The Impact of Dysphonic Voices on Children's Comprehension of Spoken Language

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Summary: Background. This study investigated the effect of teachers' dysphonic voices on children's listening comprehension.

Methods. One hundred thirty-four grade three and four students were recruited from local primary schools in Hong Kong. They were required to listen to six passages, three in Cantonese and three in English, which were either read in normal, mildly dysphonic, or severely dysphonic voices. The students were required to complete six multiple-choice comprehension questions upon listening to each passage. Comprehension performance across languages, dysphonic severities, genders, and question types were examined.

Results. The results showed that listening comprehension was significantly poorer even when speaker's voice quality was mildly impaired. Performance in Cantonese was generally better than that in English but no significant difference in the pattern of decline was found. Both boys and girls suffered to similar extent under dysphonic situations. Differences in performance in various question types were discussed.

Conclusions. These findings support the urgent need to implement voice care education for the teaching profession.

Key Words: Dysphonia−Listening comprehension−Teachers−Voice problems−Preventive voice care.

BACKGROUND

Teachers are a high-risk population for voice disorders. According to a large-scale survey done by Roy et al,[1] the prevalence of voice problems in teachers is significantly higher than that in non-teaching populations (11.0% vs. 6.2%). In Hong Kong, the prevalence of teachers with dysphonia is even higher using self-reported survey. Lee et al[2] carried out a survey with 714 teachers and found that almost 70% of primary school teachers have suffered from dysphonia in the last 12 months. Tang[3] did a questionnaire study on 85 secondary school teachers in Hong Kong and revealed that 75% of the teachers reported voice problems.

Voice disorder, or dysphonia, exists when a person's voice quality, pitch, loudness, and flexibility differ from that of others of similar age, gender, and cultural group.[4] Teachers are particularly susceptible to dysphonia predominantly because of their high demand of voice use in teaching and the need to speak in unfavorable acoustic environment such as classrooms, where background noise is high.[5,6] The risk of developing vocal pathologies is high. The most common types of vocal pathologies in teaching professions are vocal nodules and polyps. The presence of vocal pathologies can result in deviant voice qualities, namely hoarseness or breathiness, reduced pitch and loudness range, discomfort or pain during voice use, and increased phonatory effort.[7]

The impacts of dysphonia on teachers are extensive. Yiu and Ma[8] investigated such impact using the Voice Activity and Participation Profile (VAPP)[9] in 30 teachers enrolled in a workshop for improving voice use in teaching. Their findings revealed that most teachers were affected in the areas of occupation, daily communication, social communication, and emotion. Roy et al[10] interviewed 2400 teachers and nonteachers in the United States via telephone using a voice disorder questionnaire. Their findings suggested that teachers, compared with the general public, were more likely to report reduced job performance, miss work days, and consider quitting job because of the voice problems. Chen et al[11] did a questionnaire study on 117 teachers in Taiwan and indicated that dysphonia in teachers significantly impact on their overall communication ability, social ability, emotional state, and job satisfaction.

Yet, although a body of literature has focused on the effects of dysphonia on teachers themselves, only a few studies have examined the academic impact of teachers' dysphonic voice on children. In the study by Morton and Watson,[12] 24 children (mean age: 11 years 5 months) were tested on the ability to recall words and to draw a final target inference after listening to passages spoken by either a normal voice or a dysphonic voice. Results showed that voice significantly affected performance in word recall but not in identifying inference. Rogerson and Dodd[13] examined the effects of teachers' dysphonic voices on children's spoken language processing. One hundred seven children from primary schools (mean age: 9 years 10 months) were required to answer comprehension questions after listening to grade-appropriate passages spoken in normal voice, mildly dysphonic voice, and severely dysphonic voice. Their results suggested that even mildly dysphonic voice by teacher could significantly reduce children's performance in listening comprehension.

The impacts of teachers' dysphonic voices on language comprehension warrant specific investigation for two reasons. First, when voice is impaired, additional working memory resources have to be allocated to the perceptual processing of degraded acoustic information, thereby reducing the resources available for processing the meaning of that information.[14] Children between 6 and 13 years old have less flexibility in their perceptual strategies;[14,15] they may thus be particularly vulnerable to poorer comprehension when listening to dysphonic voices.

Accepted for publication March 8, 2018.

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Journal of Voice, Vol. 33, No. 5, pp. 801.e7−801.e16

0892-1997

https://doi.org/10.1016/j.jvoice.2018.03.004

Second, a poor classroom listening environment may further exacerbate children's comprehension of a teacher's dysphonic voice. Crandell[16] examined the effects of classroom acoustics on children with normal hearing and found that noise and reverberation in classroom could synergistically hamper speech recognition. Nabelek and Nabelek[17] further reported a particular susceptibility of children under the age of 13 to such effects. As children are likely to spend 50%–90% of their time listening to their teachers,[18] the possible educational effect of teachers' dysphonic voices on children's spoken language comprehension could not be underestimated.

