Design and Usability Evaluation of Speech Rehabilitation APP Interface for Patients with Parkinson's Disease

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Abstract. Most patients with Parkinson's disease suffer from speech disorders which can be effectively improved through continuous speech therapy. However, there are very few speech therapists in Taiwan, so the patients do not have enough access to rehabilitation therapy, thereby contributing to poor rehabilitation outcomes. Based on motor speech disorder therapy and the service design process, this study proposed a Speech Rehabilitation mobile application software (App) interfaces for patients with Parkinson's disease. The sound interface usability is verified by the actual operation of two patients, and the pronunciation is significantly improved after a short-term use. In the future, the results could be extended to develop long-distance rehabilitation services, expecting to enhance the rehabilitation motivation and effectiveness of patients.

Keywords: Parkinson's disease · Speech rehabilitation · App interface design · Usability evaluation

1 Introduction

Approximately 60–90% of patients with Parkinson's disease (PD) will experience speech disorders, which include monopitch, feebleness, slowness, incoordination, hoarseness and irregular articulatory breakdown [1]. The current solution to speech disorders is to combine levodopa with speech therapy. According to speech and language therapist (ST) planning, patients with PD will receive a series of face-to-face corrections, such as Lee Silverman Voice Treatment and Pitch Limiting Voice Treatment [2], including pronunciation exercises, control the speed of speech, articulation exercises, emotion expression, intonation exercises, volume control, breathing regulation, etc. Besides, auditory feedback device, amplifiers, rhythm boards and other auxiliary equipment are used based on the actual needs [3, 4]. However, speech therapy is a highly personalized and time-consuming course of treatment [5]. It was mentioned that at least 26.2 STs were required for every 10 million people, but this ratio is relatively low (only 1.6 STs for every 10 million people) in Taiwan. In addition, most

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of the STs worked in medical centers or rehabilitation institutions in cities. As a result, patients with PD cannot receive sufficient treatment from STs, leading to reduced rehabilitation effectiveness. After returning home, only a few patients can follow the ST's instructions and independently carry out related training. Moreover, the repeated, monotonous and drab traditional rehabilitation movements lower the patient's rehabilitation willingness, and worse still, the effectiveness of patients' self-exercises at home is difficult to control [6].

In recent years, because of the immense advances in intelligent mobile devices digital contents can be efficiently transmitted and presented to the users, hence also providing a more convenient way of rehabilitation. In the era of "Time is Brain", mobile devices can provide patients with information and images, assisting them in overcoming space-time barriers, and enhance the motivation and effectiveness of home-based rehabilitation [7, 8]. In other words, mobile devices have become an integral part of telemedicine. Therefore, this study aimed to design the Speech Rehabilitation APP interface and conduct the usability evaluation for patients with PD.

2 Empirical Study

2.1 Operation Task

Three patients with PD (Hoehn-Yahr stages I to III) were recruited to participate in the empirical study. The detailed information was shown in Table 1.

Table 1. Description of the subjects

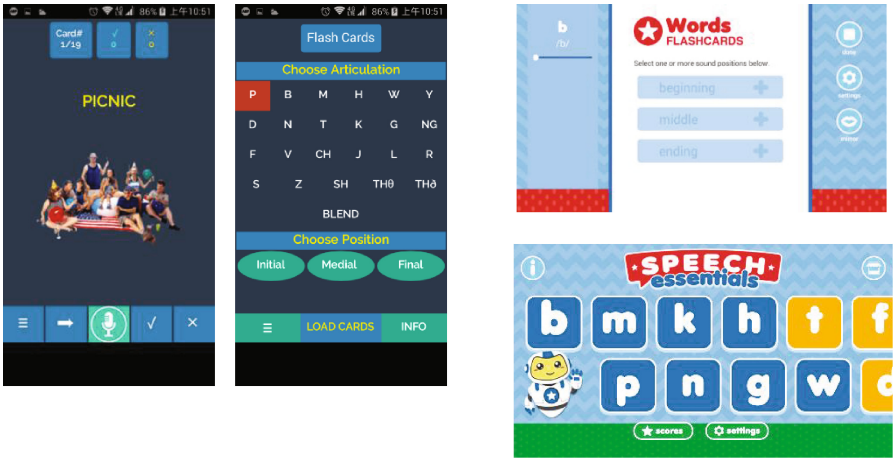
	Sex	Age	Education	Visual ability	Tablet experience	Stages
1	Male	78	Less than high school	Presbyopia, cataract	No	I
2	Male	84	Bachelor	Presbyopia, cataract	No	III
3[a]	Male	62	Bachelor	Presbyopia	Yes	II

