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Study on Effect of Voice Analysis Applying on Tone Training Software for Hearing Impaired People

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Abstract

According to the current oral training and necessity of the hearing impaired people, this study would develop mobile based tone training software for them. The withdrawal design (A-B-A design) of single-subject research designs has been applied for this study. The subjects of study are 4 hearing impaired university students. The software training has been applied for 3 successive days of baseline phase, 5 days of intervention phase and 3 days of maintenance phase. The result shows that: (1) the average level difference of the 4 subjects from baseline phase to intervention phase is +17.85 (subject A is +25.8%, subject B is +12.4%, subject C is +23.4%, and subject D is +9.8%). This shows that there has been positive effect to tone articulation of the 4 subjects. (2) The overlapped percentage of the 4 subjects from intervention phase to maintenance phase is 74.75% (subject A is 66%, subject B is 100%, subject C is 100%, and subject D is 33%). This shows that there has been maintenance effect for the tone articulation of the 4 subjects. (3) According to the result of the experiment, it has been verified that combining ocular feedback approach and mobile based software for oral training of the hearing impaired people have certain effects and prospects.

Keywords

Hearing Impaired People, Oral Training, Voice Analysis, Withdrawal Design

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1. Introduction

Due to the loss of hearing ability, it does not only affect the daily life, communication approach and interpersonal relationship of the hearing impaired people, but also reduces their cognition and language learning ability significantly. It may even indirectly cause frustration and diffidence of the hearing impaired people. The relevant literatures show that the oral of the hearing impaired people may be usual, including articulation, rhythm, voice and diction. Their frequency of their voice would be too high or low comparing with normal people, the inflection of tone would be over or insufficient, phonetic tone would be unclear, and oral expression has no cadence [4, 13]. Therefore, the common communication problems of hearing impaired people include unclear language expression and low competence of language.

The sound amplification of hearing aid provides the maximum remaining hearing of the hearing impaired people and helps them improving the language learning ability. However, both hearing aid and electronic ear require regular hearing test for the hearing impaired people in order to ensure the hearing aid equipment could work effectively to help the hearing impaired people. For the serious hearing impaired people, they need several times of frequency transferal comparing with normal hearing impaired people in order to recognize the pitch curve. However, most of the hearing impaired people could get benefit from the hearing aid [10].

However, there is shortcoming for the electronic ear. In the past, many literatures have pointed out that: the hearing impaired people wearing electronic ear have great defect on

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tone perception [6, 12, 15, 16]. The tone heard by the hearing impaired people wearing electronic ear is distorted. It is because the current technology of electronic ear does not include the perception of fundamental frequency [17].

Chinese belongs to tone language. Each word could have different meanings for different tones. The purpose of tone is to help the speaker speaking a sentence clearly and meaningfully. However, it is not easy for hearing impaired people speaking the 4 tone of phonetic clearly, which will affect their tone articulation and cause incomplete expression [2].

The hearing impaired people are unable receiving the complete acoustic stimulation from outside. Besides, they have no complete feedback from their own speaking and articulation. Therefore, several problems are commonly found, including vowels and consonants replacing each other, skewed error of articulation, incorrect rhythm, relatively low speaking speed, heavy nasal tone, and lack of modulation [11]. It indirectly affects the oral articulation and causes poor capability of understanding [3]. The tone problem of speaking is the major reason affecting the speaking articulation of hearing impaired people [7].

There are 14 different communication approaches with hearing impaired students from early day to nowadays, including auditory-verbal approach, and oral-ocular method. If the hearing loss level is not considered, the speaking articulation of hearing impaired people using oral and sign language has significant different. The hearing impaired people using both oral and sign language would have fair articulation of pronunciation. The hearing impaired people with oral education would have the best articulation of pronunciation. Through the intensive oral training, the oral ability of the hearing impaired people would be further improved. The method involves recognizing the voice and pronouncing it to understand the meaning [14].

