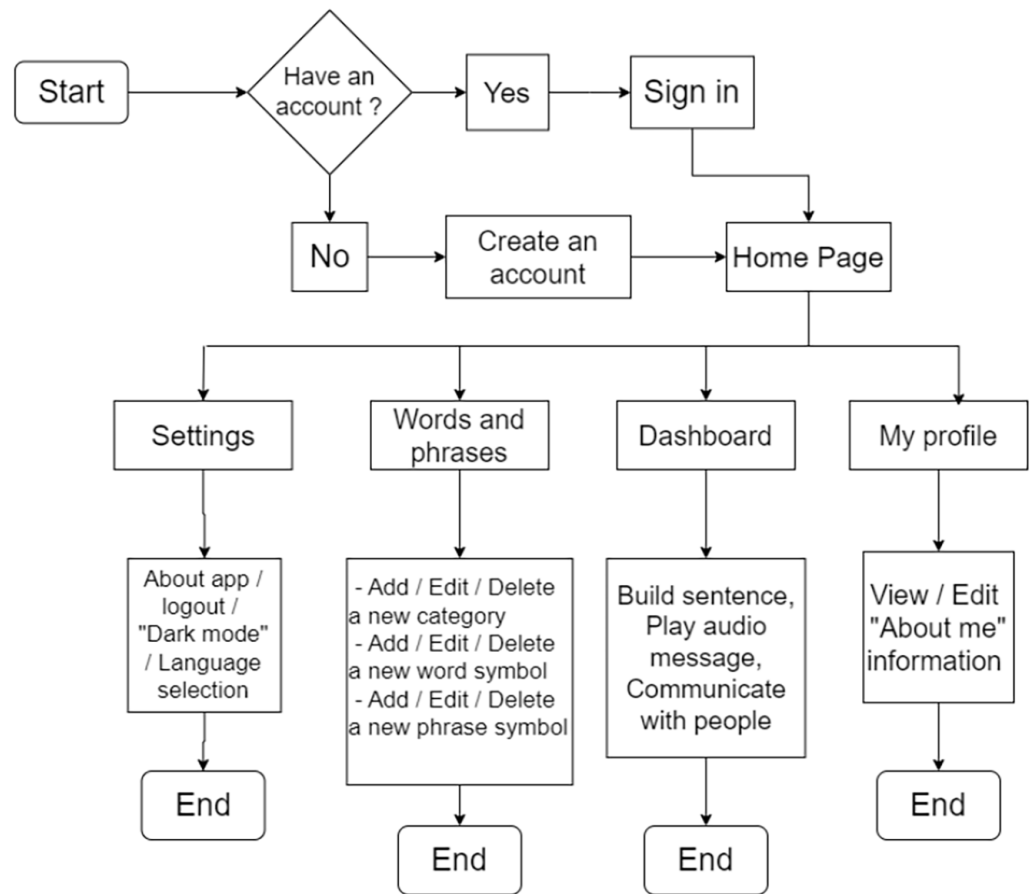


Fig. 6. My Voice home page main sections

As mentioned earlier, the child can create new categories and add new word or phrase symbols. As each category or symbol in My Voice will be viewed through a representative image, users have to upload these images to the database. Figure 7 shows the Firebase folders that were built in order to upload all the images representing new categories or symbols added by the users.

The flow chart in Figure 8 shows a detailed description of the “Dashboard” section. The flexibility in My Voice can be noticed by providing three communication modes. The first mode allows the user to simply write a sentence using a regular keyboard. This mode is ideal for older users who can type normally and have only a physical speech difficulty. Moreover, the app provides a range of graphical word symbols, each of them representing a feeling, a need, or an object. The user can use the second dashboard mode and collect a number of word symbols, then combine them to create a meaningful sentence. This visual method is helpful for younger children who may find symbols easier to understand than words or prefer a more graphical way of communication. Even more, in order to speed up the communication process, the app offers a library of phrase symbols where each of them represents a complete predefined sentence. Users can simply select and use these phrases to express their ideas in a fast and accurate way, a choice that may suit the users who have motion problems or can’t use regular keyboards efficiently. Whatever the selected mode was, the user can play the constructed sentences as audio messages, benefiting from the TTS component included in My Voice. Further details about every dashboard mode will be presented in the upcoming implementation section.

