

Chronaxy Measurement of the Nervus Recurrens and its Applications

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The various experiments, briefly outlined in the previous number of this journal (cf. Journal of the S.A. Logopedic Society, Vol. 4, No. 2, p.10. *seq.*) led R. HUSSON to measure "in situ" the excitability of the N. recurrens of man and to discuss the practical uses of his measurements. (cf. R. HUSSON: "La mesure 'in situ' de l'excitabilité recurrentielle chez l'homme et ses applications . . .", Bulletin de l'Académie Nat. de Méd., No.s 1 et 2, 1955.) HUSSON says that MOULONGUET'S experiments, which proved that there exists a congruity between the action potentials of the N. recurrens and the vibrations of the vocal folds, has made it possible to measure the chronaxy of the recurrent nerve. He works out a simple basic formula to determine the maximum frequency:

$$\text{Maximum Frequency} = N = \frac{1000}{K C} \quad (\text{R. Husson } \textit{ibid.}, \text{ p. 1})$$

In this formula C is the chronaxy of the recurrent nerve in milliseconds, and its refractory period lasts K chronaxies. This formula makes it

possible to calculate the highest note a subject can produce, if (through some method or other) one knows the chronaxy of his recurrent nerve. Conversely, the highest note sung by a subject makes it possible to calculate his chronaxy.

There is another important finding worth mentioning in this connection: the chronaxy which is calculated from the N. recurrens is the same as the one which is easily measured on the motor point of the sternocleidomastoid muscle. HUSSON describes the simple method of measuring the chronaxy: — the subject holds in his hand the anode electrode, and the examiner applies the cathode electrode to the motor point of the M. sternocleidomastoideus.

The study of just over 100 subjects, mostly singers with well trained and well established voices, made it possible for HUSSON to draw up a table, which gives the values of the recurrent chronaxy for each type of grown-up voice, i.e. from the ultra high soprano of chronaxic value 0.055 to the deepest bass of chronaxic value 0.170.

The following table shows the correlation between the measurements of N. recurrens chronaxy and the voice classification of singing voices:

<i>Male Voice</i>	<i>Chronaxy Values in Milliseconds</i>	<i>Female Voice</i>
	0.055	..... Ultra-high soprano
	0.060	..... Ultra-high soprano
	0.065	..... Very high soprano
Very high tenor	0.070	..... High soprano
Middle tenor	0.075	..... Middle soprano
Low tenor	0.080	..... Low Soprano
Intermediary voice	0.085	..... Intermediary voice
Intermediary voice	0.090	..... High mezzo soprano
High baritone	0.095	..... Middle mezzo soprano
Middle baritone	0.100	..... Deep mezzo soprano
Deep baritone	0.105	..... Intermediary voice
Intermediary voice	0.110	..... High mezzo contralto
Intermediary voice	0.115	..... Middle mezzo contralto
High lyric bass	0.120	..... Deep mezzo contralto
Deep lyric bass	0.130	..... Intermediary voice
Middle bass	0.140	..... Intermediary voice
Middle bass	0.150 Contralto
Deep bass	0.160 Contralto
Deep bass	0.170 Contralto

(R. HUSSON, *ibid.*, p.6)

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This table shows that for each sex there are not only 3 or 4 types of voice, but that there is an infinity of voice types, one leading into the other. All chronaxic values are possible between 0.055 and 0.170. Many voices, therefore are intermediary among the classical types of voice. This explains the difficulty some singers have to fall into one particular category; i.e. with regard to their innate voice range. Chronaxic values only determine *pitch*, but in no way intensity or timbre.

Looking at HUSSON'S table, one might be surprised at finding that men and women have identical excitability of the N. recurrens and consequently the same chronaxic values. A man and a woman of identical recurrent chronaxies present a voice range with a difference of exactly one octave. This difference is due to the fact that the man uses a *monophasic* recurrent conduction (chest register), whereas the woman uses a *biphasic* recurrent conduction (head register). Nevertheless a man can make use of his *biphasic* register in high tones (falsetto voice), but he cannot keep it up continuously without experiencing fatigue. A woman can also use her *monophasic* register in deep tones, but not for a prolonged time without feeling fatigued.

Research has also been done on the voices of children, and E. J. GARDE and HUSSON found that in children, aged 8-15 years, whom they examined, the chronaxies were ranging from 0.060 to 0.160, i.e. exactly as in adults. It would be interesting to know, if the recurrent chronaxy before and after pubertal voice change remains the same or undergoes changes. The publications I have read do not contain any information on this subject. Research in this field might give revealing results. On the other hand, research has been carried out to show that certain medications influence the chronaxy of the recurrent nerve (e.g. the diminishing effect of thyroxine). A

change in the recurrent chronaxy, which is of particular interest to the Logopedician, is the one which has been observed in cases of phonasthenia.

