COMPARATIVE PHONETIC-ACOUSTIC ANALYSIS BEFORE AND AFTER SPEECH THERAPY OF VOICES SUFFERING FROM RECURRENS PARESIS

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1. Introduction

Within the field of speech therapy very little research has been done on the effectiveness and results of speech training.

This report deals with three cases of paralysis of the recurrens nerve caused by operative damage after struma operations. The voices were tape recorded before and after the speech therapy. Afterwards the recordings have been phonetically analyzed in order to get some kind of quantitative description of the change in voice quality.

The investigation is only meant as as pilot investigation showing possible methods for analysing speech defects such as dysphonia caused by paresis, etc.

2. Recurrens paresis

Patients with partial defects of the recurrens nerve often undergo very typical changes in voice quality. The voice sounds dull, soft, feeble, hoarse, and unstable with a considerable amount of noise in the acoustic spectrum. Occasionally the unstability is so marked that the voice sounds diplophonic.

During the (often very short) period of voice training the quality of the voice normally changes, and the voice develops into a lighter, more modulated, and less noisy quality without tendency to diplophonia. The fundamental frequency[1] is lowered, and the intonation range is increased.

3. The patient material used in this investigation

The three voices are characteristic examples of the voice change taking place in connection with recurrens paresis, the first one being a weak, dull voice with a poor content of overtones and almost exclusively used in the head register, and the second and third ones being hoarse, grating voices with characteristic tendencies of diplophonia.

3.1. Case No 1, (TH) :

Woman 48 years old, operated March 25, 1963.

Clinical investigation June 14, 1963: Left vocal fold immovable in intermedian position, with slight concavity and shortening. Right vocal fold with free mobility, but not reaching left vocal fold during phonation.

Speech therapy from August 16 till November 8, 1963, a total of 19 lessons of 25 minutes each. Recording dates: September 3 and September 17, 1963 (after 7 lessons).

Clinical observation November 8, 1963: Left vocal fold in median position, not concave. Right vocal fold with good mobility, reaches left vocal fold with good occlusion during phonation.

3.2. Case No 2, (RH) :

Woman 43 years old, operated October 16, 1963 for a struma from which she had suffered for twenty years.

Clinical investigation November 15, 1963: Right vocal fold immovable in paramedian position. Left vocal fold with free mobility and good occlusion during phonation.

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1) In the following the shorter term "pitch" has been used in the sense of fundamental frequency.

Speech therapy from November 15 till December 16, 1963, a total of 17 lessons of 25 minutes each. Recording dates: November 12 and December 2, 1963.

Clinical observation December 13, 1963: Both vocal folds with good mobility and good occlusion. Thus the right-sided recurrens paresis has disappeared.

In the first recording this voice, which is predominantly characterized by a very hoarse, grating phonatory quality, discloses glimpses of normal function. This is clearly heard at least in one word and observed in this word as well as in other cases of shorter duration in the sonagrams and pitch curves. (This agrees with the description of the laryngoscopic appearance in the first clinical investigation: "a good occlusion during phonation", and suggests a functional rather than organic cause of the marked tendency to diplophonia before speech therapy.)

The two voices mentioned above have been treated only with speech exercises, whereas the third one mentioned below was treated introductorily with speech exercises and then, as this gave poor results, with paraffin injection in the paretic vocal fold, and finally again with speech therapy.

3.2. Case No 3. (EH) :

Woman 44 years old, operated October 15, 1954.

Clinical investigation October 25, 1968: The patient has through many years - after a struma operation 14 years ago, which caused her to lose her voice - got accustomed using a high-pitched maidenlike register. Laryngoscopic picture: Right vocal fold is seen immovable, shortened, and concave in paramedian position. Left vocal fold with free mobility and normal appearance.

Speech therapy after operation from November 17, 1955 till May 28, 1957. Resumption of speech therapy from September 2, 1968 till February 5, 1969, 3o lessons. Then paraffin injection February 12, 1969, and finally speech

therapy from February 24 till June 8, 1969, 12 lessons.
Recording dates:

September 6, 1968 (diplophonia and head register)
February 24, 1969 (after paraffin injection)
April 28, 1969 (1o lessons after injection)
January 12, 197o (7 months after cessation of Speech therapy).

Clinical observation April 28, 1969: Right vocal fold immovable, slightly concave in respiration position. Left vocal fold with normal mobility. Good occlusion during phonation, voice normal.

Before the paraffin injection this voice practised two types of function, one with a marked diplophonia without any moments of normal function, and another with a thin, high-pitched head register.

4. The speech therapy

The primary aim has been to show possible methods for analyzing dysphonic speech before and after speech therapy. Of course, any expedient method for training the voice can be used. These three cases were all treated with professor Svend Smith's method of speech therapy. This method aims at the training, not of the individual, weakened musculatures, but of the whole functional-dynamic relation between the expiration pressure and the voice muscular activity. The subglottal pressure is developed and trained during the phonation by means of the abdominal-diaphragmatic respiration, so that the increase of pressure reflectorily triggers off the antagonistic resistance in the larynx musculature as a whole. In this way the distribution of muscular energy between stressed and unstressed (accentuated and unaccentuated) phonatory activities is trained as a reaction to the increased subglottal pressure.

This process is utilized with special reference to the function of the accentuated syllables in normal speech, and therefore the methodology has been referred to as

"The Accent Method".

5. The acoustic analysis

Very little has been written in the phonetic and phoniatric literature about the acoustics of dysphonia.

A few sonagrams appeared in Visible Speech (2). These sonagrams give objective proof of the lack of harmonics in dysphonic speech, especially in the F2-F3 region.

The auditive result of too little energy in this frequency region is a shift in timbre in the direction of rounded back vowels (a more dull quality). According to I. Lehiste and G. Peterson (1) the vowel identification is reduced to 5o % if all energy above 11oo cps is filtered away. A similar reduction in intelligibility would probably occur with a dysphonic voice which only contains harmonics below 11oo cps. Furthermore, Svend Smith (3) has found in recordings of numerous patients (at the Institute of Speech Disorders, Hellerup, Denmark) that the spectrum above 1ooo cps is intensified during the speech therapy.

It thus seems that a registration of the relative energy above 1ooo cps should be a possible way of indicating the spectral changes during the voice training.

There is often a good deal of noise to be seen in voices with recurrens paralysis. It is caused by an insufficient glottal closure. It may be observed in sonagrams, especially in narrow band sections, where the noise occurs between the harmonics in the upper part of the spectrum (most clearly seen in the sections of [a] , Fig. 5).

The typical change in the mean pitch during treatment of the recurrens paresis patients normally starts with a considerable fall, and towards the end of the therapy the average pitch may be raised again. The intonation range is often expanded, which gives the impression of a more lively voice.

Diplophonia may be observed both on sonagrams (narrow band sonagrams as well as wide band sonagrams) and on mingograms showing recordings of the pitch.

The actual analysis is mainly based on mingograms. Fig. 1 shows the record/reproduce procedure. The most important traces are no. 5: fundamental frequency, no. 6: intensity above 1000 cps, and no. 7: intensity below 1000 cps.

6. The phonetic material

Unfortunately the recordings of patient no. 3 (EH) are based on another text than the recordings of patients no. 1 (TH) and no. 2 (RH). Short segments of the texts containing a few sentences (duration about 60 seconds) have been chosen from each recording for the acoustic analyses.

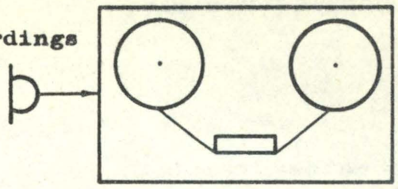
In the first two cases the analysis is based upon 39 words containing 21 stressed and 18 unstressed vowels, and in the third case the analysis is based upon 22 words containing 12 stressed and 10 unstressed vowels. All the vowels have been analysed by means of a pitchmeter and two intensity meters with external filters as shown in the block diagram (Fig. 1). In several cases sonagrams have been made, too.

7. The illustrations

Patient no. 1 (TH): The vowels [oˀ] and [a] in the sentence "forstod hvad der var blevet sagt" [fɒˈsdoˀð va dɛʁ vɑ ble:ð ˈsɑgtʰ] have been chosen as typical examples of the changes in the spectral composition during the voice therapy. A comparison of the cross sections of the two vowels (Fig. 3) before and after the voice training shows the intensified energy in the upper part of the spectrum.