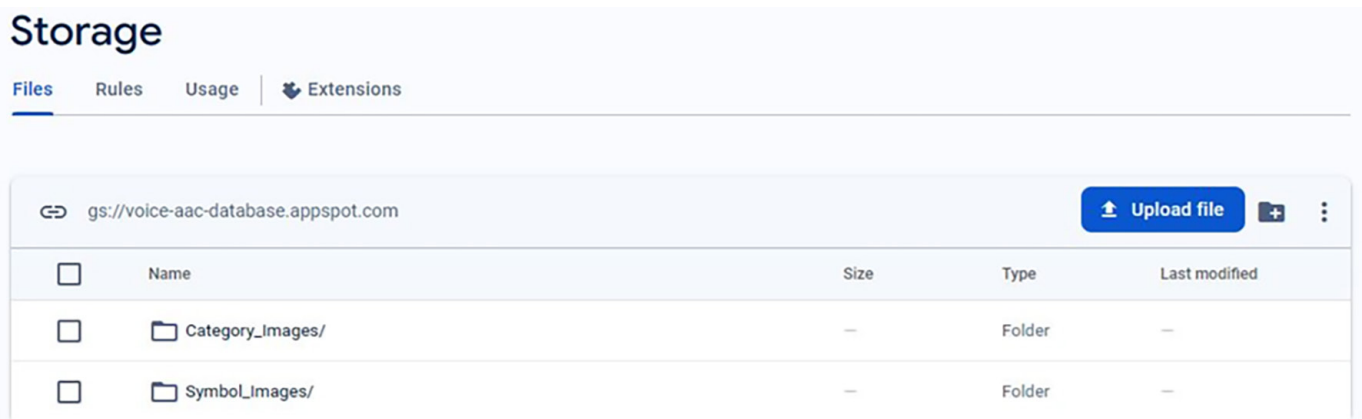


Fig. 7. The folders contain the new categories' and symbols' images in the database

As mentioned earlier, My Voice AAC is dedicated to AOS children who may have limited verbal communication skills. This means that we must be careful with every aspect of the design. Hence, the colors we selected in the interfaces, the button sizes, and the font size we used have made the app's navigating experience smooth and comfortable. The key factor for ease of use is the graphical user interface; it should be as simple as possible. The children should be able to express their needs and communicate with other people easily and quickly. Figure 9 shows the My Voice home screen presented in both Arabic and English interfaces. As we can notice, the screen is simple in its design, colorful without being distracting, and readable with its big icons and large font text.

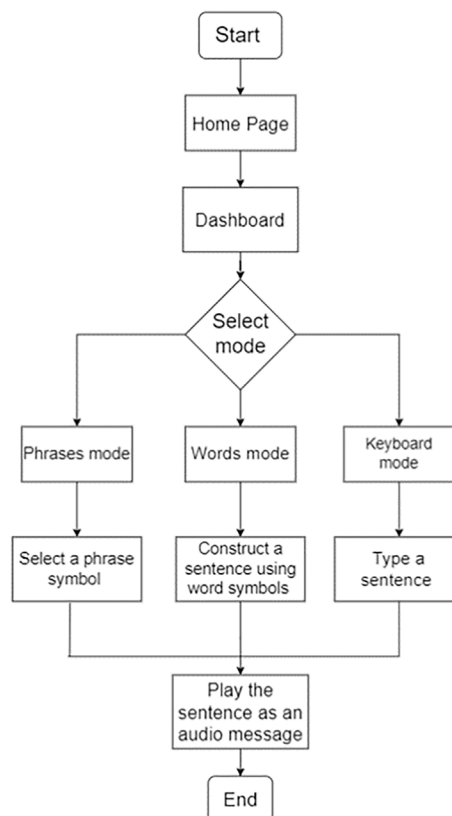


Fig. 8. Dashboard three communication modes

4 IMPLEMENTATION AND RUN SCENARIO

In order to review My Voice features in a way that connects all parts together for the reader in a logical way, we present in this section a comprehensive scenario from a potential user perspective. In this scenario, Ali is a child who suffers from apraxia and wishes to communicate with other people in an efficient way. Hence, he decides to install My Voice and benefit from the services included in it.

First of all, the user has to select an interface language between Arabic and English. My voice was originally designed for AOS children in Arabian countries to help them communicate better. However, English is a universal language that is widely used around the world either as a first or a second language. As a result of that, adding English in addition to Arabic to our app was essential. Moreover, we will show all of our scenario screens in both Arabic and English interfaces for the convenience of the reader of this paper.



Fig. 9. My Voice home screens

As a new user, Ali is asked to create a personal account by filling out the form shown in Figure 10. The signing-up process includes inserting the first name, family name, email address, date of birth, and a password. After creating the account, Ali will be able to log into the home page screen, which is shown in Figure 9, and choose one of the four available sections: “My profile,” “Dashboard,” “Words and phrases,” and “Settings.”

“My profile” is the first section in the home screen that shows the personal information of the user. As appears in Figure 11, the user’s first name, last name, and age appear as set during the sign-up process. These fields can be edited by Ali by clicking the edit button, which will lead to the “Edit my profile” screen in Figure 12. Additionally, users have the option to supplement their profiles with additional personal details, facilitating self-introduction to others. This is done by filling the about me field with a personal message that presents Ali during the conversations with other people, as will be explained later.