The studies by Morton and Watson[12] and Rogerson and Dodd[13] focused on teacher's voice quality in English language only. Whether similar effects would be found in other languages that have different segmental or suprasegmental features, such as Cantonese, is yet to be assessed. Cantonese is a variant of the Yue dialect in Chinese. It is spoken by over 50 million of people in Southern China and millions of overseas Chinese.[19] One main difference in the nature of Cantonese and English lies in suprasegmental, or prosodic, features. English is a stress language. Stressed and unstressed syllables can be distinguished in terms of duration, amplitude, fundamental frequency movement, and segmental structure.[20] The position of stress is usually fixed, and therefore, stress in English is not lexically distinctive for most of the time. In contrast, Cantonese is a lexical tonal language. Lexical tone is defined as "the use of fundamental frequency to distinguish minimal word pairs that are not differentiated by segmental information" (p. 190).[21] Tones in Cantonese often affect the meaning of that word. For example, /si$_{55}$/ (poem), /si$_{35}$/ (history), and /si$_{21}$/ (time) all share the same segmental structure and they are distinguished only by tones. There are six contrastive lexical tones in Cantonese,[22] which can be distinguished acoustically by their relative fundamental frequencies and by their changes in fundamental frequency over the whole vocalic segment.[23]

Given that tone in Cantonese shares a high functional load in differentiating word meanings, dysphonia may result in an even greater impact on the comprehensibility of Cantonese spoken language as it may reduce pitch variation and hence tonal distinguishability. Laures and Weismer[24] used a resynthesis technique to produce English speech with flattened frequency contour and found that speech intelligibility was significantly reduced when pitch variation was artificially eliminated. Whether Cantonese will suffer more from dysphonia is worthwhile to be examined.

In contrast, whether the effect of dysphonia on listening comprehension may differ on children's native language (L1) and subordinate language (L2) processing is not investigated. In Hong Kong, English is an official language in addition to Chinese. All local children in Hong Kong are entitled to English education since preschool (information retrieved from the Education Bureau of Hong Kong, 2015), making English a popular L2. Although children in Hong Kong receive education in English (L2) relatively early, it is usually taught only as a subject in classroom, and most children lack the opportunity to practice it in a wider context. Cantonese remains the dominant language used by more than 90% of Hong Kong people in everyday communication (Hong Kong Census and Statistics Department, 2016). As a result, students are considerably less proficient in English, which may lead to a different listening strategies adopted during comprehension. According to Berne,[25] in comprehending a more proficient language (ie, Cantonese), students are able to attend to larger chunk of input, grasp the over meaning of input, relate what they hear to previous experiences, and guess the meaning of novel words. They are generally better at using existing linguistic knowledge to aid comprehension. In contrast, in comprehending a less proficient language (ie, English), students tend to process the input word by word, rely heavily on key words and pronunciation of words, and make fewer inferences. They are more prone to comprehension breakdown when linguistic information is degraded, as in dysphonic conditions. Thus, it is possible that students, given their long-term exposure to Cantonese and high frequency of usage in communication, are better in using different listening strategies to compensate for the degraded Cantonese voices. Such strategies may not be available for English.

Of the two studies that investigated the effect of dysphonic voices on children's language processing,[12,13] only L1 was examined. It is not known if comprehension of L2 suffers disproportionately in dysphonia. Given the high prevalence of Chinese-English bilingualism in Hong Kong, a comparison of the impact of teacher's voice quality on children's L1 and L2 comprehension is warranted.

Research questions and hypothesis

This study aimed to investigate whether speakers' dysphonic voices have an impact on children's comprehension of spoken language. The effect across Cantonese and English will be compared. Research questions include the following:

(1) What is the effect of severity of speakers' dysphonic voices on children's comprehension of spoken language?

It is hypothesized that the more severe the dysphonia is in any language, the poorer the spoken comprehension performance will be. This is because additional demands are placed on children's perceptual processing and less capacity is available for spoken word comprehension overall.

(2) Does the performance of listening comprehension under dysphonic voices differ across the two languages being tested (ie, Cantonese and English)?

There are two hypotheses for this research question. From the perspective of suprasegmental difference, listening comprehension in dysphonic voices is hypothesized to be poorer in Cantonese because of its tonal nature. Yet, from the perspective of language proficiency, English (L2) comprehension is hypothesized to suffer more for Hong Kong children in dysphonic voices as they are less competent in using various listening strategies. It is predicted that the effect of language proficiency overweighs that of suprasegmental difference as students may still be able to make use of existing linguistic knowledge to compensate for degraded voice quality and

reduced tonal distinguishability in comprehending Cantonese, which is their native language.

(3) Does gender play a role in listening comprehension performance under dysphonic voices?

There have been studies showing that girls generally perform better than boys in terms of educational achievement especially in early years by the age of 8 years.[26,27] However, other studies suggested that boys could soon catch up with or even outperform girls by 16 years of age.[28] As the participating children are from grade three and four (with approximate age range being 9−10 years old), it is hypothesized that the effect of gender on listening comprehension of dysphonic voices is negligible (ie, boys and girls perform similarly in different voice qualities).

(4) Does the performance of listening comprehension under dysphonic voices differ across question types?

The question types used in the study by Rogerson and Dodd[13] were adopted as the framework to set out the questions in this study. It is predicted that children perform better for questions that do not require particular attention to specific text extract or words in the passage (eg, selecting an appropriate title of the story), and perform poorer for questions that require special focus to particular texts in the passage (eg, understand a novel vocabulary with the use of limited contextual information from the passage).