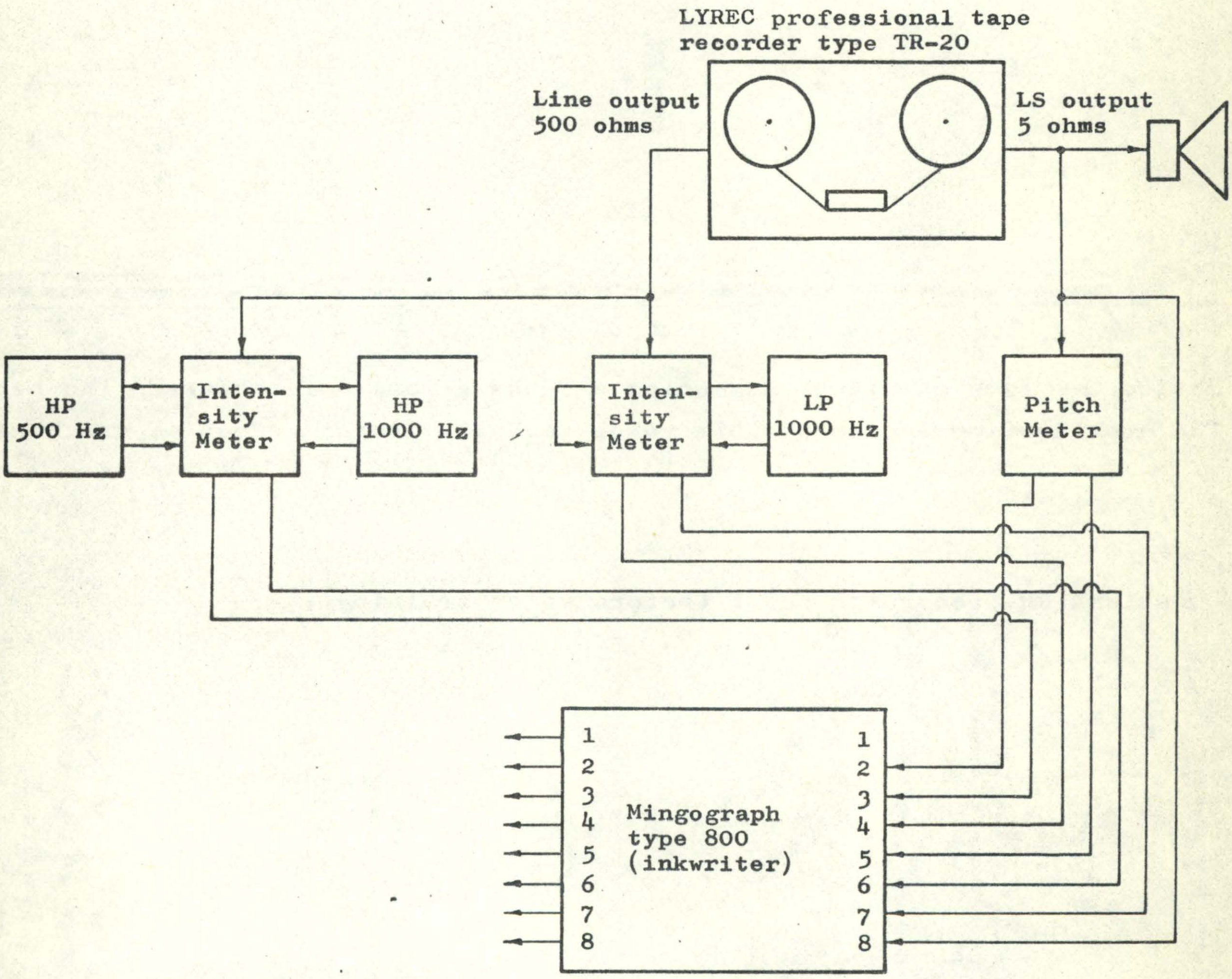
The mingograms of the same text (Fig. 4) indicate an increase of the higher frequencies, which may be seen in trace 5 and 6 under the arrows. After voice training trace

RECORDING PROCEDURE



Patients T. H. and R. H. recorded by means of a LYREC professional tape recorder. Patient E. H. recorded by means of a UHER type 4000 L tape recorder.

PLAYBACK AND PROCESSING PROCEDURE

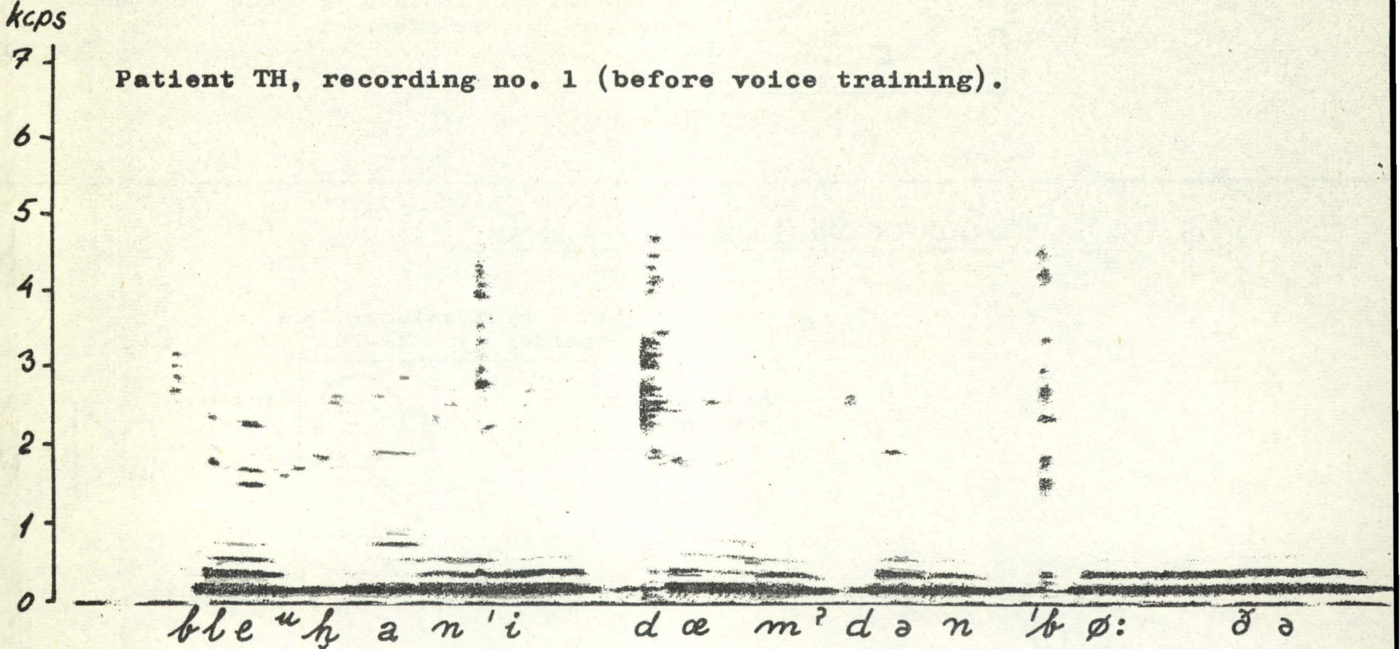


The mingograms consist of the following 8 traces:

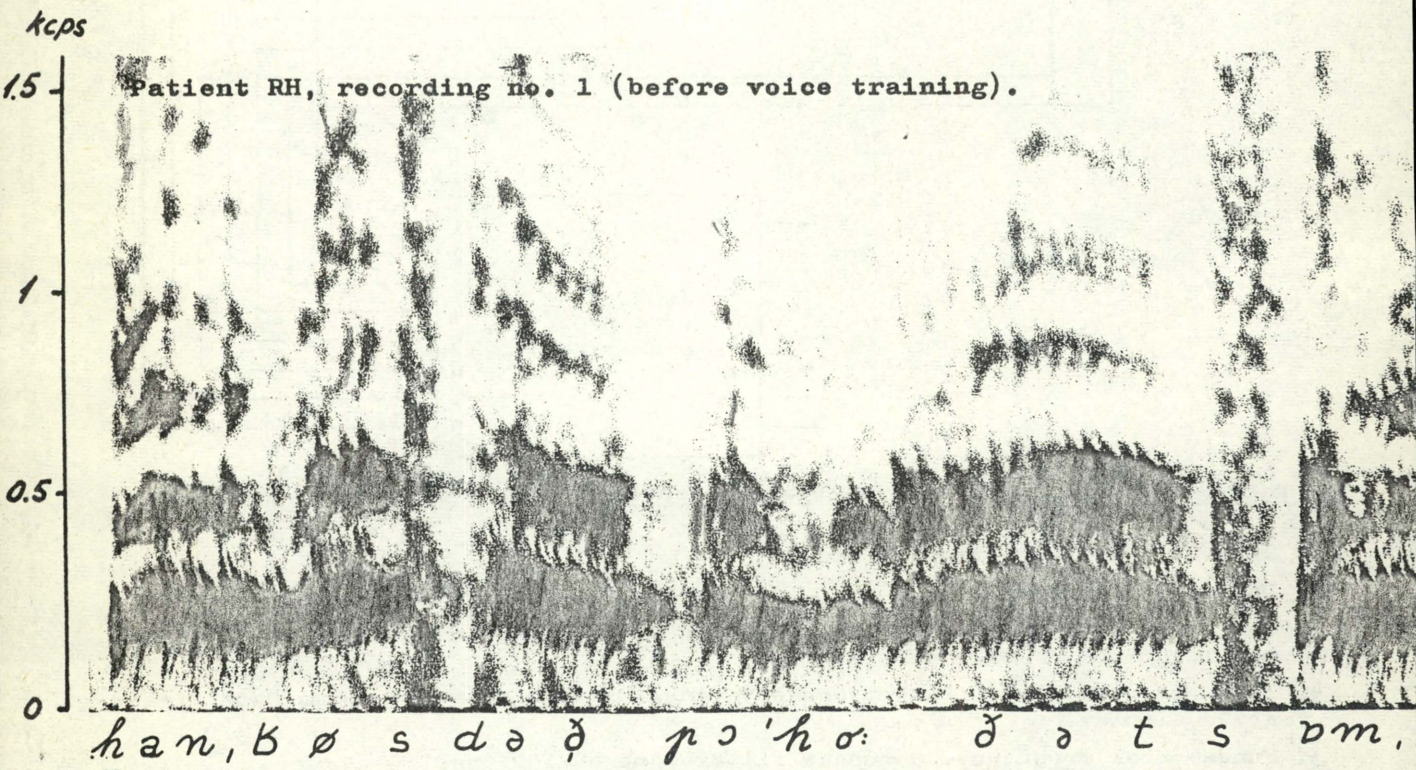
1. 1/1 and 1/100 sec. time marking.
2. Duplex oscillogram.
3. Intensity level with highpass filtering at 500 cps, integration time 2.5 ms, and logarithmic scale display.
4. Intensity level with full frequency range, integration time 5 ms, and linear scale display.
5. Fundamental frequency, bandpass filtered at 60-150 cps.
6. Intensity level with highpass filtering at 1000 cps, integration time 10 ms, and linear scale display.
7. Intensity level with lowpass filtering at 1000 cps, integration time 10 ms, and linear scale display.
8. Normal oscillogram.

Fig. 1.

TYPICAL SONAGRAMS OF TWO DIFFERENT FORMS OF UNILATERAL PARALYSIS OF THE RECURRENT LARYNGEAL NERVE CAUSED BY OPERATIVE DAMAGE.



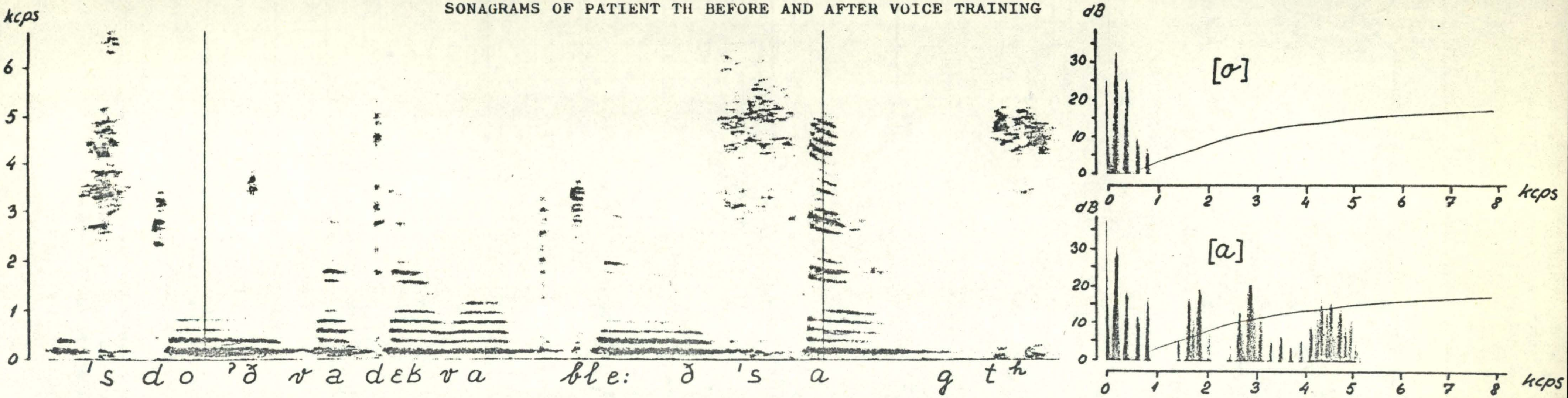
Notice the lack of higher harmonics and the strong noise between the harmonic The auditive impression of this voice is dull, languid, feeble, and hoarse.



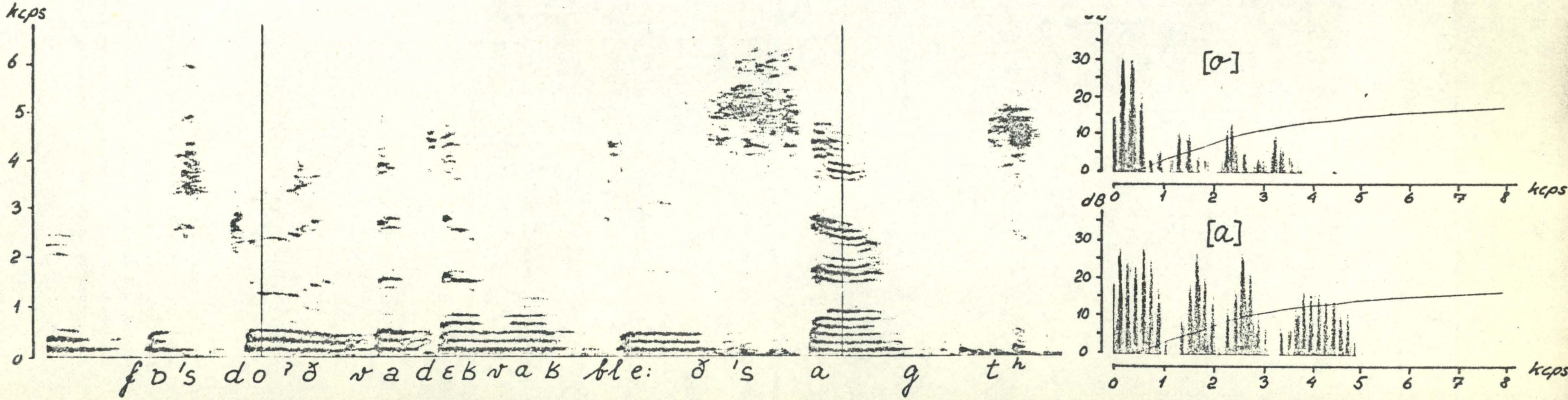
Notice the tendency to diplophonic phonation. The auditive impression of this voice is unstable, grating, and hoarse. Occasionally the phonation may switch to head register (not shown in this sonagram). Scale magnifier has been used.

Fig. 2.