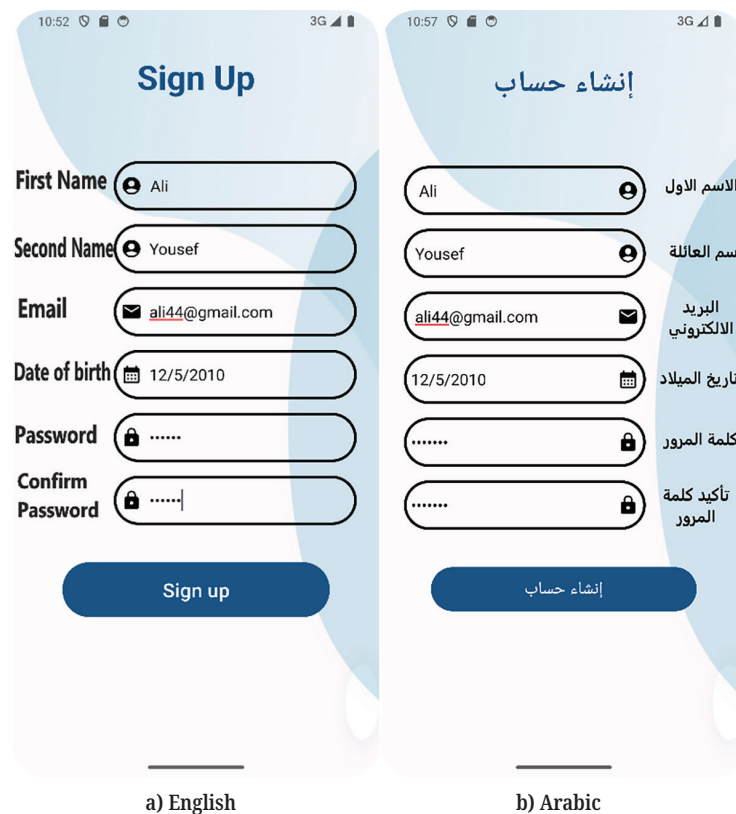


Fig. 10. My Voice sign up screens

The “Words and phrases” section contains many icons that are used as graphical representation symbols for words or phrases. These symbols can be used to construct sentences and express different needs and feelings by the user. When Ali enters this section, the screen in Figure 13 appears where he selects the “Words” subsection over “Phrases.” The word screen is divided into a number of categories, each of which contains many word symbols of the same type, as Figure 14 shows. The available categories may include verbs, pronouns, feelings, food, and sports, among others. Having different categories helps the user to find any symbol in a short time instead of searching inside one big category filled with hundreds of symbols. In the same way, the phrases are also distributed over a number of categories where Ali can look for any phrase he may need to use.

After entering the food category, Ali navigates through the word symbols as shown in Figure 15. Subsequently, he selects the symbol representing chocolate, and hence the word “chocolate” in English or “شوكولاتة” in Arabic appears in the message bar. As mentioned earlier, every symbol in our app comes with a TTS feature that converts words into sounds. Hence, clicking on the triangle button will cause the selected word to be pronounced as an audio in the same language as the text.



Fig. 11. "My profile" screens



Fig. 12. "Edit My Profile" screens

The “Words and phrases” section in My Voice comes initially with many useful categories that cover most of the daily life needs for any user. However, Ali can create new categories and add new symbols to fulfill his personal needs in case the existing categories and symbols don’t cover all the words or phrases he may need. This allows Ali to create his own version of the app to represent his personal fields of interest. For example, Ali likes a lot to eat a local meal called “Mansaf”. However, as this word is not originally included in the food category, he decides to add it by clicking the add button that appears at the bottom of the screen in Figure 15, and then the fill form appears as shown in Figure 16.

The add symbol form requires selecting the destination category and fill the new symbol word in both Arabic and English in addition to uploading a picture to represent this new symbol and relate it with the added word as shown in Figure 16. Now, Ali can include the word “Mansaf” in his conversations with other people and maybe ask his mother to prepare it for him. Moreover, any newly added word symbols will also be included by the TTS feature in My Voice. This means that clicking the word symbol of “Mansaf” will cause pronouncing the word in Arabic or English based on the interface language. Even more, the new word symbol can be used to construct full sentences and phrases in the same way we use the original ones. In the same way, Ali can add a new phrase symbol to one of the existing phrase categories. Even more, he can create a new word or phrase category and fill it with new symbols. However, our user can only edit or delete the categories or symbols added by him but not the originally existing ones. Deleting an entire added category will automatically remove all the symbols included in it.