[a]Received deep brain stimulation

They were asked to operate two types of Apps related to speech therapy and three types of voice recording APPs (Figs. 1 and 2) using Sony Xperia™ Z4 tablet computer (Android 5.0, 10.1″, WQXGA 2560 × 1600 pixel). The researcher observed the subjects' operational behaviors and inquired them about their reflections on operation task (Fig. 3).

2.2 Results of Empirical Study

From the empirical study, we found some defects when subjects operating above speech therapy and voice recording APPs:



(a) (b)

Fig. 1. Speech therapy Apps. (a) Speech therapy word list; (b) speech essentials therapy.

(a) (b) (c)

Fig. 2. Voice recording Apps. (a) ASR; (b) sound recorder; (c) Hi-Q MP3 voice recorder

1. Inconvenient APPs download and installation process: the researcher asked subjects download assigned APPs to the Tablet from the Google Play store. All of the subjects could not complete this task. Then, researchers ask the subjects to operate the installation process after assisting download the specified APPs, they still could not successfully complete the task, especially in fill in basic information in the registration stage.
2. Inconvenient recording process: the researchers asked the subjects facing the tablet computer microphone and said a passage. But the subjects did not know the location of the microphone. After reminding the location of the Tablet computer, the subjects move the device to the mouth side and then talk. However the subjects represent that they could not see the screen content, and not sure whether complete the task successfully.

(b)

Fig. 3. Subject (a) No. 2 and (b) No. 3 participated in this study.

3. Cannot find past records: In addition to ask the subject operating above APPs, it also asked the them to find just recorded files. It was found that even if there was a date and time code, the subjects were unable to find the recorded files that were just recorded in a few pieces of existing information.
4. The icon is difficult to understand: Most of App interface were designed on the bases of image. In the case of patients with PD are elderly who have no experience on App operation. It is difficult to understand the meaning of the illustration, therefore affects the fluency and efficiency at the time of operation.
5. Lack of explanation: For aesthetic reasons, APP interface design significantly reduce the text explanation that led to the operation of the user inconvenience. Subjects represent that they would like to have a written description of the APP.

3 Interface Design

3.1 Operation Process

According to those defects, we build the speech rehabilitation service blueprint for patients with PD. Through the interaction, visible and internal interaction lines,

the whole service process was divided into four sections: Customer Action, Front-of-stage, Back-of-stage, and Support Process, respectively (Fig. 4). This service blueprint focused on the speech rehabilitation service actions and were classified into the traditional rehabilitation, the pre-therapy stage, the therapy course, and the post-therapy stage.

Then, the speech rehabilitation service process was conducted. The most important stage is the therapy course, which includes: pronunciation practice, monophonetic practice (including the exercises of volume, persistence, high pitch and low pitch), phrase practice, and sentence practice (mainly including the exercises of volume and

