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Computer-aided diagnosis of voice disorders

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COMPUTER-AIDED DIAGNOSIS OF VOICE DISORDERS

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The field of communicative disorders is still a relatively young one. Speech and language are extremely complex processes, which are not yet fully understood. But, as the rest of science and technology is advancing by leaps and bounds, so is the study of these complex processes. New technology makes the researcher's job easier, as well as the clinician's. This paper will highlight just a few of the many advantages that one major technological advancement - the computer - provides for the field of Speech Pathology. Before computer's contributions can be examined, however, it is imperative to come to a basic understanding of normal phonation, various voice disorders, and prevalent treatment modalities.

I. NORMAL PHONATION

Briess (in Research Potentials in Voice Physiology, p. 259) explained the physiology of phonation very concisely in this way:

> The vocal cords shorten and thicken when the thyroarytenoids, which are responsible for the 'full vibration,' contract. The full mass of the vocal lips vibrates and produces a substantial tone which is sometimes called the 'fundamental voice' or the 'chest voice.' Upon contraction, their anatogonists, the cricothyroid muscles, stretch and lengthen the cords. These muscles produce the 'free edge vibration' in isolated function; that is, if the thyroarytenoids are relaxed, the produced tone is called 'falsetto' or 'head voice.'

Voice production is also dependent on several other characteristics. These include the rate of airflow through the glottis, the shape, size, and mass of the vocal folds, and the size and shape of the larynx, oropharynx, and nasopharynx. Abnormalities in any of the above anatomical features or abnormal usage of the organs of phonation can result in voice disorders.

II. VOICE DISORDERS - GENERAL

Voice disorders, like most speech and language disorders, are first identified by the way they sound. Traditionally, they are grouped into four basic categories: quality, resonance, loudness, and pitch (Wilson, p.3). These categories are by no means mutually exclusive. It is often the combination of characteristics which leads to a diagnosis. It is, however, useful to assess each patient in each of the four categories.

III. DISORDERS OF VOCAL QUALITY

There are several basic descriptions for abnormal voice quality:

1. Harsh - unpleasant and rough, tense, abrupt glottal attack, low pitch, weak.

2. Breathy - vocal fold noise, whisper-like air turbulence, more than 150 c.c. of air expelled before beginning phonation.

3. Hoarse - a combination of harsh and breathy - random frequency variability

4. Vocal fry - popping, cracking, very low frequency, low air-flow rate, high subglottic air pressure. (Wilson, p.3-4)

Disorders of quality are usually related to some sort of vocal fold pathology. Some common examples are:

Laryngitis

- edema of the laryngeal mucosa and vocal folds; characterized by irritation and blood accumulation; can be due to hyperfunction or an infection.

Vocal Fold Thickening

- free glottal edges become granular, somewhat rounded, pinkish, resulting in breathy air escape (and a lower fundamental frequency); due to either chronic abuse or infection.

Vocal Nodules

-dysphonia, huskiness, low intensity, frequent throat clearing; usually due to prolonged hyperfunction; usually bilateral; located in the anterior middle 1/3 of vocal fold.

Polyps

- hoarse, breathy, but high pitch; usually unilateral,

located in the anterior middle 1/3 of fold; more vascular and enlarged than a nodule; secondary to hyperfunction.

Contact Ulcer

- voice tires easily, occasional laryngeal pain; low incidence - found primarily in men who overwork at tense jobs; possible diaphragmatic hernia.

Papilloma

- dysphonia, hoarseness; benign tumor, childhood; **surgery is strongly indicated to preserve the airway.**

Spastic Dysphonia

- OVERADDUCTION: strained, creaking, hard glottal attack, tense; may be most prominent when speaking in anxiety-producing situations; poor prognosis.

- UNDERADDUCTION: (less common) widened glottis; sudden aphonia or breathy dysphonia.

Laryngeal Web

- web-like growth between proximal vocal folds; dysphonia, shortness of breath; usually due to laryngeal trauma or infection; surgery is indicated.

Vocal Fold Paralysis

- BILATERAL: aphonia; due to central or peripheral nerve damage; UNILATERAL: breathy, unable to elevate pitch, hoarse, lack of vocal variation and loudness.

Cordectomy

- voice is weak and breathy

Laryngectomy

- total aphonia (Boone, p.48-70)

IV. DISORDERS OF PITCH

Pitch disorders generally fall into four general categories: modal frequency that is too high or low, narrow pitch range, excessive pitch breaks, or pitch that is either too high or low in specific situations. Once again, these categories are extremely interdependent. Generally, they are seen in combination with either the endocrine imbalances and mutational changes associated with puberty, or with vocal fold pathology.

