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Electrocardiographic Anxiety Profiles Improve Speech Anxiety

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Abstract The present study was to set out in efforts to determine the effect of electrocardiographic (ECG) feedback on the performance in speech anxiety. Forty-six high school students participated in a speech performance educational program. They were randomly divided into two groups, an experimental group with ECG feedback (N = 21) and a control group (N = 25). Feedback was given with video recording in the control, whereas in the experimental group, an additional ECG feedback was provided. Speech performance was evaluated by the Korean Broadcasting System (KBS) speech ability test, which determines the 10 different speaking categories. ECG was recorded during rest and speech, together with a video recording of the speech performance. Changes in R–R intervals were used to reflect anxiety profiles. Three trials were performed for 3-week program. Results showed that the subjects with ECG feedback revealed a significant improvement in speech performance and anxiety states, which compared to those in the control group. These findings suggest that visualization of the anxiety profile feedback with ECG can be a better cognitive therapeutic strategy in speech anxiety.

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Introduction

Speech anxiety is the fear of public speaking. It commonly presents in delivering a speech that leads to interfere with social communication. Speech anxiety has been investigated in the field of communication and psychology. In language education, assessment of the anxiety state and developing a new strategy to overcome such state has been the primary focus. However, because anxiety can affect speech performance, other academic fields have also participated in treating speech anxiety (Daly et al. 2009; Pull 2012). For example, anxiety that is caused by the negative experience-trait anxiety is managed by consultation psychology. State anxiety, which is caused by similar circumstance with uncomfortable memory, can be approached by a different field.

In educational aspect, known strategies from the fields of psychology or communication are limited. Even in the educational program, current etiologies and strategies (Table 1) do not provide a satisfactory solution to cope with speech anxiety (Ministry of education, Science and technology 2009). Phenomenon of speech anxiety is different from reducing the anxiety. It is not caused by lack of insight, but from inability to perform despite knowing what needs to be spoken. ‘Practice the speech as many times as possible with positive self-suggestion’ may no longer be a specific strategy. Although there exist methods to which speech anxiety is assessed, including the observation, self-report and measurement of biofeedback, or interview (Kim 1995), overcoming speech anxiety requires further modalities.

Table 1 Etiologies and strategies of speech anxiety

Etiologies	① Lack of confidence or preparation of speech content
	② Phobia to public audience
	③ Loss of self conception or esteem
	④ Little experience in public speech
	⑤ Lack of familiarity with the environment or with the audience
Strategies	① Accept the speech anxiety as a natural phenomenon
	② Analysis of speech anxiety by oneself
	③ Perfect preparation and practice
	④ Relieve the tension in the body
	⑤ Positive self-suggestion to recover from speech anxiety

Ministry of education, Science and technology (2009)

Bio-signals, such as an electroencephalogram, electrocardiography, or blood pressure monitoring, can reflect objective values in the individuals. Most bio-signals have been extensively investigated in medicine, physiology or engineering. However, lack of collaborative efforts on bio-signals analysis and feedback strategies limit us to gain the biological information on speech anxiety.

Anxiety is associated with physiological changes, such as an increase of heart rate, perspiration, muscle tension, or rapid respiration (Barlow 2001). Anxiety increases sympathetic discharge in the nervous system. Increased blood supply to the heart relatively decreases the blood flow in the digestive system, which results in diarrhea or constipation (Fox 2008). Since speech anxiety also influences the autonomic nervous system with physiological responses, it enables 'speech anxiety' that expresses bio-signals, which reflects the degree of anxiety. An electrocardiogram (ECG) records periodic electrical activities of the heart. Clinically, wave abnormalities are frequently used to elucidate cardiac dysfunction, such as a depressed 'ST segment' in patients with angina (Garcia and Holtz 2003). Variabilities of R–R intervals have been used to provide heart rate, thus, subsequently interpreting the autonomic nervous system during the anxiety status (Sinji 2004; Yang et al. 2009; Jang et al. 2010).

