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journal: STL-QPSR
volume: 33
number: 1
year: 1992
pages: 099-113

http://www.speech.kth.se/qpsr
PERCEPTUAL ANALYSIS OF CHILD HOARSENESS USING CONTINUOUS SCALES

Elisabeth Sederholm*, Anita McAllister*, Johan Sundberg, & Jan Dalkvist**

Abstract
Fifty-eight 10-year old children were recorded and judged by a panel of voice expert listeners, who rated the voices along 16 voice parameters represented by visual analogue (continuous) scales on a test form. Interjudge reliability was high. Rank ordered rating means revealed a discontinuity in the distribution for most parameters. A factor analysis revealed three factors of major relevance to the perception of these voices. These factors were closely associated with hoarseness, pitch, and phonatory effort. The hoarseness factor was found to have high loadings in gratings, breathiness, hyperfunction, roughness, instability, and voice breaks. A stepwise multiple regression analysis revealed that breathiness, hyperfunction and roughness are good predictors of hoarseness.

INTRODUCTION
Child hoarseness has been studied rather extensively. Still, this topic has not been entirely covered. First, many voice experts assume that child hoarseness is harmless and automatically disappears during puberty (Håkansson & Kitzing, 1984). Therefore, little consideration seems to have been attributed to long-term developmental characteristics or to medical implications.

Some authors have taken the opposite view. Cohen, Geller, Thompson & Birns (1983) claimed that by over-looking voice changes during childhood, pathologies may be diagnosed at too late a stage. Chronic child hoarseness has also been reported to sometimes lead to organic voice disorders (Sédlacková, 1960). In the management of child hoarseness, there has often been a lack of consideration of psychological factors which are known to sometimes underlie the phenomenon (Toohill, 1975). Sédlacková (ibid) stated that voice disorders in children were symptoms of anxiety. Nemec (1961) claimed that children with hyperkinetic dysphonia were more aggressive, more immature and less able to handle stressful situations than their peers. Having a hoarse, dysfunctional voice might influence on the child’s self-perception as well as the listeners’ evaluation of her/his personal traits and capacities (Ruscello, Lass, & Podbesek, 1988). Furthermore, child hoarseness may influence a child’s possibilities to pursue a musical interest.

Another complication concerning the phenomenon of child hoarseness has been that the term hoarseness itself has been considered to be vague and indistinct, being a varying conglomerate of several perceptual voice parameters. Three attempts at a definition have been made in studies of the prevalence of child hoarseness. According to Baynes (1966) hoarseness is “a quality of voice that is rough, grating, harsh, more or less discordant, and lower in pitch than normal for the individual.” Silvermann & Zimmer (1974), applying the definition of Moore (1971), regarded hoarseness as characterized by “noise of a relatively high frequency that is produced by transient or highly unstable vibrations.” Casper, Abramson, & Forman-Franco (1981)

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defined hoarseness as "a deviation in the tonal quality of the voice resulting when
the vocal cords vibrate in an aperiodic or haphazard manner."

A third question regarding child hoarseness concerns the perceptual evaluation of
children's voices in general. To our knowledge, systematic perceptual analyses of
children's voices have not been carried out. There is reason to believe that the per-
ceptual parameters used when evaluating mature voices might not be generally
applicable when listening to children's voices. Disregarding the obvious differences
in vocal tract size and associated formant frequency differences, the physiological
conditions of the larynx, in particular the inner structure of the vocal fold, gradually
change and develop as one grows (Hirano, Kurita, & Nakashima, 1983).