Patients with hoarse voice often exhibit abnormally low pitch. Pitches below 125 Hz in a male, below 225 Hz in a female, or below 250 Hz in a pre-adolescent child may indicate that some guttural effort is being used in phonation (Shearer, p.218). Along with the low pitch and hoarseness, pitch breaks may occur due to the increased tension and effort required to effortfully lower the pitch of the voice.

During the adolescent years, the vocal folds go through a mutation in which the fundamental frequency of the voice will become lower. During this transition period, pitch breaks are common. Post-adolescent males may also experience the rather embarrassing disorder of persistent mutational falsetto, in which they continue to use a high pitch level appropriate to a child after the traditional shift should have occurred (Weinberg, p. 155). The clinician must be aware of the age and developmental stage of the patient in any evaluation of pitch disorders.

V. DISORDERS OF RESONANCE

Disorders of resonance usually manifest themselves as hypernasality or hyponasality. The most common causes of hypernasal speech are cleft palate, palatal paresis, submucous cleft, congenital short palate, or psychogenic causes. Denasal speech is often caused by enlarged adenoids, polyps, and a deflected septum (Greene, p.259). Hypernasality is most noticeable in the vowels, as well as the consonants s, k, sh, z, and g. Nasal air emission may also be present. Hyponasality is most noticeable as substitutions of b/m, d/n, and g/ng (Wilson, p.5)

VI. DISORDERS OF LOUDNESS

The last category of voice disorders are those of loudness. Once again, these occur most often in conjunction with other symptoms. Excessively loud speech is defined by Wilson as speech of an intensity of 86 dB or above. Excessively soft is defined as quieter than 46 dB. The most comfortable listening level for speech is 64.35 dBSPL, while the best intelligibility is achieved at 69.31 dBSPL (p.6).

VII. ETIOLOGY

According to Boone (p. 2) the majority of voice disorders are the direct result of abuse and misuse, or hyperfunction, which is simply defined as excessive muscular force in the wrong places. Boone discusses several common sites of vocal hyper-function.

The first possibility is hyperfunction of the respiratory tract. Patients may speak on indadequate expiration, or on residual air (p.4-5). Hyperfunction may also occur at several sites along the vocal tract itself. In the hypopharynx (most immediate supraglottal area), retraction of the tongue and constriction of the pharynx cause a restriction of oral resonance. Hyperfunctional use of the soft palate can result in hyper- or hyponasality. Mandibular hyperfunction (clenching the jaw) places the burden of articulation on the tongue, with resulting vocal fatigue. Some patients have also been observed to overuse the tongue and lips in articulation, with an accompanying hard glottal attack (p.9).

The most common voice disorders, however, are due to hyperfunction at the level of the vocal folds themselves. Hard glottal attack or excessive force of approximation are two broad classes of behaviors. Wilson lists shouting, screaming, cheering, excessive talking, strained vocalizations, reverse phonation, explosive vocalization, excessive coughing or throat clearing, and talking in noise as more specific examples of vocal fold hyperfunction (p.87). Hyperfunction of the vocal folds often leads to the vocal fold pathologies previously discussed.

VIII. DIAGNOSIS

According to Shearer (in Cooper, p.217), "the diagnostic evaluation has three main goals. The first is to determine as specifically as possible all of the observable characteristics of the faulty voice. The second is to determine which factors in the client's vocal habits are contributing to the voice problem, and the final goal is to list specifically how the speech patterns and related conditions should be modified in order to reduce or eliminate the problem." A decision must be made as to whether the disorder is due to functional or organic causes, or both. The clinician must assess the adequacy of the anatomical structures necessary for phonation, the client's control over these organs, and the client's willingness to produce changes in his/her voice (Damste' and Lerman, p. 24).

Weinberg (p. 158-159) lists seven basic steps to a vocal evaluation:

1. Obtain a history of the voice disorder.

2. Complete a laryngoscopic head and neck examination.

3. Examine the functional adequacy of the phonatory apparatus and describe the typical manner of behavior of the respiratory/phonatory apparatus during voice production.

4. Provide a description of the patient's voice.

5. Evaluate hearing function.

6. Summarize findings/observations and come to a diagnosis.

7. Recommend treatment options and specify when additional forms of evaluation (need for referral to other specialties) are needed.