The purpose of this present study is to investigate whether the monitoring of R–R intervals can be a potential therapeutic strategy. We hypothesized that the group provided with ECG feedback will show a significant improvement. We attempted to monitor the real time measurement of the R–R intervals, with video recording during speech. As a feedback, R–R interval-based anxiety profiles were provided together with speech performance.

Methods

Subjects

They were 46 high school students and all of them were men. There were more male students with speech anxiety than that of female students in Korea. The main reason of the subjects being only male students was to attempt to exclude the possible bias due to sexual differences. Recruited subjects were volunteers for a 3-week speech educational program. This procedure was performed between May 17 and June 10 of 2011. All the subjects were able to understand and follow the instructions. They were allowed to stop or continue the project, during this program. For the positive control, announcers during training course (N = 6) were also participated to visualize ECG anxiety profiles.

Experimental Protocol

The subjects were divided into two groups. One group was provided with the speech performance test from Korean Broadcasting System (KBS) (Kim 2010) with a video (N = 25). The other group received an additional anxiety profile from ECG monitoring (N = 21). The difference in the sample size was due to randomization. Following the baseline evaluation with KBS speech performance test and ECG, three performances and feedbacks were given, during

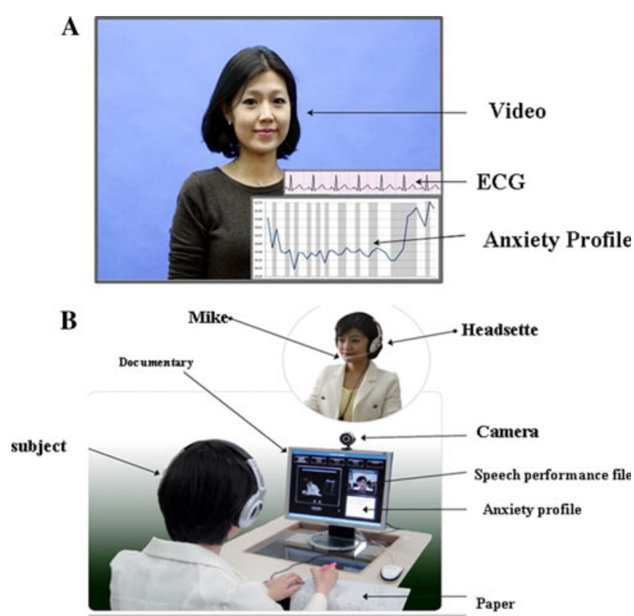

Fig. 1 Computer based test (CBT) and ECG anxiety profiles on the screen. **a** Speech anxiety profiles were shown on the screen that the subject can recognize the anxiety part in detail. **b** Experimental setting for CBT. The instructions and speech performance were done by computerized system. (written permission from the subject)