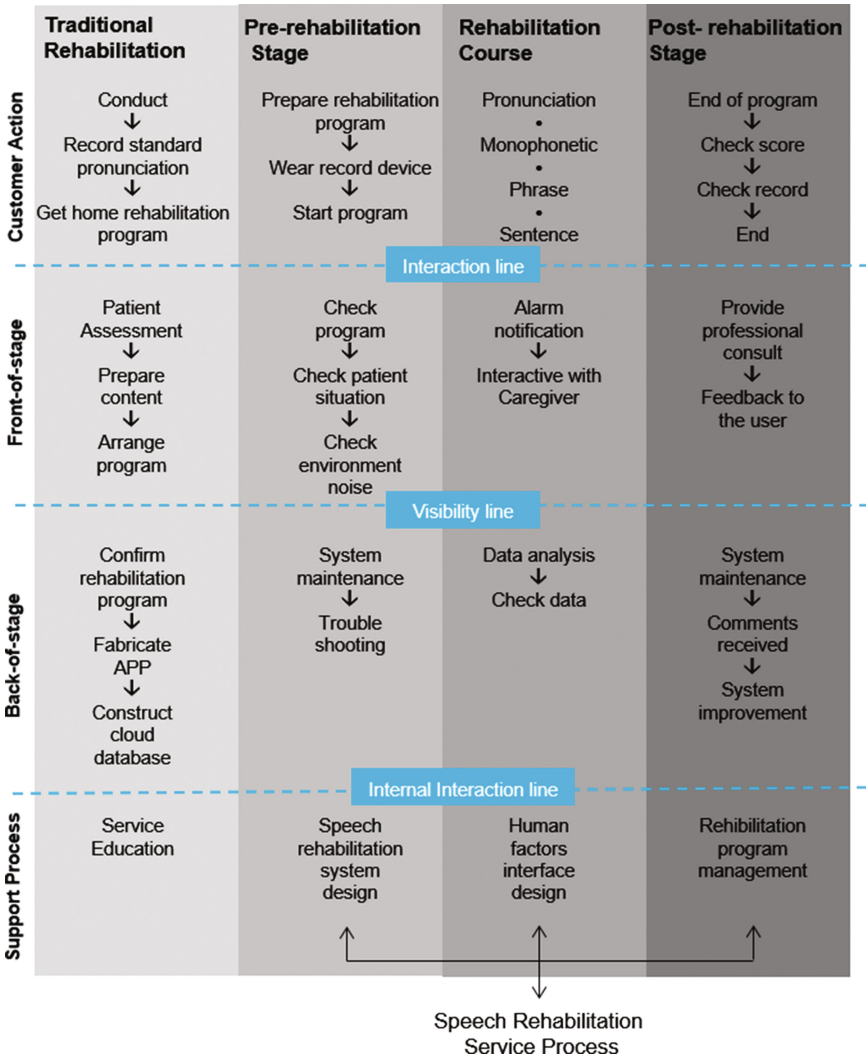


Fig. 4. The service blueprint of Speech Rehabilitation for the patients with PD

intelligibility). At the end of practice, it would provide the patients with the evaluation data of rehabilitation effects. It was expected to provide the comprehensive score (weighted from the volume level and intelligibility scores) as a reference for the user. The rehabilitation results would also be recorded.

3.2 Interface Design

The framework of the Speech Rehabilitation APP for patients with PD is presented in Fig. 5:

When the users starts the App, the software will first test the background noise of field environment. If the ambient noise exceeds the threshold 50 dB [9], the patients are