Step 4 above calls for essentially a perceptual evaluation of the client's voice. Weinberg (p. 168-169) goes on to list several things to assess in such an evaluation:

1. Voice production in discourse.

2. Vowel prolongations - constant pitch and loudness.

3. Phonational or pitch range (pitch matching exercises).

4. Prolonged use of the voice (counting 1-100, speaking for 3-5 minutes).

5. Cough and hard glottal attack.

6. Realization of intonation, stress, and voicing distinctions - prosody.

All of the above listed procedures are admittedly rather subjective. More objective procedures do exist. Damste' and Lerman (p.27) list some of these: recording sound intensity, fundamental frequency, and quality (harmonic analysis, describing an impulse-period in time); stroboscopic laryngoscopy (allows examiner to see vibrating folds as if stationary); estimation or measurement of vocal fold length; X-ray examination of the vocal mechanism, electromyography (recording action potentials in groups of contrasting muscle fibers); and the measurement of respiratory capacity, breathing movements, and respiratory air flow.

IX. SELECTING A THERAPY PLAN

Before a therapy plan can be made, any medical remediation necessary must be completed first. For several disorders, therapy without surgical correction would be useless. But even with surgical intervention, some speech therapy is indicated.

Darmste' and Lerman prescribe the following guidlines for selecting a therapy plan (p.26):

> 1. Improvement of the organic conditions by surgical intervention...
>
> 2. Pharmaceutical treatment of constitutional defects, deficiencies, or bodily disequilibrium (sedatives, hormonal agents)...
>
> 3. Modifying a noxious function (exercises for relaxation, breath control, voice therapy)...
>
> 4. Improving circumstantial or situational conditions (talking with employer or relatives) or desensitizing the patient to the provocative factors in his environment.

It may be difficult at first to convince the patient that voice therapy can really help. According to Emerick (p. 56), "By and large, persons ignore their potential to improve their voice because it is produced by physiological systems that are not under direct and conscious control... how does one modify his voice to reflect various moods of sarcasm or irony? Somehow, by a process not clearly understood and largely involuntary, we simply make all these vocal changes." The key is to make the client aware of specific behaviors which can be changed in order to produce the best voice possible.

There are a great many therapy approaches for remediation of voice disorders. Some are extremely disorder-specific, while others can be widely applied. The approaches discussed here will be of a more all-purpose nature.

X. COMMON THERAPY APPROACHES

First, since the majority of voice disorders are the direct result of vocal abuse, the logical approach would be to eliminate the abusive behaviors. Boone suggests identifying with the client the specific abusive behaviors, discussing the need to reduce them, and then instructing the client to self-monitor and graph their frequency. The goal is to achieve a sloping, decremental curve (p.139).

Boone also recognizes that abusive behaviors are often situation-specific, and that the situations which encourage abuse are often anxiety-producing. For this, Boone suggests hierarchy analysis to rank these anxiety-producing situations. The patient then learns to recreate the pleasant, relaxed feelings of the "least anxious" situations while in the "most anxious" situations. The approach is much like one used for stuttering (p. 153).

Another widely used approach is relaxation techniques. The client is asked to first tense and then relax specific muscle groups in the body. The relaxation moves from the limbs and trunk to the head, scalp, forehead, eyes, facial muscles, lips, jaw, tongue, palate, throat, etc. (Boone, p.171).

The yawn-sigh approach has also been proven effective. It is usually used in combination with other techniques - rarely alone. The approach starts out with explanations and demonstrations of a yawn (prolonged inspiration with maximum widening of the supraglottal airways). Then phonation is

introduced during the yawning. The client then proceeds to speaking words while yawning. The client will then progress to an omission of the yawn, and instead use an open-mouthed inhalation followed by a prolonged open-mouthed sigh. Phonation should begin on the sigh. The client should begin phonation with "hah." Encourage carryover of the technique into conversational speech (Boone, p.180).

The chewing approach is a holistic method which can be very useful with hyperfunction which is due to excess tension. The client often clenches the teeth and articulates with only the tongue - much like a ventriloquist. To introduce the approach, the client is instructed to imagine that he/she is chewing on a stack of four or five crackers. Then the client phonates along with the chewing movement. Tongue movements are added to vary the sound. The client then chant-chews words. The client progresses to counting tasks, running speech, and finally conversation, by this time using auditory feedback (Boone, p. 130-131).

Shearer suggests (in Cooper, p. 224) that in therapy for pitch problems, it may be best to work on widening the pitch range, which may be more effective than shooting for some "optimum pitch." The client can then feel the relative effort required to achieve various pitch levels. The voice should eventually shift to the pitch which requires the least effort for phonation.

The Lombard Test has been found to be useful in the treatment of dysphonias (Boone, p. 158). It is based on the voice-reflex idea: when the patient can't monitor his/her own

voice (it is masked), it often becomes louder and clearer. The clinician should tape record the voice throughout the procedure, alternating masking and silence. If the procedure is successful (voice quality is improved when the voice is masked), the tape can be played for the client. The procedure is then repeated, so that the client can <u>feel</u> the difference in voice production. The ultimate goal is carryover into normal conversational speech. If voice quality does not improve with masking, however, discontinue the procedure.