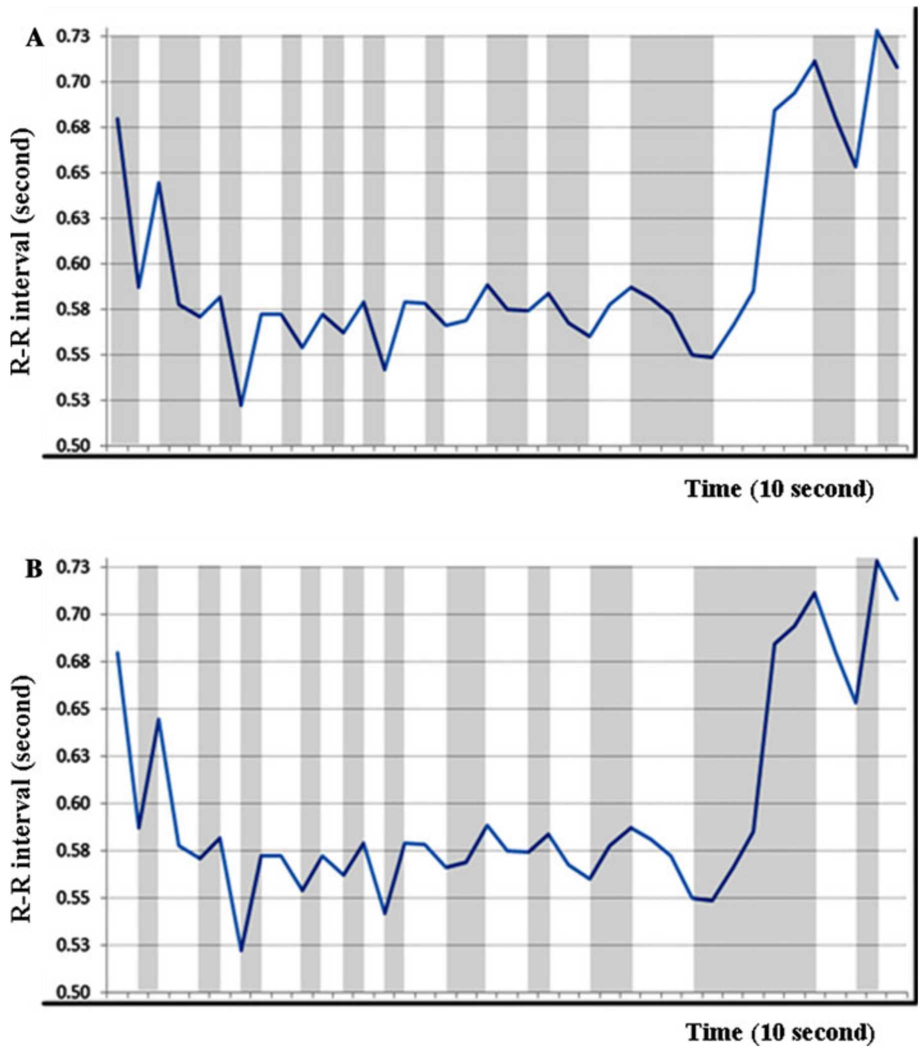

Fig. 2 Changes in R–R intervals. **a** The *gray zone* indicated the area with anxiety, where the speech performance was decreased. R–R interval is shortened reflecting an increased heart rate. **b** The *gray zone* in this graph reveals the increased R–R interval with a decreased heart rate

the 3-week program. To avoid bias from the appearance or voice of the instructor, instruction and feedbacks were provided by one researcher who was unaware of the hypothesis, wearing the same costumes with similar voice and tone. For the control group, feedback was given by the video recording of the previous speech performance. In the experimental group, anxiety profiles by ECG were displayed simultaneously on the screen (Fig. 1a). Protocols for the procedure were in compliance with guidelines and were approved by the institutional review committee of NECA (National Evidence-based Healthcare Collaborating Agency). All of the subjects participated voluntarily and written consent forms were received from their parents.

Speech Performance Test

The subject viewed a 10-min documentary, and was asked to summarize the content as a three-minuet speech. The data on speech performance was expressed by the KBS speech performance score. KBS speech evaluation is comprised of two testing components, 'contents' and 'expressions' with 10 categories (five categories respectively). In brief, for the evaluation of contents, 'impressive introduction', 'understandable explanation', 'emphasis on the important point,' 'organized content' and 'effective summary' were scored. For the expression ability, 'appropriateness of semi-verbal language', 'adequate selection of words and grammar', 'fluency', 'proper use of non-verbal language' and 'effective time arrangement' were included. Each category was assessed by scores ranging from 1 to 5 points, and a higher score, indicated a better performance. Assessment of score was performed by the trained personnel in KBS, who was not aware of the experimental protocols. For the performance rating, multiple raters were involved for the agreement of the assessment. There were three to nine raters for each subscale. The averaged scores were used from the raters. The experimental procedure was done with a computer based test (CBT) method (Fig. 1b). The speech performance was recorded, reviewed, and given a score with feedback.