The prevalence of child hoarseness has remained an open question, in spite of
considerable research efforts, see Table I. In the beginning of this century, two in-
vestigations were carried out, one in Germany by Flatau & Gutzmann (1908) and one
in Sweden by Weinberg (1914). The German investigation included 575 children and
revealed a prevalence of hoarseness of 42%. In the Swedish study, Weinberg exam-
ined and listened to 800 children 7 to 14 years of age. The degree and occurrence of
hoarseness varied from age group to age group with a peak prevalence of 43% for
chronic hoarseness at the age of 14. In 515 children hoarseness was accompanied by
positive laryngeal findings, and of these approximately 37% were due to infections.
The overall average prevalence of chronic hoarseness for all school ages was 26%.
More recent studies, such as Curry (1949), Baynes (1966), Senturia & Wilson (1968),
Sonninen & Sonninen (1976), Leeper, Leonard, & Iverson (1980), Michailova (1987),
and Powell, Filter, & Williams (1989), have reached very differing results, reporting
a prevalence of hoarseness between 1% (Gillespie & Cooper, 1973) and 80% (Curry,
1949), see Table I. The number of children included in these studies also varied
greatly, ranging from 80 to 32,500. The large difference in sample size suggests that
varied research methods have been used.

When dealing with hoarseness, one problem to consider is the difference between
acute and chronic voice change. Acute and chronic hoarseness do not necessarily
differ perceptually. To differentiate between acute and chronic hoarseness, many re-
searchers have evaluated the children's voices on at least two separate occasions
(Weinberg, 1915; Baynes, 1966; Silverman & Zimmer, 1974; Yairi, Horton-Currin Bul-
ian, & Yairi, 1974; Casper & al., 1981) and accompanied their perceptual evaluations
with laryngeal inspection.

Also, it is of great importance to take into consideration what age groups were
studied when evaluating the results of prevalence studies. Generally, the largest
number of hoarse children can be found in the age group six to seven years. The
prevalence then tends to fall during the period of latency, and rise again with the on-
set of puberty, also for girls. It is well known that the voice is fragile during the pe-
riod of mutation (Curry, 1949; Cornut & Venet, 1966) and that hoarseness might be
quite common during this time. According to Weiss (1950), the first mutational voice
changes are characterized by huskiness and unsteadiness of the voice and a some-
what lower pitch. Onset of puberty has been reported to take place at an earlier age
nowadays. By comparing reports on voice mutation, Schilling & Karhaus (1961)
found that onset of puberty was one to two years earlier in 1960 than in 1900. Blatt
(1983) argued that "in the 1980s children in many areas of Europe and North Amer-
ica are reaching puberty three to five years sooner than in the decades gone by." It
seems clear that some of the variability in the findings regarding occurrence of child
hoarseness is related to the differences between the investigations with respect to the age groups examined. The need for standardization of both terminology and procedures is apparent.

