Phonetographic aspects of physiological and perceptual voice characterist

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journal: STL-QPSR
volume: 33
number: 2-3
year: 1992
pages: 041-056

http://www.speech.kth.se/qpsr
Abstract

Pitch and intensity ranges of 60 children were recorded and plotted in terms of phonetograms. Different aspects of the phonetograms were investigated, such as minimum phonation threshold, pitch range, and maximum dynamic range. The vocal cord status of all children was determined in a phoniatric examination. Seven voice experts listened to recordings of the voices and rated their properties along 16 parameters including hoarseness. Using these ratings, the hoarse children were identified. The phonetogram characteristics of adults and children were compared, as well as those of chronically hoarse and nonhoarse children and ten-year-olds with and without vocal nodules or glottal chinks. The phonetograms of children with beginning mutational voices were compared to those of adults.

INTRODUCTION

In recent voice investigations, phonetograms, or voice range profiles, have been frequently used (Coleman, Mabis, & Hinson, 1977; Gramming, 1988). Although it only displays sound pressure level of softest and loudest possible phonation versus fundamental frequency of phonation throughout the total pitch range, it has been found informative also with respect to other voice characteristics than those related to dynamics (Schutte, 1980; Ohlsson, Järvholm, & Löfqvist, 1987; Gramming & Åkerlund, 1988). Pabon & Plomp (1988) supplemented phonetography by aperiodicity information and observed that dysphonic voices of various types, apart from aperiodicity characteristics, also frequently exhibited deviant phonogram contours. This suggests that it might be worthwhile to examine the relations between phonetograms and hoarseness in more detail.

Among voice experts, hoarseness is often considered a controversial term, comprising several perceptual parameters. Still, according to a previous study, the term was found to be reasonably well-defined and unequivocal within a panel of speech and language pathologists (Sederholm, McAllister, Sundberg, & Dalkvist, 1992). We identified three predictors of hoarseness: hyperfunction, breathiness and roughness, a result that was in clear accordance with the findings of Isshiki, Okamura, Tanabe, & Morimoto (1969).

In the past, child hoarseness has sometimes been assumed to be harmless and to automatically disappear during puberty (Håkansson & Kitzing, 1984). However, some authors have taken the opposite view, claiming that by over-looking voice change during childhood, pathologies may be diagnosed at too late a stage (Cohen, Geller, Thompson, & Birns, 1983). Also, child hoarseness may reflect psychological factors or specific personality traits that may be important (Toohill, 1975). Having a hoarse, dysfunctional voice might influence negatively the child's self perception as well as the listeners' evaluation of her/his personal traits and capacities (Ruscello,
Furthermore, child hoarseness may prevent a child from pursuing a musical interest or career. Children’s voices have previously been analyzed by means of phonetography by Klingholtz, Martin & Jolk (1985; 1989), Pedersen, Munk, Bennet, & Möller (1983) and Pedersen, Möller, Krabbe, Munk, Bennet, & Kitzing (1984). All these studies concerned choir singers’ pitch ranges and registers, and Pedersen, et al. also included the effects of voice mutation.

The purpose of the present investigation, which is part of a larger research project centered around the occurrence of and factors behind hoarseness among children, was to elucidate how hoarseness and other phonation characteristics of non-singer children’s voices are reflected in the phonetogram.

METHODS
a) Subjects
Included in the entire research project were 63 children, 37 boys (59%) and 26 girls (41%), grade three (10 years old) from three public schools in the Stockholm area. The schools were chosen so as to guarantee a certain socio-economic variability, although there was no ambition to make the sample strictly statistically representative in that respect.

To establish pubertal status, the parents were asked to estimate the child’s growth during the last year; according to endocrinologists, a growth index exceeding 10 cm/year indicates onset of puberty (Taranger, Engström, Lichtenstein, & Svennberg-Redegren, 1976).

b) Tape recordings
When dealing with hoarseness, one problem is the difference between acute and chronic voice change. To differentiate these types, many researchers have evaluated the children’s voices on at least two separate occasions (Weinberg, 1915; Baynes, 1966; Silverman, & Zimmer, 1974; Yairi, Horton-Currin, Bulian, & Yairi, 1974; Casper, Abramson, & Forman-Franco, 1981), and accompanied their perceptual evaluations with laryngeal inspection.