For the oral training for the hearing impaired people, this study shows that most of the language therapists ignore the tone training. Most of the trainings focus on consonant and vowel. On the other hand, tone training cannot be practiced by observing the shape of the mouth. Therefore, most of the tone training remains on traditional tactile exploration and shadowing. Unfortunately, the achievement of this type of training is very limited [5].

There has been a study about the hearing impaired Thai students, for which two anime and game applications have been developed for oral training of hearing impaired students. The result shows that the 36 hearing impaired students have been improved significantly [1]. Interview with language therapists have been conducted in another study in order to get the suggestions about the design of oral training application [9].

2. Method

2.1. Subjects

The subject of study has been 4 hearing impaired university students (average age 20.5). The hearing loss level is medium or above (3 of them are serious and one of them is medium). The details and oral expression is shown in Table 1 below.

Table 1. Basic information of the subjects.

Subject	Sex	Age	Hearing Loss Level	Using Hearing Aid
Subject A	Male	22	Serious	Left ear: Electronic ear Right ear: no equipment
Subject B	Male	21	Serious	Left ear: Electronic ear Right ear: no equipment
Subject C	Female	20	Serious	Left ear: Hearing aid Right ear: Electronic ear
Subject D	Male	19	Medium	Both ears: Hearing aid

2.2. Experiment Design

The withdrawal design of single-subject research designs has been applied on this study. There have been 3 phases for this experiment: (1) in baseline phase, the subjects have been invited for experiment in 3 successive days. They have pronounced 15 two-word nouns and have been recorded. The tone articulation has been counted. (2) In intervention phase, the subjects have used the tone training software developed by this study in 5 successive days. Then the tone articulation has been counted. (3) In maintenance phase, the subjects have been invited to record and estimate the tone in 3 successive days without using the training software.

2.3. Research Tool

Some scholars applied website structure and visual approach to build the web version of Praat application. It breaks many limitation of the old standard desktop version of Pratt software. As a result, it is more convenient to apply the Praat voice analysis software [8]. The backend voice analysis technology of the tone training software developed by this study comes from the website version of Praat voice learning software.

For the software interface, as shown in Figure 1(a), the home page shows the software Logo and Begin button. As shown in Figure 1(b), slip upward to start operation and there will be an instruction about the operation. As shown in Figure 1(c), user would choose the suitable oral level to start practice. As shown in Figure 1(d), the current question number and the total question numbers are shown on the top. The questions are randomly selected from the corpus. Before the users start recording and practice, they can use the correct pronunciation button to hear the correct pronunciation first. As shown in Figure 1(e), hold the record button to start recording. The cursor at the bottom of tone graph will move automatically and user follows the instruction of the cursor to start shadowing. Leave the record button to complete recording. As shown in Figure 1(f), the system analyzes and shows the tone contour of the user, and reviews the user's tone as shown in the figure. User could press the button on the right to listen the difference of the voices. As shown in Figure 1(g), when it is the last question of this level of practice, user could press "Finish" button to leave the current practice. As shown in Figure 1(h), in the Finish page, user could press "Home" returning to home page, or press "Repeat the practice" button to repeat practicing that unit.

