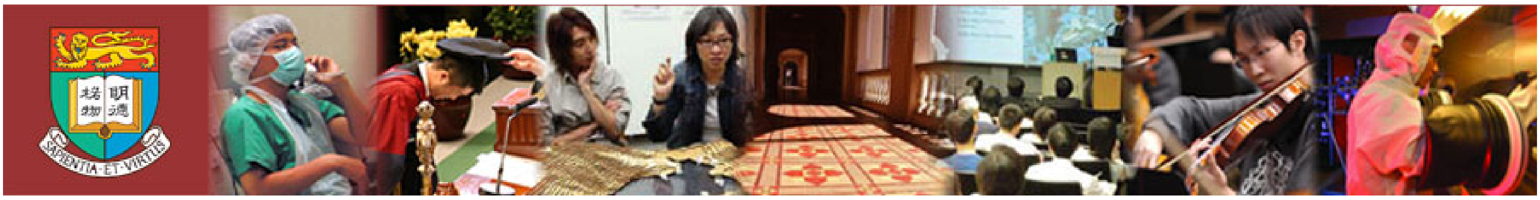

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Effects of practice variability on learning of relaxed phonation in vocally hyperfunctional speakers

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Abstract

This study investigated the effects of practice variability on learning of relaxed phonation using a motor learning perspective. Twenty-one dysphonic patients were evenly and randomly assigned to three groups of practice conditions: constant, blocked, and random practice conditions. During training, participants in constant practice condition were asked to read aloud sentence stimuli with four Chinese Characters. Participants in the blocked practice condition were asked to read aloud sentences with increasing sentence length, starting from sets of two characters to five characters. Participants in the random practice condition were asked to practise reading sentence stimuli of variable length presented in a random fashion. Results demonstrated that for all participants, motor learning was evidenced by the decreased sEMG levels in delayed retention test. Generalization to untrained paragraph was shown as well. However, results did not reveal any difference in learning between practice conditions. These findings contradicted the hypothesis of contextual interference, which states that practice using variable items presented in a random mode is more beneficial to learning than practice using constant items.

Keywords: Practice variability, voice motor learning, dysphonia, contextual interference, delayed retention

Hyperfunctional voice disorders can be characterized by the use of excessive laryngeal muscle tension during phonation (Freeman & Fawcus, 2001). A common voice therapy approach to hyperfunctional dysphonia is the use of relaxed phonation therapy, which aims at releasing excessive laryngeal tensions during phonation (Colton, Casper, & Leonard, 2006). During relaxed phonation therapy, motor control of muscles is involved as dysphonic individuals learn new skills in adjusting and coordinating their phonatory organs so that they can phonate effectively with minimal effort (Boone, MaFarlane, & Von Berg, 1999).

Motor learning is defined as “a set of processes associated with practice or experience leading to relatively permanent changes in the capability for movement” (Schmidt & Lee, 1999, pp. 264). Therefore, learning should be assessed using long-term follow-up tests rather than short-term tests during training sessions. Long-term follow-up performance can be evaluated using retention tests and generalization transfer tests with novel, untrained stimuli.

The literature has documented different learning parameters that can affect how individuals learn a motor skill. One parameter is practice variability. It refers to the movement variety and context characteristics the learner experiences when practising a motor skill (Magill, 1998). It is argued that practising a motor skill in various ways can provide learners with a wider range of movement experiences (Rose, 1997). Three practice conditions have been proposed in the literature. They are constant, blocked and random practice. Constant practice involves practising a skill under one condition (Schmidt & Wrisberg, 2000). Blocked practice involves practising a skill under different conditions and the conditions are arranged in a fixed sequence (Rose, 1997). Random practice involves practising a skill under different conditions and the conditions are arranged in a random order (Schmidt & Wrisberg, 2000).

Contextual interference has been used to explain practice variability and motor learning. Contextual interference refers to the disruption effects that the context of a task has on its performance and learning. Practice under conditions with high contextual interference (as in random practice condition) results in higher retention and transfer performance than practice under conditions with low contextual interference (as in constant practice condition). Currently, there are two hypotheses proposed to account for this effect: Elaboration Hypothesis and Forgetting and Reconstruction Hypothesis. Shea and Morgan (1979) first put forward the Elaboration Hypothesis. It illustrates that random practice condition provides learner with opportunities to compare and contrast the variations of the motor learning skills (which are arranged in a random fashion) during practice. This facilitates the learner to develop richer mental representations of the motor skills and establish more distinct memories following random practice condition than that in constant and blocked practice conditions. As a result, the comparison process during random practice conditions promotes retention and transfer. On the contrary, constant and blocked practice conditions allow individuals to bypass the comparison process and produce separate tasks automatically due to the repetitive nature of the task (Schmidt & Wrisberg, 2000). Therefore, better performance of motor skills during acquisition phase in constant and blocked practice conditions would be observed. Yet, retention and transfer tests that require individuals to undergo more comparison fail to show such improvement.

Lee and Magill (1985) proposed another hypothesis called the Forgetting and Reconstruction Hypothesis to explain practice variability. This hypothesis states that a learner is required to temporarily forget the previous motor trial from the working memory, so that the following trials can be planned effectively. Thus, being able to remember the previous motor learning skills in blocked practice condition promotes good performance in acquisition, but degrades the forgetting processes that facilitates learning in retention and transfer. In contrast, random practice condition contributes forgetting, which is detrimental to acquisition performance but facilitates retention and transfer.

In the field of sport sciences, there have been some studies carried out to investigate the effects of contextual interference on motor learning. Shea and Morgan (1979) compared learning of basketball free throw between blocked and random practice conditions. Their results showed that subjects who underwent blocked practice condition performed better than those who underwent random practice. However, subjects who practised using random practice conditions showed superior performance during retention and transfer sessions. In the area of communication disorders, Knock and colleagues (2000) found that random practice conditions facilitated relearning of speech production skills in individuals with acquired apraxia of speech than blocked practice conditions. Recently, attempts have also been carried out to investigate how contextual interference affects motor learning in the voice area. Yu (2005) studied how practice variability contributed to motor learning of relaxed phonation in 20 vocally healthy subjects. Her study did not reveal any significant effects of practice variability. It would be interesting to further investigate whether her findings would be generalized to voice-disordered individuals.