METHODS

Participants

One hundred fifty-three participants (81 boys and 72 girls) participated in the study. They were recruited from three local primary schools in Hong Kong. Fifty-one students were from grade three, whereas 102 students were from grade four. Case history information, such as medical history, family history, and language background were collected from parents of the participants via phone interviews (see Appendix for the interview items). Participants were excluded from this study if they (1) were currently receiving speech therapy in school or in other settings, (2) were not native Cantonese speakers, or (3) were using Cantonese as means of communication for less than 70% of the day. Ten students failed to meet these criteria and were excluded from the study. In addition, the hearing status of participants was screened using pure-tone audiometry, with the passing criteria set at 25 dB at hearing threshold levels of octave frequencies from 500 to 8000 Hz for both ears. Nine students failed the hearing screening test and were excluded from the study. These resulted in a total of 134 students (70 boys and 64 girls) participated as listeners.

Materials

Selection of passages

Seven short passages, four in Cantonese and three in English, were selected and modified from Chinese and English reading comprehension supplementary exercises for grade three or grade four levels. Each passage contained a short and factual text with grade-matched syntactic complexity and vocabulary. Passages of the same language were of similar length (340, 337, 337, and 350 characters for the four Chinese passages; 139, 136, and 139 words for the three English passages). One of the Chinese passages was used as sample passage for students to familiarize themselves with the experimental procedures. The remaining six passages were used as testing passages.

Six multiple-choice questions, each consisted of four choices, were set for each passage. The positions of correct answer were randomized across the four choices. The question types used in the study by Rogerson and Dodd[13] were adopted as the framework to set out the questions for this study. The six questions assessed the student's ability to (1) determine the subject of the story, (2) ascertain the theme of the story, (3) understand supporting information from the story, (4) derive an implicit conclusion, (5) understand vocabulary in context, and (6) select an appropriate title for the story.

Recording of passages

Recordings were made on three dysphonic severities (ie, normal, mild, and severe) for each of the six testing passages. The sample Cantonese passage was recorded only with normal voice quality. This yielded a total of 19 recordings (6 passages with 3 dysphonic severities each plus 1 sample passage of normal voice quality). A female native Cantonese and a female native English speaker recorded the Cantonese and English sets of passages, respectively. Female speakers were selected to reflect the high proportion of female teachers in primary schools. Also, female teachers were found to report a higher frequency of voice problems than male teachers.[29] Both female speakers were voice researchers and were experienced in imitating dysphonic voice qualities. They did not have any voice problems and speech problems. They first recorded the passages using their normal voices. They then recorded the passages using simulated mild and severe dysphonic severities. This simulation method was used to ensure the same speaking style (ie, articulation, speech rate, and perceived personality) across passages in the same language set. The Cantonese sample passage was recorded in normal voice only by a female final-year speech pathology student.

The passages were recorded using a headset microphone (AKG Acoustics C420, Vienna, Austria) through an external sound card (M-Audio MobilePre USB, Avid Technology, Irwindale CA, USA). The recordings were made in a soundproof booth. During the recording, the microphone was maintained at 8 cm away from the speaker's mouth corner. Speakers were allowed to practice reading aloud the passages several times as familiarization before the actual recording.

Rating of voice samples

To ensure a systematic difference among the three dysphonic severities, a perceptual rating assessment was performed on the 19 passages recorded. The voice samples were rated by an experienced speech pathologist with more than 10 years of experience in managing individuals with dysphonia on a daily

TABLE 1.
Perceptual Rating Result for Dysphonic Severity

Passage	Targeted Severity	Rated Severity
Cantonese sample passage	Normal	Normal
Cantonese passage 1	Normal	Normal
	Mild	Mild
	Severe	Severe
Cantonese passage 2	Normal	Normal
	Mild	Mild
	Severe	Severe
Cantonese passage 3	Normal	Normal
	Mild	Mild
	Severe	Severe
English passage 1	Normal	Normal
	Mild	Mild
	Severe	Severe
English passage 2	Normal	Normal
	Mild	Mild
	Severe	Moderate
English passage 3	Normal	Normal
	Mild	Mild
	Severe	Moderate

basis. The speech pathologist was asked to rate the voice samples as either normal, mildly dysphonic, moderately dysphonic, or severely dysphonic. The 19 passages were randomized in order and each passage was played twice during the rating session. When rating results of the same version differed in the two trials, the speech pathologist was told about the disagreement and was required to rate that version one final time. Table 1 lists the results of perceptual rating by the speech pathologist. Except for the "severely dysphonic" versions of English passages 2 and 3, which were rated as moderately dysphonic, all other passages were rated at their targeted dysphonic severities. This confirmed that the target levels of dysphonia needed for this study had been met.

Procedure

Pilot testing

Pilot testing was conducted on four children (two at grade three, two at grade four). The same procedure and task as in the actual testing was conducted. The children were asked to comment on the difficulty level of the passages and the questions. All children reported that the passages were of grade-appropriate, with suitable level of difficulty for grade three and grade four students. They also reported that the task requirements were clear and comprehensible to them.

Actual testing

Participants were divided into six groups. Each group was required to listen to all six testing passages. The passage's dysphonic severity and presentation order of passage were randomized across the six groups. Table 2 shows the number of students in each group with the presentation order of passages.