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Ages</th>
<th>N</th>
<th>Prevalence (%)</th>
<th>Terms used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatau &amp; Gutzman</td>
<td>1908</td>
<td>7-15</td>
<td>575</td>
<td>42</td>
<td>Chronic hoarseness</td>
</tr>
<tr>
<td>Weinberg</td>
<td>1914</td>
<td>7-14</td>
<td>800</td>
<td>26</td>
<td>Hoarse vs husky vs clear</td>
</tr>
<tr>
<td>Fröschels</td>
<td>1920</td>
<td>4-14</td>
<td>380</td>
<td>.5</td>
<td>Organic hoarseness</td>
</tr>
<tr>
<td>Curry</td>
<td>1949</td>
<td>10</td>
<td>40</td>
<td>55</td>
<td>Hoarse-husky</td>
</tr>
<tr>
<td>Curry</td>
<td>1949</td>
<td>14</td>
<td>40</td>
<td>80</td>
<td>Hoarse-husky</td>
</tr>
<tr>
<td>Pont</td>
<td>1965</td>
<td>5-14</td>
<td>639</td>
<td>9</td>
<td>Hoarseness</td>
</tr>
<tr>
<td>Baynes</td>
<td>1966</td>
<td>6-12</td>
<td>1012</td>
<td>7</td>
<td>*</td>
</tr>
<tr>
<td>James &amp; Cooper</td>
<td>1966</td>
<td>8</td>
<td>718</td>
<td>6</td>
<td>Voice disorders</td>
</tr>
<tr>
<td>Senturia &amp; Wilson</td>
<td>1968</td>
<td>5-18</td>
<td>32,500</td>
<td>5</td>
<td>Voice deviation</td>
</tr>
<tr>
<td>Gillespie &amp; Cooper</td>
<td>1973</td>
<td>2-18</td>
<td>5054</td>
<td>1</td>
<td>Voice problem</td>
</tr>
<tr>
<td>Silverman &amp; Zimmer</td>
<td>1974</td>
<td>5-13</td>
<td>162</td>
<td>23</td>
<td>*</td>
</tr>
<tr>
<td>Yairi &amp; al.</td>
<td>1974</td>
<td>6-12</td>
<td>1549</td>
<td>5</td>
<td>Unpleasant, husky</td>
</tr>
<tr>
<td>Pannebacker</td>
<td>1975</td>
<td>6</td>
<td>93</td>
<td>9</td>
<td>Chronic hoarseness</td>
</tr>
<tr>
<td>Sonninen &amp; Sonninen</td>
<td>1976</td>
<td>8</td>
<td>90</td>
<td>65</td>
<td>Unclear voice</td>
</tr>
<tr>
<td>Warr-Leeper &amp; al.</td>
<td>1978</td>
<td>11-13</td>
<td>999</td>
<td>8</td>
<td>Vocal deviation</td>
</tr>
<tr>
<td>Leeper &amp; al.</td>
<td>1980</td>
<td>6-11</td>
<td>1481</td>
<td>7</td>
<td>Perc.dev. fr. normal</td>
</tr>
<tr>
<td>Casper &amp; al.</td>
<td>1981</td>
<td>6-16</td>
<td>96</td>
<td>4.12**</td>
<td>*</td>
</tr>
<tr>
<td>Krahulec &amp; al.</td>
<td>1985</td>
<td>5-6</td>
<td>81</td>
<td>75</td>
<td>Voice dysfunction</td>
</tr>
<tr>
<td>Michailova</td>
<td>1987</td>
<td>1-15</td>
<td>3000</td>
<td>6</td>
<td>Dysphonia</td>
</tr>
<tr>
<td>Powell &amp; al.</td>
<td>1989</td>
<td>6-10</td>
<td>847</td>
<td>17</td>
<td>Phon. disorders</td>
</tr>
</tbody>
</table>

Table I. Prevalence studies on child hoarseness (adapted from Södersten, 1990).
*Definition cited in text above.
**Referring to judgments before and after summer camp.

In January 1991, the authors started a research project on hoarseness among children. The project was inspired by reports on voice deterioration in children by teachers in a music school in Stockholm (Adolf-Fredrik). Every year these music teachers listen to approximately 1000 ten-year-old children who apply for the school. The general impression among the teachers is that hoarseness and a restricted vocal range has become more common during the last decade.

The purpose of the present investigation was to explore how the concept of hoarseness relates to other perceptual voice parameters in ten-year old children.

Methods
a) Subjects

All children from three classes, grade 3, from three primary schools in the Stockholm area were included in the study. The subject of the investigation was known to the class teachers, so there was not a strictly random selection of classes. The schools were chosen from different socio-economic districts. Fifty-eight children, 24 girls and 34 boys (ten years old), participated in the present investigation. As a growth rate exceeding 10 cm/year indicates puberty (Taranger, Engström, Lichtenstein, & Svännberg-Redegren, 1976), the children's parents were asked to estimate the growth during the last year.
b) Tape recordings
The 58 children were recorded in acoustically reasonably attenuated rooms in the schools using a Sony TCD-D1 (pitch range) DAT 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 to read a short story and to retell it in their own words. When the latter was not feasible, a short interview was carried out.

c) Perceptual ratings
Cassette recorder copies of the original DAT recordings of the 58 voices were perceptually evaluated by seven speech pathologists, all experts on voice disorders.