SONAGRAMS OF PATIENT TH BEFORE AND AFTER VOICE TRAINING

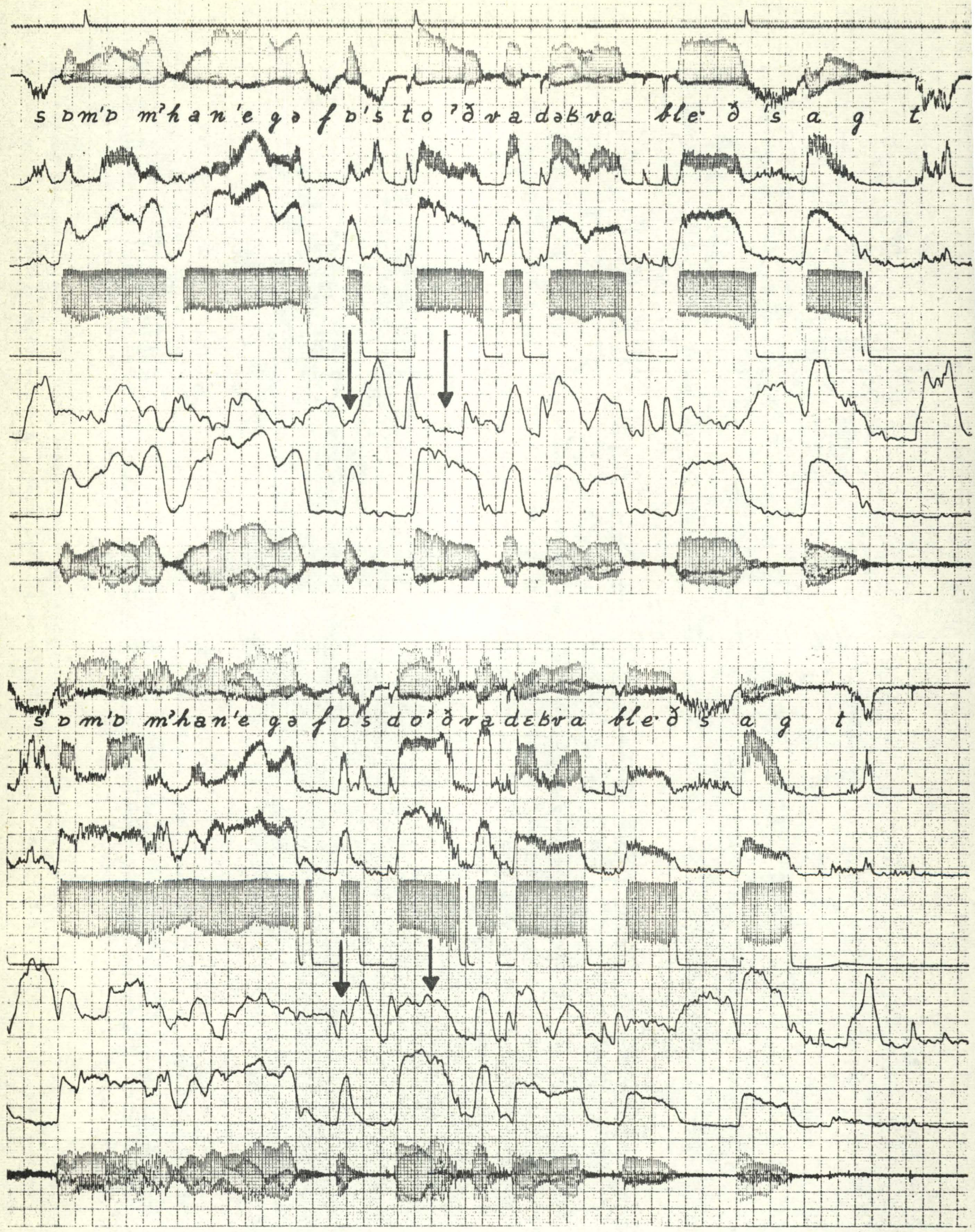


On this sonagram the vowels [o] and [a] have been selected for a more informative analysis of the spectral composition at a given moment. These analyses are shown to the right. Notice the total lack of the harmonics above 1000 cps in the [o], and the very weak higher spectrum in [a]. Between 4000 and 5000 cps in [a] there is a good deal of fricative noise, possibly due to insufficient glottal closure.



Notice here how the harmonics are intensified after the voice training. Compare the two section analyses of [o] and [a] before and after voice training. The harmonics in [o] are recognizable up to at least 3,500 cps, the intensity levels of the formants are raised, and the formants stand out more clearly.

Fig. 3.



Notice especially the relation between the energy above 1000 cps (trace 6) and below 1000 cps (trace 7) before voice training (the upper mingogram) and after voice training (the lower mingogram).

During the voice training the intensity of the higher harmonics has been considerably enforced. An enforcement of the lower harmonics in relation to the fundamental frequency can be observed when comparing the oscillograms of the two recordings.

Fig. 4.

no. 5 (the energy above 1ooo cps) contains a good deal more energy in relation to trace no. 6 (the energy below 1ooo cps) than before the training.

A similar comparison of the vowels [a] and [ɑ] in the same sentence spoken by patient no. 2 (RH) is presented in Fig. 5. Especially the vowel [a] contains much more noise before than after the therapy. The noise is considerably reduced through the training.

The tendency to diplophonia may be noticed in the left part of the sonagram, but it is more clearly observed in the mingograms of the same sentence (Fig. 6).

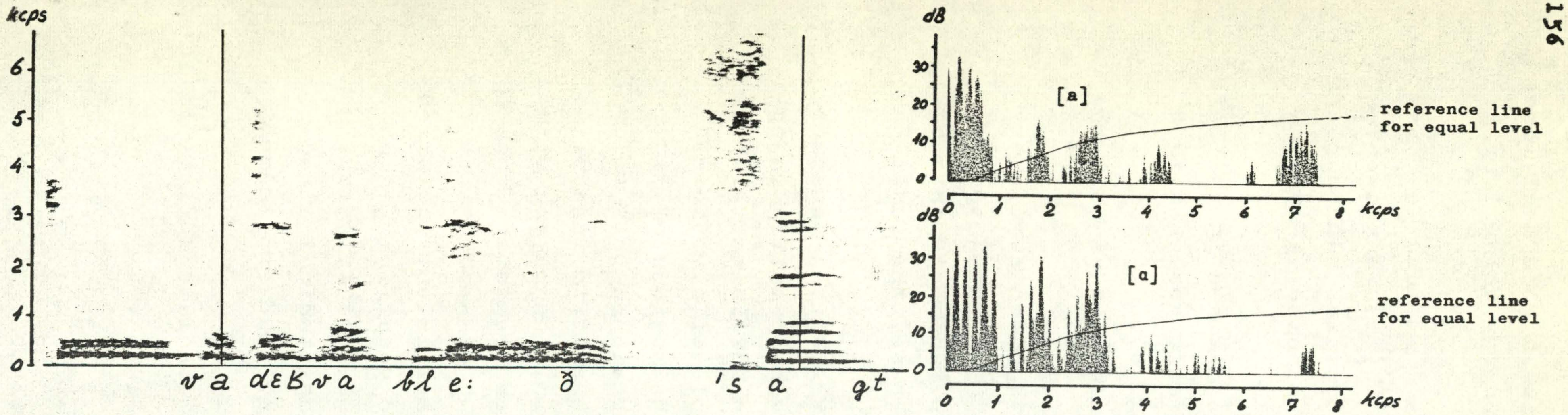
The curves show that the diplophonia attacks both the pitch and the intensity level.

In cases of recurrens paresis it is often seen (very clearly, for example, in the word "sagt" [s ɑ gtʰ] spoken by patient no. 2 (RH)) that there are sporadic elements of the normal phonation. When this is the case, the function is often easily trained in a rather short time. If it is not the case, as for instance where there is a constant, marked concavity of the paretic vocal fold, paraffin injection can be necessary in order to obtain sufficient glottal closure in the chest register. An example of a voice of that kind is shown in the two upper illustrations of Fig. 9, patient no. 3 (EH). As previously mentioned this voice practised two modes of phonation before paraffin injection: a chest register function with marked diplophonia and without moments of normal function, and a head register function, very high-pitched and with a "thin" timbre.

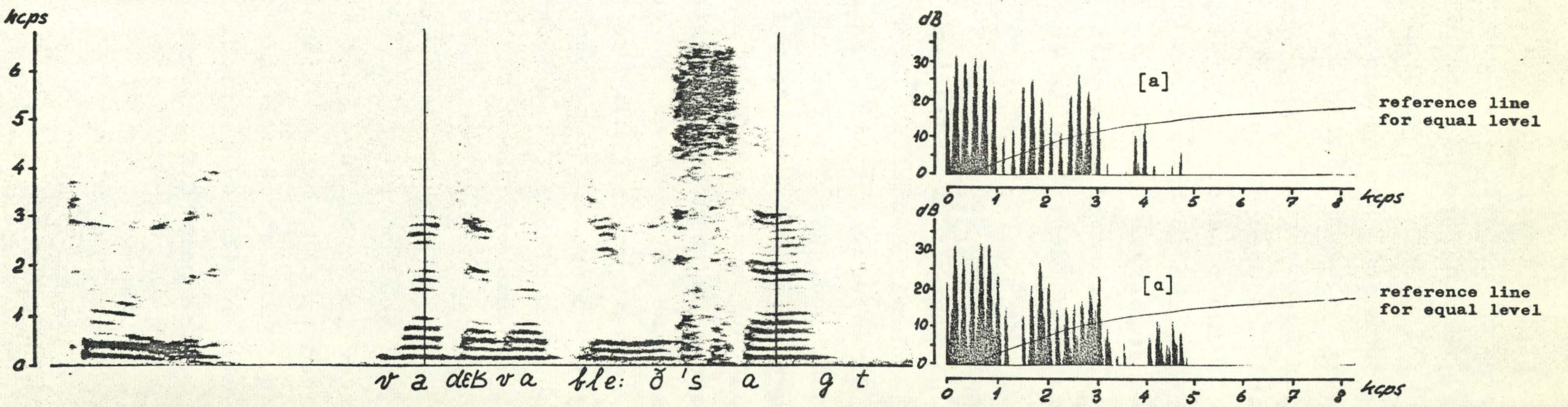
It is sometimes possible to make sufficient occlusion in the head register, though the paretic vocal fold is observed to be concave. It may be supposed that this is caused by the strong extension in the longitudinal direction, which stretches the excavated vocal fold and thereby levels out the excavation.