XI. COMPUTER-AIDED DIAGNOSIS

The use of computers in diagnosis by no means implies that it is preferable for the client to be able to sit down at a keyboard and monitor, punch some keys, and be able to diagnose and treat himself. Human judgment, patience, and ingenuity are still indispensable in the entire process. But computers can, when properly utilized, make the entire process much more efficient.

One of the most obvious uses of a computer is word processing. This research paper is living proof of the computer's usefulness in this capacity. With but a few keystrokes, I can insure that a word will be overprinted, underlined, or centered on the line. I can type a draft, move paragraphs around, check the spelling, delete, add, edit, etc., and when I'm done composing, I press a button and it is typed for me with perfect margins and no errors.

The computer obviously has many uses beyond being a glorified typewriter. The attached program is just one example of the many uses that a computer can have during a diagnostic evaluation.

The program is designed to simplify both the actual evaluation, and the paperwork that must follow. It would be especially helpful in a situation where the clinician must see a high volume of clients in a short period of time, evaluate them, and write a clinical report to be filed with some other agency.

The program starts out by asking identification questions, such as the client's name and age, the clinician's name, and the

date. The information is then automatically printed in proper format.

Next, the program instructs the clinician to have the client read aloud and to make observations of the voice during this time. The clinician is then simply asked a lot of yes/no questions (the response is "y" for "yes," "n" for "no" on the computer keyboard) about the quality of the client's voice. The answers are then also printed out in proper format, instead of the clinician writing notes out longhand.

The next portion of the program assesses pitch range. The computer is programmed to produce tones for the client to match up and down the scale from C3 to C4. Again, the clinician is asked yes/no questions about pitch adequacy.

Breath support is then assessed by measuring the duration of a vowel prolongation. The clinician is given the option of having the computer time the prolongation, or using a stop watch. A subroutine is contained in the program for timing the event.

Next, the clinician is asked whether or not a laryngeal examination has been performed. If it has, the results are reported. If not, the probability of nodules is assessed by calculating the relative durations of /s/ and /z/. If the s/z ratio is .5, the chance for nodules is about 50%. An s/z ratio > 1.5 indicates a 75% chance for nodules, while if the s/z ratio < 1.5, the chance is only 35%. The theory behind this is that if the s/z ratio is very large, (the duration of /s/ is much longer than /z/), the client does not have adequate valving of air at the level of the glottis when the vocal folds are being

used to produce sound. The assumption is that this may be occurring due to an abnormal mass on one or both of the folds which is creating an abnormally wide glottis opening during phonation, allowing too much air to escape.

The next part of the program asks for the clinician's clinical impressions. Here the clinician actually types in her/his professional opinion on the client's prognosis for therapy. The computer functions as a typewriter, transferring the information again to the clinical report. The same is true for the "SUMMARY AND RECOMMENDATIONS" section of the program.

Finally, the computer prints a line for the clinician's signature, with the clinician's name typed below.

The program contains a second subroutine which counts each printed line. When the report gets to 55 lines in length, the printer advances 14 lines, to insert a page break. The counter is then reset to 0.

XII. CONCLUSION

To keep up with a rapidly changing world, it seems that computer skills will soon be invaluable to any person in any profession. The key is to recognize the limitations of machinery, and the necessity for the human factor. Computers are a tool to make life easier and less complicated. They should be neither worshipped nor feared - but simply put to use in the most efficient way possible. In a field such as Speech-Language Pathology, the ideal use is to let computers cut down on administrative (paperwork) time so that clinicians can devote more time to interacting with the client.

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SAMPLE HARD COPY FROM THE PROGRAM

EVALUATION OF THE VOICE

CLIENT'S NAME [redacted]n [redacted]

DATE:4/24/86

CLIENT'S AGE:13

CLINICIAN:Terri Brancewicz

OBSERVATIONS DURING ORAL READING

The client demonstrated the following characteristics:
Tension in the neck and shoulders

The voice quality was:
Harsh
Hoarse
Raspy

Additional phonatory irregularities:

Hard glottal attack
Pitch breaks

PITCH OBSERVATIONS

Pitch was observed as the client attempted to glide up and down the scale.
Observed pitch range:
Pitch range is adequate.

OBSERVATIONS DURING VOWEL PROLONGATION

The client used a hard glottal attack intermittantly.
DURATION OF 'AH':
TRIAL 1 = 00:00: 23
TRIAL 2 = 00:00: 21

LARYNGEAL FUNCTION

S/Z RATIO, TRIAL 1= 1.846154
S/Z RATIO, TRIAL 2= 2.181818

THE AVERAGE S/Z RATIO IS: .3663637
The probability for nodules is only 35%.