In order to establish the children’s voice status, recordings were made on two separate occasions. In recording 1, fifty-eight children (34 boys and 24 girls) participated. They were recorded in acoustically reasonably attenuated rooms in the schools using a Sony TCD-D1 (pitch range) digital audio tape recorder and a Sony ECM-55B microphone. The microphone was mounted on a pair of glasses to ensure a stable and constant microphone distance and to eliminate the risk of air blast. The children were asked first to read a short story and then to retell it in their own words. When the latter was not feasible, a short interview was carried out.

Two months later, the children were recorded a second time. This recording included 60 children (36 boys and 24 girls) and was made in a sound treated room (532x285x270cm) with an ambient noise level lower than 40 dB above 125 Hz. Each child read a short text and sang a simple tune. The same equipment as in the first recording was used.

c) Perceptual ratings
To identify the hoarse voices, the recordings were perceptually analyzed by seven speech and language pathologists, all experts on voice disorders. The voice evaluation
sheet (see Appendix 1) included a number of different voice parameters that could be assumed to be relevant for describing children’s voices. These parameters were selected from those used by Hammarberg (1986). A preliminary set of parameters was tried out in a listening session with four voice experts, including co-authors AM and ES. Based on the experience from this session, 14 voice parameters, including two pertaining to nasality, were chosen. In addition hoarseness was included, being the key concept of the entire research project. Finally, a blank parameter was added, thus offering the listener the possibility to suggest one additional parameter.

The experts were instructed first to estimate the general impression of hoarseness before proceeding to the other parameters. Using visual analogue scales, each parameter was represented by a 100 mm continuous line (Wewers & Lowe, 1990). The extremes represented non-existence and extremely high occurrence of the trait, respectively.

d) Audiometry

The hearing of the children who were recorded a second time was screened in a sound treated booth, using a GSI 17 audiometer. The screening level was set to 20 dB.

e) Laryngoscopic examination

To identify possible laryngeal pathologies, the 60 children who took part in recording 2 were examined by a phoniatrician, using indirect microlaryngoscopy, and if possible, also stroboscopy. The entire examination could be followed by both the child and the examiner on a Philips colour monitor (8802). The examination was recorded on a Nordmende VHS audio-video recorder (V 1005) by means of a Panasonic (WVCD 110-AF) video camera connected to a Zeiss microscope (Opmi 9-FC), and a Brüel & Kjær stroboscope (4914).

Apart from the larynx, the examination also included ear, nose and throat. The observations were written down on a specific form constructed for this purpose, see Appendix 2. On this form certain anamnestic data were also recorded.

The video recordings were examined by another expert phoniatrician who was asked to quantitatively evaluate glottal closure patterns adapted from Södersten & Lindestad (1990), vocal fold color, and shape on a form (see Appendix 3).

f) Phonetograms

Phonetograms were made of all 60 voices involved in recording 2. The procedure followed the recommendations of the Union of European Phoniatricians (Schutte & Seidner, 1983) using a Brüel & Kjær sound level meter (2215). However, the SPL was measured by means of a flat frequency curve rather than in dB(A) (Gramming & Sundberg, 1988; Pabon & Plomp, 1988). Such a flat frequency curve has the advantage of facilitating a physiological interpretation (Gramming, 1991). The advantage of an A-weighted curve, on the other hand, is that the sensitivity to low frequency noise in the recording room is suppressed.

In these measurements, the microphone distance was approximately 30 cm. The subjects were asked to sing at each specific pitch on the vowel [æ:]. A synthesizer, CASIO SA-20, was used for giving the subjects reference pitches. Whenever required, these pitches were also sung by the experimenter. To get an appropriate registration, it was sometimes necessary for the experimenter to sing together with the child at the desired pitch and then let the child continue alone.
RESULTS

a) Perceptual analysis

We used the results of the voice experts' perceptual analysis to identify the voices that could be labeled as hoarse. For the statistical analysis, the SPSS/PC + 4.0 statistics and advanced statistics analysis systems were used (Norusis, 1990). In order to determine the interjudge reliability in recording 1, Cronbach's alpha reliability coefficient was computed for the listeners' ratings of all parameters except the blank parameter (other voice quality), see Table I.

The interjudge reliability was satisfactory throughout, voice breaks constituting the only exception with an alpha value of .36. This means that the expert listeners' perception of the voices were in good agreement, even though the concept of voice breaks seemed to have caused some problems. Interestingly, the controversial parameter hoarseness received the highest alpha value of all, namely .92 in recording 1.