The paraffin injection causes an immediate ability to

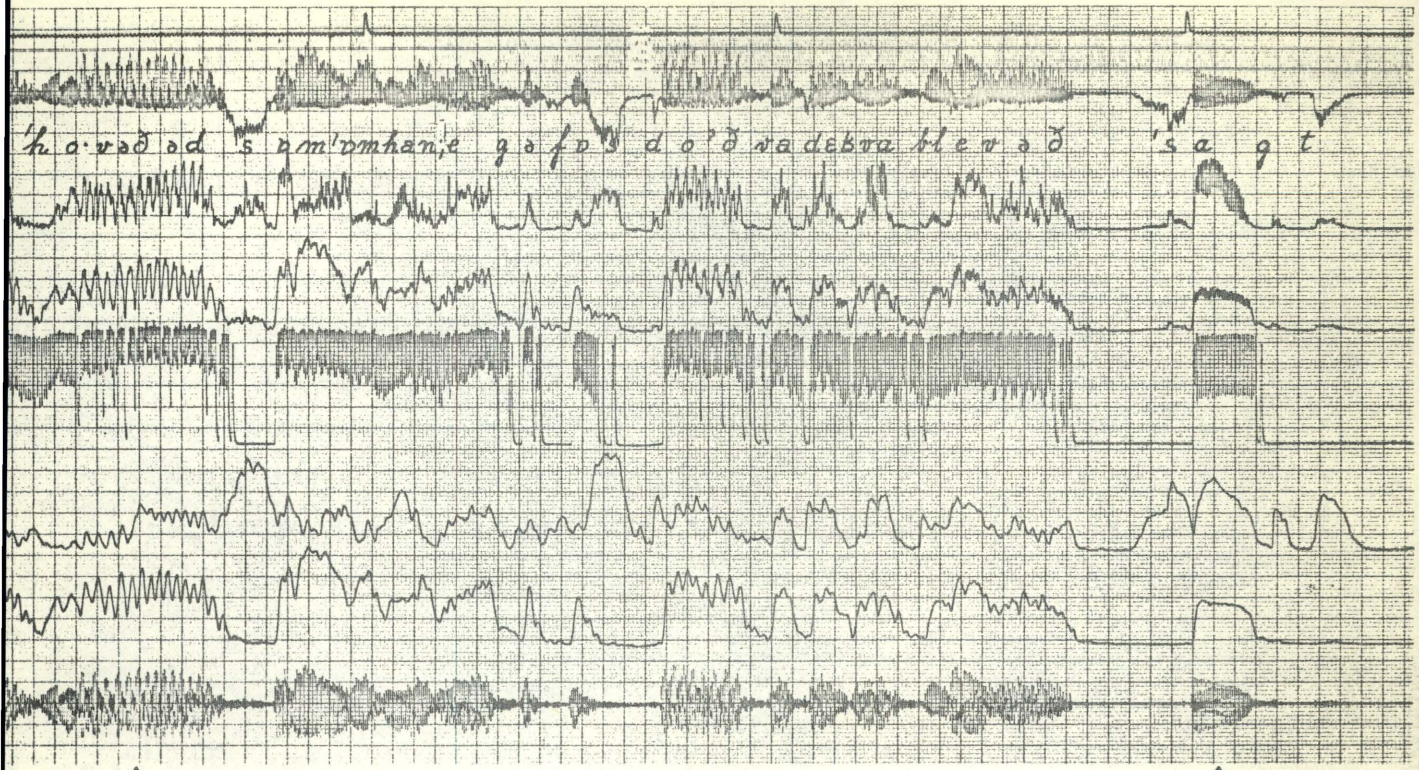
SONAGRAMS OF PATIENT RH BEFORE AND AFTER VOICE TRAINING



Sonagrams of voices with recurrent paralysis normally show spectra with very weak higher harmonics as is seen in the upper sonagram [a] . However, if the voice occasionally displays a function with normal distribution of spectral energy as shown in the upper sonagram [ɑ] it should be possible to train this function.



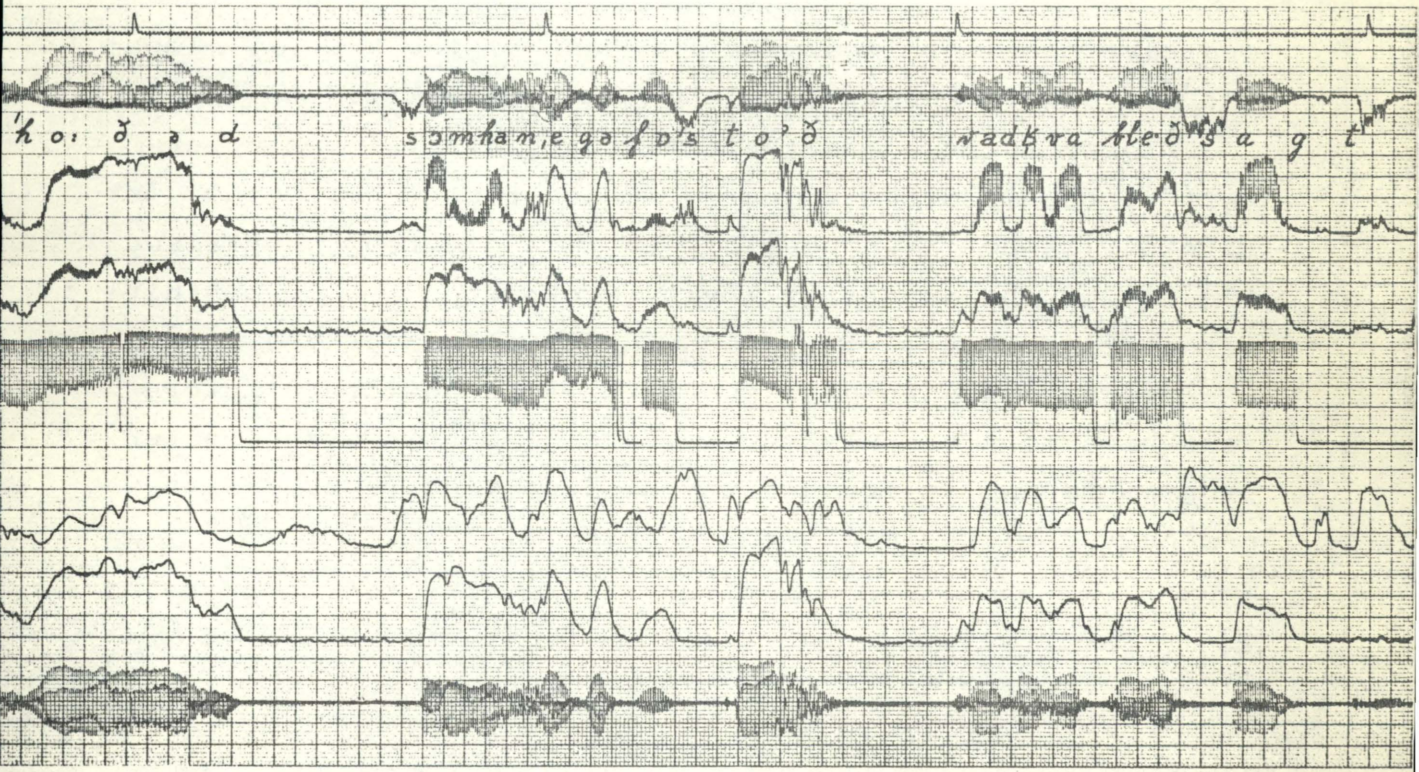
After a voice training period of less than 2 months the correct chest register function is reestablished. All the vowels now have considerably stronger harmonics (compare [a] before and after the voice training).



This mingogram shows very clearly

a) that the normal chest register function may appear spontaneously (see the last word [sɑgt]),

b) the way in which the diplophonia modulates the phonation. Both the fundamental frequency and the intensity level is continuously shifted between two levels (see the first word [hɔvəðəd]).



The same text recorded after a voice training period of less than two months. Notice the totally different traces of the fundamental frequency and the intensity levels.