ECG Analysis and Anxiety Profiles

For ECG analysis, the QECG-3 (Quantitative electrocardiography-three limb lead, LXC3203, Daejeon, Korea) model was used. Standard three limb leads (lead I, lead II, lead III) were applied, according to the manufacture's recommendation. The ECG electrode sensors were attached to the subjects at the resting state in a sitting position. Real time values of R–R intervals were monitored and displayed. The anxiety score was represented by the mean values of the R–R interval. Shortening of the R–R interval was interpreted as activation of sympathetic activity, which indicated greater levels of anxiety (Fig. 2a). In contrast, a longer R–R interval represents the decreased activation of sympathetic activity, reflecting a lesser degree of anxiety (Fig. 2b).

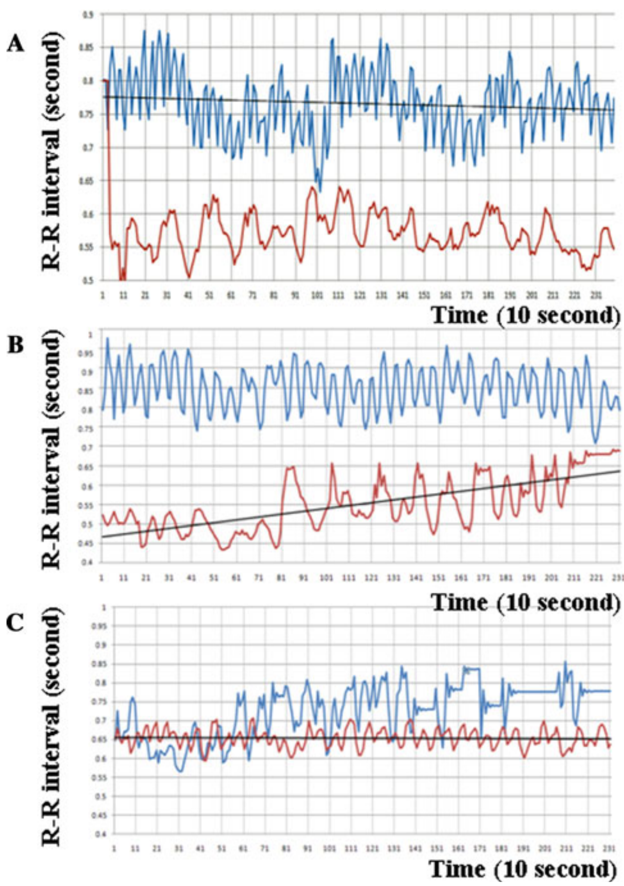

Fig. 3 Representative profiles of speech anxiety during test performance. **a** Subject with poor performance, due to severe speech anxiety. *Blue line* is the R–R intervals of resting state. *Red line* is the R–R intervals during speech. It shows that R–R intervals were shortened immediately after speaking. However, shortened R-R intervals do not increase until the end of recording. It suggests that anxiety is not relieved during this testing period. **b** The graph of normal subject shows that the R–R intervals were gradually increased to the point of resting state. **c** A graph from well-trained announcer. R–R interval differences are not detected between the rest and the speech performance, suggesting they do not have the increased level of anxiety during delivering the speech

Data Analysis

The baseline characteristics in the control and the experimental groups were performed by an independent t test. Statistical analysis on the effects of feedback was determined by comparing the groups before and after the performance, by repeated measures ANOVA. Cohen's effect size evaluation was performed to reveal the fold increase in the R–R interval. For the further analysis of each category, they were compared by repeated measures ANOVA. The values were presented as mean ± standard deviation. A P value below of 0.05 was considered to be statistically significant.

Results

The R–R Interval and Anxiety

There were changes in ECG between the rest and the speech. Following the resting state, we observed a shortening of R–R intervals during speech (Fig. 2).