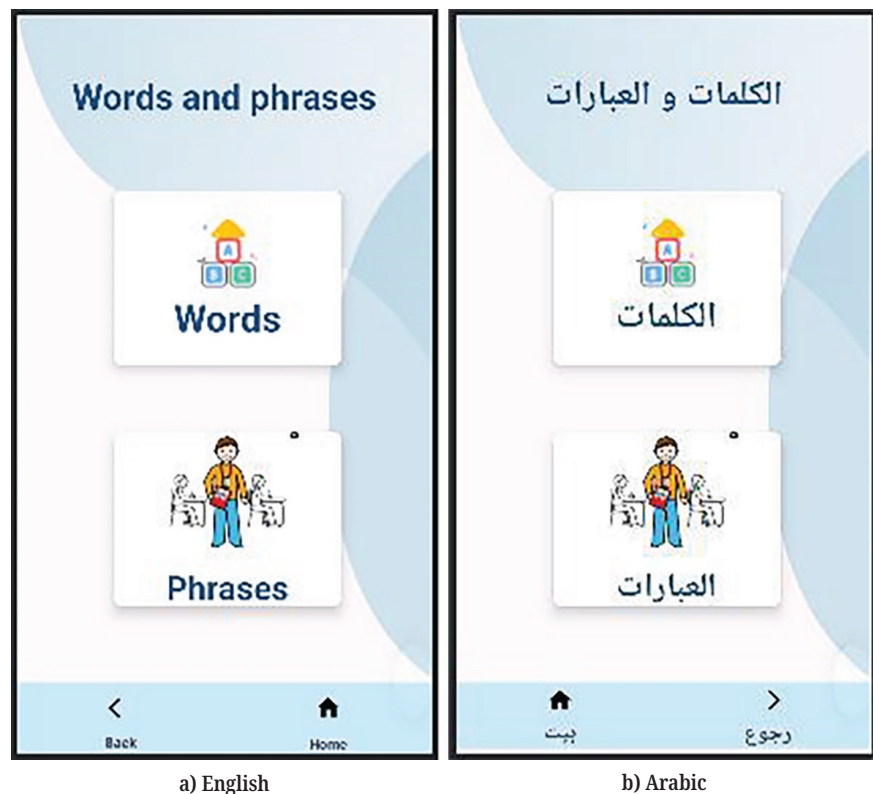


Fig. 13. Selecting between words’ or phrases’ subsections



Fig. 14. Words' categories screens

As mentioned earlier, the “Dashboard” section allows Ali to express his ideas and feelings in an efficient way by writing sentences that will be translated into audio messages that will be heard by the people talking to him. The user can communicate with others and write full sentences either by combining word symbols together, selecting a phrase symbol, or typing through a regular keyboard. At the top part of the dashboard appears in Figure 17, we can find the message bar in addition to four buttons, which are: “About me,” “Play,” “Delete,” and “Home.” On the sidebar of the dashboard, Ali can toggle easily between the three communication modes simply by clicking any of the buttons “Words,” “Phrases,” or “Keyboard.”

The “Words” mode allows Ali to combine a group of word symbols to create a meaningful sentence. As Figure 17a shows, the words dashboard is filled with symbol words' icons, which are divided into grouped columns that we numbered in red. The group under number 1 represents the category “Pronouns” symbol words. Ali clicks the “I” symbol, which fills the message bar with this pronoun. After that, he clicked the “am” symbol word from group 2, which represents the “Linking tools” category. Finally, Ali clicks the “Hungry” symbol from group 3, which represents the most used symbols by the user based on his usage history. The three clicked symbols (circled in red) combined construct the sentence “I am hungry” that appears in the message bar. By clicking the triangle button, the sentence will be played as an audio message, allowing Ali to express his feeling of hunger to his mother. Moreover, Ali can always change his mind and delete the message by clicking the button with (x). Moreover, clicking the house button will simply close the dashboard and lead the user back to the home page.

On the other hand, group 5 views all the word categories included in My Voice to help Ali look for any symbol that may not be found in group 3. For example, clicking the food category in group 5 will cause all the symbols in this category to appear inside group 4. In the same manner, the Arabic interface in Figure 17b shows the equivalent message written in Arabic by clicking the red-circled symbols where the numbered groups 1, 2, 3, and 4 represent the pronouns, the most-used symbols, the selected category symbols, and the word categories, in order.



Fig. 15. Selecting the chocolate word symbol from the food category and playing its audio record

The second communication mode, “Phrases,” allows Ali to benefit from the existing phrase symbols included in My Voice in addition to the ones added by him. The user can construct a full sentence by clicking one button only, as we see in Figure 18. In fact, the dashboard symbols are divided into three groups of columns. Group one shows Ali’s most used phrases based on his personal usage history. Actually, these phrases are expected to be used regularly, and hence they appear through group one for faster access. In our scenario, Ali is tired; hence, he clicks the circled “Tired” symbol. This action will fill the message bar with the sentence, “I’m feeling tired. It’s time for bed” or its equivalent Arabic phrase in Figure 18b. However, if Ali scrolls down through group 1 and doesn’t find the required phrase, he can simply click the related category from group 3 and then look for it inside group 2, which will be filled with all of the phrase symbols included in the selected category.

