Design and Implementation of an Augmentative and Alternative Communication System Based on MATLAB GUI

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Abstract. In clinical practice, augmentative and alternative communication (AAC) is an effective training tool to improve the communication skills of individuals with language impairment, hearing impairment, and autism. However, there are few studies on the development of augmentative communication systems based on Mandarin Chinese in China. This study presents an augmentative communication system developed using the MATLAB GUI platform. The system consists of two parts: a learning part and a communication part, where the learning part provides the basis of the vocabulary content for the system, covering 5558 words, and its content is mainly a word list designed based on the content of special school language textbooks. The communication part provides the system with a complete discourse training content, mainly by arranging and combining the vocabulary content of the learning part to form a complete discourse. This aided communication system can expand the vocabulary of people with language expression disorders and improve their social communication skills. In addition, the effectiveness of the system was tested in a single-subject experiment, and the results showed that the augmentative communication system is effective in learning pronunciation, expanding vocabulary, and improving the social communication.

1. Introduction
Among many AAC systems there are few that are currently developed based on Mandarin and can be widely used in mainstream operating systems to achieve a system that allows patients with expressive language disorders to install and use the system for learning correction with a simple operation on an electronic device[1-3]. As the society has been developing fast, people with speech disorder need to improve their life quality by receiving treatment and training [4-5]. Therefore, this study proposes an AAC system based on the MATLAB GUI platform. The system is easy to operate for the Chinese Mandarin speakers. It facilitates the use of patients with language expression disorders in therapeutic training in China.

2. System Framework
The system consists of four major components: communication symbols, communication aids, communication techniques and communication strategies, which are complementary to each other. Based on the MATLAB GUI technology, the system is designed with an interface, pictures and audio that match the word list content.

Communication symbols: A symbol that collects the required information through tactile, visual and other sensory symbols, and then transmits it to others through body language or other devices, such as gestures, pictures, words, etc.
Communication aids: Patients who are unable to express their ideas to others through the use of language to achieve the purpose of communication need to use other assistive devices to complete communication.

Communication technique: The way and method for patients to use communication aids. It can be divided into direct selection and indirect selection. Direct selection means that the patient selects options such as buttons on the augmentative communication device through his or her body parts (e.g., fingers, mouth, etc.), while indirect selection means that the patient operates the augmentative communication system through other objects such as pens and chopsticks instead of his or her body parts.

The communication strategy in this system consists of communication symbols, communication aids, and communication techniques. The communication strategy mainly enables the rehabilitation physician to provide a specific augmentative rehabilitation plan based on the individual patient's real situation, thus improving the patient's use and rehabilitation process.

3. MATLAB GUI Programming

First open MATLAB software, enter lowercase GUIDE in Command Window command box and enter.

In the New GUIDE file interface, choose to create a blank file 'Blank GUI', select the file storage location, store it in a folder, click OK to generate the GUI file and has been saved.

To display the background photo, add the following corresponding code to function figure1_CreateFcn(hObject, eventdata, handles).

```matlab
ha=axes('units','normalized','pos',[0 0 1 1]);
uistack(ha,'down');
ii=imread('background.jpg');
image(ii);
colormap gray
set(ha,'handlevisibility','off','visible','on');
```

Click on the image to make it sound, insert the button, double-click on the button logo, enter the property editor, delete "button" from the property string, change the property Units to pixels, and add the following two procedures to the OpeningFcn in the editor.

```matlab
icon_name=importdata('filename.jpg');
set(handles.pushbutton1,'CDAT',icon_name);
```

After the image is added, the sound insertion, right click 'call back' to enter the program writing interface, the software directly to the corresponding program framework is built and displayed, add the corresponding sound insertion procedures below it, the procedure is as follows.

```matlab
[y,Fs]=audioread('filename.mp3');
Soud(y,Fs);
```

To switch between the two interfaces, you need to insert a button, right click 'call back' to enter the program writing interface and insert the corresponding program.

```matlab
set(gcf, 'visible', 'off');
UI_name ('visible', 'on');
```

The above is the completion of the basic writing of the program, on the basis of this pilot test, you can again write the secondary enrichment content as needed.

4. Construction of AAC system

The interface of the system is shown in Figure 1. To attract users' interest, a simple and clear layout is used and the color scheme of the interface is slightly warm. The two functional modules of the system are linked in the interface. In this interface, users can click on either the Learning section or the Communication section for different purposes of learning and training.

Augmentative communication systems can be targeted to help use patients to achieve better rehabilitation training purposes, can stimulate their willingness to want to communicate, and reduce
the sense of failure and frustration they suffer when they cannot successfully communicate with others. It improves their communication skills and enables them to have a healthy psychological development. This auxiliary system consists of two parts, the learning chapter and the communication chapter, which form the main body, and generates a multi-level and multi-content learning and communication interface through the function of interlinking between interfaces and interfaces, while keeping the interface simple and not easily cumbersome for users.