In the present study, surface electromyography (sEMG) was used to provide augmented visual feedback for dysphonic individuals in the relaxed phonation therapy. Previous studies have demonstrated the use of sEMG in voice training to help dysphonic individuals reduce muscle tension. Stemple and his colleagues (1980) demonstrated that individuals with vocal nodules could significantly reduce their laryngeal tension levels in eight sessions of sEMG biofeedback training. Andrews and colleagues were also able to demonstrate the success of using sEMG as visual feedback to treat hyperfunctional dysphonia (Andrews, Warner, & Stewart, 1986a, 1986b). Similar success was reported in a case study by Allen, Bernstein and Chait (1991), who used visual sEMG as a biofeedback training tool to help a young boy with hyperfunctional dysphonia and vocal nodules to reduce laryngeal muscle tension. They found significant reduction in the laryngeal tension level and the treatment also resulted in the elimination of the vocal nodules.

The aim of the present study was to investigate the effects of practice variability on the learning of relaxed phonation in individuals with hyperfunctional dysphonia. It was hypothesized that the participants receiving random practice condition would demonstrate the best motor learning on relaxed phonation when compared with participants receiving blocked and also constant practice conditions. Besides, participants from the blocked practice group would have better learning on vocal relaxation than the constant practice group.

Methods

Participants

Twenty-one dysphonic individuals (18 females and 3 males) (mean age = 26.71 years, SD = 8.50, range = 19 – 48 years) were recruited from The University of Hong Kong and the general public to participate in this study. All participants 1) were aged between 20 and 50 years old to minimize the effects of puberty (under age 20) and aging (over age 50) voices, 2) could speak and read Cantonese fluently, 3) suffered from voice problems and laryngeal discomfort for at least three consecutive weeks to exclude acute voice problems and 4) did not receive any prior voice training and experience in using surface electromyography (sEMG) prior to the present study. Participants were excluded from the current study if they 1) failed the hearing screening tested at 30dB HL for octave frequencies between 2 kHz and 8 kHz; 2) had a previous history of, or present with respiratory and severe allergy, or 3) had a previous history of, or present with any form of neurological speech and language disorders. Each participant was informed of the objective of the study and was required to sign a consent form to confirm their contributions in the current study.

Experimental set-up

The sEMG system (AD Instrument PowerLab Unit, model ML 780 with an eight-channel Dual Bio Amp model ML 135) and silver/silver chloride electrodes (10 mm in diameter) with electrolyte gel were used in the study. The PowerLab Chart 5 programme was used for recording the EMG signals while another software programme Labview was used for displaying the stimuli to the participants and analyzing the EMG signals. Vocal intensity levels were monitored throughout the training to ensure they maintained similar range of intensity levels during phonation (Cheung, 2004).

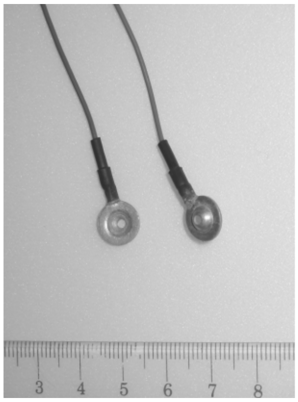


Figure 1. Electrodes for the sEMG (Yiu, et al., 2005)

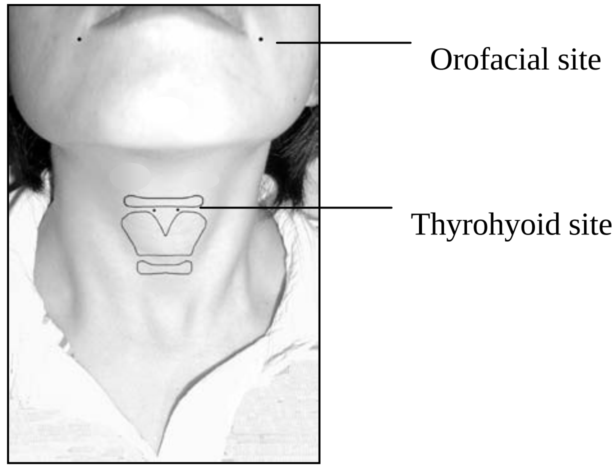


Figure 2. Two sites of surface electrode placement in this study (Yiu, et al., 2005)

Participants took part individually in the study. Special abrasive scrub was applied onto the participant's orofacial and thyrohyoid site to prepare for EMG measurements. Electrodes (Figure 1) with electrolyte gel for reducing impedance at the sites of contacts were positioned. In this study, the orofacial site and thyrohyoid site were used as they could capture relatively stable sEMG signals (Yiu, et al., 2005). A pair of electrodes was placed on thyrohyoid area, with 0.5 cm away from the midline of thyrohyoid membrane whereas another pair of electrodes was placed on the orofacial site, with 1 cm away from the lip corner on each side of the face (Figure 2) after the preparation of skin with the scrub. A dry earth strap was wrapped firmly around each participant's wrist. After the electrodes and the dry earth strap were secured in place, the participants were asked to rotate their heads to ensure no movement artifact was shown in the EMG recordings.

Training stimuli

Three lists of training stimuli were prepared (Appendix 1a, 1b and 1c). Each training list contained 24 Chinese characters as target characters. They covered all phonemes (19 consonants, 8 vowels, 10 diphthongs) and 6 lexical tones in Cantonese. The target characters were selected from the 750 most frequently occurring Chinese characters in Hong Kong (Ho, 1993) (Appendix 2). The first list of training stimuli comprised 24 target characters, which were embedded in the Cantonese carrier phrase /ji$_{55}$ kɔ$_{33}$ hɐi$_{22}$ (target character) / [meaning ‘this one is (target character)’] to form a sentence stimulus (See Appendix 1a). The second list of training stimuli consisted of sentences of increasing sentence lengths starting from sets of two characters to five characters across training blocks (See Appendix 1b). The third list of training stimuli comprised all 24 target characters embedded in variable lengths of phrases being presented in a random fashion (See Appendix 1c). Each training list consisted of four training blocks and they were used as the training stimuli in baseline, training and retention testing.

