

IMPACT OF TEACHERS' VOICE QUALITY ON CHILDREN'S LANGUAGE PROCESSING SKILLS

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Teachers are a professional group highly exposed to dysphonia, the accumulation of a high vocal demand and detrimental working environments are auspicious to the development of vocal disorders. Yet, the voice of a teacher is his main tool for conveying knowledge to his students, thus a teacher's voice is of highest value. Recent studies have shown that altered vocal quality have an adverse impact on listeners' speech processing skills. The objective of our study was to investigate the impact of dysphonic voice on the speech processing skills of 68 eight-year-old children on a text comprehension task and on a minimal pair discrimination task. Children were tested preliminarily according to their auditory attention skills and their lexical and phrasal skills. Children listened to a female voice that read a text and a list of minimal pairs first in a normal voice and then in a dysphonic voice. Their comprehension of the text was evaluated by their score at seven questions about the text and their discrimination score was defined according to the number of correctly discriminated pairs. Results show that dysphonic voice quality lowers the score of all children, regardless of age, gender or language processing skills and across both tasks ($p < 0,05$); the negative effect of the dysphonic voice quality is more marked on the discrimination task ($p < 0,05$). The results of this study clearly advocate for the prevention of voice disorders in teachers.

Keywords

dysphonia, teachers, language processing, text comprehension, minimal pairs.

Introduction

Speech is the main tool for a teacher to convey knowledge. The teacher has to maintain his students' attention for several hours a day. His vocal quality has an influence on his students, either stimulating them, or bore them. In brief, a teacher's voice plays an important role in the receptiveness of his students. Also, teachers are an exposed group when it comes to vocal abuse or vocal overuse since the vocal demand on them is high. The teaching voice has a higher intensity than the normal speaking voice (Bistafaa & Bradley, 2000), is used during longer periods (Titze, 1999) and it has to be "projected" (Le Huche & Allali, 2001). Moreover, environmental factors like bad room acoustics (Kob et al., 2006), loud surrounding noise (Bistafaa & Bradley, 2000; Shield & Dockrell, 2000) or dry and dusty rooms (Hemler, Wieneke & Dejonckere, 1997) are contributing factors to the development of dysphonia. Bad acoustics and loud environmental noise generate the Lombard effect (unconscious raise of vocal intensity (Simberg, 2004; Inserm., 2006) and interfere with speech intelligibility (Johnson, 2000; Yang & Bradley, 2009). Several studies have shown the high prevalence of vocal disorders in the teaching population as compared to the general population (Simberg, 2004; Inserm., 2006 ; Sapir, Keidar & Mathers-Smith, 1993;

Chen et al., 2010): to meet the vocal demand their profession puts on them, teachers often produce a vocal effort with increased exertion that leads, in adverse situations, to the downward spiral of vocal strain (Le Huche, & Allali, 2001; Giovanni, Sacre & Robert, 2007). The resulting dysphonia can be dysfunctional or organic in nature, translating into deviant acoustical and perceptual cues. The most frequent symptoms are vocal fatigue, throat dryness, vocal roughness and physical discomfort (Sapir, Keidar & Mathers-Smith, 1993; Gotaas & Starr, 1993).

In the teaching profession, women have a greater predisposition than men to develop dysphonia (Inserm., 2006; Smith et al., 1998; Russell, Oates & Greenwood, 1998; Roy, 2004). They are physiologically less protected than men because of a lesser viscosity of vocal fold tissue. This viscosity depends amongst other on the hyaluronic acid concentration in the lamina propria which women have a lower concentration of than men. Women in general are thus more exposed to dysphonia than men. According to the French National Institute of Health and Medical Research (Inserm: 2006), kindergarten school teachers have a risk of developing dysphonia that is superior to primary or secondary school teachers. Some authors have found that from the age of 40, more teachers complain over vocal disorders (Smith, 1997; Russell, Oates & Greenwood, 1998; Thibeault, 2004) while the report on voice from the Inserm (Inserm., 2006) shows that the age group 26-35 years is the most affected.

Teachers are also subject to physical and psychological stress (Van Dick & Wagner, 2001). This stress is related to the occurrence of vocal disorders in teachers (Mattiske, Oates & Greenwood, 1998). Some authors underline that vocal disorders also can be the origin to anxiety and stress and have a negative impact on the teaching experience (Gotaas & Starr, 1993). Gender, age, stress, environment, physiology and professional demand are all factors influencing the teachers' vocal quality.