Participants were first briefed about the purpose of this study and the task requirements. They were given the question-answer booklet and were reminded not to flip the page until they were told to do so. Next, the sample passage was presented with sound level controlled at audible level. This sound level was confirmed by all students as a comfortable loudness level and was adopted for the entire testing session. After the sample passage was presented, participants were required to complete the six multiple-choice comprehension questions within 4 minutes. Correct answers were given and explained to the participants after completion of questions, and any enquiries were clarified. Subsequently, the first testing passage was presented. The same procedure was replicated for all six testing passages as that of the sample passage, except that correct answers were not given for testing passages and participants were required to continue listening to the subsequent passages after completing the questions of the previous one.

RESULTS

Language and severity

Table 3 lists the distribution of scores for all 134 participants across the two languages and three dysphonic severities.

A two-way within-subject analysis of variance (ANOVA) was conducted with two within-subject factors: language (two levels: Cantonese, English) and dysphonic severity (three levels: normal, mild, severe). Mauchly test of sphericity revealed nonsignificant value for severity (approximate chi square$_{(2)} = 2.38$, $P = 0.31$). This suggested that the assumption of sphericity was not violated (ie, equal variance was assumed between the three levels of severity). The listening comprehension performance in Cantonese

TABLE 2.
Number of Students in Each Group and Presentation Order of Passages

Group	Number of Students	Order of Passage Presentation					
		First	Second	Third	Fourth	Fifth	Sixth
1	20	C1N	C2M	C3S	E1N	E2M	E3S
2	14	C2S	C3N	C1M	E2S	E3N	E1M
3	26	C3M	C1S	C2N	E3M	E1S	E2N
4	21	E1N	E2M	E3S	C1N	C2M	C3S
5	45	E2S	E3N	E1M	C2S	C3N	C1M
6	8	E3M	E1S	E2N	C3M	C1S	C2N

Abbreviations: C, Cantonese; E, English; 1, passage 1; 2, passage 2; 3, passage 3; N, normal voice; M, mildly dysphonic voice; S, severely dysphonic voice.

TABLE 3.
Mean Scores and Standard Deviation for the Six Passages

Language	Voice Quality of the Passage	N	Minimum Score	Maximum Score	Mean Score	(Standard Deviation)
Cantonese	Normal	134	0	6	3.52	(1.54)
	Mild	134	0	6	3.05	(1.32)
	Severe	134	0	6	2.87	(1.32)
English	Normal	134	0	5	2.02	(1.21)
	Mild	134	0	6	1.84	(1.28)
	Severe	134	0	5	1.73	(1.34)

passage was significantly better than that in English passage ($F_{(1, 133)} = 166.94$, $P = 0.0001$, partial eta squared = 0.56). The analysis also revealed a significant difference in listening comprehension performance across the three dysphonic severities ($F_{(2, 266)} = 10.95$, $P = 0.0001$, partial eta squared = 0.08). The language × dysphonic severity interaction effect was not significant ($F_{(2, 266)} = 1.98$, $P = 0.14$, partial eta squared = 0.02).

Follow-up *post hoc* analysis, using Bonferroni-adjusted paired sample *t* tests, revealed that participants' performance in listening to normal voice passages (mean = 2.77, standard error = 0.09) was significantly better than that in mildly dysphonic passages (mean = 2.44, standard error = 0.09), with a mean difference of 0.33 ($P = 0.004$). Performance in listening to normal passages was also significantly better than that in severely dysphonic passages (mean = 2.30, standard error = 0.09), with a mean difference of 0.47 ($P = 0.0001$). However, there was no significant difference in performance between mildly dysphonic and severely dysphonic passages, with a mean difference of 0.14 ($P = 0.49$).

Question type

Figure 1A and 1B shows the participants' performance across the six multiple-choice questions. To statistically analyze whether participants performed differently on different types of questions, a three-way within-subject ANOVA was conducted with three within-subject factors: language (two levels), dysphonic severity (three levels), and question types (six levels: questions 1 to 6). Mauchly test of sphericity revealed significant value for question types (approximate chi $square_{(14)} = 32.8$, $P = 0.003$). This suggested that equal variance between the six levels of question types was not assumed.

The results revealed that there was a significant effect of question types ($F_{(4.57, 608)} = 23.37$, $P = 0.0001$, partial eta squared = 0.15). None of the other interaction effects reached a significant level at $P = 0.05$ (language × question types: $F_{(4.42, 587)} = 0.93$, $P = 0.46$, partial eta squared = 0.007; dysphonic severity × question types: $F_{(8.39, 1115)} = 0.17$, $P = 1.00$, partial eta squared = 0.001; and language × dysphonic severity × question types: $F_{(8.84, 1176)} = 0.44$, $P = 0.91$, partial eta squared = 0.003).

Gender

Table 4 summarizes the listening comprehension performance of boys and girls. A three-way mixed ANOVA, with two within-subject factors (language, severity) and one between-subject factor (gender), was performed to test whether gender played a role in students' listening comprehension of dysphonic voices. Result revealed that there was not a significant main effect of gender ($F_{(1, 132)} = 2.45$, $P = 0.12$, partial eta squared = 0.02). None of the other interaction effects reached a significant level at $P = 0.05$ (severity × gender: $F_{(2, 264)} = 0.74$, $P = 0.48$, partial eta squared = 0.006; language × gender: $F_{(1, 132)} = 0.14$, $P = 0.71$, partial eta squared = 0.001; and language × severity × gender: $F_{(2, 264)} = 0.80$, $P = 0.45$, partial eta squared = 0.006). Performance in listening comprehension of dysphonic voices did not significantly differ for boys and girls.