Procedures

Participants were evenly and randomly assigned to one of the three practice conditions. They were required to engage in a four-week relaxed phonation therapy, with two sessions per week. All training sessions were taken place in a sound-treated booth. During training, each participant was seated upright comfortably in a chair that was one meter away from the 17-inch computer monitor. The monitor was used to display the sentence stimuli and sEMG biofeedback in turns of root-mean-square (RMS) values of EMG voltages using the Labview programme.

Pre-training baseline (session 1). In the first session, participants were required to read aloud four blocks of training stimuli (24 sentences per block). They were also required to read aloud the paragraph “北風和太陽” (North Wind and the Sun) (Yiu & Chan, 2003) (Appendix 3) at their most comfortable pitch and loudness. At this pre-training baseline, no feedback was given to the participants on their performance. The sEMG signals at both orofacial and thyrohyoid sites were recorded for each sentence stimulus and saved for later analysis.

In order to evaluate the participants’ self perception of functional impacts due to the voice disorders, each participant was also asked to complete the Voice Activity and Participation Profile (VAPP) (Ma & Yiu, 2001).

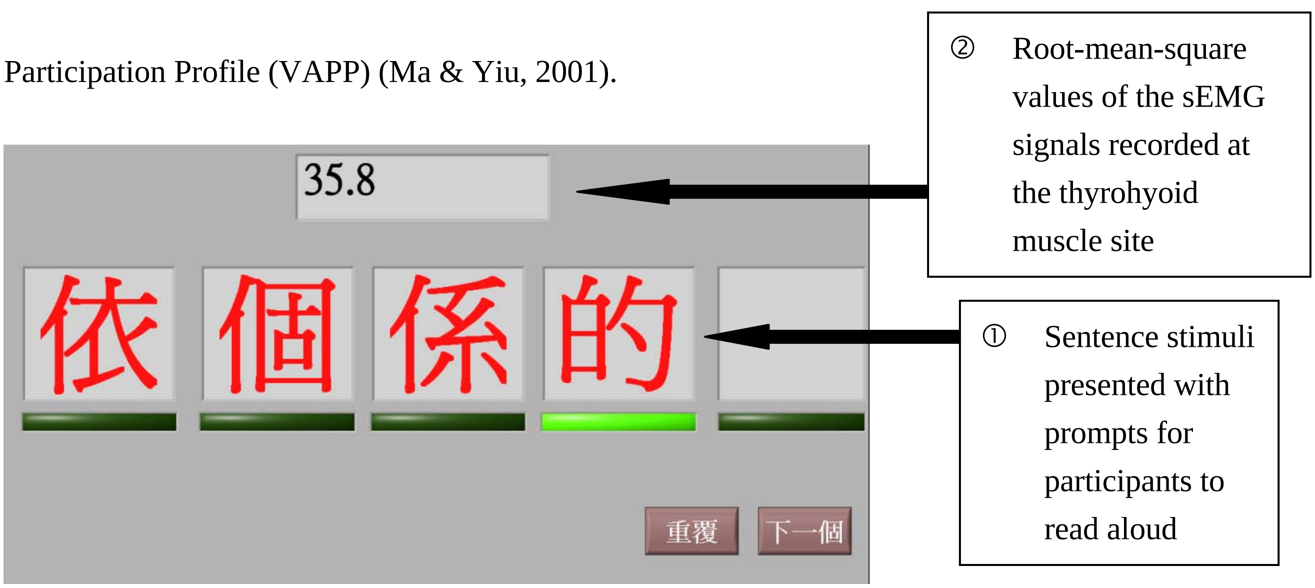


Figure 3. The Labview interface

Training sessions (session 2 - 9). At the beginning of the training sessions, each participant was introduced with the Labview interface for relaxed phonation therapy program (Figure 3). The Labview program presented and prompted the participants to read aloud the sentence stimuli. During the sentence reading, the root-mean-square values of sEMG signals recorded at the participant's thyrohyoid site would be automatically calculated by the Labview interface and presented as a numerical value on the computer screen (See Figure 3) as visual feedback. Participants were explained that the value displayed by the interface represented the laryngeal muscle activities. They were told that the larger the number, the more muscle activities and hence muscle tension. Each participant was informed of the objective of the training was to reduce the value by relaxing the neck muscles during the reading task. Throughout the recording, participants were only allowed to view the value after the production of every two sentences (Cheung, 2004). The presentation of such visual feedback was evenly distributed to ensure that all groups received the same amount of feedback. Table 1 shows the experimental design of the current study.

Table 1

Experimental design of the study

Tasks	**Pre-training baseline (Session 1)**	**Training sessions (Session 2 – 9)**	**Post-training measurement (Session 10)**
Reading of training sentence stimuli (4 blocks)	+	+	+ (Retention test)
Reading of paragraph (北風和太陽)	+	–	+ (Transfer test)
Completing the Voice Activity and Participation Profile	+	–	+

Note: + denotes the presence of tasks while – denotes the absence of tasks

Post-training measurement (session 10). A retention test using the trained stimuli was conducted one week after the completion of the eighth training session. A transfer test was also carried out by reading the novel, untrained paragraph "北風和太陽". In the post-training measurement, no root-mean-square value was given to the participants, but the muscle activities at orofacial and thyrohyoid sites were recorded for later analysis. The Voice Activity and Participation Profile was implemented again as an outcome measure for the relaxed phonation therapy.