CLINICAL IMPRESSIONS:
[redacted] was extremely attentive and cooperative throughout the diagnostic session. I am convinced that he would be very successful in therapy.
*

SUMMARY AND RECOMMENDATIONS:
Although the probability for vocal nodules is well

below 35%, I still feel that [redacted]n [redacted]s suffering with some vocal fold pathology. He has been observed by his teacher to use an extreme amount of force with his voice when he becomes very excited. I recommend therapy three times a week for one half hour each session to reduce vocal abuse.
*

Terri Brancewicz
CLINICIAN

THE PROGRAM

```
2600 GOTO 2660
2610 LPRINT:LPRINT TAB(10)"The presence of unilateral nodules is indicated"
2620 LPRINT TAB(10)"in the laryngeal exam.": GOSUB 3040
2630 GOTO 2660
2640 LPRINT TAB(10)"No nodules were found in the laryngeal exam.": GOSUB 3040
2650 GOTO 2660
2660 GOSUB 3040
2670 CLS
2680 PRINT
2690 REM ----------------CLINICAL OBSERVATIONS--------------------------
2700 PRINT
2710 PRINT"NOW IT'S TIME TO WRITE THE CLINICAL OBSERVATIONS"
2720 DIM L$(100)
2730 LPRINT: GOSUB 3040
2740 LPRINT: GOSUB 3040
2750 LPRINT TAB(5)"CLINICAL IMPRESSIONS:"
2760 GOSUB 3040
2770 PRINT"WRITE YOUR IMPRESSIONS.  PRESS `RETURN' AFTER EACH LINE.  DON'T"
2780 PRINT"USE COMMAS.  WHEN FINISHED, ENTER `*'AND PRESS `RETURN'"
2790 FOR H=1 TO 15
2800 LINE INPUT "CLINICAL IMPRESSIONS:";L$(H)
2810 IF L$(H)="*" GOTO 2830
2820 NEXT H
2830 FOR H=1 TO 15
2840 LPRINT TAB(5) L$(H): GOSUB 3040
2850 IF L$(H)="*" GOTO 2870
2860 NEXT H
2870 LPRINT:LPRINT:CLS
2880 PRINT"NOW FOR THE SUMMARY AND RECOMMENDATIONS. AS BEFORE, PRESS"
2890 PRINT"`RETURN' AT THE END OF EACH LINE, AND ENTER `*' WHEN FINISHED."
2900 FOR K=1 TO 15
2910 LINE INPUT"RECOMMENDATIONS:";L$(K)
2920 IF L$(K)="*" GOTO 2940
2930 NEXT K
2940 LPRINT TAB(5)"SUMMARY AND RECOMMENDATIONS:"
2950 GOSUB 3040
2960 FOR K=1 TO 15
2970 LPRINT TAB(5) L$(K):GOSUB 3040
2980 IF L$(K)="*" GOTO 3000
2990 NEXT K
3000 LPRINT:LPRINT
3010 LPRINT TAB(40)"_____"
3020 LPRINT TAB(40)" "CL$
3030 LPRINT TAB(40)"CLINICIAN": GOTO 3110
3040 L=L+1
3050 IF L=55 THEN 3080
3060 RETURN
3070 RETURN
3080 LPRINT:LPRINT:LPRINT:LPRINT:LPRINT:LPRINT:LPRINT:LPRINT:LPRINT:LPRIN
T:LPRINT:LPRINT:LPRINT
3090 L=0
3100 RETURN
3110 END
```

```
1950 GOSUB 3040
1960 INPUT"WHAT WAS THE DURATION OF /S/";S
1970 INPUT"WHAT WAS THE DURATION OF /Z/";Z
1980 GOSUB 3040
1990 LPRINT TAB(10)"S/Z RATIO, TRIAL 1 = ";S/Z
2000 CLS:LPRINT
2010 GOSUB 3040
2020 PRINT"ASK THE CLIENT TO PROLONG /Z/ AGAIN."
2030 GOSUB 2420
2040 LPRINT TAB(5)"TRIAL 2 - /Z/ DURATION= ";TIME$
2050 GOSUB 3040
2060 CLS
2070 PRINT"NOW ASK THE CLIENT TO PROLONG /S/ AGAIN."
2080 GOSUB 2420
2090 LPRINT TAB(5)"TRIAL 2 - /S/ DURATION= ";TIME$
2100 GOSUB 3040: GOTO 2180
2110 GOSUB 3040