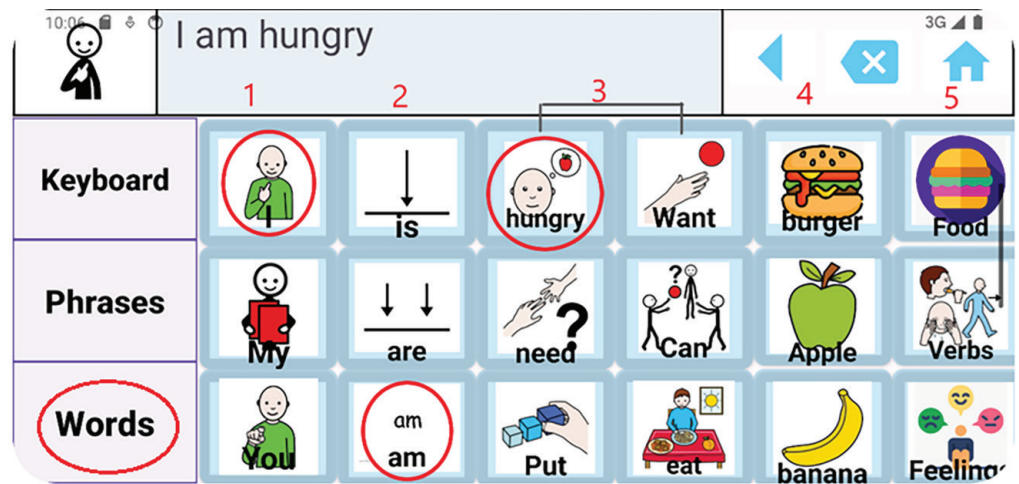


Fig. 16. Adding a new word symbol to the food category

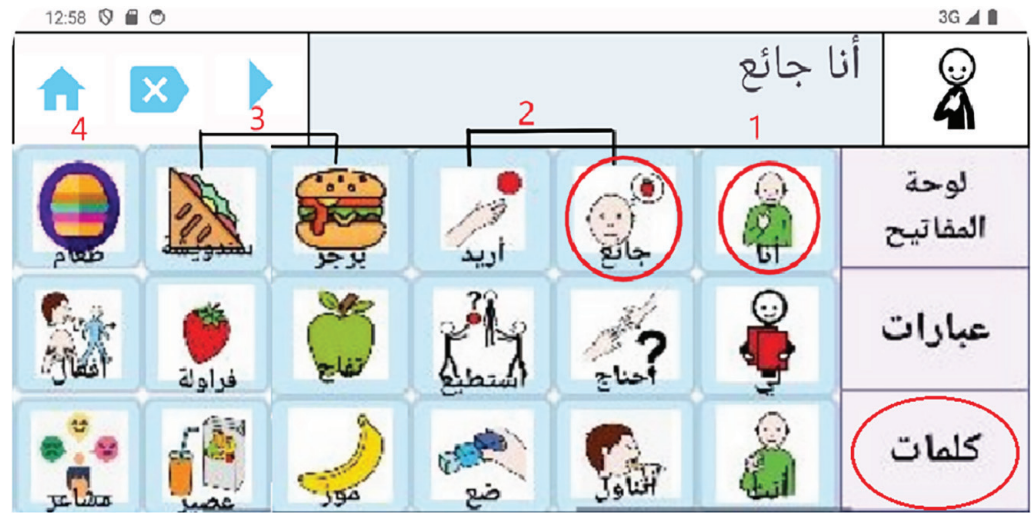
The third and last communication mode is the “Keyboard.” As its name implies, it is a regular keyboard that allows Ali to print a sentence letter by letter and then play it as an audio message. Figure 19 shows the sentence, “My friend and I have finished the homework at school,” and its equivalence in Arabic. Moreover, Ali can easily toggle between English and Arabic by simply clicking the red-circled button for the keyboard language selection. As mentioned earlier, this mode can be useful for adults or users who prefer printing rather than looking for words or phrases or symbols.

The “About me” button is a definitive message that allows Ali to present himself to new people in an efficient way. By clicking the circled button in Figure 20, the message bar will show an introductory script that includes Ali’s personal details, such as name, age, and hobby. In fact, we wrote a code that collects the information inside the fields of the “Edit my profile” screen in Figure 12 and presents it in the form of a paragraph to give it a human touch. Even more, the user can edit the filled script directly and add more details if he wants without saving the edited part permanently. In fact, this “About me” button is available through the three communication modes we have introduced.

“Settings” is the last section in the home page in My Voice. As assumed, it collects a number of standard editable options and buttons, which we can see in Figure 21. The “About app” button will show a brief description of the My Voice app: the creators, its scope, and contact info. On the other hand, the “Change language” option will allow Ali to select the language of the interface between Arabic and English. The third “Dark mode” button can be useful for the visually impaired users who can’t see clearly when using the light default interface of the app. Figure 21b shows an example of a dark screen that can be selected by enabling the dark mode option. Finally, the log-out button causes the current account.