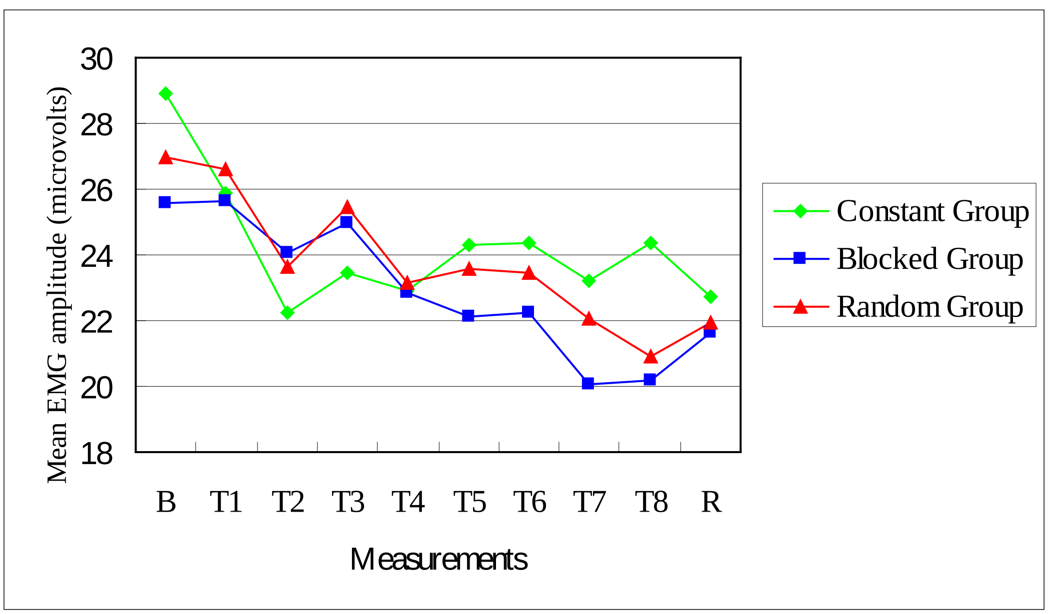
Motor learning was determined by comparing the results of root-mean-square of the EMG voltages at pre-treatment baseline with those at post-treatment measurement (retention test). Generalization effect was concluded by comparing the results in the pre-treatment baseline and those in the transfer test. The Voice Activity and Participation Profile scores at both pre- and post-treatment measurements were compared and served as the outcome measures to demonstrate if the participants' perceptual judgments on the severity of dysphonia had improved after the relaxed phonation therapy.

Results

Effects of Learning

A three-way within- and between- subjects ANOVA were used to confirm the effects of learning. All the data presented were proved to be homogenous with the use of Levene's Test of Equality of Error Variances (Pallant, 2005). The root-mean-square value of the EMG voltage (averaged from each sentence) was the dependent variable. The within-subject variables included time (ten sessions across baseline measurement, training and retention test) and electrode sites (orofacial and thyrohyoid sites). The between-subject variable included three practice conditions (i.e., constant, blocked and random practice conditions). The Multivariate Pillai's Test of Significance was considered to be a robust test against violation of assumptions in multivariate tests (Coakes & Steed, 2001). It was used to determine the main effects (time, electrode site, practice condition) and interaction effects of motor learning. An overall significance level of $p = 0.05$ was set for statistical analysis. Table 2 lists the means and standard deviations of the constant, blocked and random practice groups at orofacial and thyrohyoid sites across three measurement phases.

Time effect. Figure 4 shows the changes of muscle tension (pooled data) of all participants. The Pillai's Trace ANOVA confirmed that the main effect of time was significant [F (9, 11) = 3.11, $p = 0.05$]. The pooled data, across three measurement phases also demonstrated a decreasing trend in muscle tensions at both the orofacial and thyrohyoid sites across the three groups, indicating the presence of motor learning across time.



Key: B – Pretreatment baseline T – Training R – Retention test

Figure 4. Changes of muscle tension of all participants across ten measurements

Table 2

Means (standard deviations) in microvolts of muscle tension at orofacial and thyrohyoid sites for constant, blocked and random practice conditions across 3 measurement phases

	Baseline	**Training**								**Retention**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
CONSTANT PRACTICE										
Pooled data	**28.89**	**25.85**	**22.24**	**23.44**	**22.88**	**24.30**	**24.35**	**23.22**	**24.35**	**22.75**
Orofacial site	37.53	34.18	27.24	30.85	30.19	32.82	33.75	31.04	34.11	30.78
	(9.03)	(14.35)	(7.39)	(8.90)	(7.48)	(13.28)	(18.26)	(7.87)	(5.92)	(8.76)
Thyrohyoid site	20.24	17.52	17.23	16.03	15.56	15.77	14.95	15.40	14.58	14.71
	(4.11)	(4.68)	(3.70)	(4.20)	(4.40)	(3.99)	(3.17)	(4.23)	(3.06)	(3.82)
BLOCKED PRACTICE										
Pooled data	**25.56**	**25.63**	**24.05**	**24.94**	**22.86**	**22.13**	**22.25**	**20.05**	**20.18**	**21.66**
Orofacial site	34.13	34.62	31.79	33.75	30.21	28.81	30.32	27.08	27.34	30.98
	(11.96)	(21.82)	(9.67)	(20.27)	(14.06)	(11.03)	(14.85)	(12.16)	(11.96)	(12.78)
Thyrohyoid site	16.98	16.63	16.30	16.12	15.50	15.45	14.18	13.01	13.01	12.33
	(3.62)	(3.58)	(3.37)	(2.36)	(2.51)	(2.19)	(2.64)	(2.34)	(1.95)	(1.90)
RANDOM PRACTICE										
Pooled data	**26.96**	**26.62**	**23.65**	**25.44**	**23.13**	**23.58**	**23.43**	**22.04**	**20.93**	**21.93**
Orofacial site	32.81	31.83	29.92	33.20	29.58	30.55	30.97	29.25	27.36	28.86
	(15.19)	(10.64)	(6.79)	(11.62)	(6.58)	(8.46)	(10.20)	(7.07)	(9.06)	(9.82)
Thyrohyoid site	21.10	21.41	17.38	17.67	16.68	16.61	15.88	14.83	14.50	15.00
	(3.80)	(3.80)	(3.61)	(2.84)	(2.35)	(1.47)	(1.88)	(2.65)	(2.96)	(3.26)

Group effect (variable practice). There was no significant main effect of practice variability on laryngeal muscle relaxation [F (2, 18) = 1.09, $p > 0.05$]. The analysis failed to demonstrate better learning of one practice condition over the other.