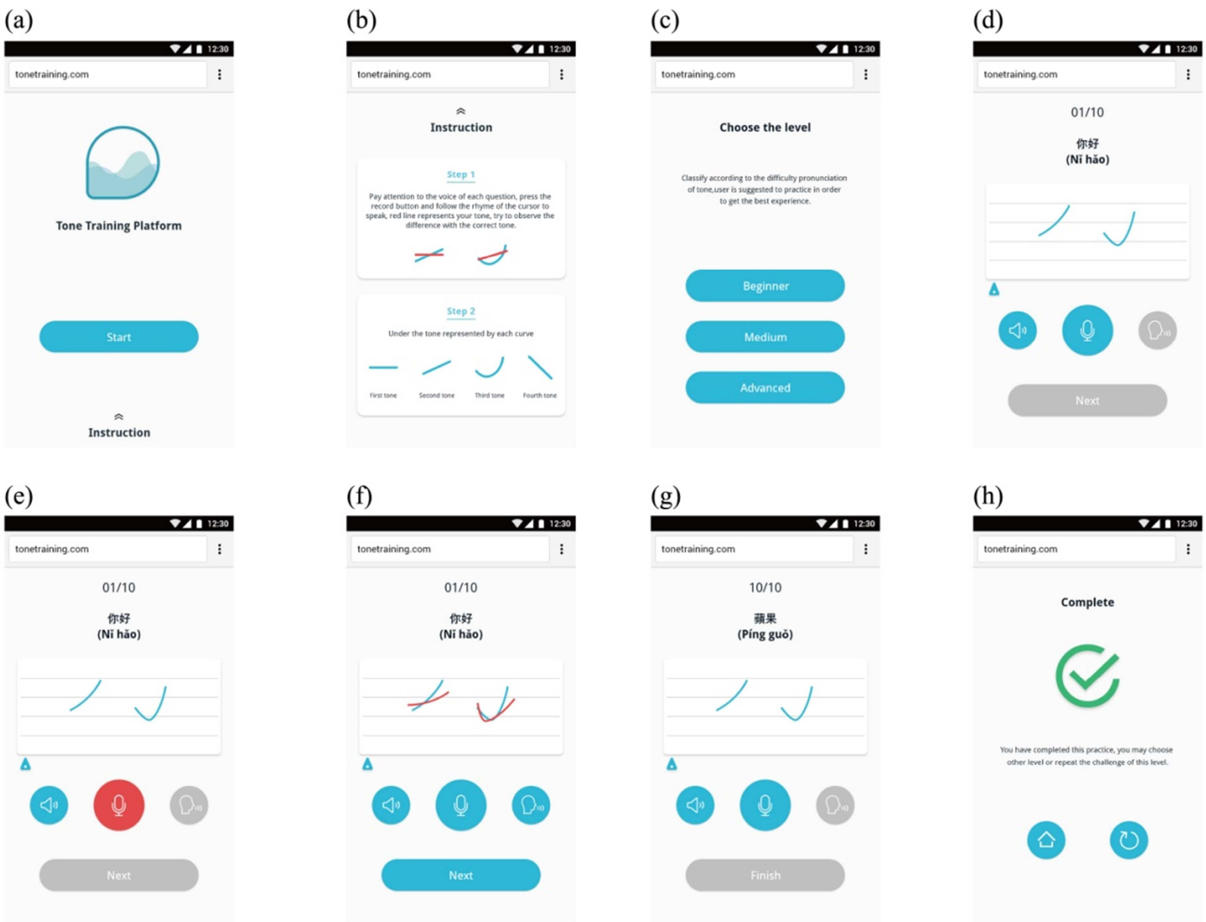

Figure 1. The software interface developed by this study.

The research tool applied in this study is "Mandarin Word Tone Assessment" edited by Chang et al. [2]. There are 15 types of word combination, including watermelon, puzzle, lighthouse, popsicle, scarf, sailboat, cliff, soap, truck, bear, grassland, caring, balloon, iron, photo.

The tone articulation has been assessed by human. The assessors are 3 postgraduate students with normal hearing. The measuring method refers to the measuring method of human ear assessing the tone articulation by Chien & Chen [4] and Chang et al. [2]. According to the numbers of test with correct pronunciation by subjects, the percentage will be calculated. Finally, the scores will be obtained by adding up and averaging.