<table>
<thead>
<tr>
<th>Perceptual variable</th>
<th>Cronbach's alpha, α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoarseness</td>
<td>.92</td>
</tr>
<tr>
<td>Breathy</td>
<td>.88</td>
</tr>
<tr>
<td>Hyperfunctional</td>
<td>.90</td>
</tr>
<tr>
<td>Hypofunctional</td>
<td>.81</td>
</tr>
<tr>
<td>Gratings</td>
<td>.78</td>
</tr>
<tr>
<td>Rough</td>
<td>.82</td>
</tr>
<tr>
<td>Voice breaks</td>
<td>.36</td>
</tr>
<tr>
<td>Unstable pitch/quality</td>
<td>.86</td>
</tr>
<tr>
<td>Hard glottal attacks</td>
<td>.72</td>
</tr>
<tr>
<td>Vocal fry</td>
<td>.74</td>
</tr>
<tr>
<td>Audible inhalation</td>
<td>.84</td>
</tr>
<tr>
<td>Hypernasality</td>
<td>.84</td>
</tr>
<tr>
<td>Hyponasality</td>
<td>.89</td>
</tr>
<tr>
<td>Pitch</td>
<td>.91</td>
</tr>
<tr>
<td>Register</td>
<td>.74</td>
</tr>
</tbody>
</table>

Table I. Interjudge reliability coefficients, rec. 1, for ratings of 15 perceptual voice parameters.

The mean hoarseness values, calculated across experts for each voice, were plotted in rank order, see Figs. 1 and 2. The curve showed a marked discontinuity near the hoarseness values of 35 mm and 40 mm for the two recordings, respectively. Using this discontinuity as the criterion for hoarseness, 14 out of the 58 children in recording 1, and 14 out of 60 children in recording 2, were identified as being hoarse. Thus, the prevalence of hoarseness in the population participating in the first recording came to 24% and 23% in the second. Fifty-seven children took part in both recordings. Among these, 8 boys were rated as hoarse on both occasions. None of these boys had a cold at the second recording. This implies that these boys, or 14% of all the examined children, suffered from chronic hoarseness.

Ten out of the remaining voice parameters exhibited plots of rank-ordered means that were more or less similar to that of rated hoarseness. In three parameters, pitch, vo-
cal fry and breathiness, no discontinuity was observed in the rank order graphs. This implies that the distributions of these three parameters were closer to a normal distribution than those of the other parameters.

Hoarseness is often observed to be a forerunner to mutational voice change (Curry 1949). Eight of the 63 children participating in the research project, seven boys and one girl, had a growth index of 10 cm or more and could therefore be expected to be hoarse due to voice mutation. These eight children were recorded and perceptually rated at both recording occasions. Among them, no more than one boy turned out to be chronically hoarse.

![Fig. 1. Rated mean hoarseness values for the 58 voices in rec. 1 plotted in rank order. Note the marked discontinuity at the hoarseness value of 35 mm.](image1)

![Fig. 2. Rated mean hoarseness values for the 60 voices in rec. 2 plotted in rank order. Note the marked discontinuity at the hoarseness value of 40 mm.](image2)

b) Audiometry

One girl had a right ear conductive hearing loss down to the level of 50 dB at 500 Hz, which was not thought to influence the quality of her voice. Normal hearing above 20 Hz was established in the remaining 59 children.

c) Status of the vocal cords

Phoniatric inspection was feasible in 51 out of 60 children. Stroboscopy, allowing a far better judgement of glottal closure and vocal fold vibration, could be performed on 32 children.

The laryngeal status, as observed by one phoniatrician in indirect micro-laryngo(strobo)scopy and confirmed by another expert’s ratings from the video recordings, revealed six cases of bilateral vocal nodules all of which seemed long-stretched and oedematous, all in boys. Incomplete glottal closure was found in 14 cases, i.e., glottal chinks of shapes 2-4, see Appendix 3. Out of these, nine were boys and five were girls. Of the eight children who were chronically hoarse, three boys also had vocal nodules. Two other cases with both hoarseness and vocal nodules took part in recording 2 only. Therefore chronic hoarseness cannot be established for these children.

Nine of the 14 children with glottal chinks were perceptually judged to be free not only from hoarseness and its predictors hyperfunction, breathiness and roughness, but also from hypofunction. This finding is in accordance with the observations of
Södersten & Lindestad (1990), who showed that perceived breathiness due to incomplete closure of the posterior parts of the glottis could be regarded as normal in female voices. The present results suggest that this might be applicable to children as well.