Site effect. There was significant main effect of site [F (1, 19) = 63.10, $p = 0.001$], in which the thyrohyoid site demonstrated significant lower muscle tension than the orofacial site.

Interactions. None of the interactions reached a significant level at 0.05 criterion (site by group interaction, F =0.22, $p > 0.05$; time by group interaction, F = 0.92, $p > 0.05$; site by time interaction, F = 0.34, $p > 0.05$; and the site by time by group interaction, F = 1.22, $p > 0.05$).

Effects of Generalization

Table 3 lists the means and standard deviations of the constant, blocked and random practice groups at orofacial and thyrohyoid sites across two measurement phases (pre-treatment baseline and transfer test). Generalization of relaxed phonation skills to untrained paragraph 北風和太陽 was observed by comparing muscle tension values in the baseline measurement (reading of paragraph) to those in the transfer test (the same paragraph) with the use of Friedman Test and Kruskal-Wallis Test as the data violated the normality assumptions with the use of Levene's Test of Equality of Error Variances (Pallant, 2005).

Time effect. Figure 5 shows the changes of muscle tension of all participants at orofacial and thyrohyoid sites. Friedman Test confirmed that the main effect of time was significant at thyrohyoid site [Friedman's Chi-Square = 21.81, d.f. = 2, p = 0.001] and at orofacial site [Friedman's Chi-Square = 8.67, d.f. = 2, p = 0.01]. A significant improvement was observed in the muscle tensions at both sites across baseline measurements (reading of paragraph) and transfer test (reading the same paragraph).

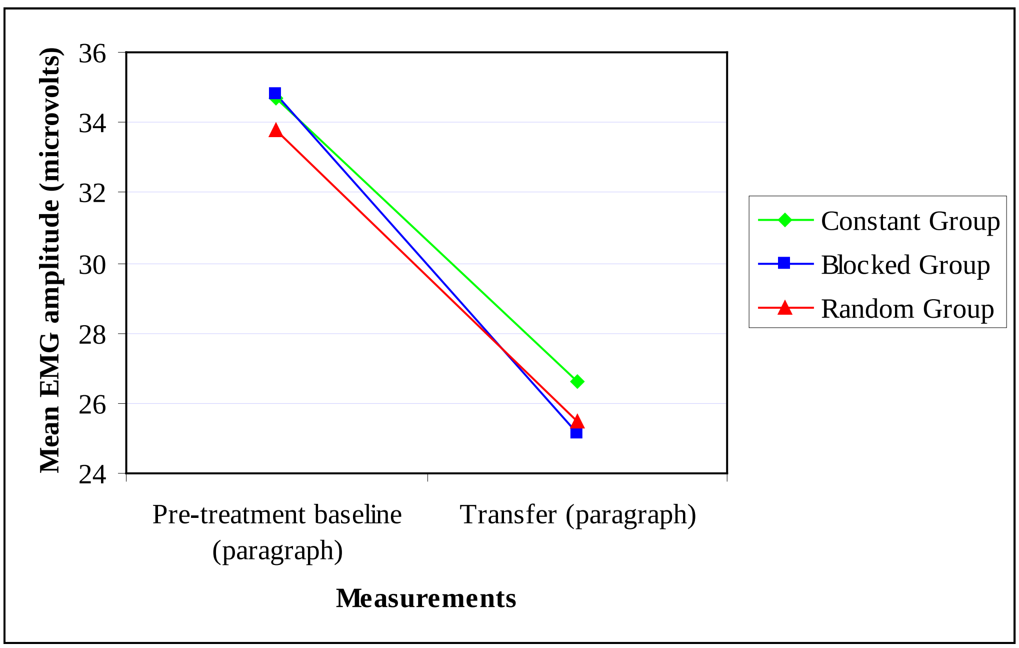


Figure 5. Changes of muscle tension of all participants across two measurements (pre-treatment baselines and transfer test)

Table 3

Means (standard deviation) in microvolts of muscle tension at orofacial and thyrohyoid sites for constant, blocked and random practice conditions across 2 measurement phases

	Pre-treatment baseline	**Transfer test**
	Reading of paragraph	**Reading of paragraph**
CONSTANT PRACTICE		
Pooled data	**34.72**	**26.61**
Orofacial site	44.87	37.13
	(15.71)	(5.59)
Thyrohyoid site	24.56	16.08
	(9.59)	(4.62)
BLOCKED PRACTICE		
Pooled data	**34.83**	**25.15**
Orofacial site	52.18	36.55
	(32.96)	(14.01)
Thyrohyoid site	17.48	13.74
	(4.23)	(3.94)
RANDOM PRACTICE		
Pooled data	**33.78**	**25.46**
Orofacial site	43.21	36.03
	(13.87)	(10.47)
Thyrohyoid site	24.34	14.88
	(3.79)	(2.28)

Group effect (variable practice). The Kruskal-Wallis Test confirmed that the main effect of variable practice was not significant on generalization of laryngeal muscle relaxation. There was no significant main effect of practice conditions ($p > 0.05$) on laryngeal muscle relaxation at the two electrode sites across the two measurements (pre-treatment baseline and transfer test). The analysis failed to demonstrate better learning of one practice condition over the other.

VAPP as outcome measures

Table 4 lists the statistical results of 14 scores of Voice Activity and Participation Profile (VAPP) in terms of *p*-level values. Fourteen one-way between and within ANOVAs across time and group (Ma & Yiu, 2001) were used to examine the changes of the 14 perceptual ratings (the scores listed in VAPP) before and after the therapy, confirming the effectiveness of the relaxed phonation therapy.