The R–R intervals of a subject with severe speech anxiety showed a difference between the resting state and the speech state. This difference did not change, thus, there was no overlap between times until the end of the test (Fig. 3a). In case of a fluent and a well-trained announcer, a positive control, showed the overlapping of R–R intervals, indicating that R–R intervals, during rest and speech, were not different (Fig. 3c). Most subjects showed an initial separation of the R–R intervals, which was then subsequently overlapped as the speech was continued (Fig. 3b).

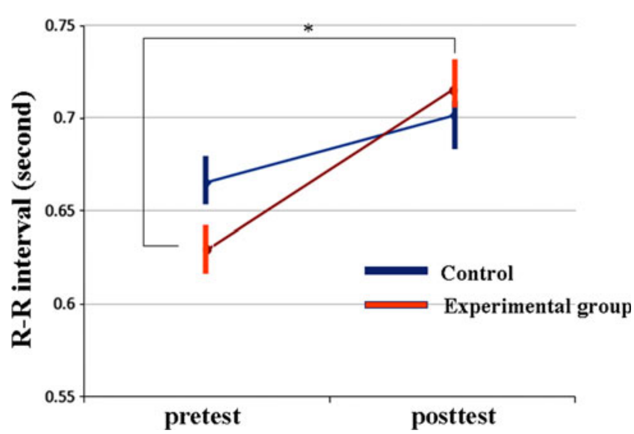

Fig. 4 R–R intervals (ECG anxiety profiles) and speech performance. Pre- and post-training evaluation of the feedback trial showed significant improvement in the experimental group. The control group with repetitive tests also shows an improving tendency, although it does not reach statistical significance. It indicates that ECG feedback is more effective in reducing speech anxiety than that of video-alone in control

Table 2 R–R intervals following the ECG anxiety profile feedback trial

Variables	Category	Experimental group (N = 21) Mean (SD)	Control group (N = 25) Mean (SD)	Source	F	P
R–R intervals	Pretest	0.629 (0.081)	0.665 (0.112)	Group	0.214	0.646
	Post-test	0.715 (0.112)	0.701 (0.098)	Time	10.678	0.002*
				Group × Time	1.812	0.185

* $P < 0.05$, *SD* standard deviation

Table 3 Speech evaluation list of pretest homogeneity

Evaluation area	Experimental group (N = 21) M (SD)	Control group (N = 25) M (SD)	t	P
1. Impressive introduction	3.174 (0.392)	3.001 (0.186)	1.964	0.057
2. Understandable explanation	3.449 (0.443)	3.252 (0.454)	1.479	0.146
3. Emphasis on the important point	3.087 (0.345)	2.986 (0.420)	0.894	0.376
4. Organized content	3.413 (0.429)	3.263 (0.446)	1.154	0.255
5. Effective summary	2.557 (0.640)	2.673 (0.571)	−0.644	0.523
6. of semi-verbal language expression	3.582 (0.656)	3.351 (0.481)	1.341	0.187
7. Adequate selection of words and grammar	3.290 (0.470)	3.259 (0.388)	0.243	0.809
8. Fluency	3.192 (0.671)	2.976 (0.616)	1.124	0.267
9. Proper use of non-verbal language	2.995 (0.753)	2.695 (0.753)	1.345	0.186
10. Effective arrangement of time	3.329 (0.635)	3.150 (0.655)	0.937	0.354

M (*SD*) mean (standard deviation)

Table 4 Speech performance following the ECG anxiety profile feedback trial

Variables	Category	Experimental group (N = 21) Mean (SD)	Control group (N = 25) Mean (SD)	Source	F	P
KBS speech test (total score)	Pretest	30.657 (3.651)	32.148 (3.337)	Group	2.945	0.093
	Post-test	56.0129 (6.859)	59.593 (6.193)	Time	3457.038	0.000***
				Group × Time	5.414	0.025*