Dysphonic voices yield more negative judgements from listeners than normophonic voices (McKinnon, Hess & Landry, 1986; Morton & Watson, 2001). Moreover, literature shows that student performance is negatively affected if the task has been presented by a dysphonic voice (Morton & Watson, 2001; Rogerson & Dodd, 2005). According to classical speech processing theory, word recognition implies several levels of representation (sublexical, lexical) and several types of processes are implied (segmentation, categorization, alignment and pairing (Frauenfelder & Nguyen, 2000). The speed and precision of word recognition is influenced, amongst other, by the lexical and phrasal context (Marslen-Wilson & Tyler, 1980).

Speech is subject to variability according to the vocal quality of the speaker. These varieties are compensated for by a mechanism of speaker normalization (McLennan, Luce & Charles-Luce, 2003 ; Goldinger, 1996). Two studies have accounted for the influence of speaker dependent vocal quality variability on spoken word recognition. One shows that a change of vocal quality has a negative impact on comprehension (Mullenix, Pisoni & Martin, 1989) and the other suggests that perceptual training of voice quality can facilitate the linguistic content analysis of the speech signal (Nygaard & Pisoni, 1998).

Young children have a holistic representation of speech (Walley, 2005; Metsala, 1997) which is eventually specified and structured around speech segments during mid-childhood (Garlock, Walley & Metsala, 2001). Increased vocabulary leads to increased familiarity (Garlock, Walley & Metsala, 2001) and the density of phonological neighborhood (Charles-Luce & Luce, 1995). Neighborhood effects associated to word frequency are stimulated and improve speech recognition (Metsala, 1997). Increased vocabulary also impacts phonological awareness (Garlock, Walley & Metsala, 2001) and segmentation and phonemic categorization processes. Children aged 6 to 12 years still show less flexibility than adults in their perceptive strategies (Hazan & Barrett, 2000).

The present study, inspired from the works of Rogerson and Dodd (Rogerson & Dodd, 2005) and Morton and Watson (Morton & Watson, 2001) addresses the consequences of speaker dependent vocal quality variations (dysphonic versus normophonic voice) in teachers, on the speech processing skills of their students.

Material and methods

Subjects

68 children participated (34 boys, 34 girls). Mean age was 8 years 5 months, with a standard deviation (SD) of 8 months. The children's parents all signed an informed consent form allowing their child's participation in the study. They also answered a questionnaire about their child's medical history, audition was specifically addressed.

Children were all individually assessed with regard to (1) their auditory selective attention skills, with the subtest "*Attention et fonctions exécutives*" from the assessment material NEPSY (Korkman, Kirk & Kemp, 2003). The child has to listen to a list of 180 words and has to put a red square in a box only when the word "red" is heard. This task is evaluating a double mechanism: a selective process necessitating concentration on a target and an active inhibition of the distractors. It refers to the most common concept of «attention», namely being «concentrated » as opposed to being «distracted». (2) Their receptive lexical skills, with the subtest "*LexR*" from the assessment material ELO (Khoms, 2001). Boards with four images are presented and the child has to point on the image corresponding to the object named in a read sentence (20 items). (3) Their comprehension skills, with the subtest "*C2*" also from ELO (Khoms, 2001). Boards with four images depicting an action are presented to the child who has to point at the one corresponding to a read sentence (20 items).

Tasks

Comprehension

The first task was a comprehension task based on two read short texts equal in length (60 and 64 words, duration of 22 seconds each). The texts were taken from a test for the assessment of memory for children (Cohen, 2001) and are part of the subtest "*Histoires*". The texts are standardized for children aged 5-8 years. The two texts relate a different story but in a similar structure. Each text was recorded once with a non-dysphonic (normal) voice and once with a dysphonic voice.

Seven multiple choice questions were elaborated for each text according the structure of the Rogerson and

Dodd questionnaire (2005) to test the following skills: (1) understanding the topic of the story, (2) understanding the theme of the story, (3) understanding the vocabulary according to the specific context, (4) understanding a detail of the text, (5) understanding the chronology, (6) understanding the end of the story, (7) choosing an appropriate title. Every question had four answer options, only one correct, presented in a random order. A pilot study with 19 third grade students was undertaken to test the validity of the two texts and questionnaires. The texts were read aloud to the students by their class teacher before they answered the questions in a written mode. The results from this pilot study showed a mean comprehension score of 8,53/10 (SD: 2,40) for text A and 9,23/10 (SD: 1,40) for text B. No significant difference was found between the mean scores of questionnaire A and questionnaire B, this was tested with a Wilcoxon signed rank test ($T=25,5$, $p:0,50$).

Discrimination

The second task was a discrimination task. Two lists of minimal pairs of words were created. The words of each pair differentiated on the initial phoneme which was either voiced or voiceless while the articulation place and mode were kept identical (ie :pois/bois). Auditory discrimination of minimal pairs is classically used to control the accurate perception of the phonological structure.