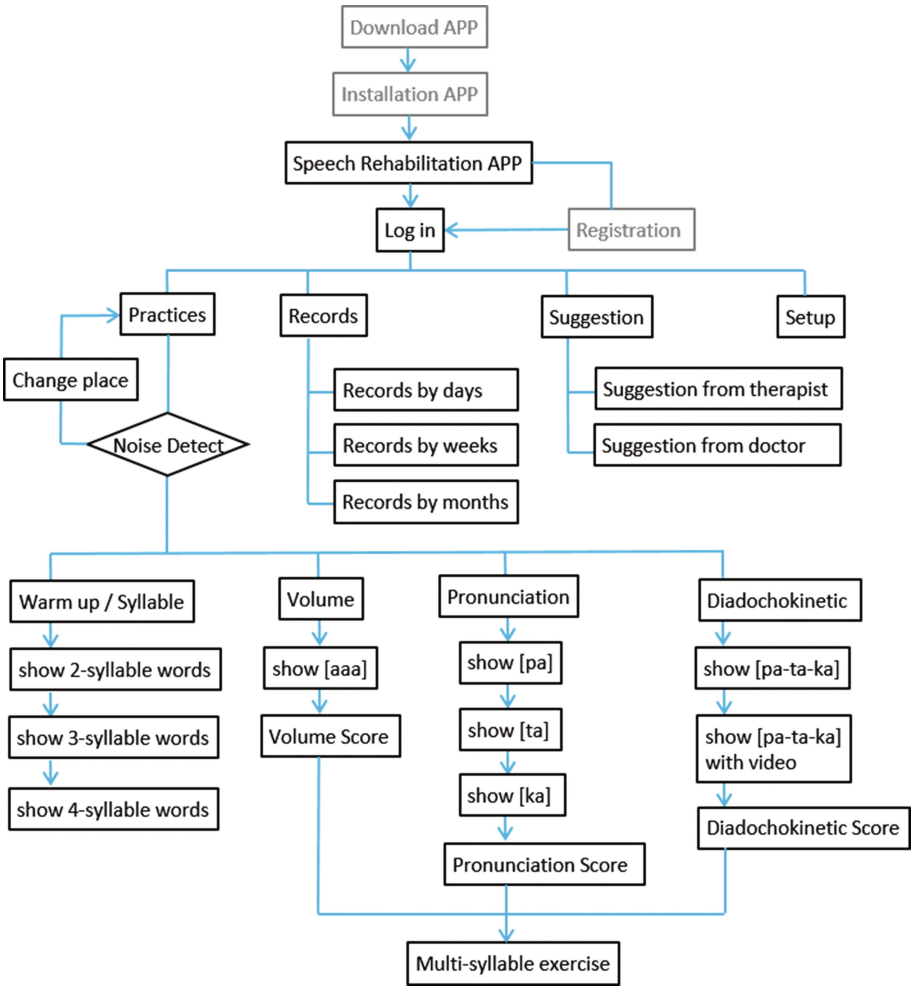


Fig. 5. The framework of the Speech Rehabilitation App

recommended to exercise in other rooms. If the background noise is within the acceptable range, then it will be go to the main menu. Then, the patients choose a. Volume, b. Pronunciation, c. Diadochokinetic, d. Syllable exercise or other exercises. a. Volume exercise means that users are asked to utter long sound of a-a-a. The louder and longer the sound is, the better it is. Such exercise is designed to record whether the patients' sound frequency is stable. b. Pronunciation exercise means that patients are

Fig. 6. The interface design of the Speech Rehabilitation App.

asked to quickly move their lips and to continuously emit such sounds as pa, ta, and ka. c. Diadochokinetic exercise means that patients are asked to quickly move their lips and to continuously emit the sound pa-ta-ka. d. Syllable exercise means that patients are asked to read words of 2, 3, and 4 syllables, and aims at warming up. Some interface design of the APP were shown in Fig. 6.

The mean and duration of the patient's sound pressure level (SPL) are important indicators of evaluating the degree of speech disorders. In the visits to the department of rehabilitation, ST may use sound level meter, chromatic tuner, stopwatch and other equipment to evaluate the patients' SPL. This study used headphones to measure the patients' SPL. Patients can repeat the same exercises or conduct other exercises according to the therapy program. Both patients and STs can check records and scores.

4 Usability Test

4.1 Usability Test Process

Two (No. 1 and 2) of three patient with PD from empirical study were invite to attend the usability test (Fig. 7). They were asked to perform tests in accordance with typical operational tasks. The steps are as follows:

1. Press the [LOGIN] to log in.
2. Press the [RESUME] to perform today's speech rehabilitation.
3. Select a quiet place for speech rehabilitation and press the [START].
4. Carry out re-detection in case of failed environmental noise detection.
5. Change to a quiet place for noise testing.
6. Detection succeeds and ready to carry out rehabilitation.
7. Click [START] to warm up.
8. Begin speech rehabilitation after and Click [START] to perform VOLUME exercise.
9. Shout out a-a-a.
10. Watch the volume exercise score.
11. Click [START] to start the PRONUNCIATION exercise.
12. Read aloud pa, ta and ka.
13. Watch the pronunciation exercise score.
14. Click [START] to perform the DIADOCHOKINETIC exercise.
15. Read [pa-ta-ka] according to the correct shape of lips and speed.
16. Watch the rhythm exercise score.
17. Click the [MAIN MENU] to return to the main menu.
18. Check past records.
19. Check the one-day record of 11 February 2016.
20. Click the [MAIN MENU] to return to the main menu.
21. Check the doctor's advice.
22. Click the [MAIN MENU] to return to the main menu.

(a)

(b)

Fig. 7. Subject (a) No. 1 and (b) No. 2 operate the Speech Rehabilitating APP.