2120 PRINT"ASK THE CLIENT TO PROLONG FIRST /S/ AND THEN /Z/"
2130 PRINT"RECORD THE DURATION OF EACH"
2140 INPUT"WHAT WAS THE DURATION OF /S/";S
2150 INPUT"WHAT WAS THE DURATION OF /Z/";Z
2160 LPRINT TAB(10)"S/Z RATIO, TRIAL 1=";S/Z
2170 PRINT"NOW REPEAT THE PROCEDURE."
2180 INPUT"WHAT WAS THE DURATION OF /S/ ON THIS TRIAL";S
2190 INPUT"WHAT WAS THE DURATION OF /Z/ ON THIS TRIAL";Z
2200 LPRINT TAB(10)"S/Z RATIO, TRIAL 2= ";S/Z
2210 GOSUB 3040
2220 LPRINT
2230 GOSUB 3040
2240 INPUT"WHAT WAS THE S/Z RATIO FOR TRIAL 1";X
2250 INPUT"WHAT WAS THE S/Z RATIO FOR TRIAL 2";Y
2260 R=(X+Y)/Z
2270 LPRINT TAB(10)"THE AVERAGE S/Z RATIO IS: ";R
2280 GOSUB 3040
2290 IF R>1.5 GOTO 2350
2300 IF R<1.5 GOTO 2390
2310 LPRINT TAB(5)"The probability for nodules is near 50%.": GOSUB 3040
2320 LPRINT TAB(5)"A laryngeal exam is recommended."
2330 GOSUB 3040
2340 GOTO 2660
2350 LPRINT TAB(5)"The probability for nodules is 75%.": GOSUB 3040
2360 LPRINT TAB(5)"A laryngeal exam is strongly recommended."
2370 GOSUB 3040
2380 GOTO 2660
2390 LPRINT TAB(5)"The probability for nodules is only 35%."
2400 GOSUB 3040
2410 GOTO 2530
2420 PRINT"PRESS `B' AND THEN `RETURN' AT THE BEGINNING OF SOUND PRODUCTION"
2430 PRINT"AND `E' AND `RETURN' AT THE END."
2440 PRINT"BE SURE THE `CAPS LOCK' IS ON."
2450 INPUT"ENTER B";B$
2460 TIME$="00:00:00"
2470 CLS
2480 PRINT"PRESS `E' NOW, AND GET READY TO HIT `RETURN' WHEN SOUND"
2490 PRINT"PRODUCTION ENDS."
2500 INPUT E$
2510 RETURN
2520 TIME$="00:00:00"
2530 CLS:GOTO 2690
2540 LPRINT:GOSUB 3040:LPRINT:GOSUB 3040
2550 INPUT"ARE NODULES INDICATED BY THE LARYNGEAL EXAM";A$
2560 IF A$="N" GOTO 2640
2570 INPUT"ARE THE NODULES BILATERAL";A$
2580 IF A$="N" GOTO 2610
2590 LPRINT TAB(10)" Bilateral nodules were reported in the laryngeal exam.":GOS
UB 3040
```

```
290 IF A$="N" GOTO 1320
300 LPRINT TAB(10)"Pitch is too low for age."
310 GOSUB 3040
320 LPRINT: GOSUB 3040
330 LPRINT: GOSUB 3040
340 CLS
350 PRINT"THIS CONCLUDES PITCH OBSERVATIONS"
360 LPRINT TAB(20)"OBSERVATIONS DURING VOWEL PROLONGATION":GOSUB 3040:LPRINT
370 GOSUB 3040
380 PRINT"PRESS `RETURN' TO CONTINUE"
390 INPUT P$
400 PRINT
410 REM ----------------END OF PITCH OBSERVATION--------------
420 CLS
430 PRINT"NOW ASK THE CHILD TO PRODUCE REPETITIONS OF A VOWEL SOUND"
440 PRINT"SUCH AS `AH'"
450 INPUT"DOES THE CHILD USE A HARD GLOTTAL ATTACK";A$
460 IF A$="N" GOTO 1530
470 INPUT"IS THE HARD GLOTTAL ATTACK INTERMITTANT";A$
480 IF A$="Y" GOTO 1510
490 LPRINT TAB(10)"The client used a hard glottal attack.": GOSUB 3040
500 GOTO 1530
510 LPRINT TAB(10)"The client used a hard glottal attack intermittantly."
520 GOSUB 3040
530 CLS
540 PRINT"NEXT, ASK THE CHILD TO PROLONG `AH' FOR AS LONG AS POSSIBLE."
550 LPRINT TAB(5)"DURATION OF `AH':"