Vocal recording of the texts and the minimal pair lists

A speech language therapist (SLP) specialized in voice disorders read both texts and lists of minimal pairs in a normal voice and then while imitating a dysphonic voice. Using the same person for both normal and dysphonic mode allowed us to control for accent, prosody and articulation. A female voice was chosen due to the great proportion of female teachers in primary schools. The recordings were made with the Computer Speech Lab (CSL 4300; Kay Elemetrics) and an AKG head worn microphone.

An SLP specialized in voice and seven last year SLP students graduating in voice, all naïve to the study, graded the two readings of the texts and of the lists according to the GRBAS-I. This scale for perceptual assessment of voice quality is composed of five parameters evaluated on 4 grades where 0 reflects normality of the parameter and 3 reflects severe pathology. The normal voice was evaluated a grade 0 on all parameters while the judgments of the dysphonic voice quality ranged from G2 R2 B1 A0 S2-I0 to G3 R3 B2 A2 S2-I1 (see table 1).

Table 1. GRBAS-I evaluations of the dysphonic voice made by the 7 SLP students majoring in voice.

	0	1	2	3
G				100%
R			42,86%	57,14%
B			58,71%	14,29%
A		28,57%	71,43%	
S			57,14%	28,57%
I	42,86%	57,14%		

Procedure

We first proceeded with the text comprehension task. Before listening to the recordings of the texts, the students received the following instructions: *"I'm going to let you listen to a short text. You need to pay attention because I'm going to ask questions on the text afterward. You all have a paper upside down on your table with seven multiple choice questions. You will need to ring in the correct answer to each question. You will turn up the paper only when I tell you to."* The students listened to the recordings with the high speakers Altsc Lansing ACS 45.1. The bass high speaker was positioned on a table facing the students, in a median position; the two additional high speakers were positioned on the sides at equal distance. Sound pressure level was adapted empirically to the dimensions and acoustics of the different classrooms in order to be sufficient to be heard clearly by the students sitting in the rear end of the classroom.

Two classes listened to a text read with normal voice quality first and then with dysphonic voice quality and the other two classes listened in the reverse order. After each text, the students answered the questionnaire; both questions and answer options were read aloud in addition to the written presentation.

Secondly, we proceeded with the discrimination task. Before listening to the recording, the students received the following instructions: *«You will hear 12 pairs of words; you will have to decide if the two words you hear are the same or not the same. If they are the same you make an x in the first column and if they are not the same you make an x in the second column. You have to pay attention because it is going quite fast.»* An example was given before the list was played. Presentation order of the normophonic and dysphonic voices was alternated for the different groups.

Just after hearing the list in the dysphonic voice quality, the students were asked to answer additional questi-

ons regarding that voice: “What did you think about that voice?”, “How did that voice affect you?”, “Write down all you think about, if you do not know what to write, you do not have to write anything.”

Results

Statistical analyses were made with Statistica 8.0 (StatSoft).

Auditory selective attention

Distribution of the scores was analyzed with Shapiro-Wilk test. The distribution was not normal ($W:0,95$, $p<0,05$). The minimal score observed was 7 and the maximal score was 15 (Mean: 11, SD:2,01). This confirms that no student has a deficiency in auditory selective attention.

Tasks

The distribution of the scores at the comprehension task and the discrimination task were not normally distributed as shown by a Shapiro-Wilk analysis ($p<0,05$) and thus, non-parametrical tests were used to analyze the data.

Intra-subject performances according to voice quality

Wilcoxon signed rank test was used to evaluate score differences between the two voice conditions.

Comprehension task

Results show that $T = 225$, $p<0,05$. The null hypothesis can be rejected, the score means are not equal on the different conditions; the dysphonic voice quality yields significantly lower scores than the normal voice quality.

Discrimination task

Results show that $T = 210,0000$, $p<0,05$. The null hypothesis can be rejected, the score means are not equal on the different conditions, the dysphonic voice quality yields significantly lower scores than the normal voice quality.

Interaction of voice type and task

A two-factor ANOVA with repeated measures was used to analyze the impact of voice quality and task.

General effect of voice quality

Results show that $F(1,67) = 63,18$, $p<0,05$. This indicates that the scores at both the discrimination and comprehension tasks are taken together, the scores are significantly different for the different voice qualities.

General effect of task

The results show that $F(1,67) = 11,830$, $p<0,05$. This indicates that if we consider the scores in both vocal condi-

ons globally, there is a significant difference between the scores at the discrimination and comprehension task.

Interaction of the factors “task” and “voice”

Results show that $F(1,67) = 9,52$, $p<0,05$. This indicates that the score differences observed between voice conditions are significantly different according to the task.

The comprehension task yields better scores than the discrimination task in normal voice condition, but this difference is bigger when the tasks are presented in dysphonic voice condition. The voice quality has a greater impact on the discrimination task than on the comprehension task.