![Figure 1. User Interface of Components of an AAC system.](image)

The content of the learning chapter is based on the content of the special school language materials and the corresponding design of the learning word list, which covers almost all the high-frequency basic words involved in daily life. For example (Table 1): numbers, people, colors, sports, weather, common plant and animal names, etc. After the user clicks the learning chapter on the initial interface to enter the learning, the vocabulary content will be presented to the user in a combination of voice and picture, and the user can learn and train the pronunciation by clicking the picture or text. The user can click on the same pronunciation repeatedly during the training process to make the training effect more obvious.

| Number  | People  | Animal | Item   | Color |
|---------|---------|--------|--------|-------|
| Sports  | Body    | Direction | Food  | Weather |

The content in the communication chapter was mainly derived from reviewing related literature and research. In the research, the types of communication were identified by observing the common words used by preschool and school-age children. In the communication chapter, patients are taught how to link, use, and combine vocabulary, and learn the high-frequency vocabulary in the chapter to make a complete communication statement. For example: statements that express the patient's wishes: I want to (can be combined with statements such as: eat apples, eat bananas, buy cars, wear clothes, etc.) / I don't want to (can be combined with statements such as: take a plane, make bread, eat rice, drink water). Commonly used statements in life; (dad, mom, teacher) hello, thank you (classmate, uncle, aunt), (I'm) full, I'm hungry, and a full range of example sentences to meet the different needs of users. The background of the communication module is different from that of the learning module, so that it can be better differentiated. The communication module uses warm and beautiful photos, which can make patients take the initiative to learn and experience different feelings from the learning module. The function of the communication module also adds a picture function that matches the text content, and adds a voice function, which makes it easier for patients to learn to master the
pronunciation of statements and enhance their ability to understand the meaning of statements when using the communication module, so as to train them to express complete statements.

5. Experiment
A single-subject experimental design method was used. The single-subject experimental design is mainly aimed at quantitative assessment of single or few subjects and can compensate for the inaccuracy of statistical results due to insufficient sample size. The improvement of users' (i) correct pronunciation vocabulary and (ii) correct communication rate over time was directly observed. The experimental design was specified as follows.

5.1. Subjects' basic information.
Two children with hearing impairment: A and B, male, both 5 years old, received cochlear implant surgery, had basically recovered hearing function, did not attend kindergarten, had received speech rehabilitation training for 1 month, had established initial awareness of speech, and had some learning ability.

5.2. Experimental methods.
(1) Measurements of correct pronunciation vocabulary: The experiment used an A-B single baseline experimental design, with A as the baseline period and B as the treatment period.

First, the baseline experiment was conducted. The vocabulary list was obtained from the learning module of the communication aid system designed in this paper, and a total of 545 words were screened, and each word was worth 1 point.

Second, a treatment period experiment was conducted. Each subject was asked to use the communication aid system to learn the pronunciation of the vocabulary. A learning period of 7 days was used, and at the end of each period, the correct pronunciation vocabulary score was performed. The entire intervention period was 21 days, and the correct pronunciation vocabulary scores for the intervention period were obtained in 3 sets of scores in chronological order.

Finally, the A-B single-baseline line graphs were drawn based on the "correct pronunciation vocabulary" scores obtained in the baseline and treatment periods, and significance tests were performed on the data from both periods.

(2) Communication correctness: The experiment still adopts the A-B single baseline experimental design, where A is the baseline period and B is the treatment period. The "communication correctness" measure covered 10 communication scenarios, each of which consisted of 2 sets of communication statements. These scenarios were taken from the communication module of the communication aid system, and subjects were scored 1 point for each scenario in which they correctly used AAC to complete 1 set of communication. Communication correct rate = correct score / total score of communication scenarios × 100%.

First, a baseline period experiment was conducted. The "communication correctness" of the two subjects was counted three times in each period, and the scores were recorded once a day. The results of communication correctness were calculated and recorded.

Second, a treatment period experiment was conducted. Each participant was asked to use the communication module of the communication aid system to learn the vocabulary of communication terms. A learning period of 5 days was used, and at the end of each period, the communication correctness score was performed. The entire intervention period was 15 days, and the communication correctness scores for the intervention period were obtained in 3 sets of scores in chronological order.

Finally, a single baseline A-B line graph was drawn based on the "communication correctness" scores obtained for the baseline and treatment periods, and the data from the two periods were subjected to significance.
5.3. Significance tests of indicator data in both periods were performed.
Significance tests of indicator data for the baseline and treatment periods were analyzed by t-test with SPSS 19.0, and the results of significant differences are shown in Table 2.

As can be seen from Table 2, for both subjects A and B, their two indicators (i) the amount of correct pronunciation vocabulary and (ii) the rate of correct communication were significantly different between the baseline and treatment periods, especially the rate of correct communication for subject B was extremely significantly different between the baseline and treatment periods. The results indicate that the communication aid system can play a more significant role in pronunciation learning and improving the communication success rate for patients with language expression disorders.

Table 2. Data significance tests for baseline and treatment periods.

|                                | Subject 1 (Sig.) | Subject 2 (Sig.) |
|--------------------------------|------------------|------------------|
| Correct pronunciation vocabulary| 0.02*            | 0.030*           |
| Communication correctness       | 0.018*           | 0.009*           |

6. Conclusion
This study is based on the MATALB platform, which is easily changeable, and can be upgraded at a later stage, such as adding to the augmentative communication system, types of pictures, categories, styles, etc., as well as improving the functions of the system, adding recording functions, game animation functions, search functions, and other related functions such as the patient's own combination of statements, adding personalization for different kinds of users with different interests. The system is designed for different kinds of users with different interests to choose the content they want to learn, etc. On the basis of this system, we can improve the system individually for different individuals to better mobilize patients' interest in learning, so that they can learn in entertainment and achieve better training effect. It is also possible to find professional announcers to modify and enrich the system's audio resources and add corresponding pronunciation, word meaning and sentence meaning to provide users with correct and guaranteed quality audio resources. On the basis of this system, it is also possible to add a networking function to connect the system with mainstream electronic mobile devices in the market, so as to assist users in learning and training through mobile terminals or to install the system on mobile devices for easier and faster use. In the connection with mobile devices, it can also be combined with artificial assistants, VR, AR and other functions, through a variety of ways to make users more willing to use the aided communication system, improve communication and learning ability, and achieve good training results, so as to better help users achieve the purpose of rehabilitation.

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