For the perceptual analysis a form was constructed, see Appendix. It contained 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 choice 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 added to the list, being the key concept of the entire research project. Also, a blank parameter was added, thus offering the listeners a possibility to suggest one additional parameter that according to their judgement was missing in the list.

When evaluating register, the experts were given not only the traditional options, chest and falsetto, but also a parameter labelled “normal child register”. This seemed desirable as it could not be assumed that children’s voice registers could be classified into the same categories as those used for mature voices.

d) Construction of scales
In systematic perceptual evaluations of speech and voice quality, 5-point or 7-point category rating scales are generally used (Darley, Aronson, & Brown, 1975; Hammarberg, 1986). This procedure may suffer from certain limitations. For one thing, the number of categories may be too small to do full justice to the ability of professional listeners to discriminate among various degrees of a given voice parameter, particularly, perhaps, within some critical range. In effect, this amounts to loss of potentially available, useful information. Indeed, such information may be needed in order to exactly delineate a group of voices perceived as hoarse. Second, in using category rating scales, one may run the risk that the listener’s quantitative judgements become affected by qualitative judgements. For example, a particular figure on the scale may, by convention or for some other reason, be taken to indicate some pathological state. Such qualitative judgements may conceivably act to distort the scale. Third, there seems to be no support for the idea that listeners’ perception is quantized.

In view of those arguments, we decided to use a graphic, or visual analogue, scale, VAS (Wewers & Lowe, 1990). Fourteen parameters (including the blank parameter) were represented by a 100 mm continuous line, the extremes of which corresponding to non-existence and extremely high occurrence of the trait, respectively. The pitch parameter was represented by a 200 mm line, since values both below and above "neutral" could be expected. A category scale was used for register, as men-
tioned. The experts were instructed to estimate the overall impression of hoarseness before proceeding to the other parameters.

RESULTS

Perceptual data

For the statistical analysis, the SPSS/PC + 4.0 statistics and advanced statistics analysis systems was used (Norusis, 1990). Cronbach's alpha reliability coefficient was computed for the listeners' ratings of all parameters except the blank parameter (other voice quality), see Table II. The experts used the blank parameter 27 times to suggest the following complementary terms: diplophonic, intermittently aphonie, monotonous, husky, throaty, and screechy (Swedish terms: diplofon, afonisinslag, monoton, beslöjad, halsig/guttural, gnissel). Two voices received comments from one listener on throat clearing and snuffling (harkling, snörling).

According to the unanimous judgement of all expert listeners, 37 of the 58 children were speaking in a "normal child register" as opposed to chest or falsetto.

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.

<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 II. Interjudge reliability coefficients for ratings of 15 perceptual voice parameters.*

The mean, standard deviation and skewness scores for all perceptual voice parameters, except the blank parameter (other voice quality), and register were calculated for all experts and all voices, see Table III. From the skewness scores obtained, we concluded that the distribution of ratings deviated more or less from normal for all parameters, especially voice breaks and hypernasality. In these two cases, only small fractions of the scales were used by the raters.
Table III. Descriptive statistics for 14 voice parameters calculated across 58 voices based on the ratings of seven experts. Thirteen of the parameters were represented by 100 mm continuous scales, while the scale for pitch was 200 mm.

The mean value for each parameter, calculated across experts for each voice, was plotted in rank order. These graphs are shown in Figs. 1 and 2.
Fig. 2. Rated means of the indicated voice parameters for the 58 voices plotted in rank order.
The plot obtained for hoarseness has been shown in Fig. 1. As can be seen, the
curve exhibits a marked "elbow", with an abrupt associated discontinuity. This sug-
gests the existence of a distinct borderline between the two groups of voices. While
perceived hoarseness is absent, or present only to a mild degree, in one part of the
subject group, it is clearly exhibited, in varying degree, by the other group. The bor-
derline between the two groups is indicated between the values of 35 and 42 mm.
Using this borderline for an operational definition of hoarseness, 14 out of 58 chil-
dren, twelve boys and two girls, were identified as being hoarse, the prevalence in
this particular population thus being 24%. It could be noted that eight of the chil-
dren, seven boys and one girl, had a growth index of 10 cm or more. This implies
that they have entered the period of mutation. Two of these boys were rated as being
hoarse.