Additional effects

We further analyzed possible correlations between lexical skills and comprehension scores, impact of gender or school but no results were significant.

Students’ subjective reactions to the dysphonic voice

88,23 % of the students gave their view on the dysphonic voice. A predominance of negative terms is observed (98,33%). A large proportion of the terms were emotionally tainted (44,12%) such as “sad, monster, dying, ugly”. More than half of the students used at least one term relating to pathology such as “broken, ill, throat-ache ...”.

Discussion

Our study aimed to measure the impact of a dysphonic voice on the ability of students to process speech.

Rogerson and Dodd (Rogerson & Dodd, 2005) showed that students’ comprehension performances are worse when they are tested on a text read with a dysphonic voice. The authors suggest that a disordered voice demands additional cognitive resources in the listener to process speech. The resources allocated to comprehension are thus diminished. Morton and Watson (Frauenfelder & Nguyen, 2000) obtained similar results with an inference task, on texts that were read with normal or dysphonic voice, thus corroborating the results from two former studies. Mullenix et al. (1989) studied the impact of speakers’ vocal variability on spoken word recognition. Inter speaker voice variability produced negative effects on listeners’ skills. These authors suggest that early processes of spoken language, which consist in extracting phonetic information from the acoustic signal, are strongly linked to analysis of speaker voice quality. Their conclusions could explain the lower comprehension scores in the dysphonic voice condition in our study.

The auditory task permitted us to investigate if the students' perception was affected at the phoneme level. We chose to differentiate the first phoneme on the voiced/voiceless parameter, because "dysphonia is an impairment of the vibration of the vocal folds and impacts voiced phonemes, which are produced with a glottal vibration. Voiceless phonemes, inversely, are produced with open, non-vibrating vocal folds" (Revis, 2004). Our results show that our students' scores, in dysphonic voice condition, are significantly lower than in normal voice condition. These results not only corroborate earlier findings (Rogerson & Dodd, 2005, Frauenfelder & Nguyen, 2000), they give a supplementary cue to the origin of the comprehension difficulties linked to dysphonic voice quality. A distortion of phonemes on the voiced/voiceless parameter could occur, that could be assimilated to an articulatory error. A phoneme substituted by noise is restored by the listener with the influence of lexical context (perceptual restoration), a context that is voluntarily neutralized in the minimal pair discrimination task. Hazan and Barrett (2000) suggest that 6-12 years-old children show lesser flexibility in their perceptual strategies than adults and Johnson (2000) shows that children's ability to identify consonants in noisy or reverberating environments are not fully developed until adolescence. Thus, our results could be explained by noisy classroom acoustics and the difficulty linked to the absence of lexical context in the task in addition to children's weaker perceptual skills. It is to be noticed that we tried to keep the task accessible to children by placing the distinctive phoneme in initial position because children 7-8 years have more facilities to discriminate phonological dissimilarities in the initial syllable (Walley, 2005).

Our results show that the dysphonic voice condition impairs the students' results in both the comprehension and the discrimination task, but the effect is even more marked in the discrimination task.

Marslen-Wilson and Tyler (1980) showed that word recognition is facilitated by sentence context which could contribute to lexical identification. In our study, the short texts could have had this facilitating effect in the dysphonic voice quality condition. The discrimination task has no such contextual support and thus leads to more mistakes than the comprehension task.

Morton and Watson (2001) noted spontaneous reactions from the students on the dysphonic voice that was used in their study. Negative reactions were noted. Their observations are concordant with the results obtained in

our study. These negative judgments could be correlated to the notion of "internal referent" introduced by Fex (1992), which means that the listeners unconsciously compare the voices they hear with what they consider being a "normal voice" that they make judgements from. This "normal voice" referent is unique to every listener. In our study, one remark from a student illustrates this particularly: «*it sounds like my grandmother, that's nice, I like it a lot*» by revealing this student's personally and emotionally tainted internal referent. We observe that the students have a great lexical diversity in their emotional judgments of the voices, as well as a frequent use of words issued from the pathological domain. It is interesting to note the link they make between the vocal quality and the pathological state.

Conclusion

Our results revealed an impact of dysphonic voice on eight year old children's ability to process speech. We observe a significant lowering of the scores both in a comprehension and a discrimination task when these are presented in a dysphonic voice quality. The impact of the dysphonic voice is significantly more important on the discrimination task as compared to the comprehension task. We observe that dysphonic voice quality affects performance regardless of gender, school, lexical level or general comprehension skills. The impact of dysphonic voice quality is further underlined by the majorly negative judgements the children made on the dysphonic voice. Our results support the importance of good teaching conditions. Vocal prevention programs should be encouraged both for the teachers' and the students' well-being.

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