**d) Phonotographic analysis**

Ten of the children were so called hummers, i.e., they were not able to phonate at the pitches requested, and were therefore excluded from the phonotographic analysis.

To facilitate an analysis of the phonotogram characteristics of hoarse voices, a control group was established. This group was selected on the basis of the perceptual analysis. In a preceding investigation, Sederholm, et al. (1992) found hyperfunction, breathiness and roughness to account for 91% of the variance of rated hoarseness among these voices. Thus, these parameters are good predictors of hoarseness. Out of the total of 50 phonotographically recorded children, 24 children, 13 girls and 11 boys, were perceptually judged to be free of hoarseness, hyperfunction, breathiness as well as roughness. In addition, they all had a normal glottal status. These voices were selected to constitute the control group and will henceforth be referred to as the spotless group. The group of non-humming children with chronic hoarseness consisted of six boys. Ten children, five girls and five boys, constituted the group with glottal chinks. Five boys with completed phonotograms had vocal nodules. Pubertal onset was established in eight cases; of these six were successfully registered phonotografically and thus constitute the group of mutational voices.

The phonotograms were analyzed with regard to pitch range in semitones (st), and maximum dynamic range defined as the difference between the upper and lower contour at a given fundamental frequency (Coleman, et al., 1977; Gramming, 1988). The mean pitch range for the whole group was G2-G4 (196 Hz-784 Hz.), with an average of 24 st. It should be noted that 15 of this group of 50 nonsinger children had a pitch range exceeding 30 st; one boy’s range was no less than 38 st, from F2-G5 (175 Hz-1568 Hz) and with a maximum dynamic range of 26 dB.

Descriptive statistical measures of pitch range (PR) and maximum dynamic range (MDR) for all five groups of voices are shown in Table II. Figure 3 shows a comparison of the pitch ranges for the whole group and the five subgroups, respectively. The lower fundamental frequency limit varied within a rather narrow range, about a semitone or 6%, for the various groups. Hence, the variation between the groups was due to a variation of the upper limit.

<table>
<thead>
<tr>
<th>Voice group</th>
<th>N</th>
<th>Mean, PR st</th>
<th>Std Dev., PR</th>
<th>Mean, MDR</th>
<th>Std Dev., MDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spotless</td>
<td>24</td>
<td>25.0</td>
<td>7.0</td>
<td>21.4</td>
<td>5.9</td>
</tr>
<tr>
<td>Chronic hoarseness</td>
<td>6</td>
<td>22.0</td>
<td>4.5</td>
<td>21.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Glottal chinks</td>
<td>10</td>
<td>27.0</td>
<td>5.8</td>
<td>22.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Vocal nodules</td>
<td>5</td>
<td>19.0</td>
<td>7.8</td>
<td>22.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Mut. voices</td>
<td>6</td>
<td>29.0</td>
<td>6.9</td>
<td>22.8</td>
<td>6.6</td>
</tr>
</tbody>
</table>

*Table II. Descriptive statistical measures of pitch range, PR (in semitones), and maximal dynamic range, MDR (in dB) for five groups of voices.*
Following the procedure described by Gramming, Sundberg, Ternström, Leandersson, & Perkins (1988), averaged phonetograms were calculated for the different groups of voices shown in Table II. The procedure implied an averaging of the upper and lower contours within each tenth of the normalized pitch range. Fig. 4 shows such an averaged phonetogram for the spotless group. For comparison, Gramming’s (1991) data for nonsinger female adults are also shown. The upper contour was rather similar, particularly at lower pitches, while the female adults had a clearly lower phonation threshold and also a wider dynamic range.

Figure 5 compares the mean phonetograms for the spotless group and Gramming’s data for nonsinger male adults. Here, the children demonstrate a lower phonation threshold than the men, who on their part had a considerably higher upper contour. In Fig. 6, the spotless group is compared to the averaged phonetogram of the chronically hoarse children. Both the upper and lower contours are somewhat higher for the hoarse voices.

An elevated lower contour was also found for the nodule group, as shown in Fig. 7. The lower contour for the children with visible glottal chinks, on the other hand, tends to lie below that of the spotless group, particularly in the upper half of the spectrum as shown in Fig. 8.

The averaged phonetogram of the mutational voices illustrates an approximation of the vocal capacity towards more adult phonetographic contours, see Figs. 9 and 10. The upper curve for the mutational voices is very similar to that of the female voices, while the lower curve approaches that of the men.