Significant main time effect was observed in all the scores except the Participation Restriction Score on job and all the scores on social communication. Time by group interaction was confirmed on perceived severity, activity limitation scores (ALS) on job, total activity limitation scores (Total ALS) and total Voice Activity and Participation Profile (VAPP) scores, indicating that participants demonstrated a change of perception towards the functional impacts of their voice disorders across group.

Table 4

Statistical results (main effects of time and interaction effects between group and time in terms of p-level values) on 14 scores of Voice Activity and Participation Profile (VAPP)

VAPP Scores	**Time effect** ***p*-level**	**Time by group effect** ***p*-level**
Self-perceived severity of voice problems	0.001	0.03
Job		
Section Scores	0.002	N.S.
ALS	0.000	0.03
PRS	N.S.	N.S.
Daily communication		
Section Scores	0.002	0.03
ALS	0.005	0.02
PRS	0.003	N.S.
Social communication		
Section Scores	N.S.	N.S.
ALS	N.S.	N.S.
PRS	N.S.	N.S.
Emotions Section Scores	0.02	N.S.
Total VAPP Scores	0.002	0.04
Total ALS Scores	0.001	0.008
Total PRS Scores	0.006	N.S.

Key: ALS - Activity Limitation Score PRS - Participation Restriction Score

N.S. - Not significant

Discussion

The objective of the current study was to investigate the effects of practice variability on relaxed phonation therapy in a group of dysphonic individuals. Root-mean-square values of the EMG voltage recorded at the participants' thyrohyoid site were given to all participants as biofeedback during trainings. It was hypothesized that the participants receiving random practice condition would demonstrate the best motor learning on relaxed phonation when compared with participants receiving blocked or constant practice conditions. Besides, participants from the blocked practice group would have better learning on vocal relaxation than the constant practice group. However, the present findings did not support the hypothesis. Several possible explanations were discussed to account for the findings in the current study: the complexity and difficulty of the tasks and the methodological design of the relaxed phonation therapy used.

First, Li and Wright (2000) commented that random practice was associated with higher cognitive demand than in blocked practice. Therefore, the random practice used in the current study was considered to be more difficult and require more cognitive demand than blocked practice and constant practice. All dysphonic participants who took part in the present study did not receive any prior voice training in the past. Therefore, they were fresh to the specially designed relaxed phonation therapy and could be considered as "beginning learners" of this relaxed phonation skills. With respect to Guadagnoli and Lee

(2004), low levels of contextual interference would be better for beginning skill levels and higher levels of contextual interference would be better for more highly skilled individuals. As mentioned above, all participants were considered as beginners for learning the relaxed phonation skills, so random practice might not be the optimal practice schedules for the participants to acquire the relaxed phonation skills. Alternatively, a reduction in task difficulty (as in constant practice condition) early in practice might facilitate the participants' learning of the skill (Jones & French, 2007).

The second possible explanation relates to the severity and duration of symptoms presented by the participants. The participants might have different severities of dysphonia and durations of symptoms. Colton, Casper and Leonard (2006) commented that the earlier the voice problem was identified, the more positive was the prognosis for improvement. Therefore, some dysphonic participants might have suffered from dysphonia for only one month while others might suffer from voice disorders for two years. As a result, the prognosis and improvement of each participant might be different, giving rise to a lack of difference in learning between practice conditions in the study.

Although the research findings did not indicate preference of any practice condition, the pooled data revealed that the EMG voltages at both orofacial and thyrohyoid sites were significantly reduced across time. These findings suggest the effectiveness of the relaxed phonation therapy used in the present study. Apart from demonstrating effective motor learning in the thyrohyoid site, the relaxed phonation skills were generalized to the novel, untrained paragraph "北風和太陽" in the transfer phase. According to Schmidt and Lee (1999), transfer of motor skills depends on the similarity of the two tasks being considered. Similarity can be defined as the abilities that are common in the two tasks or the motor programs that are utilized in both tasks. The sentences and passage to be read during training and transfer phases were all in Cantonese. Besides, reading the trained sentences and the untrained passage both required the use of the same motor program of relaxed phonation skills. As a result, the high similarity between the two tasks facilitated the participants to generalize the relaxed phonation skills in sentence level learnt during the trainings to narrative level.

Besides, the EMG voltages dropped significantly across time at both muscle sites. The participants' self-perceived functional impacts of voice problems also revealed significant improvements. This was demonstrated by the significant decrease in Voice Activity and Participation Profile scores at the end of the training program. The scores proved that the relaxed phonation therapy was effective to improve the participants' quality of life, especially on their jobs and daily communication.

Last but not least, the thyrohyoid site demonstrated better learning than the orofacial site in the current study. This finding contradicted previous studies by Cheung (2004), Yiu, et al. (2005) and Yu (2005), in which the unintended learning was in the orofacial site but not the thyrohyoid site. This finding could be explained by the nature of participants involved in the current study. In the three above-mentioned studies, individuals with normal voices were recruited while the present study involved dysphonic individuals. The presence of voice problems in dysphonic individuals might have changed their attention focus in the training. Further studies are warranted to evaluate this hypothesis.

Limitations of the present study and future research directions

Subjects with different severities of voice disorders. The severity of voice disorders and the onset of symptoms were different between participants in different groups. In the current study, only 21 dysphonic participants were recruited with seven participants in each practice condition. The sample size might not be large enough to fully demonstrate the effects of practice variability on motor learning. As a result, a larger sample size (i.e. at least 20 participants per group) should be targeted in future studies to generate group difference. This also facilitates better control of the severity of voice disorders and the duration of voice symptoms.

Inclusion of instrumental voice analyzes as outcome measures. In the present study, sEMG values and Voice Activity and Participation Profile scores were used as the impairment and functional outcome measures respectively for the relaxed phonation therapy program. Future studies can include aerodynamic acoustic measures to achieve multi-dimensional evaluation of outcomes. Perceptual voice evaluation can also be included in the outcome assessment battery.