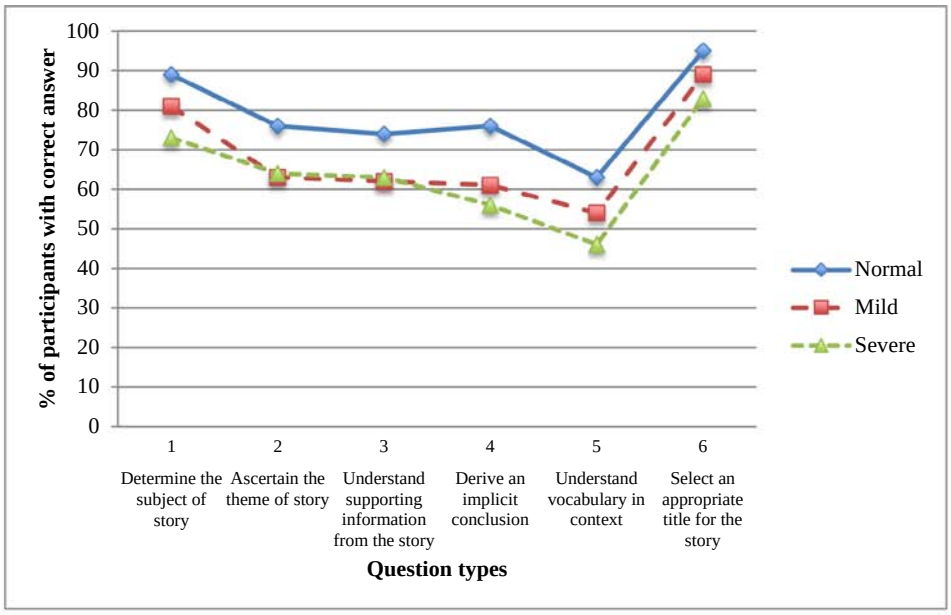
DISCUSSION

The aim of the present study was to investigate whether speakers' dysphonic voices have an impact on children's comprehension of spoken Cantonese and English. A listening comprehension task was used. Three Cantonese passages and three English passages were recorded, each consisting of three versions: normal, mildly dysphonic, and severely dysphonic voices. The results of the two-way within-subject ANOVA (language and severity) suggested that students' performance in listening comprehension dropped significantly for passages recorded with dysphonic voices. This finding is consistent with previous studies by Morton and Watson[12] and Rogerson and Dodd[13] that dysphonic voice hampers children's processing of spoken language. One possible explanation for the results is that, in speech perception, working memory resources are allocated to both perceptual processing (ie, to analyze and synthesize the acoustic information in perceptual storage) and comprehension of information.[30] Therefore, when a speaker's

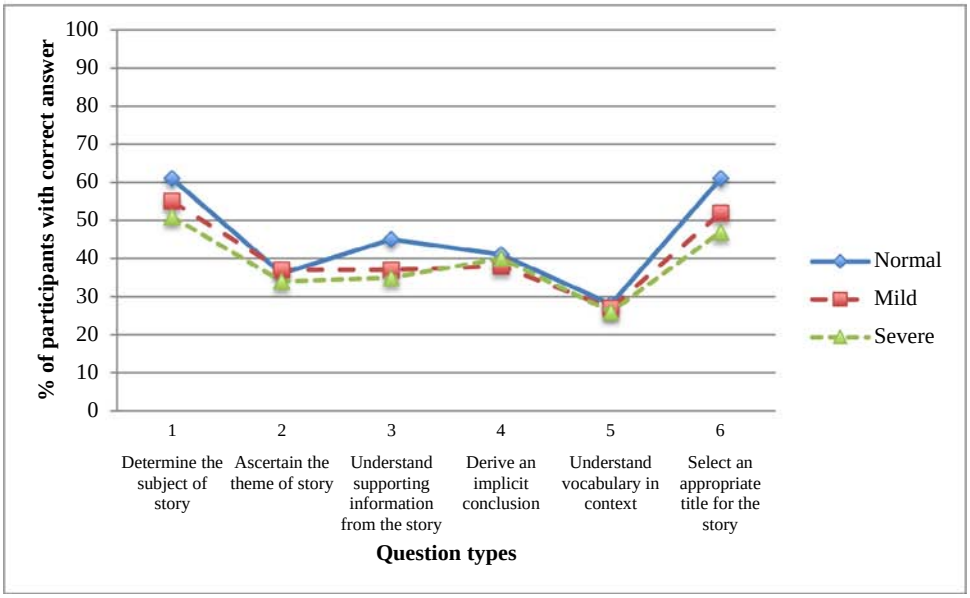
TABLE 4.
Performance in Listening Comprehension in Male and Female

Gender	N	Minimum Score	Maximum Score	Mean Score
Male	70	4	29	2.40
Female	64	4	25	2.60

Notes: The maximum and minimum scores were based on all six passages (possible maximum score = 36).