Figure 11 compares the phonetogram for a boy with hoarseness and a mutational voice, with that of an average for female singers (Gramming, 1991). For the highest pitches the upper phonetogram contour is similar to that of the female singers but at lower pitches this boy clearly exceeds the female values. A comparable increase of the upper contour was not be found in any other of the children investigated. His lower contour was elevated as compared to the female values. Despite this, his voice shows good dynamic capabilities similar to those of the female singers, with a maximum dynamic range at one and the same frequency level of 33 dB. His pitch range was 32 st, ranging from $E^3$, 165 Hz, to $C^5$, 1048 Hz.
Fig. 4. Averaged phonetograms for 24 children, 13 girls and 11 boys, with normal glottal status and no perceived hoarseness, hyperfunction, roughness or breathiness, the "spotless" group (lines) and 10 nonsinger women with normal voices (open circles). FO is expressed as percentages of the normalized total range.

Fig. 5. Averaged phonetograms for 24 children, 13 girls and 11 boys, with normal glottal status and no perceived hoarseness, hyperfunction, roughness or breathiness, the "spotless" group (lines) and 10 nonsinger men with normal voices (open circles). FO is expressed as percentages of the normalized total range.

Fig. 6. Averaged phonetograms for 6 children with chronic hoarseness (lines) and 24 children with normal glottal status and no perceived hoarseness, hyperfunction, roughness or breathiness, "spotless" group (open circles).

Fig. 7. Averaged phonetograms for 5 children with vocal nodules (lines) and 24 "spotless" children (open circles).
Fig. 8. Averaged phonetograms for 10 children with glottal chinks (lines) and 24 "spotless" children (open circles).

Fig. 9. Averaged phonetograms for six mutational voices (lines) and ten nonsinger women with normal voices (open circles).

Fig. 10. Averaged phonetograms for six mutational voices (lines) and ten nonsinger men with normal voices (open circles).

Fig. 11. Averaged phonetogram for one hoarse and mutational boy (lines) and 10 singer females (open circles).
DISCUSSION

Few investigations regarding phonetograms have dealt with nonsinger children’s voices, perhaps because of difficulties in getting such children to perform the task required for phonetogram analysis. The first results regarding pitch range in children were published as early as in the beginning of this century. A normal pitch range for a group consisting of both singer and nonsinger children of the age considered here was from B♭-E♭, (247 Hz-659 Hz), with an average of 15-16 semitones (Weinberg, 1915). Flatau & Gutzman (1908) investigated 50 ten-year old children in two different schools. The mean pitch range was found to be 21 semitones and the range from A♭-F♯, (220 Hz-740 Hz). In an investigation by Blatt (1983), in which five boys were 9-10 years old, a mean pitch range of 26 semitones was found, ranging from G♯-A♯, (208 Hz-923 Hz). All boys had singing experience of various lengths. Thus, our results regarding pitch range appear to be in good accordance with earlier findings.

The mutational period generally starts around the age of 12 for girls and 13 for boys according to Dejonckere (1984). In the above mentioned investigation by Blatt (1983) one boy out of five in the age group 9-10 years had a mutational voice. This occurrence does not seem clearly different from the one found in the present investigation, viz., 8 out of 63.

Weiss (1950) defined the premutational vocal changes as a "certain loss of vocal power, a slight lowering of the pitch and frequent indispositions of the voice" and Curry (1949) states that hoarseness is generally alleged to precede male voice mutation. During this period the larynx undergoes dramatic changes (Aronson, 1980). Our results, one case out of 8 of mutation combined with chronic hoarseness, give weak support to the assumption that hoarseness accompanies mutational voice change.

It can be assumed that the lower phonetogram contour is related to the structural properties of the vocal fold mucosa. It is likely to reflect the willingness of the vocal folds to vibrate at low driving pressures. The upper contour, on the other hand, seems to depend on the muscular capacity to cope with high pressures (Åkerlund & Gramming, manuscript for publication; Kitzing, personal communication). The phonetogram measurements of the mutational voices revealed an approximation to the adult voices. This may be a reflection of the fact that the differentiation of the layer of elastic fibers from that of collagenous fibers takes place approximately at the time of mutational voice change (Hirano, Kurita, & Nakashima, 1983). Our group of "spotless" children exhibited a rather restricted dynamic range. The lower contour was slightly elevated as compared to that of adult females thus suggesting that the vocal fold structure of these children demands higher subglottal pressures. The upper contour was lower than that of adult females and thus may reflect a restricted ability of the vocalis muscle to resist high pressures.