a) English



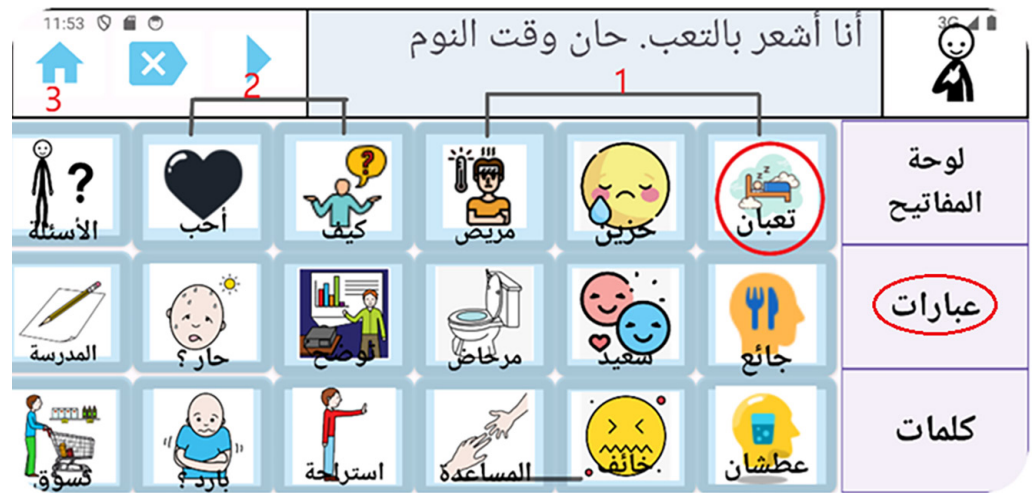
b) Arabic

Fig. 17. Using the "Words" mode to build a sentence



a) English

Fig. 18. (Continued)

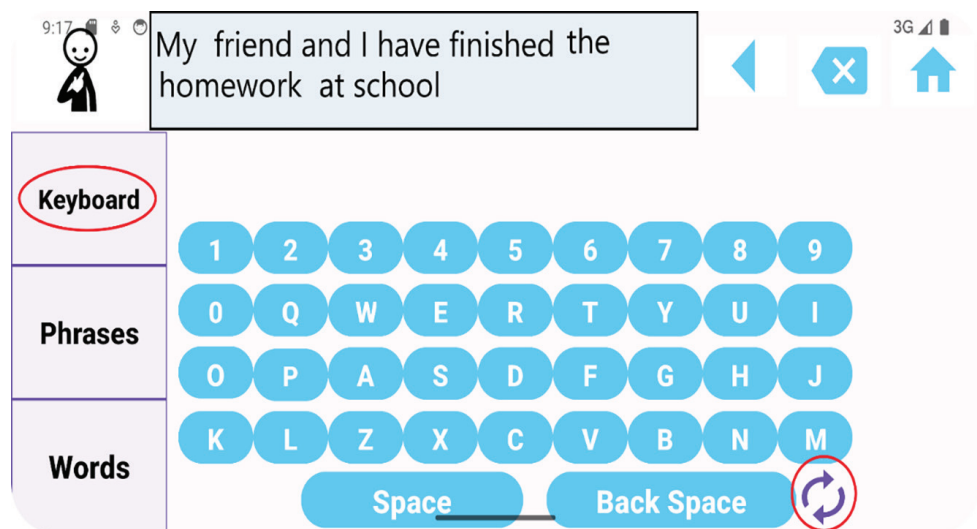


b) Arabic

Fig. 18. Using the “Phrases” mode to construct a sentence



a) Arabic



b) English

Fig. 19. Using the “Keyboards” mode to construct a sentence

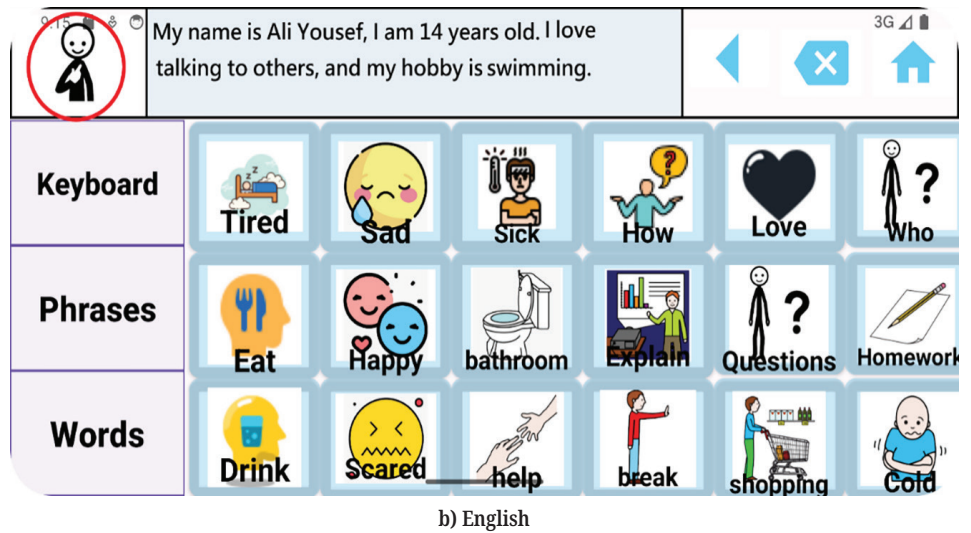


Fig. 20. Using the “About me” button to introduce Ali to others



Fig. 21. The “Settings” section options

5 EVALUATION AND SURVEY RESULTS

In order to get a realistic evaluation of My Voice, we have prepared a comprehensive survey to be completed by a group of potential users. The number of our final test sample members was 200. Table 2 shows the demographic distribution of the selected users based on three classification criteria. As we can notice from the table, this test sample tried to cover different categories of users who may be strongly related to the research topic, such as parents of AOS children or specialists who work with them, computer engineering students at the University of Jordan (UoJ), and students from UoJ's medical faculties. In addition to that, we have also included other users who may not be directly related to AOS or app programming in order to cover a wider user spectrum. On the other hand, the numbers of males and females in our test samples were relatively close, with more women included, as many of them were mothers of AOS children. In order to accurately rate our app's design and how user-friendly it is, we have widened our sample to include different age ranges' users. As a result, we have included a number of under 18-year old users to get the feedback of young people who are normally more attached to smartphone applications and new technologies. Moreover, we have also included a number of users over 50 years old to include the category of people who usually find it harder to handle smartphones' apps.