Fig. 6.

produce a normal chest register voice. Speech therapy afterwards stabilizes and strengthens the chest register; this is seen in Fig. 9, illustration no. 3. The final result of the training is shown in the bottom illustration, Fig. 9. Notice the intensified spectrum above 1ooo cps.

The progress of patient no. 3 (EH) is excellently illustrated by means of the mingograms of the four tape recordings. Segments of the mingograms are shown in Fig. 1o. The text is the same as in Fig. 9: "pippede klagende" [pʰibəðə kla:ɣ̩nə] . The arrows indicate the places where the most typical changes in the intensity level above 1ooo cps may be found.

8. Statistical treatment[2] of the changes in voice quality

Each word has been measured for minimum and maximum pitch. Afterwards, the arithmetic mean pitch, the pitch variation range in cps, and the relative pitch variation range in percentage of the arithmetic mean pitch have been calculated.

The overall intensity and the intensity above 1ooo cps have also been measured for each of the vowels. Then the overall intensity level has been normalized to 45 dB in all recordings, and the intensity level of the upper part of the spectrum adjusted in accordance herewith. In this way it has been possible to make a direct comparison (in dB) of the intensity levels above 1ooo cps in the different recordings. The standard deviations of the data and the above-mentioned averages with 99 % confidence intervals have been calculated by means of a standard computer program taking in account the different degrees of freedom caused by the different numbers of data.

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2) Carl Ludvigsen has assisted us in discussion of the statistical treatment.

Statistical calculations based on measurements of pitch and intensity before and after voice therapy

SD = Standard deviation

CI = Confidence interval

	unit	before speech therapy			after speech therapy			change during therapy		number of vowels
		means	SD	99 % CI	means	SD	99 % CI	change ± SD	CI better than	
Mean of max. pitch	cps	208	14.6	208 ± 9.0	186	14.9	186 ± 9.2	-22 ± 8.6	99.9 %	21 stressed vowels
Mean of min. pitch	cps	174	4.3	173 ± 2.6	144	9.9	144 ± 6.1	-30 ± 5.9	99.9 %	
Mean pitch	cps	191	8.2	191 ± 5.1	165	10.0	165 ± 6.2	-26 ± 17.1	99.9 %	
Absolute mean pitch variation in words	cps	34	13.9	34 ± 8.6	42	15.5	42 ± 9.6	+ 8 ± 10.2	99.5 %	
Relative mean pitch variation in words	%	17.8	7.3	——	25.4	9.4	——	+ 7.6 ± 8.7	99.9 %	
Overall mean intensity	dB	45	2.5	45 ± 1.6	45	1.8	45 ± 1.1	——	——	
Mean intensity above 1000 cps	dB	15	5.2	15 ± 3.2	21	6.5	21 ± 4.0	——	——	
Normalized mean intensity above 1000 cps	dB	15	5.2	15 ± 3.2	21	6.5	21 ± 4.0	+ 6.1 ± 3.8	99.9 %	
Mean of max. pitch	cps	206	12.6	206 ± 8.6	180	12.8	180 ± 8.4	-26 ± 9.7	99.9 %	18 unstressed vowels
Mean of min. pitch	cps	175	5.5	174 ± 3.8	146	11.5	146 ± 7.9	-29 ± 6.3	99.9 %	
Mean pitch	cps	190	7.6	190 ± 5.2	163	10.0	163 ± 6.8	-27 ± 6.7	85 %	
Absolute mean pitch variation in words	cps	31	12.0	31 ± 8.2	34	14.8	34 ± 10.1	+ 3 ± 12.2	68 %	
Relative mean pitch variation in words	%	16.3	6.3	——	20.8	9.1	——	+ 4.5 ± 6.7	98 %	
Overall mean intensity	dB	45	2.6	45 ± 1.8	45	2.4	45 ± 1.7	——	——	
Mean intensity above 1000 cps	dB	15	5.1	15 ± 3.5	21	5.2	21 ± 3.5	——	——	
Normalized mean intensity above 1000 cps	dB	15	5.1	15 ± 3.5	21	5.2	21 ± 3.5	+ 6.1 ± 3.6	99.9 %	

Patient No. 1. (TH)

Fig. 7.

Statistical calculations based on measurements of pitch and intensity before and after voice therapy

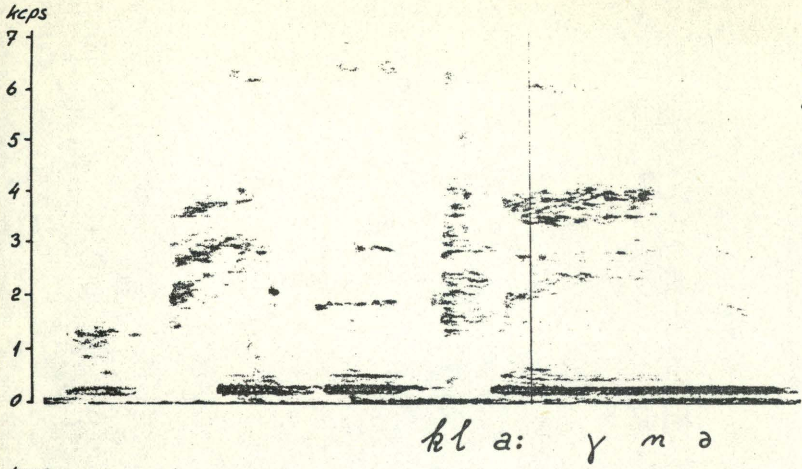
SD = Standard deviation
CI = Confidence interval

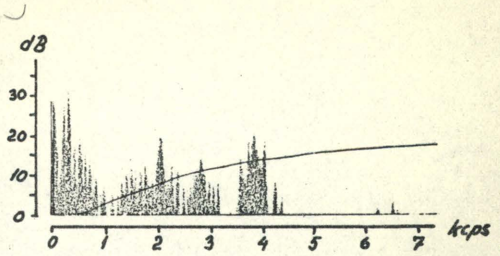
	unit	before speech therapy			after speech therapy			change during therapy		number of vowels
		means	SD	99 % CI	means	SD	99 % CI	change ± SD	CI better than	
Mean of max. pitch	cps	246	36.7	246 ± 26.0	220	37.2	220 ± 23.1	-26 ± 40.1	98 %	21 stressed vowels
Mean of min. pitch	cps	153	17.0	153 ± 12.1	156	17.9	156 ± 11.1	+ 3 ± 22.3	35 %	
Mean pitch	cps	200	21.8	200 ± 15.4	188	23.7	188 ± 14.7	-12 ± 22.8	96 %	
Absolute mean pitch variation in words	cps	98	40.0	98 ± 28.3	68	40.0	68 ± 25.6	-31 ± 35.0	99.5 %	
Relative mean pitch variation in words	%	49	20	——	36	21.3	——	-13 ± 20.6	98 %	
Overall mean intensity	dB	46	2.3	46 ± 1.5	44	2.2	44 ± 1.9	——	——	
Mean intensity above 1000 cps	dB	19	4.2	19 ± 2.9	19	5.8	19 ± 3.7	——	——	
Normalized mean intensity above 1000 cps	dB	18	4.2	18 ± 2.9	20	5.8	20 ± 3.7	2.4 ± 5.8	90 %	
Mean of max. pitch	cps	228	25.7	228 ± 23.1	207	24.7	207 ± 17.5	-21 ± 25.5	75 %	18 unstressed vowels
Mean of min. pitch	cps	151	17.1	151 ± 15.4	161	19.4	161 ± 13.7	+10 ± 18.3	93 %	
Mean pitch	cps	189	17.0	189 ± 15.3	184	17.8	184 ± 12.6	- 5 ± 17.3	60 %	
Absolute mean pitch variation in words	cps	77	27.3	77 ± 24.5	46	26.7	46 ± 19.0	-31 ± 27.0	99.5 %	
Relative mean pitch variation in words	%	41	15.9	——	25	14.5	——	-16 ± 15.9	99.9 %	
Overall mean intensity	dB	45	2.2	45 ± 1.7	43	2.8	43 ± 1.9	——	——	
Mean intensity above 1000 cps	dB	17	3.8	17 ± 2.9	19	4.2	19 ± 2.8	——	——	
Normalized mean intensity above 1000 cps	dB	17	3.8	17 ± 2.9	21	4.2	21 ± 2.8	+ 3.8 ± 5.8	97 %	

Patient No.2. (RH)

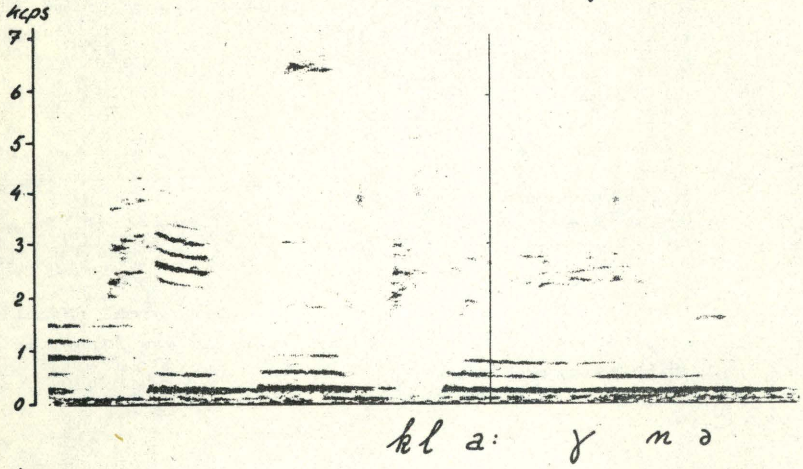
Fig. 8.