Ten out of the remaining voice parameters exhibited plots of rank-ordered means
that were more or less similar to that of rated hoarseness. These plots are shown in
Fig. 2.

![Graphs showing voice parameters](image)

Fig. 3. Rated means of the voice parameters
vocal fry, breathy, and pitch for the 58
voices plotted in rank order.

In three parameters, pitch, vocal fry, and breathy, no discontinuity was observed in
the rank order graphs, (cf. Fig. 3). This implies that the distributions of these param-
ters in the voices were closer to a normal distribution than the distributions of the
previous parameters. It was to be expected that pitch would exhibit a normal distri-
bution. According to many voice experts a certain degree of vocal fry is not a path-
ological trait but rather typical of a normal voice and would therefore also be ex-
pected to show a normal distribution. Södersten & Lindestad (1990) have shown 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 is applicable to children as well.

**Factor analysis**

We computed the Pearson correlations for the experts' mean ratings of all 15 perceptual variables across the 58 voices, disregarding the blank parameter. The three options "chest", "normal child register" and "falsetto" of the register parameter were coded in rank order from 0 to 2 in the order mentioned, whereas the option "other", when used, was coded as a missing value and not included in the analysis.

Four parameters showed only weak correlations with the other parameters: hyper- and hyponasality, audible inhalations, and vocal fry. These results are not surprising. While most of our parameters concerned phonatory aspects of voice quality, the hyper- and hyponasality parameters are associated with articulation; phonation and articulation can be regarded as independent of each other. Audible inhalations have sometimes been observed to accompany phonatory disorders in adults, but this did not seem to be the case in these children's voices. Vocal fry may be a phonatory universal in children's voices.

The eleven remaining correlations were factor analyzed by means of principal factoring and subsequent Varimax rotation. The final set of factors was selected on the basis of Kaiser's criterion, retaining those factors that have eigen-values greater than or equal to one. Three factors, explaining 74% of the total variance, were obtained. The factor loading matrix is shown in Table IV.

<table>
<thead>
<tr>
<th>Perceptual variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoarseness</td>
<td>.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grating</td>
<td>.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breathy</td>
<td>.76</td>
<td>-49</td>
<td></td>
</tr>
<tr>
<td>Hyperfunctional</td>
<td>.75</td>
<td>.57</td>
<td></td>
</tr>
<tr>
<td>Rough</td>
<td>.74</td>
<td>-42</td>
<td></td>
</tr>
<tr>
<td>Unstable pitch/quality</td>
<td>.65</td>
<td>-44</td>
<td></td>
</tr>
<tr>
<td>Voice breaks</td>
<td>.50</td>
<td>-44</td>
<td></td>
</tr>
<tr>
<td>Pitch</td>
<td>.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Register</td>
<td>.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypofunctional</td>
<td></td>
<td>-.88</td>
<td></td>
</tr>
<tr>
<td>Hard glottal attacks</td>
<td></td>
<td>.75</td>
<td></td>
</tr>
<tr>
<td>Variance explained</td>
<td>38%</td>
<td>21%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table IV. Factor loadings for the perceptual parameters and the variance explained by the three factors.

The first factor received high loadings in all variables except pitch, register, hypofunctional, and hard glottal attacks. The loading was particularly high for hoarseness. This suggests that this factor may be termed Hoarseness.
The second factor had high positive loadings on *pitch* and *register* and moderate negative loadings on *voice breaks* and *rough*. *Pitch* and *Register* both depend on voice fundamental frequency. The negative loading of *rough* may reflect the pitch dependence of roughness in complex tones (Terhardt, 1974). Regarding the relationship with *voice breaks* the combination of falsetto register and voice breaks was apparently rare in our material, which does not seem surprising. It seems appropriate to label this factor *Pitch*.