Conclusion and Clinical implication

The current study did not support the hypothesis of contextual interference. The research findings did not demonstrate significant group effect (practice conditions) on motor learning and generalization. However, there was significant muscle tension reduction at the thyrohyoid site across time after the relaxed phonation therapy. Results of the present study suggested the effectiveness of relaxed phonation therapy for dysphonic population. It is recommended to continue employing this training in coming studies involving dysphonic individuals. However, modifications of the methodological design of the current study are warranted, namely the inclusion of a larger subject pool and the inclusion of more instrumental outcome measures.

References

Allen, K.D., Bernstein, B., & Chait, D.H. (1991). EMG biofeedback treatment of pediatric hyperfunctional dysphonia. *Journal of Behaviour Therapy and Experimental Psychiatry, 22*, 97-101.

Andrews, S., Warner, J., & Stewart, R. (1986). EMG biofeedback and relaxation in the efficacy treatment of hyperfunctional dysphonia. *Journal of Disorders of Communication, 21*, 353-369.

Boone, D.R., & MaFarlane, S.C., & Von Berg, S. L. (1999). *The voice and voice therapy* (6th ed). Needham Heights, MA: Allyn & Bacon.

Cheung, C. (2004). *The effect of continuous versus fading feedback on laryngeal muscle relaxation learning.* Unpublished BSc dissertation. The University of Hong Kong.

Coakes, S.J., & Steed, L.G. (2001). *SPSS: Analysis without anguish. Version 10.0 for Windows.* Brisbane: John Wiley & Sons.

Colton, R.H., & Casper, J. K., & Leonard, R. (2006). *Understanding voice problems: A physiological perspective for diagnosis and treatment* (3rd ed.). New York: Williams & Wilkins.

Freeman, M., & Fawcus, M. (2001). *Voice disorders and their management* (3rd ed.). London: Whurr.

Guadagnoli, M.A., & Lee, T.D. (2004). Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behaviour, 36*(2), 212-224.

Ho, K.C. (1993). *A comparison of the 2,000 most frequently used Chinese characters found in three frequency counts carried out in China, Taiwan and Hong Kong.* Hong Kong: Institute of Language in Education.

Jones, L.L., & French, K.E. (2007). Effects of contextual interference on acquisition and retention of three volleyball skills. *Perceptual and Motor Skills, 105,* 883-890.

Knock, T.R., Ballard, K.J., & Schmidt, R.A. (2000). Influence of order of stimulus presentation on speech motor learning: A principled approach to treatment for apraxia of speech. *Aphasiology, 14* (5-6), 653-668.

Lee, T.D., & Magill, R.A. (1985). Can forgetting facilitate skill acquisition? In D. Goodman, R.B. Wilberg, & I.M. Franks (Eds.), *Differing perspectives in motor learning, memory and control.* Amsterdam: North-Holland.

Li, Y., Wright, D.L. (2000). An assessment of the attention demands during random- and blocked-practice schedules. *The Quarterly Journal of Experimental Psychology, 53A*(2), 591-606.

Ma, E. P.-M., & Yiu, E. M.-L. (2001). Voice activity and participation profile: Assessing the impact of voice disorders on daily activities. *Journal of Speech, Language and Hearing Research*, *44*(3), 511-524.

Magill, R.A. (1998). *Motor learning: Concepts and applications (*5th ed.). Boston, Mass: WCB McGraw-Hill.

Pallant, J. (2005). *SPSS survival manual: A step by step guide to data analysis using SPSS for Windows (Version 12) (*2nd ed.). Maidenhead, Berkshire: Open University Press.

Rose, D.J. (1997). A *multilevel approach to the study of motor control and learning.* Allyn and Bacon.

Schmidt, R.A., & Lee, T.D. (1999). *Motor control and learning: A behavioural emphasis (*3rd ed.). Champaign, Ill,: Human Kinetics.

Schmidt, R.A., & Wrisberg, C.A. (2000). *Motor learning and performance (*2nd ed.). Champaign, Ill,: Human Kinetics.

Shea, J.B., & Morgan, R.L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory, 5*, 179-187.

Stemple, J.C., Weiler, E., Whitehead, W., & Komray, R. (1980). Electomyographic feedback training with patients exhibiting a hyperfunctional voice disorder, *Larygoscope, 90*(3), 471-476.

Yiu, E. M. -L., & Chan, K. M.-K. (2003). *A simple guide to better voicing: For teachers and professional voice users* (2nd ed.). Hong Kong: INSTEP.

Yiu, E.M.-L., Verdolini, K., & Chow, L.P.-Y. (2005). Electromyographic study of motor learning for a voice production task. *Journal of Speech, Language, and Hearing Research, 48*(6), 1254-1268.

Yu, G. (2005). *The Effect of Practice Distribution on the Training of Laryngeal Muscle Relaxation.* Unpublished BSc dissertation. The University of Hong Kong.

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Appendix 1a

Training list: Group 1 (Constant Practice)

Block 1:
依個係**的** 依個係**不** 依個係**有** 依個係**在** 依個係**了** 依個係**我** 依個係**為**
依個係**這** 依個係**水** 依個係**起** 依個係**解** 依個係**果** 依個係**情** 依個係**每**
依個係**月** 依個係**教** 依個係**老** 依個係**片** 依個係**給** 依個係**男** 依個係**父**
依個係**卻** 依個係**談** 依個係**群**

Block 2:
依個係**的** 依個係**不** 依個係**有** 依個係**在** 依個係**了** 依個係**我** 依個係**為**
依個係**這** 依個係**水** 依個係**起** 依個係**解** 依個係**果** 依個係**情** 依個係**每**
依個係**月** 依個係**教** 依個係**老** 依個係**片** 依個係**給** 依個係**男** 依個係**父**
依個係**卻** 依個係**談** 依個係**群**

Block 3:
依個係**的** 依個係**不** 依個係**有** 依個係**在** 依個係**了** 依個係**我** 依個係**為**
依個係**這** 依個係**水** 依個係**起** 依個係**解** 依個係**果** 依個係**情** 依個係**每**
依個係**月** 依個係**教** 依個係**老** 依個係**片** 依個係**給** 依個係**男** 依個係**父**
依個係**卻** 依個係**談** 依個係**群**