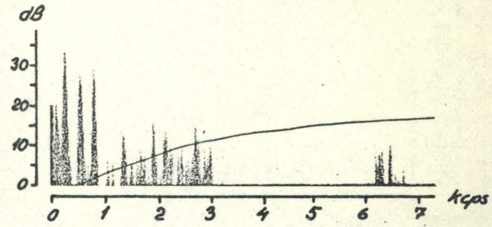
SONAGRAMS OF PATIENT EH BEFORE INJECTION OF PARAFFIN, AFTER INJECTION OF PARAFFIN, AND AFTER VOICE TRAINING.



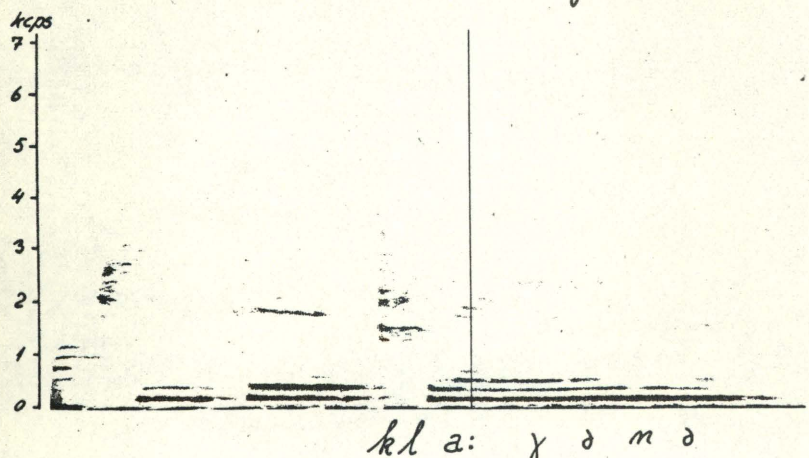


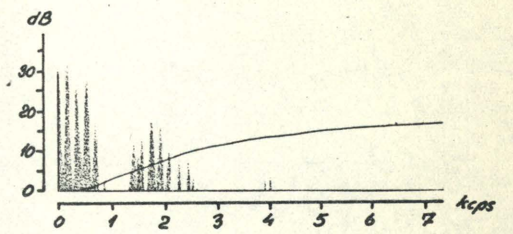
Recording no. 1
(The normal phonation before operation)
The vowel formants consist mainly of noise.



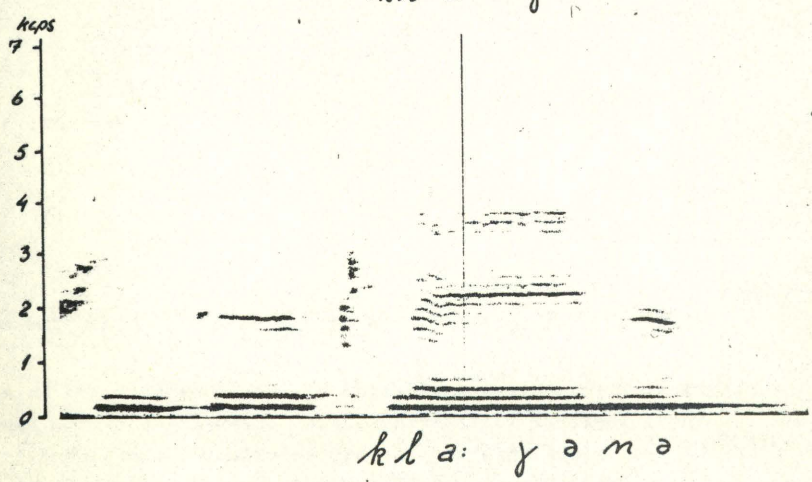


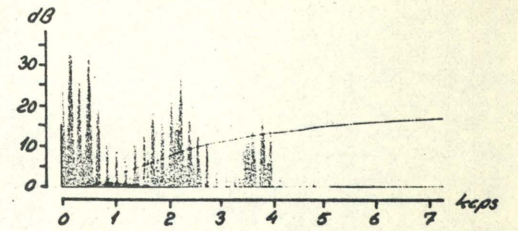
Recording no. 2
(Head register function before operation)
The fundamental frequency is too high, and the spectrum above 1000 cps consists mainly of noise.





Recording no. 3
(After injection of paraffin)
The fundamental frequency is lowered, and there is no tendency to diplophony any more.

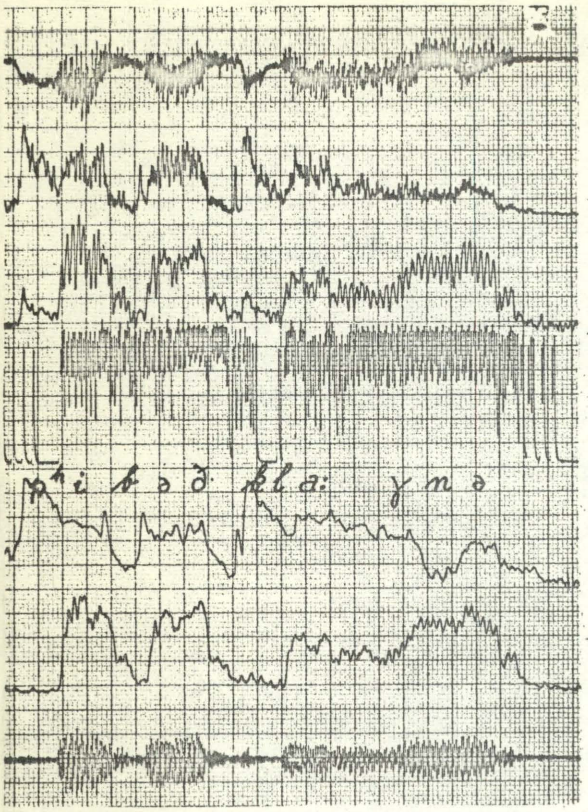




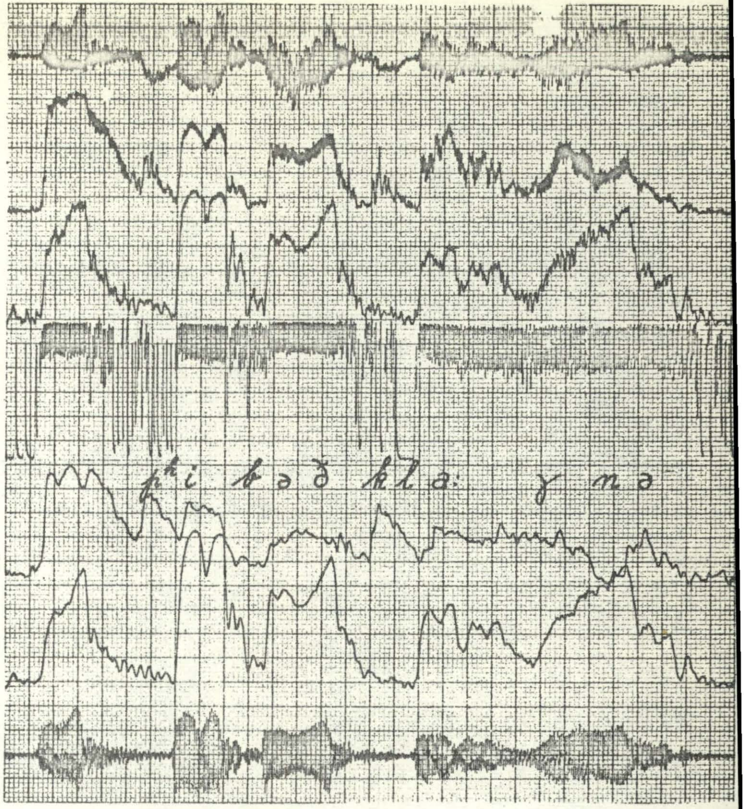
Recording no. 6
(After voice training)
Both the sonagrams and the section of [a] look quite normal in this recording.