This study has applied Pearson product-moment correlation as the internal consistency check. For the 11 times of human ear consistency check for subject A, the consistency check of scores from the 3 assessors are 0.646 ($P \leqq .05$), 0.805 ($P \leqq .01$) and 0.864 ($P \leqq .01$) respectively. This shows that the tone assessments from the 3 assessors for subject A have certain consistency. For the 11 times of human ear consistency check for subject B, the consistency check of scores from the 3 assessors are 0.878 ($P \leqq .01$), 0.921 ($P \leqq .01$) and 0.942 (P

≦.01) respectively. This shows that the tone assessments from the 3 assessors for subject B have certain consistency. For the 11 times of human ear consistency check for subject C, the consistency check of scores from the 3 assessors are 0.703 (P≦.05), 0.608 (P≦.05) and 0.856 (P≦.01) respectively. This shows that the tone assessments from the 3 assessors for subject C have certain consistency. For the 11 times of human ear consistency check for subject D, the consistency check of scores from the 3 assessors are 0.7083 (P≦.05), 0.796 (P≦.01) and 0.819 (P≦.01) respectively. This shows that the tone assessments from the 3 assessors for subject D have certain consistency.

3. Result

This study has used diagram showing the analysis of tone articulation of subjects in different phase in this experiment. Figure 2 shows the global evaluation curve of the 4 subjects. This shows the overall improvement of the 4 subjects after joining the 3 phases of experiment.

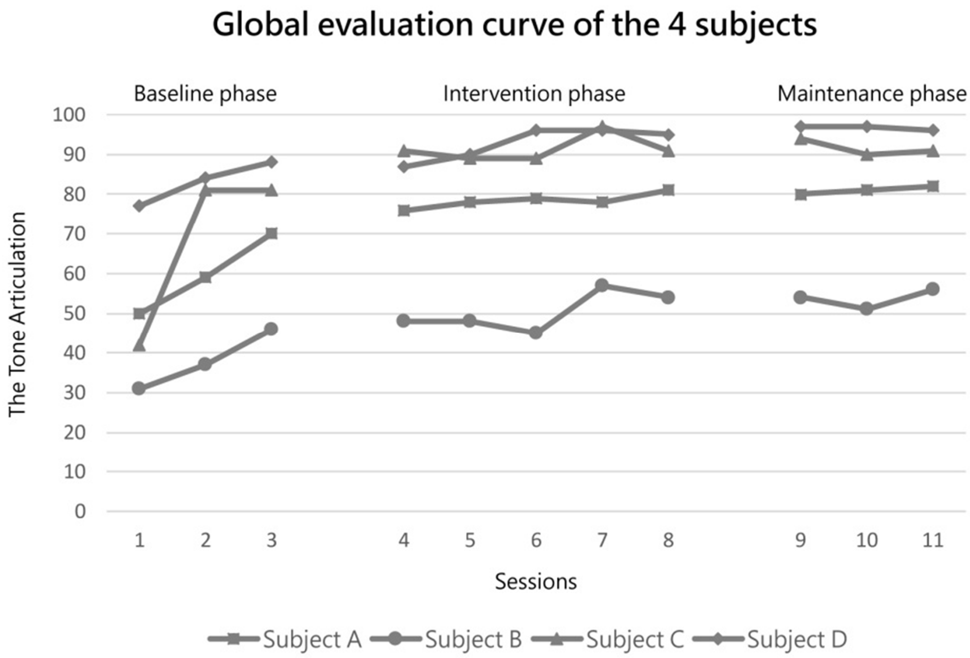

Figure 2. Global evaluation curve of the 4 subjects.

This study has applied visual analysis to analyze the tone articulation of the 4 subjects in baseline phase, intervention phase, and maintenance phase. The summary of analysis in each phase is listed below.

3.1. Analysis of Subject A in the Experimental Phases and Between the Phases

As shown in Table 2, in the baseline phase, the trend stability is stable 100%, the level stability is inconstant 33%, the level range is 50 to 70 and level change is +20. In the intervention phase, the trend stability and level stability are both stable 80%, the level range is 76 to 81 and level change is +5. In the maintenance phase, the trend stability and level stability are both stable 100%, the level range is 80 to 82 and level change is +2.

Table 2. Summary of analysis of subject A in the experimental phases.