* $P < 0.05$, *** $P < 0.001$, *SD* standard deviation

The Changes in Speech Anxiety with ECG Profiles

To evaluate the effect of feedback by the speech anxiety profile, mean values of the R–R interval were analyzed. During rest, mean R–R interval for the control group was 0.785 ± 0.102 s and 0.722 ± 0.130 s for the experimental group ($t = 1.810$; $P = 0.077$). Before the speech, the R–R intervals were 0.665 ± 0.112 s (mean ± standard deviation) for the control and 0.629 ± 0.081 s for the experimental group, which indicated that there was no difference (independent t test; $t = 1.263$, $P = 0.213$). Following the three-week feedback trials, the mean value of experimental group showed to be 0.629 to 0.715, a 0.086 increment (Fig. 4), whereas the control group revealed the mean value of R–R intervals to be increased from 0.665 to 0.701, an increment of 0.036. Repeated measures ANOVA showed that the R–R intervals of 'within-subject effects' showed to be significantly different ($F = 10.678$, $P = 0.002$). However, between-subject effects ($F = 0.214$, $P = 0.646$) and interactions between the two types of effects were found to be not significant ($F = 1.812$, $P = 0.185$) (Table 2). Cohen's effect size between the experimental group and the control group revealed a post-test value of 0.133, indicating a onefold increase, whereas that of the pretest was −0.368, with mean treatment effect size of 0.501.[1]

[1] Effect size estimated on the equation of m1 − m2/Sp, where m1 was mean of the experimental group, m2 was the mean of control group, and Sp was the pooled standard deviation. Cohen described small, medium, and large effect sizes as 0.2, 0.5, and 0.8 respectively.

Table 5 Improved categories of speech performance following the ECG anxiety profile feedback trial

Variables (scales)	Categories	Experimental group (N = 21) Mean (SD)	Control group (N = 25) Mean (SD)	Source	*F*	*P*
1. Impressive introduction	Pretest	3.001 (0.186)	3.174 (0.392)	Group	7.828	0.008**
	Post-test	2.990 (0.119)	3.192 (0.387)	Time	0.003	0.954
				Group × Time	0.053	0.820
2. Understandable explanation	Pretest	3.252 (0.454)	3.449 (0.443)	Group	3.701	0.061
	Post-test	3.246 (0.380)	3.434 (0.450)	Time	0.018	0.893
				Group × Time	0.003	0.958
3. Emphasis on the important point	Pretest	2.986 (0.420)	3.087 (0.345)	Group	1.429	0.238
	Post-test	2.989 (0.380)	3.080 (0.355)	Time	0.001	0.975
				Group × Time	0.005	0.946
4. Organized content	Pretest	3.263 (0.446)	3.413 (0.429)	Group	1.311	0.258
	Post-test	3.329 (0.470)	3.415 (0.428)	Time	0.174	0.678
				Group × Time	0.151	0.700
5. Effective summary	Pretest	2.673 (0.571)	2.557 (0.640)	Group	3.056	0.087
	Post-test	3.514 (0.319)	3.282 (0.398)	Time	50.056	0.000***
				Group × Time	0.271	0.605
6. Appropriateness of semi-verbal language expression	Pretest	3.351 (0.481)	3.582 (0.656)	Group	3.766	0.059
	Post-test	3.632 (0.346)	3.868 (0.402)	Time	12.169	0.001**
				Group × Time	0.001	0.976
7. Adequate selection of words and grammar	Pretest	3.259 (0.388)	3.290 (0.470)	Group	0.105	0.747
	Post-test	3.258 (0.399)	3.295 (0.469)	Time	0.001	0.982
				Group × Time	0.002	0.967
8. Fluency	Pretest	2.976 (0.616)	3.192 (0.671)	Group	2.519	0.120
	Post-test	2.908 (0.491)	3.179 (0.682)	Time	0.150	0.701
				Group × Time	0.072	0.790
9. Proper use of non-verbal language	Pretest	2.695 (0.753)	2.995 (0.753)	Group	55.693	0.000***
	Post-test	3.896 (0.350)	3.520 (0.392)	Time	8.563	0.005**
				Group × Time	0.084	0.774
10. Effective arrangement of time	Pretest	3.150 (0.655)	3.329 (0.635)	Group	0.802	0.375
	Post-test	3.227 (0.670)	3.304 (0.645)	Time	0.040	0.842
				Group × Time	0.156	0.695