560 INPUT "WOULD YOU LIKE TO USE THE COMPUTER FOR TIMING";A$
570 IF A$="Y" GOTO 1660
580 PRINT"THEN TIME THE VOWEL PROLONGATION BY WATCH"
590 INPUT"WHAT WAS THE `AH' DURATION";T
600 LPRINT TAB(10)"TRIAL 1 = 00:00:";T
610 PRINT"HAVE THE CLIENT PROLONG `AH' AGAIN"
620 INPUT"WHAT WAS THE `AH' DURATION ON THIS TRIAL";T
630 LPRINT TAB(10)"TRIAL 2 = 00:00:";T
640 GOTO 1740
650 PRINT
660 GOSUB 2420
670 LPRINT:GOSUB 3040
680 LPRINT TAB(10)"TRIAL 1 =";TIME$
690 GOSUB 3040
700 CLS
710 PRINT "NOW REPEAT THE PROCEDURE."
720 GOSUB 2420
730 LPRINT TAB(10)"TRIAL 2 =";TIME$
740 GOSUB 3040:LPRINT:GOSUB 3040:LPRINT:GOSUB 3040
750 LPRINT TAB(20)"LARYNGEAL FUNCTION":GOSUB 3040
760 GOSUB 3040
770 INPUT"DOES THE MEDICAL HISTORY INDICATE A LARYNGEAL EXAM";A$
780 IF A$="Y" GOTO 2550
790 CLS
800 PRINT"IF NO LARYNGEAL EXAM WAS PERFORMED, YOU MAY USE AN S/Z RATIO"
810 PRINT"TO ESTIMATE THE LIKELIHOOD OF NODULES."
820 INPUT"WOULD YOU LIKE TO USE THE COMPUTER TO TIME THE S/Z RATIO";A$
830 IF A$="N" GOTO 2120
840 LPRINT TAB(20)"S/Z RATIO CALCULATION.":GOSUB 3040:LPRINT:GOSUB 3040
850 PRINT
860 PRINT"FIRST, ASK THE CLIENT TO PROLONG /S/ FOR AS LONG AS POSSIBLE."
870 GOSUB 2420
880 LPRINT TAB(5)"TRIAL 1 - /S/ DURATION= ";TIME$
890 CLS
900 GOSUB 3040
910 PRINT"NOW ASK THE CLIENT TO PROLONG /Z/, USING THE SAME TIMING"
920 PRINT"PROCEDURE"
930 GOSUB 2420
940 LPRINT TAB(5)"TRIAL 1 - /Z/ DURATION = ";TIME$
```

```
630 LPRINT: GOSUB 3040
640 LPRINT TAB(5)"Additional phonatory irregularities:"
650 LPRINT: GOSUB 3040
660 INPUT "intermittantly aphonic";A$
670 IF A$="N" GOTO 700
680 LPRINT TAB(10) "Intermittant aphonia"
690 GOSUB 3040
700 INPUT "phonation breaks";A$
710 IF A$="N" GOTO 740
720 LPRINT TAB(10) "Phonation breaks"
730 GOSUB 3040
740 INPUT "hard glottal attack";A$
750 IF A$="N" GOTO 780
760 LPRINT TAB(10) "Hard glottal attack"
770 GOSUB 3040
780 INPUT "intermittant fry";A$
790 IF A$="N" GOTO 820
800 LPRINT TAB(10) "Intermittant fry"
810 GOSUB 3040
820 INPUT "pitch breaks";A$
830 IF A$="N" GOTO 860
840 LPRINT TAB(10)"Pitch breaks"
850 GOSUB 3040
860 LPRINT: GOSUB 3040
870 LPRINT: GOSUB 3040
880 PRINT
890 REM - - - - - - - -PITCH OBSERVATIONS - - - - - - - - - -
900 PRINT
910 CLS
920 PRINT"THIS ENDS OBSERVATIONS DURING ORAL READING"
930 LPRINT TAB(30)"PITCH OBSERVATIONS": GOSUB 3040
940 PRINT"PRESS `RETURN' TO CONTINUE"
950 INPUT P$
960 CLS
970 PRINT"NOW ASK THE CHILD TO GLIDE UP AND DOWN THE PITCH SCALE"
980 PRINT"TO DO THIS, HAVE THE CLIENT MATCH THE COMPUTER TONES"
990 PRINT "THE QUESTIONS TO FOLLOW WILL ADDRESS PITCH RANGE"
1000 PRINT "BE SURE THE `CAPS LOCK' IS ON"
1010 PRINT"PRESS `RETURN' TO CONTINUE"
1020 INPUT P$
1030 PLAY"03 L2 P1 C D E F G A B 04 C"
1040 PLAY"04 L2 C 03 B A G F E D C"
1050 CLS