Phase	Baseline phase	Intervention phase	Maintenance phase
Duration	3	5	3
Trend direction	/ (+)	/ (+)	- (=)
Trend stability	Stable 100%	Stable 80%	Stable 100%
Level range	50~70	76~81	80~82
Level change	70-50 (+20)	81-76 (+5)	82-80 (+2)
Average of level	59.6	85.4	81
Level stability	Inconstant 33%	Stable 80%	Stable 100%

Table 3 shows that during the baseline phase to intervention phase, the trend stability is stable to stable, the average level difference is +25.8 and the overlapped percentage is 0%. During the intervention phase to maintenance phase, the trend stability is stable to stable, the average level difference is -4.4 and the overlapped percentage is 66%.

Table 3. Summary of analysis of subject A between the experimental phases.

Phases for comparison	Baseline - intervention	Intervention - maintenance
Trend path and change of effect	/ (+) to / (+) Positive	/ (+) to - (=) Positive
Change of trend stability	Stable to stable	Stable to stable
Level change between the phases	76-70 (+6)	80-81 (-1)
Average level difference	85.4-59.6 (+25.8)	81-85.4 (-4.4)
Overlapped percentage	0%	66%

3.2. Analysis of Subject B in the Experimental Phases and Between the Phases

As shown in Table 4, in the baseline phase, the trend stability is stable 100%, the level stability is inconstant 33%, the level range is 31 to 46 and level change is +15. In the intervention phase, the trend stability and level stability are both inconstant 60%, the level range is 45 to 57 and level change is +12. In the maintenance phase, the trend stability is inconstant 66%, the level stability is stable 100%, the level range is 51 to 56 and level change is +5.

Table 4. Summary of analysis of subject B in the experimental phases.

Content	Baseline phase	Intervention phase	Maintenance phase
Duration	3	5	3
Trend direction	/ (+)	/ (+)	/ (+)
Trend stability	Stable 100%	Inconstant 60%	Inconstant 66%
Level range	31~46	45~57	51~56
Level change	46-31 (+15)	57-45 (+12)	56-51 (+5)
Average of level	38	50.4	54.6
Level stability	Inconstant 33%	Inconstant 60%	Inconstant 100%

Table 5 shows that during the baseline phase to intervention phase, the trend stability is stable to inconstant, the average level difference is +12.4 and the overlapped percentage is 20%. During the intervention phase to maintenance phase, the trend stability is inconstant to inconstant, the average level difference is +4.2 and the overlapped percentage is 100%.

Table 5. Summary of analysis of subject B between the experimental phases.

Phases for comparison	Baseline - intervention	Intervention - maintenance
Trend path and change of effect	/ (+) to / (+) Positive	/ (+) to / (+) Positive
Change of trend stability	Stable to inconstant	Inconstant to inconstant
Level change between the phases	48-46 (+2)	54-54 (+0)
Average level change	50.4-38 (+12.4)	54.6-50.4 (+4.2)
Overlapped percentage	20%	100%

3.3. Analysis of Subject C in the Experimental Phases and Between the Phases

As shown in Table 6, in the baseline phase, the trend stability is stable 100%, the level stability is inconstant 0%, the level range is 42 to 81 and level change is +39. In the intervention phase, the trend stability is inconstant 40%, the level stability is stable 60%, the level range is 89 to 97 and level change is +8. In the maintenance phase, the trend stability is inconstant 33%, the level stability is stable 100%, the level range is 90 to 94 and level change is +4.

Table 6. Summary of analysis of subject C in the experimental phases.

Content	Baseline phase	Intervention phase	Maintenance phase
Duration	3	5	3
Trend direction	/ (+)	/ (+)	\ (-)
Trend stability	Stable 100%	Inconstant 40%	Stable 33%
Level range	42~81	89~97	90~94
Level change	81-42 (+39)	97-89 (+8)	94-90 (+4)
Average level	68	91.4	91.6
Level stability	Inconstant 0%	Stable 100%	Stable 100%

Table 7 shows that during the baseline phase to intervention phase, the trend stability is stable to inconstant, the average level difference is +23.4 and the overlapped percentage is 0%. During the intervention phase to maintenance phase, the trend stability is inconstant to inconstant, the average level difference is +0.2 and the overlapped percentage is 100%.