Table 2. Test sample demographic distribution

Classification	AOS Relevance			
Category	AOS parents and specialists	Computer engineering students	Medical schools students	Other
Number	46	39	77	38
Classification	Age Range			
Category	Under 18	18–25 years	25–50	Over 50
Number	20	85	71	24
Classification	Gender			
Category	Male		Female	
Number	89		111	

The survey consists of 10 questions that have been selected after consulting both technical workers in the field of smartphone apps and AOS experts. The first part of the survey covers four general questions about AAC tools and AOS apps without mentioning My Voice. These questions try to measure the current knowledge related to AOS helping apps before using ours. The following five questions in the survey are dedicated to evaluating different aspects of My Voice after the test period ended. These questions ask about the general design of the app, the ease of use, how useful it can be, the evaluation of the dashboard, and the value of the customization feature. Finally, the last question allows the users to express themselves freely to describe their experiments, report any technical difficulties, and propose any additions to the work.

Table 3. Survey and statistical results

Questions and Answers			
Q1: Have you ever used an Augmentative and Alternative Communication (AAC) application before? If yes, how useful did you find it?			
Very Useful	Quite Useful	Not Useful	Never used an AAC app before
56.5%	16.5%	0%	27%
Q2: Do you think AAC apps can help in building confidence among AOS children?			
Yes	Maybe	No	
80%	8.5%	11.5%	
Q3: How important do you find it for an AAC application to support multiple languages?			
Very Important	Important	Neutral	Not Important
60%	18.5%	21.5%	0%
Q4: Would it be more practical to have an Arabic interface in AAC apps for the users in the Arabic region?			
Yes		No	
98.5%		1.5%	
Q5: Do you think that the My Voice application can help AOS children through daily life activities?			
Yes		No	
95%		5%	
Q6: Do you think that My Voice users can benefit from having a dashboard with different communication modes in order to communicate faster with people?			
Very Useful	Quite Useful	Not Useful	
78.5%	20%	1.5%	
Q7: Do you think that My Voice is a friendly and easy to use app especially for AOS children?			
Yes	No	No opinion	
72.5%	9.5%	18%	
Q8: In general, what do you think about My Voice design (colors, fronts, and general design)?			
Excellent	Very Good	Good	Poor
66.5%	25%	8.5%	0%
Q9: How useful did you find My Voice customization feature? (The ability to add categories/phrases symbols/or words symbols to your account)			
Very Useful	Quite Useful	Not Useful	
68.3%	31.6%	0%	
Q10: In general, what is your opinion about AAC? (If you have any proposed suggestions don't hesitate to tell us)			
<ul style="list-style-type: none"> ○ A suggestion that parents desperately need for their children. I hope to advance this work and strive to develop and present it. ○ It is an excellent application. I hope it will be implemented in Arab countries soon. ○ The application is very useful and enhances self-confidence. We need an IOS version. ○ It's a very useful way to help children communicate, please add new languages. ○ It is a little complicated for me. 			

Our selected users were asked first to use the app for a test period of one month. After that, they filled out a 10-question evaluation survey based on their personal experiments. In general, the feedback was very encouraging with several points to consider in the future. Table 3 shows the outcomes of the published survey with a detailed distribution for each question response over the available choices.

In further detail, three out of four test group members having previously used an AAC app, with the majority of them have found it useful based on question one. In response to question two, 80% of our respondents believe that this type of app can be helpful in gaining confidence among children with AOS. On the other hand, around two-thirds of the participants thought that AAC apps should support multiple languages, according to question three. In fact, almost all question four responses agree that each AAC app needs to present an Arabic interface for the Arabic region users. Regarding My Voice itself, question five revealed that 95% of our test group members have agreed that it can help AOS children through daily life activities. Even more, the great majority of our respondents have agreed that providing a dashboard with multiple communication modes can help children communicate faster with other people, according to question six. Question seven's results have revealed that most of our users have found My Voice a user-friendly app that is easy to use by AOS children. Moreover, most of the users have also shown a general acceptance toward the app's interfaces and general design of the screens. On the other hand, the ability to customize personal accounts by being able to add and edit categories, word symbols, and phrase symbols was welcomed by all of the users but in different degrees based on question nine responses. Finally, question 10 was a free area that allowed our respondents to express their opinions about My Voice in their own words and suggest any modification they may find useful. Table 3 shows several samples in response to question 10 with very positive opinions and a few useful suggestions, which we will consider in the future.