Hoarseness in children’s voices is often reported to be accompanied by vocal nodules (Wilson, 1979). Vocal nodules can be expected to correspond to an elevated phonation threshold in the phonetogram, since the nodules can be assumed to interfere with the vibratory process. Such a tendency can be seen in our results.

Both the upper and lower phonetogram contours were somewhat higher for the hoarse voices than for the spotless voices. It is possible that this difference reflects a divergence in the vocal cord structure and/or in the phonatory habits.
The children with glottal chinks had a lower phonation threshold than the spotless group. A similar difference has been revealed between women and men, women tending to have a lower phonatory threshold than men (Gramming, 1991). According to Södersten & Lindestad (1990) glottal chinks are found in many normal female adults.

Further data on subglottal pressure and different vibratory modes in children’s voices may help to elucidate the physiological background of our data.

CONCLUSIONS

The occurrence of hoarseness in this study was 23%. The incidence of chronic hoarseness, as rated on two separate occasions, was 14%. Ten percent of the children had vocal nodules, 23% glottal chinks and 13% had entered puberty. Boys were generally overrepresented in all these groups.

Clear differences were found in the phonetogram contours between normal/spotless voices and those suffering from chronic hoarseness, nodules, as well as glottal chinks. The children with mutational voices exhibited phonetogram contours resembling those of adults. Children in general seem to have somewhat compressed phonetogram contours, reflecting restricted dynamic vocal capabilities.

ACKNOWLEDGEMENTS

The kind and courageous cooperation of the children is gratefully acknowledged. This work was supported by a grant from Axel and Margaret A:son-Johnsons Foundation, Stockholm.

REFERENCES


Åkerlund, L. & Gramming, P. (manuscript for publication): "Average loudness levels, mean fundamental frequency and subglottal pressure: Comparison between female singers and non-singers."
APPENDIX 1

Perceptual voice evaluation sheet. The scale for pitch was made twice as long as the others, since values both below “neutral” could be expected. Swedish terminology is given in parentheses.

| General impression of Hoarseness (Heshet) | None | Extremely hoarse |
| Voice quality | Absence of | Severe degree of |
| Breathy (Läckage) | | |
| Hyperfunctional | (Pressad, hyperfunktionell) | |
| Hypofunctional | (Hypofunktionell) | |
| Gratings (Skrap) | | |
| Rough (Skrovlig) | | |
| Voice breaks (Registerbrott) | | |
| Unstable pitch/quality | (Instabil klang/läge) | |
| Hard glottal attacks | (Hårda ansatser) | |
| Vocal fry (Knarr) | | |
| Audible inhalation | (Hörbar inandning) | |
| Other voice quality | (Annan röstkvalitet) | |
| Hypernasality | (Öppet nasal) | |
| Hyponasality | (Slutet nasal) | |

| Pitch (Röstläge) | Low | High |
| Register | Chest | Falsetto | Normal child register | Other |
APPENDIX 2

Laryngoscopic examination sheet.

Child no

Anamnesis:
- Prevalence of otitis:
- Medicines used:
- Temperament:

Status:
- Ears:
- Mouth & pharynx:
- Voice:

Allergy:

Hoarseness:

Nose:

Larynx:
APPENDIX 3

Glottal status assessment sheet.
Rater ________________  Voice no ________________

VISUALIZATION
1. Full length view of the vocal folds.  2. View of the posterior third of the vocal folds.
3. View of the anterior third of the vocal folds.  4. View of the medial third of the vocal folds.

STATUS OF THE VOCAL FOLDS

COLOUR
1. Pale  2. Pale, with visible blood vessels  3. Reddened

SHAPE
1. Smooth, even edges  2. Spindleshaped, longstretched oedema
3. Other oedema

CLOSURE
1. Complete closure along the vocal folds – possibly with an indicated incomplete closure of the cartilaginous part.
2. Incomplete closure along the posterior half or two thirds of the vocal folds.
3. Triangular, incomplete closure posterior of the processus vocalis.
4. Incomplete closure all along the vocal folds.

OTHER CLOSURE PATTERNS
5. Incomplete closure, "hourglass".
6. Incomplete closure of the membranous part of the vocal folds, spindle-shaped.

1.  2.  3.  4.  5.  6.