Table 7. Summary of analysis of subject C between the experimental phases.

Phases for comparison	Baseline - intervention	Intervention - maintenance
Trend path and change of effect	/ (+) to / (+) Positive	/ (+) to \ (-) Positive
Change of trend stability	Stable to inconstant	Inconstant to inconstant
Level change between phases	91-81 (+10)	94-91 (+3)
Average level difference	91.4-68 (+23.4)	91.6-91.4 (+0.2)
Overlapped percentage	0%	100%

3.4. Summary of Analysis of Subject D in the Experimental Phases

As shown in Table 8, in the baseline phase, the trend stability and level stability is both stable 100%, the level range is 77 to 88 and level change is +11. In the intervention phase, the trend stability is stable 80%, the level stability is stable 100%, the level range is 87 to 96 and level change is +9. In the maintenance phase, the trend stability is inconstant 66%, the level stability is stable 100%, the level range is 96 to 97 and level change is +1.

Table 8. Summary of analysis of subject D in the experimental phases.

Content	Baseline phase	Intervention phase	Maintenance phase
Duration	3	5	3
Trend direction	/ (+)	/ (+)	- (=)
Trend stability	Stable 100%	Stable 80%	Inconstant 66%
Level range	77~88	87~96	96~97
Level change	88-77 (+11)	96-87 (+9)	97-96 (+1)
Average level	83	92.8	96.6
Level stability	Stable 100%	Stable 100%	Stable 100%

Table 9 shows that during the baseline phase to intervention phase, the trend stability is stable to stable, the average level difference is +9.8 and the overlapped percentage is 20%. During the intervention phase to maintenance phase, the trend stability is stable to inconstant, the average level difference is +3.8 and the overlapped percentage is 33%.

Table 9. Summary of analysis of subject D between the experimental phases.

Phases for comparison	Baseline - intervention	Intervention - maintenance
Trend path and change of effect	/ (+) to / (+) Positive	/ (+) to - (=) Positive
Change of trend stability	Stable to stable	Stable to stable
Level change between phases	87-88 (-1)	97-95 (+2)
Average level difference	92.8-83 (+9.8)	96.6-92.8 (+3.8)
Overlapped percentage	20%	33%

4. Discussion

This study has involved visual feedback of oral training combing with existing oral analysis technology to develop mobile based tone training software. Hearing impaired people have been invited in the experiment in order to explore the actual performance of the tone training software for hearing impaired people. The objective of this study is: applying withdrawal design (A-B-A design) of single-subject research designs and inviting hearing impaired joining the experiment in order to understand the training performance of this software. Besides, further discussion would be proposed according to the results.

With the rapid development of technology, it brings new innovation and change to disabled, and significantly improves their education and life. This study believes that the mobile based software or new products as the auxiliary or teaching tools for hearing impaired or visually impaired people would become the trend. This study provides mobile based software combining with existing voice technology applying on oral training of hearing impaired people. It could be considered extending to other oral training models for hearing impaired people such as articulation and articulation of pronunciation, and they are valuable for scholars to explore and study in the future.

5. Conclusion

According to the analysis above, after applying the tone training software developed by this study during the intervention phase, the tone articulation of the four subjects are higher than those in baseline phase. This shows that after applying the tone training by this software, the tone articulation of the four subjects could be improved immediately. By applying ocular feedback in tone training, it is proved that the tone articulation could be improved significantly. After removing the software and entering the maintenance phase, the tone articulation of the 4 subjects could maintain almost the same result as intervention phase. This also shows that this software could help the 4 subjects keeping the good maintenance effect of tone articulation.

The contributions of this study include: (1) this study has attempted understanding the existing oral training situation and the necessity for hearing impaired people, and has actually designed and developed the software. (2) Through the actual experiment, the software has been verified to improve the tone articulation of the 4 subjects significantly. Besides, the maintenance of tone articulation is good. This shows that the software applying ocular feedback in tone training for oral training of hearing impaired people is workable and extensible.

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