The third factor, finally, had a high or moderate positive loading in the variables *hyperfunctional* and *hard glottal attacks* and a high or moderate negative loading in the variables *hypofunctional* and *breathy*. This suggests that the third factor is closely related to *Phonatory effort*.

In order to further test whether the term *Hoarseness* could be considered an adequate label for the first factor, the correlations among the seven variables with high loadings on this factor were inspected. The correlations are shown in Table V. As can be seen, all correlations were high or relatively high and positive, indicating a high degree of homogeneity. Furthermore, the correlations for *hoarseness* were generally higher than those for any of the other variables. Together, these facts support the above conclusion that *Hoarseness* is an appropriate name for the first factor.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step No.</th>
<th>Multiple R</th>
<th>$R^2$</th>
<th>Beta weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperfunctional</td>
<td>1</td>
<td>.83</td>
<td>.69</td>
<td>.54</td>
</tr>
<tr>
<td>Breathy</td>
<td>2</td>
<td>.94</td>
<td>.89</td>
<td>.45</td>
</tr>
<tr>
<td>Rough</td>
<td>3</td>
<td>.95</td>
<td>.91</td>
<td>.17</td>
</tr>
</tbody>
</table>

Table VI. Selected statistics from a stepwise multiple regression analysis with hoarseness as dependent variable and the remaining voice parameters that showed high loadings on Factor 1, as predictor variables.
DISCUSSION

There are reasons to assume that in the evaluation of voices, a listener's perception is more faithfully reflected by continuous rather than quantized scales. Our results show that for most of the parameters studied, there is a breakpoint which can be used to separate normal from atypical in a particular population. The discontinuity might also reflect one or several factors underlying the presence of a certain vocal anomaly, e.g., a change in phonatory conditions which might imply pathology or vocal strain due to psychological factors. Consequently, the breakpoint constitutes a demarcation line between different systems. Thus, the variables could be regarded as both quantitative and qualitative at the same time.

Perceptual analysis of voice quality is always language-specific. The semantic contents of the terms used vary considerably in different languages. Also, features that might be idiomatic in one language are regarded as deviant in another. For instance, hard glottal attacks are characteristic for a native speaker of German, whereas they are considered a sign of voice strain in a Swedish-speaking individual. Furthermore, age as well as social and cultural factors, both among speakers and listeners, have been shown to influence interjudge agreement in the perceptual evaluation of voices (Sonninen & Sonninen, 1976). The interjudge reliability in the present investigation was high, however. This result is in accordance with earlier perceptual evaluations of adult pathological and normal voices by experienced Swedish speech pathologists (Hammarberg 1986; Sodersten & Lindestad, 1990). Still, the high interjudge reliability in the present study was unexpected. First, the speech pathologists were more experienced in evaluating adult voices than children's voices. Second, the term hoarseness itself is generally considered to be vague. To the untrained listener, hoarseness often implies a sudden change of voice quality. Sometimes, the term is used as a synonym for an unpleasant sounding voice. To voice experts, on the other hand, hoarseness comprises several other perceptual parameters. Indeed, some raters even claimed that it was hardly possible to estimate both occurrence and degree of hoarseness. The fact that our listeners were still in very good agreement, particularly with respect to hoarseness, suggests that the significance of these difficulties was rather limited.

The agreement in the listening panel regarding hoarseness seemingly implies that this voice parameter is uncomplicated and can be used in clinical practice. However, this would cause problems in the diagnosing and treatment of voices. Here we have shown that hoarseness is a complex concept reflecting at least three different aspects of vocal dysfunction, namely breathiness, hyperfunction and roughness. Isshiki, Okamura, Tanabe, & Morimoto (1969) identified four factors in their study on the differential diagnosis of hoarseness: R (rough), B (breathy), A (asthenic), and D (degree). Degree represents minor abnormality, according to the authors. Different combinations of these properties occur as symptoms of different pathological states and call for different types of treatment.