(A)



(B)

FIGURE 1. Participants' performance across the multiple-choice questions for (**A**) Cantonese passages and (**B**) English passages.

voice quality deteriorates, the listener may have to direct more resources to perceptual processing. This might have limited the resources allocated to processing the meaning of that information and therefore reduced children's performance in listening comprehension.

One would hypothesize that the more severe the speaker's dysphonic voice quality, the less resource available for comprehension and the poorer the performance. Interestingly, the present findings reveal that participants' performances in comprehending passages of mildly dysphonic and severely dysphonic were similar and were not significantly different from each other. It is apparent that when a speaker's voice is impaired, perceptual processing will be impeded to a certain equal extent no matter how severe the dysphonic voice is. Further research should address how the dysphonic voice severity plays a role in children's performance in listening comprehension.

Findings from the two-way within-subject ANOVA (language, dysphonic severity) revealed that students performed significantly better for Cantonese than for English passages regardless of dysphonic severity. This result was not unexpected because all participants were native Cantonese speakers. According to their parent reports, all the children used Cantonese as the means of communication for at least 70% daily, and English was only a second (subordinate) language learnt in

school. Compared with the native language Cantonese, it would be reasonable that their level of English proficiency was considerably lower, accounting for the generally lower mean scores.

No significant interaction effect was found between language and dysphonic severity, suggesting that reduction in comprehension performance caused by impaired voice quality was the same for both Cantonese and English. It was hypothesized that whether Cantonese and English suffer disproportionately under dysphonic situations in this study depends on two counterbalancing factors: suprasegmental and language proficiency. First, from a suprasegmental perspective, comprehending Cantonese is likely to suffer more in dysphonic because of its lexical-tonal nature. Tone in Cantonese shares a high functional load in differentiating word meanings, whereas stress in English is usually not lexically distinctive. In dysphonic situations where pitch variation is considerably reduced, differentiating Cantonese words may be more difficult than English. From another perspective of language proficiency, English is likely to suffer more for being a subordinate language. Students are less competent in using various listening strategies in comprehending English and are more prone to comprehension breakdown especially when voice quality is degraded.[25] It was predicted that the latter factor could potentially outweigh the former because students may still be able to rely on their existing linguistic knowledge and adopt different listening strategies to compensate for the degraded voices and reduced tonal distinguishability. Unfortunately, it is not possible to address which of the above factors contribute more to the listening comprehension performance under dysphonic situations using the current research design. Further research is recommended, with controlling one of the factors while comparing the second (eg, recruiting two groups of students speaking native Cantonese and English, respectively).

Question type

Students scored the best for the question on selecting an appropriate story title and also on determining the subject of the story. However, they scored the worst for the question that required their understanding of vocabulary in context (see Figure 1A and 1B). This result is consistent with that reported in Rogerson and Dodd.[13] Such difference in performance across question types can be attributed to the task nature and the underlying skills required. In selecting an appropriate title of the story, students do not need to rely on particular text extract or word but can utilize the whole piece of information from the passage in deriving the answer. According to Martin (1982 as cited in Berne[25]), listeners first determine the main idea of the story and draw on their previous knowledge about the topic when they listen to a novel input. With additional information continually supplied, listeners attempt to match the new information from the input against the perceived main idea or previous own knowledge. Using this listening sequence, it is still possible for students to select the appropriate title by grasping the holistic idea of the story even if they fail to comprehend some of the texts because of impaired voice quality. Similarly, in determining the subject of the story, students are continually supplied with information about the subject, which appears multiple times in the passage. Thus, identifying the subject in the story may be relatively easier even if students miss out some information under dysphonic voices. In contrast, in understanding a specific vocabulary in context, students heavily depend on a short specific text extract that supplies contextual information of that vocabulary. If they overlook or cannot recognize the words of that particular text extract because of impaired voice quality, no further supporting information will be available from the remaining passage and they can only select the answer by previous knowledge or by random guessing.

The three-way ANOVA (language, severity, question type) also revealed that interaction effects between language × question type, severity × question type or language × severity × question type were not significant. This means that the performance pattern of different questions did not alter as a result of different voice qualities or languages, or both. These findings are consistent with those in Morton and Watson's[12] study. It implies that weakening of perceptual information, as in dysphonic voices, does not change the fundamental structure of speech processing but only produces processing of poorer quality. The underlying skills in completing different question types do not change when voice becomes dysphonic. It is just the poorer voice quality that reduces students' performance in general.

Gender

Results from the three-way ANOVA (language, severity, gender) revealed that gender played no significant role for students' performance in this study. No significant interaction effect between language × gender, severity × gender or language × severity × gender was found. This suggests that gender seems to be unassociated with better comprehension ability, at least at 10 years of age, and neither boys nor girls perform better when listening to dysphonic speech. Thus, boys and girls tend to experience the same impact when being taught by a dysphonic teacher.

Limitations

There are a few limitations that warrant discussion. First, this study employed the use of same speaker in recording passages of different dysphonic severity levels. Despite having rich experience in voice research, we do not know whether the speaker's version of dysphonic voice can truly resemble that from a dysphonic speaker. In particular, whether articulation changes in mimicking different severities was not examined. If these are present, students' performance may be affected as a result of different speech intelligibility but may not be due to dysphonia *per se*.