The first round of interviews was carried out after the completion of typical operational tasks. After the interview was completed, the subjects were allowed to freely operate this APP, then have the second round of interviews.

4.2 Results of Usability Test

It is found from the first round of interviews that the Speech Rehabilitation APP interface is designed by combining icons and texts. The subjects indicated that most of the tasks were performed by reading texts, and believed that icons facilitated use. The icons and text descriptions were large enough during operation, so there was no difficulty in reading, recognizing, or touching icons. Additionally, this APP provides static icon guidelines, dynamic visual feedback and video. Subjects suggested that the way of video demonstration was the easiest way to learn. However, the subjects pointed out that during the task operation, the step "19. Check the one-day record of 11 February 2016" was difficult to complete. The researchers speculated that the presentation methods of the past records do not meet the subjects' mental model.

During the second round of interviews, the subjects suggested that more interesting ways such as singing can be added in the warm-up stage, or that other more interactive ways can be added to prevent the patients from feeling bored. In the meantime, they

also mentioned that the ways of future version can be more entertaining or more diverse, instead of only a few fixed pronunciation exercise modes. Otherwise, the patients would easily lose motivation, and thus no longer used the APP. Diadochokinetic exercises should have different difficulty levels. For example, the users who just start the rehabilitation can start from the slower speed, and can choose the faster modes after they grow familiar with the exercises. Besides, they also indicated that when completing exercise, on top of APP can show performance scores and encourage words, sound feedbacks may also be added, such as applause and cheers. This not only can increase the patients' sense of accomplishment, but can promote the patients' motivation of long-term use. Apart from above recommendations, the users also indicated that their larynx and mouth muscles did exert and exercise after task completion. One of the patient's families also noted that the patient spoke less frequently due to the disease at home and was easily choked when eating. If this APP can boost the patient's opportunities of home-based rehabilitation and the willingness to speak, they will be happy to see.

5 Discussion

The patients with PD were invited to operate the speech therapy and the recording APPs using tablet computer. The site-observation and in-depth interview were adopted to develop the service blueprint and operation process and then the Speech Rehabilitation APP interface was designed. Nevertheless, not all steps are performed by the patients themselves. Specifically, downloading software, installing software, registering personal data and other functions (shown in gray box of Fig. 5) require the assist of STs or caregivers. Especially, the registration function involves the input of Chinese and English names, the choice of gender and the choice of date of birth, which are difficult to complete by patients with PD (middle-aged and elderly).

For the interface design, the minimum font size of the APP in this study presented on a tablet is about 14 pt and the minimum icon is about 1 × 1 cm. Although the subjects suffered from presbyopia, they did not argue that they could not see or could not clearly see the work descriptions. As a result, visual degradation does not affect their operation of the APP. At the same time, this study used icon and text to make redundant code to guide the users, so there are few identification errors. However, the button click is not smooth. The button will the visual feedback of becoming larger and moving to the lower right corner when correctly pressed, but due to the lack of tactile feedback, the users do not know whether they click the button correctly and hence press the screen hard. Tactile degradation is a common problem with operation of tablet computers, and if necessary, may be addressed in other ways.

In addition to the aforementioned interface usability problems, the subjects also indicated that their larynx and mouth muscles did exert and exercise after task completion. Furthermore, the researchers observed that within a short term of about 15–20 min from typical task operation, the patients' voice is significantly louder and their pronunciation is clearer. These prove that the APP does help the patients to exercise their laryngeal muscles.

6 Conclusion

Speech disorders of patients with PD will deteriorate over time, and only through uninterrupted exercises can degradation be slowed down. This study is based on motor speech therapy and proposes Speech Rehabilitation APP interfaces for patients with PD. The interface usability of the APP is verified by the actual operation of two patients, and the pronunciation is significantly improved after a short-term use. In the future, it is hoped that patients with PD can continue to use the APP for independent exercises after receiving ST treatment, and should be able to reach the effect of delaying laryngeal muscle degeneration. In the future, the research team will extend the results and make use of information and communication technology and cloud computing technology to develop long-distance rehabilitation services, expecting to enhance the rehabilitation motivation and effectiveness of patients.

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