1060 LPRINT TAB(5)"Pitch was observed as the client attempted to":GOSUB 3040
1070 LPRINT TAB(5)"glide up and down the scale.":GOSUB 3040
1080 LPRINT TAB(5)"Observed pitch range:"
1090 INPUT"DOES THE CLIENT COMPREHEND `PITCH'";A$
1100 IF A$="Y" GOTO 1140
1110 IF A$="N" GOTO 1120
1120 LPRINT TAB (10)"Client does not comprehend pitch.": GOSUB 3040
1130 GOTO 1320
1140 INPUT"IS THE PITCH RANGE BETTER THAN JUST ADEQUATE";A$
1150 IF A$="N" GOTO 1190
1160 LPRINT TAB(10)"Pitch range is good."
1170 GOSUB 3040
1180 GOTO 1320
1190 INPUT"IS THE PITCH RANGE ADEQUATE";A$
1200 IF A$="N" GOTO 1240
1210 LPRINT TAB(10)"Pitch range is adequate."
1220 GOSUB 3040
1230 GOTO 1320
1240 INPUT"IS THERE AN ADEQUATE UPPER RANGE";A$
1250 IF A$="Y" GOTO 1280
1260 LPRINT TAB(10)"The client demonstrated no upper range."
1270 GOSUB 3040
1280 INPUT"IS THE PITCH TOO LOW";A$
```

```
10 LPRINT TAB(20)"EVALUATION OF THE VOICE":GOSUB 3040
20 LPRINT:GOSUB 3040:LPRINT:GOSUB 3040
30 REM THIS PROGRAM SIMPLIFIES
40 REM THE WRITING OF CLINICAL REPORTS
50 INPUT "DATE:";D$
60 GOSUB 3040
70 INPUT "CLIENT'S NAME";N$
80 LPRINT TAB(5)"CLIENT'S NAME:";N$:GOSUB 3040:LPRINT TAB(40)"DATE:";D$
90 GOSUB 3040
100 INPUT "CLIENT'S AGE";Y$
110 INPUT"CLINICIAN";CL$
120 LPRINT TAB(5)"CLIENT'S AGE:";Y$:GOSUB 3040:LPRINT TAB(40)"CLINICIAN:";CL$:GO
SUB 3040:LPRINT:GOSUB 3040
130 GOSUB 3040
140 GOSUB 3040
150 REM - - - - - - - - - ORAL READING - - - - - - - - - - - - -
160 CLS
170 PRINT "FOR THE NEXT FEW MINUTES THE CHILD WILL READ ALOUD."
180 PRINT "THE QUESTIONS TO FOLLOW WILL ADDRESS OBSERVATIONS."
190 PRINT "YOU MAY ANSWER DURING THE ORAL READING"
200 PRINT "OR AFTER IT IS COMPLETE."
210 LPRINT: GOSUB 3040
220 LPRINT: GOSUB 3040
230 LPRINT TAB(20)"OBSERVATIONS DURING ORAL READING"
240 PRINT"PRESS `RETURN' TO CONTINUE"
250 INPUT P$
260 CLS
270 LPRINT: GOSUB 3040
280 LPRINT"     The client demonstrated the following characteristics:"
290 PRINT"TO ANSWER EACH QUESTION, PRESS `Y' FOR YES, `N' FOR NO"
300 PRINT"MAKE SURE THAT THE `CAPS LOCK' IS ON."
310 PRINT:PRINT"PRESS `RETURN' TO CONTINUE"
320 INPUT P$
330 CLS
340 INPUT "WEAK INTENSITY";A$
350 IF A$="N" GOTO 380
360 LPRINT TAB(10)"Weak intensity"
370 GOSUB 3040
380 INPUT"TENSION IN THE NECK AND SHOULDERS";A$
390 IF A$="N" GOTO 420
400 LPRINT TAB(10)"Tension in the neck and shoulders"
410 GOSUB 3040
420 LPRINT:GOSUB 3040
430 LPRINT: GOSUB 3040
440 LPRINT TAB(5)"The voice quality was:"
450 GOSUB 3040
460 INPUT"BREATHY";A$
470 IF A$="N" GOTO 500
480 LPRINT TAB(10)"Breathy"
490 GOSUB 3040
500 INPUT"HARSH";A$
510 IF A$="N" GOTO 540
520 LPRINT TAB(10)"Harsh"
530 GOSUB 3040
540 INPUT"HOARSE";A$
550 IF A$="N" GOTO 580
560 LPRINT TAB(10)"Hoarse"
570 GOSUB 3040
580 INPUT"RASPY";A$
590 IF A$="N" GOTO 620
600 LPRINT TAB(10) "Raspy"
610 GOSUB 3040
```