** $P<0.01$, *** $P<0.001$

Changes in Speech Ability by ECG Anxiety Profiles

Before feedback, in 'impressive introduction' subscale, the control group seemed to show a trend of high performance ($t = 1.964$, $P = 0.057$). There was no significant difference in all the categories between the two groups, on KBS speech test (Table 3). Following with ECG anxiety profiles, total score of KBS speech test showed a better performance. In order to test the difference between 'pre-' and 'post-test,' both in the control and the experimental groups, repeated measures ANOVA showed (Table 4) a significant improvement in the 'within-subject effects' ($F = 3457.038$, $P = 0.000$). Although 'between-subject effects' was not significant ($F = 2.945$, $P = 0.093$), while the interactions between the two types of effects were found to be significant ($F = 5.414$, $P = 0.025$). Thus, this indicates that speech performance was significantly improved in the subjects of the experimental group.

In the subscale analysis of KBS speech test (Table 5), 'effective summarizing ability' ($F = 50.056$, $P = 0.000$), 'semi-verbal expression ability' ($F = 12.169$, $P = 0.001$), and 'non-verbal expression ability' ($F = 8.563$, $P = 0.005$) showed a difference 'within-subject effects' in the experimental group, with significance. In addition, 'non-verbal expression ability' also revealed a degree of significance in the 'between-subject effects,' implying that improvement of speech performance is more effective in the experimental condition.

Discussion

Present study was to investigate whether the ECG feedback can be applied as a potential therapeutic strategy in speech anxiety. Monitoring of the real time measurement of ECG and providing the R–R intervals, as a feedback, showed a better outcome in speech performance.

ECG provides a time dependant electrophysiological factors. Since it determines the variable degree of speech anxiety by R–R intervals, it would be of benefit to detect the time point when the subject was delivering the speech. This technique has advantages over the measurement by the speech anxiety spectrum or times series analysis. The difference of this study, when comparing to that of the previous biofeedback program, is that it provided visualization process, which used ECG recording. Therefore, the changes in the R–R intervals enabled the subjects to monitor their anxiety profiles. Whereas, previously proposed strategies are 'as many practice sessions or trials as possible' or 'increase one's self confidence', and this study provided objective bio-signals that allowed the participants to self-monitor the anxiety state. Visualization of anxiety profiles, which used medical information, provides an educational significance as one of cognitive strategy. Therefore, recognition of bio-signals and experience of the recovery point are more effective when compared to that of the previous video biofeedback program.

In this study, speech performance was improved to be determined by the total score of speech test. However, it did not mean that all the categories of speech showed a better performance. Further analysis showed that 'effective summarizing ability', 'semi-verbal expression', and 'non-verbal expression ability' were effective. In particular, non-verbal expression ability was the most effective with this method of speech anxiety profiling. There does not seem to be a difference between 'contents' and 'expression'.

However, there are limitations that this study did not take into account. We attempted to start this program with a group of high school students. All of them were men and had the same age of 17 years. As an initial study to test this strategy, it might be reasonable to know the feasibility in a homogenously educated group. However, effectiveness of this technique on other age populations or gender was not determined. Further expansion of study into women and to other age groups is also warranted. The other possibility to account for the improvement can be that repeated trial itself may result in improvement. In this study, feedback with video alone, which is commonly used for the treatment of speech anxiety, also showed a trend of improvement, although it was not significant. Therefore, a better performance in the experimental group cannot be explained by the repetition itself. Instead, exploring the most optimal number of trials also needs to be determined. In addition, how long the effect can be maintained will be addressed as well. Further follow-up study is necessary to answer this question.