Second, there was uneven distribution of students across the six testing groups because of practical constraints. None of the participating schools could offer both grade three and grade four students and only a limited number of testing sessions were provided by each school. This made comparison in listening comprehension performance across different schools and grades not possible as the passages and presentation order in a particular school and grade were not fully randomized.

Third, the current research design could not address the question of whether the two languages tested (ie, Cantonese

and English) suffer disproportionately in dysphonia. There were two opposite hypotheses, in which Cantonese was predicted to suffer more because of its tonal nature, whereas English was hypothesized to have poorer comprehension performance for it being the students' second language. As there was a nonsignificant interaction effect on language and dysphonic severity, we do not know whether the factor of suprasegmental difference or difference in language proficiency contributes more to listening comprehension performance under dysphonic situations.

Future research directions

This study follows the works by Morton and Watson[12] and Rogerson and Dodd[13] in examining whether students' listening comprehension will be hindered when the voice quality of speaker is reduced. Yet, only students with no speech, language, and hearing problems were included. Further studies are recommended to explore whether children with special education needs, such as those with developmental dyslexia, specific learning difficulties, language disorders, and hearing loss, suffer disproportionately under similar situations.

The effect of age on listening comprehension of impaired voice is not examined. It may be the case that older students are more capable in employing different listening strategies and have more previous knowledge about the input, which allow them to cope with dysphonic situations better than their younger counterparts.

Lastly, whether students could acclimatize themselves to dysphonic voices when they are subjected to such conditions for over a long period of time is not investigated. Further research is recommended to provide more information on whether listeners, upon prolonged exposure to impaired voices, could better cope with dysphonia or develop new compensating listening strategies.

CONCLUSIONS

This study serves to increase the evidence base of the effect of dysphonic voices on children's listening comprehension and bridge the research gap by examining whether such effect depends on language and children's proficiency of that language. The results that children's listening comprehension are hampered even when voice quality is mildly impaired shed light on the importance of voice care education for the teaching profession. The educational authorities should take the initiative to allocate more resources in promoting voice care education for teachers through undergraduate or in-service training so as to reduce the risk of voice problems and to minimize the possible educational effects that it may bring.

IMPLICATIONS FOR SCHOOL HEALTH

Voice problems in the teaching profession are highly prevalent worldwide.[1–3] Results from the present study suggest that even a mildly dysphonic voice can impede students' processing of spoken language. As new knowledge is continually presented in classroom teaching, students who are taught by a dysphonic teacher, regardless of the dysphonic severity, are likely to suffer from a reduced quality of comprehension and hence an inferior classroom learning, which is a serious educational impact. This necessitates the implementation of specific policies to reduce the prevalence of voice disorders in teachers to alleviate the potential negative educational effect. Educating teachers with the correct use of voice and vocal hygiene would help reduce the risks of voice problems in teachers and thus improve the quality of education for students. The efficacy of voice care education on teachers has been verified in the works by Bistritsky and Frank[31] and Chan.[32]

Although money and time may be the hindering factors in implementing voice care education for teachers given their laborious schedule of teaching and administrative work, its potential educational benefits probably outweigh its costs. It is therefore recommended that more resources should be allocated to delivering voice care education to the teaching profession by professionals such as speech pathologists either in undergraduate program or through in-service training.

Human subjects approval statement

This study was approved by the Faculty of Education Human Research Ethics Committee at the University of Hong Kong.

Acknowledgments

This study was supported by the Strategic Research Partnership on Translational Research in Voice and Speech Sciences between Sik Sik Yuen and Faculty of Education, The University of Hong Kong. The authors would like to express their sincere gratitude to Dr. Elizabeth Barrett and Ms. Teresa Chan for their contribution in preparing passages for this study.

APPENDIX. INTERVIEW ITEMS ON PARENTS OF THE PARTICIPANTS

Medical history

Does your child. . .

1. Need regular medical checkup? Yes / No
   If yes, please specify the reason: _____
2. Have diagnosed medical diseases? Yes / No
   If yes, please specify: _____
3. Have hearing impairment? Yes / No
   If yes, where and when was the hearing assessment performed?
   Place: _____
   Date: _____
   Assessment result: _____
4. Have/ever had ear inflammation? Yes / No
   If yes, please specify the location, nature and age of inflammation:
   Location: ☐ Outer ear ☐ Middle ear ☐ Inner ear
   Nature: ☐ Chronic ☐ Acute
   Age: _____
5. Have speech and language assessment or therapy? Date of assessment/therapy: _____
   Venue of assessment/therapy: _____
   Result of assessment: _____
   Progress of therapy: _____

Family history

1. Does your child have sibling(s)? Yes / No
   If yes, please specify the age(s): _____
2. Does any relative(s) of the child have speech and language assessment or therapy? Yes / No
   If yes, please specify the relative's relationship to the child:
   _____

Language background information

1. What language(s) does the child speak? Please specify the approximate frequency (in %) in daily usage.
   For example: English (80%)
   _____ (_____%)
   _____ (_____%)
   _____ (_____%)
2. When did the child start learning the language(s) stated in the last question?
   For example: English (From birth)
   _____ (From _____)
   _____ (From _____)
   _____ (From _____)