Block 4:
依個係**的** 依個係**不** 依個係**有** 依個係**在** 依個係**了** 依個係**我** 依個係**為**
依個係**這** 依個係**水** 依個係**起** 依個係**解** 依個係**果** 依個係**情** 依個係**每**
依個係**月** 依個係**教** 依個係**老** 依個係**片** 依個係**給** 依個係**男** 依個係**父**
依個係**卻** 依個係**談** 依個係**群**

Note: Characters in bold typeface are target characters

Appendix 1b

Training list: Group 2 (Blocked Practice)

Block 1:
係**的** 係不 係**有** 係**在** 係了 係**我** 係**為** 係**這** 係水 係**起** 係**解** 係**果** 係**情** 係**每**
係月 係**教** 係**老** 係片 係**給** 係**男** 係父 係**卻** 係**談** 係**群**

Block 2:
請講**的** 請講不 請講**有** 請講**在** 請講了 請講**我** 請講**為** 請講**這** 請講水 請講**起**
請講**解** 請講**果** 請講**情** 請講**每** 請講月 請講**教** 請講**老** 請講片 請講**給** 請講**男**
請講父 請講**卻** 請講**談** 請講**群**

Block 3:
依個係**的** 依個係不 依個係**有** 依個係**在** 依個係了 依個係**我** 依個係**為**
依個係**這** 依個係水 依個係**起** 依個係**解** 依個係**果** 依個係**情** 依個係**每**
依個係月 依個係**教** 依個係**老** 依個係片 依個係**給** 依個係**男** 依個係父
依個係**卻** 依個係**談** 依個係**群**

Block 4:
依個字係**的** 依個字係不 依個字係**有** 依個字係**在** 依個字係了 依個字係**我**
依個字係**為** 依個字係**這** 依個字係水 依個字係**起** 依個字係**解** 依個字係**果**
依個字係**情** 依個字係**每** 依個字係月 依個字係**教** 依個字係**老** 依個字係片
依個字係**給** 依個字係**男** 依個字係父 依個字係**卻** 依個字係**談** 依個字係**群**

Note: Characters in bold typeface are target characters

Appendix 1c

Training list: Group 3 (Random Practice)

Block 1:
依個係**不**　係**我**　請講**情**　依個係**每**　係**群**　依個字係**水**　請講**月**　係**卻**　請講**了**
依個字係**父**　請講**教**　依個字係**這**　依個係**果**　係**男**　依個字係**談**　依個係**給**
請講**為**　係**起**　請講**片**　依個字係**老**　依個係**解**　係**在**　請講**的**　依個係**有**

Block 2:
係**水**　依個係**老**　係**月**　依個係**我**　係**果**　依個字係**有**　依個係**卻**　係**不**　依個字係**給**
依個係**教**　請講**父**　依個字係**解**　係**情**　依個字係**在**　請講**起**　係**了**　請講**群**
依個係**為**　係**談**　依個字係**的**　請講**這**　係**每**　依個係**男**　依個字係**片**

Block 3:
請講**果**　係**教**　依個係**談**　依個字係**起**　依個係**片**　依個字係**月**　依個係**群**
依個字係**男**　依個係**在**　請講**解**　係**的**　依個字係**每**　依個係**水**　依個字係**我**
請講**有**　依個字係**不**　請講**老**　依個係**父**　依個字係**為**　依個係**了**　請講**給**
依個係**這**　請講**卻**　依個字係**情**

Block 4:
請講**在**　依個係**情**　係**解**　請講**水**　依個字係**了**　係**為**　請講**談**　依個字係**果**
依個係**的**　請講**每**　係**父**　請講**男**　依個字係**教**　係**給**　依個係**起**　係**老**　請講**不**
依個字係**卻**　係**片**　依個係**月**　係**有**　請講**我**　依個字係**群**　係**這**

Note: Characters in bold typeface are target characters

Appendix 2

Target characters

Target Stimuli	IPA Symbol	Order of frequency based on Ho (1993)	Target Stimuli	IPA Symbol	Order of frequency based on Ho (1993)
1. 的	tik$_{55}$	1	13. 情	ts^{h}iŋ$_{21}$	176
2. 不	pɐt$_{55}$	4	14. 每	mui$_{23}$	196
3. 有	jɐu$_{23}$	5	15. 月	jyt$_{22}$	216
4. 在	tsɔi$_{22}$	6	16. 教	kau$_{33}$	231
5. 了	liu$_{23}$	7	17. 老	lou$_{23}$	239
6. 我	ŋɔ$_{23}$	9	18. 片	p^{h}in$_{33}$	246
7. 為	wɐi$_{22}$	10	19. 給	k^{h}ɐp$_{55}$	259
8. 這	tsɛ$_{35}$	11	20. 男	nam$_{21}$	328
9. 水	sœy$_{35}$	75	21. 父	fu$_{22}$	332
10. 起	hei$_{35}$	104	22. 卻	k^{h}œk$_{33}$	461
11. 解	kai$_{35}$	117	23. 談	t^{h}am$_{21}$	464
12. 果	kwɔ$_{35}$	171	24. 群	kw^{h}ɐn$_{21}$	716

The selection of target words was based on its order of frequency (Ho, 1993)

Appendix 3

The reading stimuli in the pre-treatment and the transfer test

北風和太陽

有一天，北風和太陽爭論說，到底誰的本領高。當他們爭論的時候，有一個人經過，他正穿著一件厚厚的黑色外衣。

因此他們便說，看看誰能脫去那人身上厚厚的外衣。

北風首先狠狠的吹。可是他越吹得狠，那個人就越把外衣拉緊。所以，北風就放棄了。

一會兒後，太陽出來了。那個人很快便將外衣脫下來。北風只好承認太陽較他厲害。

Note: The passage was from ‘North Wind and the Sun’ of Yiu and Chan (2003).