In conclusion, speech anxiety can affect the speech performance and the associated anxiety can be presented by the ECG bio-signal, R–R interval. Analysis and the use of R–R interval, as anxiety profile and visualization, enable cognitive strategies to cope with speech anxiety.

References

Barlow, D. H. (2001). Anxiety and its disorders: The nature and treatment of anxiety and panic (2nd ed.). NY: Guilford Press. Retrieved Mar 15th, 2012 http://www.amazon.com/s/ref=nb_sb_noss/179-6685015-4768427?url=search-alias%3Daps&field-keywords=Anxiety+and+its+disorders%3A+The+nature+and+treatment+of+anxiety+and+panic+

Daly, J. A., McCroskey, J. C., & Ayres, J. (2009). Avoiding communication: Shyness, reticence, and communication apprehension, Hampton Press. Retrieved Mar 15th, 2012 http://www.amazon.com/Avoiding-Communication-Shyness-Reticence-Apprehension/dp/1572736895/ref=sr_1_1?ie=UTF8&qid=1331479854&sr=8-1.

Fox, S. I. (2008). Human physiology (10th ed.). (trans: Park, I. K. (2008). Life science).

Garcia, T. B., & Holtz, N. E. (2003). Introduction to 12-lead ECG: The art of interpretation, translated by Professor association of Korean Emergency rescue (2009). Gun-ja press. Retrieved December 1st, 2011 from http://books.google.co.kr/books?hl=ko&lr=&id=d4e54Ya0OxUC&oi=fnd&pg=PT30&dq=Introduction+to+12-lead+ECG+:+the+art+of+interpretation&ots=qg_ok6uXba&sig=OAW4E9RtcWeLJTUyL-N6NdS4j9U#v=onepage&q&f=false.

Jang, J. Y., Cho, S. Y., Kim, S. J., Kim, Y. S., & Nam, S. S. (2010). The effect of laser acupuncture at HT(7) (Sinmun) for mental stress on short-term analysis of heart rate variability. *Journal of Korean Acupuncture and Moxibustion Society, 27*(5), 51–58.

Kim, G. H. (1995). Consultation psychology. Hakjisa. (1st ed.) (2nd ed: 2001), p. 534. Retrieved December 1st, 2011 from http://books.google.co.kr/books/about/%EC%83%81%EB%8B%B4%EC%8B%AC%EB%A6%AC%ED%95%99_%EC%97%B0%EA%B5%AC.html?id=1mssMgAACAAJ&redir_esc=y.

Kim, P. W. (2010). A study on the analysis model of speaking evaluation. Seoul National University, Doctoral thesis. Retrieved December 1st, 2011 from http://m.riss.kr/search/detail/DetailView.do?p_mat_type=be54d9b8bc7cdb09&control_no=f6704247316b4b34ffe0bdc3ef48d419.

Ministry of education, Science and technology. (2009). Explanation of Korean language education in high school. Ministry of education, Science and technology, pp. 79–81. Retrieved December 1st, 2011 from http://classroom.re.kr/2011/view.jsp?mcode=211011, http://www.kice.re.kr/ko/board/view.do?article_id=64483&menu_id=10135.

Pull, C. B. (2012). Current status of knowledge on public-speaking anxiety. *Current Opinions in Psychiatry, 25*(1), 32–38.

Sinji, M. (2004). Comfortable engineering. (trans: Min., B. C.) Sigma press. Retrieved December 1st, 2011 from http://www.aladin.co.kr/shop/wproduct.aspx?isbn=8984451037.

Yang, H. K., Lee, J. W., Lee, Y. J., Kim, K. S., Lee, K. H., & Choi, H. J. (2009). HRV evaluation under stress condition by using patch type bipolar heart activity monitoring system. *Journal of Korean Society for Emotion and Sensibility, 12*(2), 161–168.