Fig. 9.

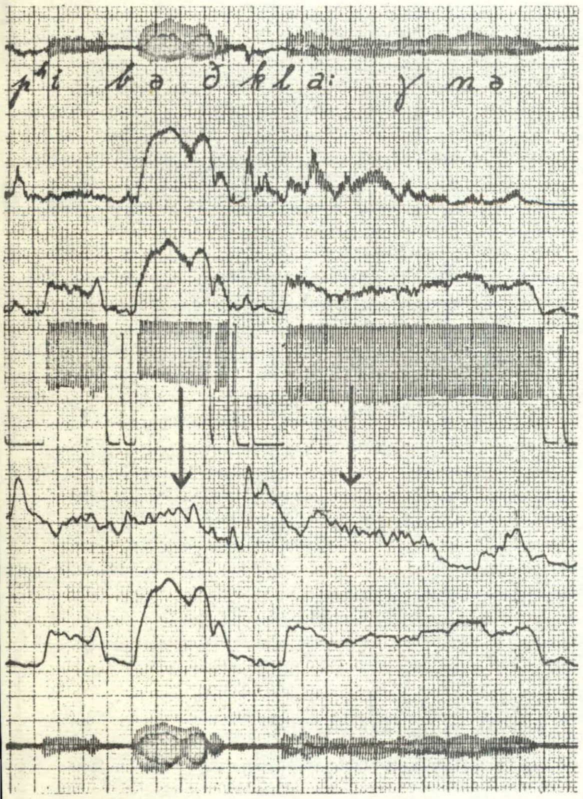
MINGOGRAMS OF PATIENT EH BEFORE INJECTION OF PARAFFIN, AFTER INJECTION OF PARAFFIN, AND AFTER VOICE TRAINING.



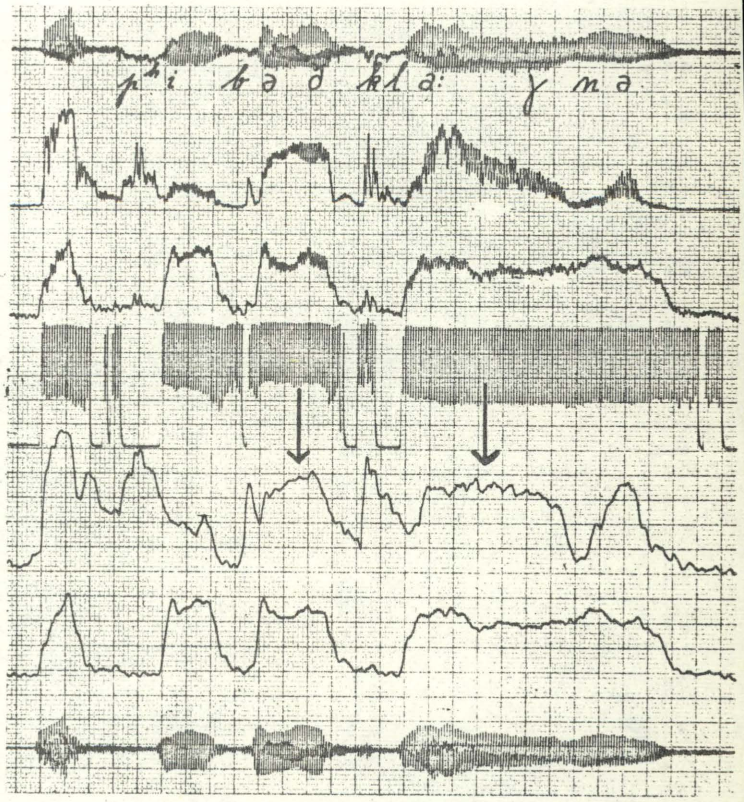
This recording shows the normal phonatory situation with the right recurrent nerve paralyzed. Notice the unstable and very diffuse traces especially for the fundamental frequency which sounds very diplophonic.



Patient EH was able to produce a rather normal phonation in the head register, but only when she was forced to use high voice effort.



After paraffin injection into the right vocal fold the normal chest register function is re-established, but still the higher part of the spectrum is too weak.



After a voice training period of about one year the normal chest register is trained and the intensities of the higher harmonics are enforced (to be seen clearly when comparing the differences between trace 6 and trace 7 in the last two mingograms).

Fig. 10.

Finally, the pitches and intensities respectively before and after speech therapy have been compared and the levels of confidence have been estimated.

For patient no. 1 (TH) these comparisons are based completely upon paired sets of data. Therefore, the standard deviation of the "change during therapy" can be calculated from $s = \sqrt{s_x^2 + s_y^2 - 2 \cdot r \cdot s_x \cdot s_y}$, where the correlation coefficient r varies between o.745 and o.48o. For patient no. 2 (RH) and patient no. 3 (EH) most of the data are paired, too.

The statistical calculations for the first two patients are shown in Fig. 7 and Fig. 8.

8.1. Stressed contra unstressed vowels

The calculations are separated into data obtained from stressed and from unstressed vowels. We expected to find some differences especially in the spectrum above 1ooo cps between the stressed and the unstressed vowels. This is apparently not the case. (E.g. patient no. 1 (TH): during the voice therapy the spectrum above 1ooo cps exhibits an average increase of 6.1 dB both in stressed and unstressed vowels.)

8.2. Changes in pitch during the voice therapy

The change in pitch is one of the most prominent changes during the voice training. Normally the pitch drops considerably in the beginning of the period of therapy, after which the pitch is raised a little in the final stage of the training. These general findings may be confirmed by means of recordings no. IV, V, and VI for patient no. 3 (EH), where the average pitch levels are calculated to 22o, 18o, and 184 cps for the stressed vowels and to 24o, 183, and 186 cps for the unstressed vowels.

Patient no. 1 (TH) and patient no. 2 (RH) have only been recorded before and after the speech training. They also show a significant lowering of the pitch during the training. The fall is 14 % both in stressed and unstressed vowels for patient no. 1 (TH) (level of significance better than o.ool) and 6 % in the stressed vowels for patient no.2 (RH) (level of significance better than o.o5), whereas the unstressed vowels are nearly unchanged.

Normally the intonation range is extended during the voice training. In this respect patient no. 1 (TH) is also typical. The word intonation[3] is increased by 7.6 % (level of significance better than o.ool) from 17.8 % to 25.4 % in relation to the mean fundamental frequencies. Patient no. 2 (RH) is atypical in this respect. In spite of a considerable fall in the maximum pitch during the training, the minimum pitch is almost unchanged. This naturally results in a reduced intonation range (from 49 % to 36 % for the stressed vowels, and from 41 % to 25 % for the unstressed vowels, both differences being significant, - see Fig. 7 and 8).

8.3. Changes in the spectral composition

Real investigations of the spectral changes have not been undertaken. Some sonagrams (Fig. 2,3,5 and 9) give visual impressions of the spectral changes. Only one parameter has been registered and calculated: the change in mean intensity level above 1ooo cps in relation to the intensity level of the full frequency spectrum.

All patients show an increased content of energy above 1ooo cps after the speech training (the F2 - F3 region is emphasized which results in a higher degree of intelligibility). The higher frequencies are increased by 6.1 dB for patient no. 1 (TH) (level of significance better than

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3) The differences between the highest and the lowest pitches in 39 random selected words.

o.ool), about 3 dB for patient no. 2 (RH) (level of significance better than o.oo5), and 3 dB for patient no. 3 (EH) (level of significance better than o.1).

9. Summary

The aim has been to point out some possibilities for objective determination of the changes in voice characteristics during voice therapy. The material used consists of tape recordings made before and after the therapy.

This pilot investigation shows that measurements of the pitch and the normalized intensity level above 1ooo cps are two usable parameters for that purpose. (The change in pitch gives a rough indication of the physiological changes during the therapy, and the changes in the spectral composition may to some extent give us information about the change in intelligibility.)

The three patients used all show both considerable lowering of the average pitch and enforcement of the upper region of the acoustic spectrum.

The statistical calculations inform us about the statistical significance of the observed changes.

References:

(1) I. Lehiste and G. Peterson, "The Identification of Filtered Vowels", Phonetica 4 (1959), p. 161-177.

(2) Ralph K. Potter, George A. Kopp and Harriet C. Green, Visible Speech, Bell Telephone Laboratories (1947).

(3) Svend Smith, "On Artificial Voice Production", Proc. of the IV. Intern. Congr. of Ph.Sc., Helsinki 1961, p.96-11o.