6 FINDINGS' IMPLICATIONS AND APP'S LIMITATIONS

My Voice is an Android app that is dedicated to helping AOS children express themselves clearly to other people. This app's implications can be noticed in multiple areas. The proposed app has a number of features that can't be found in any other similar app. For example, the Arabic interface provides an interactive and efficient tool that is convenient for the interested users in Arabian countries. As a result, this could raise awareness about this disorder in this part of the world and help people handle it in a systematic approach. Moreover, providing this app for free will be an attractive factor that will increase the number of its users and make it an attractive investment choice for any interested party. Even more, the successes of My Voice will encourage other app developers to pay more attention to developing similar apps and serving people who suffer from different disorders or syndromes. Autism, for example, is one of the most attractive syndromes to app developers around the world. Many useful apps were introduced to serve this category of users as in [55, 56]. However, the number of autism apps supporting Arabic is low, and most of the available ones are limited in their features.

Regarding the users' expected limitations, we can say with trust that My Voice does not have many major ones. The app was theoretically designed to handle any number of users. However, a large number of users may require hiring many servers through a service provider, which could cost a fortune. This in turn will

require having a funding source to allow My Voice to expand on a large scale. On the other hand, the Arabic interface cancels the language barrier for Arabic users, and the English interface makes it a possible choice for most people around the world. Even more, our app installation requirements include having any Android smartphone with no special specifications needed, no extra hardware components are required, and no fees are asked for. On the other hand, none of the people who tested the app has acknowledged us about any technical difficulties. For example, we have not received any complaints about the accuracy of speech-to-text conversion. Interestingly, comparing the responses to the major survey questions related to the design of the app and the ease of use has shown almost similar responses from the four age range groups included in Table 2. This outcome clearly indicates that MY Voice is a very user-friendly app in general. Moreover, the older age range has not shown any complaints or difficulties using My Voice based on the survey results and feedback. However, a major limitation we can mention is the absence of an iOS version, which is on the top of our future work list. Even more, the rising popularity of AI around has made it a popular addition to include in any app. In fact, several AAC tools have adopted AI in their design [57–58]. Unfortunately, the current version of My Voice does not support AI, which may limit its features in general.

7 CONCLUSIONS, HOME RECOMMENDATIONS, AND FUTURE WORK

In this paper, we have presented My Voice and an Android app that acts as an AAC tool for children with AOS. The app allows its users to express their feelings and ideas and get included in different daily life situations by translating written sentences into audio messages other people can hear and understand. The societal impact of the app includes raising AOS children's self-confidence, helping the parents interact with them effectively, and making society more stable and happier. Moreover, My Voice supports the Arabic language as it is mainly designed to help AOS children in Arabian countries. However, it also supports the English language, which makes it a useful tool for all users around the world. Although it is mainly designed for children with AOS, our app can serve as a communication tool for all people from different age ranges who may suffer from different communication and speech problems. The user of the app can create an account with personal information included. Having an account can help the user personalize it by being able to add and edit new categories, word symbols, and phrase symbols in addition to the ones included in the app by default. On the other hand, the dashboard is the main section in My Voice and is used to communicate with people. This dashboard has three modes of communication, which are "Words," "Phrases," and "Keyboard." Evermore, the "About me" button inside the dashboard can automatically play a voice message that introduces the account owner to other people.

As mentioned earlier, My Voice was originally designed to help AOS children to communicate effectively with other people. To reach this goal, we strongly recommend that the related authorities in Jordan and other countries adopt this work as an official AAC tool for AOS children. For example, our app can be a part of the official educational system in Jordan, which follows the ministry of education, or even the official healthcare system that follows the ministry of health. To do that, we will prepare a formal proposal that presents our work clearly and contact the related authorities in Jordan. In fact, adopting this app by the government can help in providing the technical and human support that is required to expand its user base to a

large scale and give it a level of formality. Even more, we recommend the app developers in Arabian countries invest in the area of the apps that serve people struggling with different disorders or syndromes. In fact, we believe that the future direction of smartphones' app markets around the world will focus on developing societal impact apps that serve people to manage their lives efficiently. In fact, these apps can serve noble causes and be financially rewarding at the same time. The targeted audience in this area of research may include people with different disorders and disabilities, elder citizens, children, and women. Finally, we recommend the parents of AOS children and their educators to encourage them to use My Voice regularly and supervise their app usage to gain the maximum possible benefit.

In order to evaluate our study, a group of 200 potential users were asked to use the app for one month and filled out a survey of 10 questions. The outcomes of the survey have revealed positive responses in general and provided us with interesting notes to consider. As a future work plan, we aim to include AI techniques in our dashboard section. Additionally, we are considering adding other popular languages to the app, such as Spanish and French, to make it more scalable among all users around the world. Finally, we are planning to provide an iOS version of My Voice for Apple phone users.

8 DECLARATIONS

- Data Availability Statement: Data sharing not applicable to this paper as no datasets were generated or analyzed during the current study.
- Compliance with Ethical Standards
 - Disclosure of potential conflicts of interest: All authors declare that there are no conflicts of interest.
 - Research involving human participants and/or animals: This paper does not contain any studies with human participants or animals performed by any of the authors.
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