3. Through what setting(s) did the child learn the languages stated above? (You may tick more than one box)
   Language: _____
   ☐ At home ☐ At school ☐ Attend interest class ☐ Others: _____
   Language: _____
   ☐ At home ☐ At school ☐ Attend interest class ☐ Others: _____
   Language: _____
   ☐ At home ☐ At school ☐ Attend interest class ☐ Others: _____

REFERENCES

1. Roy N, Merrill RM, Thibeault S, et al. Prevalence of voice disorders in teachers and the general population. *J Speech Lang Hear Res*. 2004;47:281–293.
2. Lee SYY, Lao XQ, Yu ITS. A cross-sectional survey of voice disorders among primary school teachers in Hong Kong. *J Occup Health*. 2010;52:344–352.
3. Tang PK. *Voice problems of secondary school teachers and the need for preventative education*. 2014.
4. Aronson AE, Bless D. *Clinical Voice Disorders*. New York: Thieme; 2011.
5. Sapir S, Keidar A, Mathers-Schmidt B. Vocal attrition in teachers: survey findings. *Eur J Disord Commun*. 1993;28:177–185.
6. Chan KMK, Li CM, Ma EPM, et al. Noise levels in an urban Asian school environment. *Noise Health*. 2015;17:48–55.
7. Yiu EML. Impact and prevention of voice problems in the teaching profession: embracing the consumers' view. *J Voice*. 2002;16:215–228.
8. Yiu EML, Ma EPM. Voice activity limitation and participation restriction in the teaching profession: the need for preventive voice care. *J Med Speech Lang Pathol*. 2002;10:51–60.
9. Ma EPM, Yiu EML. Voice activity and participation profile: assessing the impact of voice disorders on daily activities. *J Speech Lang Hear Res*. 2001;44:511–524.
10. Roy N, Merrill RM, Thibeault S, et al. Voice disorders in teachers and the general population: effects on work performance, attendance, and future career choices. *J Speech Lang Hear Res*. 2004;47:542–551.
11. Chen SH, Chiang SC, Chung YM, et al. Risk factors and effects of voice problems for teachers. *J Voice*. 2010;24:183–192.
12. Morton V, Watson DR. The impact of impaired vocal quality on children's ability to process spoken language. *Logoped Phoniatr Vocol*. 2001;26:17–25.
13. Rogerson J, Dodd B. Is there an effect of dysphonic teachers' voices on children's processing of spoken language? *J Voice*. 2005;19:47–60.
14. Mullennix JW. Voice adjustments. In: Johnson K, Mullennix JW, eds. *Talker Variability in Speech Processing*. San Diego, CA: Academic Press; 1997.
15. Hazan V, Barrett S. The development of phonemic categorization in children aged 6–12. *J Phon*. 2000;28:377–396.
16. Crandell C. The effects of classroom amplification on children with normal hearing: implications for intervention strategies. *Educ Audiol Monogr*. 1991;2:18–38.
17. Nabelek AK, Nabelek IV. Room acoustics and speech perception. In: Katz J, ed. *Handbook of Clinical Audiology*. 4th ed. Baltimore, MD: Williams & Wilkins; 1994.
18. Heinrich R, Molenda M, Russell J, et al. *Instructional Media and Technologies for Learning*. Englewood Cliffs, NJ: Prentice Hall; 1996.
19. Benedict PK, Bauer RS. *Introduction to Cantonese Phonology*. Hong Kong: The University of Hong Kong, Centre of Asian Studies; 1993.
20. Cutler A, Chen HC. Lexical tone in Cantonese spoken-word processing. *Percept Psychophys*. 1997;59:165–179.
21. Baudoin-Chial S. Hemispheric lateralization of modern standard Chinese tone processing. *J Neurolinguistics*. 1986;2:189–199.
22. Chao YR. *Cantonese Primer*. Cambridge: Cambridge University Press; 1947.
23. Fok-Chan AYY. *A Perceptual Study of Tones in Cantonese*. Hong Kong: Centre of Asian Studies, University of Hong Kong; 1974.
24. Laures JS, Weismer G. The effects of a flattened fundamental frequency on intelligibility at the sentence level. *J Speech Lang Hear Res*. 1999;42:1148–1156.
25. Berne JE. Listening comprehension strategies: a review of the literature. *Foreign Lang Ann*. 2004;37:521–531.
26. Blatchford P, Burke J, Farquhar C, et al. Educational achievement in the infant school: the influence of ethnic origin, gender and home on entry skills 1. *Educ Res*. 1985;27:52–60.
27. Davie R, Butler N, Goldstein H. *From Birth to Seven Years*. Harlow: Longman; 1972.
28. McNiece R, Jolliffe F. An investigation into regional differences in educational performance in the National Child Development Study. *Educ Res*. 1998;40:17–30.
29. Smith E, Lemeke J, Taylor M, et al. Frequency of voice problems among teachers and other occupations. *J Voice*. 1998;12:480–488.
30. Massaro DW. Preperceptual images, processing time, and perceptual units in auditory perception. *Psychol Rev*. 1972;79:124–145.
31. Bistritsky Y, Frank Y. Efficacy of voice and speech training of prospective elementary school teachers. *Israeli J Speech Hear*. 1981;10:16–32.
32. Chan RWK. Does the voice improve with vocal hygiene education? A study of some instrumental voice measures in a group of kindergarten teachers. *J Voice*. 1994;8:279–291.