When evaluating register, the experts in most cases preferred the "normal child register" option to the traditional chest or falsetto. Furthermore, the parameter voice breaks appeared problematic, being the only parameter which failed to reach a significant inter-judge reliability. Voice breaks are obviously closely related to vocal register. Both these observations may reflect a lack of knowledge as well as appropriate terminology for child voice registers, an area that seems insufficiently investigated.
In our group of 58 ten-year-old children, the prevalence of hoarseness was 24%. This is very similar to the 26% found by Weinberg (1914) for chronic hoarseness in 800 children, 7-14 years old. In the present investigation we did not take into consideration whether the hoarseness was acute or chronic. However, two months later, we rerecorded the same children and a phoniatric examination was carried out. The analysis of these data will be helpful in identifying which of the hoarse children suffered from a chronic hoarseness. The results of this analysis, including physiological findings, will be presented in a future report.

We also intend to study the relationships between hoarseness and various acoustic measures. For example, Dejonckere & Cuvelier (1983) showed a good agreement between the degree of hoarseness as evaluated by LTAS and the sonagraphic classification proposed by Yanagihara (1967). According to Zajac & Linville (1989), experiments with voice perturbation of adult voices show that perceived hoarseness correlates with shimmer (amplitude variations) and perceived nasality with jitter (frequency variation) while several researchers have found that jitter correlates with perceived hoarseness or roughness (Baken, 1987, p. 183).

The parents of the children were asked to fill in questionnaires concerning the medical and social history of each child. In order to provide a profile of each child’s personality, parents and teachers were also asked to describe the child using scales defined by adjectives referring to personality traits. Hopefully, analysis of these data will facilitate the identification of etiologic factors behind hoarseness.

CONCLUSIONS
The present study explored how the concept of hoarseness relates to other perceptual voice parameters. Expert listeners’ ratings along continuous scales were analyzed. Interjudge reliability was quite high, also for hoarseness. The rank ordered means, plotted in a graph, revealed a discontinuity in the distribution for each parameter. Such breakpoints seem useful as borderlines between normal and deviant voice quality. Hoarseness showed high and positive correlation with the perceptual parameters gratings, breathy, hyperfunctional, rough, unstable pitch/quality, and voice breaks. A statistical analysis revealed that hyperfunction, breathiness and roughness are good predictors of hoarseness.

ACKNOWLEDGEMENT
We are indebted to Nils Malmsten, Department of Psychology, Stockholm University, for helping us with the statistical analysis. The kind cooperation of the children, their parents and teachers is gratefully acknowledged.

REFERENCES


APPENDIX

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

<table>
<thead>
<tr>
<th>Rater</th>
<th>Date</th>
<th>Voice no</th>
</tr>
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<tbody>
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</tbody>
</table>

**General impression of Hoarseness (Heshet)**
- None
- Extremely hoarse

**Voice quality**

<table>
<thead>
<tr>
<th>Absence of</th>
<th>Severe degree of</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

- *Breathy* (Läckage)
- *Hyperfunctional*
  (Pressad, hyperfunktionell)
- *Hypofunctional*
  (Hypofunktionell)
- *Gratings* (Skrap)
- *Rough* (Skrovlig)
- *Voice breaks* (Registerbrott)
  (Instabil klang/läge)
- *Hard glottal attacks* (Härda ansatser)
- *Vocal fry* (Knarr)
- *Audible inhalation*
  (Hörbar inandning)
- *Other voice quality*
  (Annan röstkvalitet)
- *Hypernasality*
  (Öppet nasal)
- *Hyponasality*
  (Slutet nasal)

**Pitch (Röstläge)**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
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<tbody>
<tr>
<td></td>
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</table>

**Register**

<table>
<thead>
<tr>
<th>Chest</th>
<th>Falsetto</th>
<th>Normal child register</th>
<th>Other</th>
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