HUSSON writes about his findings in this field and says that in phonasthenia the change in recurrent chronaxy is most noticeable. In each case one always finds simultaneously:

1. a *decrease* of the rheobase;
2. an *increase* of the chronaxy.

In addition to this most important observation, there is another research result of the Laboratory of Physiology of the Sorbonne, which especially concerns the Logopedician: — It has been found in phonasthenia that

1. the dyschronaxy, which appears, is always unilateral;
2. the affected vocal fold is always the more "controlled" one (which means the right fold in right-handed persons, the left fold in left-handed ones). An exception to this rule has not been found.

HUSSON gives a couple of examples of cases of phonasthenia, showing the obvious correlation between handedness and recurrent chronaxy:

Subject	Recurrent Chronaxy	
	Right	Left
Miss B., aged 34, left-handed	..... 0.098	0.165
Miss D., aged 21, right-handed	0.072	0.061
Miss M., aged 24, right-handed	0.151	0.104
Master P., aged 6, left-handed	..... 0.109	0.132
Mrs. S., aged 42, right-handed	..... 0.320	0.098

(R. HUSSON, *ibid.*, p.6)

HUSON observed that as phonasthenia progresses the chronaxy of both vocal folds increases, but it always remains raised in the fold which is the more "controlled" one (cf. handedness). If phonasthenia cases are given suitable medication or only a period of strict vocal rest, one will see the following results:

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1. *increase* of the rheobase;
2. *decrease* of the chronaxy, descending to its normal physiological level.

The value of these findings to the Logopedician is evident. Even the latest laryngo-stroboscope does not give the examiner as revealing a result as the measuring of the recurrent chronaxy. Laryngo-stroboscopic examination may reveal very clearly a difference in amplitude in the vibration of both vocal folds, but never gives any information whether the amplitude is e.g. abnormally increased in the one fold or abnormally decreased in the other. A chronaxic measurement dispels all doubt: the vocal trouble is situated in that side which has the higher recurrent chronaxy. The Logopedician will be able to adapt his therapy accordingly. He may, now, find himself confronted with new therapeutic demands. This does not mean in any way that previous therapeutic approaches like relaxation and breathing exercises should be abandoned. On the contrary, in addition to therapy which in the past has proved successful, we may, now, be able to develop measures based on chronaxic measurement and thus create a more intensive, possibly more speedy, therapy.

In the above I have tried to give a brief description of the researches, which have taken place at the Sorbonne and deal with aspects of voice physiology which have caused an upheaval in the scientific world. HUSSON has a great number of followers among the leading figures of phonetic science. One of the first and foremost personalities, who have subscribed to HUSSON'S new theories, is G. PANCONCELLI-CALZIA. His publication "Breathing in Phonation, New and Old Aspects" (*Die Stimmattung, Das Neue, Das Alte*), Leipzig, 1956, is based on HUSSON'S ideas. Putting things in a nutshell, CALZIA states in this book that: "The motto of the classical old Italian school of singing was: 'Chi ben respira, ben canta.' (Who breathes well, sings well). That was wrong. It would have been more correct to say: 'Chi ben canta, ben respira', because HUSSON has proved that the activities in the larynx and pharynx contract the breathing and not vice versa. In spite of these new findings some Phoneticians and Logopedicians still adhere to the old historical sentimentality." (CALZIA, *Die Stimmattung*, p.14). In a recent publication we still find an enthusiastic adherence to what CALZIA calls "the old historical sentimentality." I am referring to the book "The Voice and its Disorders" by MARGARET GREENE, London, 1957, which I reviewed in the previous number of this Journal (cf. Vol. 4, No. 2, p.15, *seq.*). The author characteristically calls a chapter, which deals with the breathing mechanism, "The Vocal

Excitor" (cf. M. GREENE, *ibid.*, Ch.2).

HUSSON'S ideas have not been accepted everywhere, and it appears that some scientists, who repeated his experiments, have not come to the same conclusions. During an international symposium on the physiology of the larynx, organized by the French Society of Phoniatrics, held in Paris in October, 1955, some scientists, e.g. A. FESSARD and B. VALLANCIEN, tried to disprove some of HUSSON'S and LAGET'S experiments. They came to the conclusion that their experiments were incompatible with the theory that the frequency of vocal fold vibration is neurogenically determined. (cf. *Folia Phoniatrica*, 1957, vol. 9, No. 1, p.62, *seq.*, and *ibid.*, 1957, vol. 9, No. 3, p.152, *seq.*). The Danish scientist K. FAABORG-ANDERSEN comes to similar conclusions in his experiments. (cf. *Acta Physiologica Scandinavia*, 41, Supplementum 140, 1957). In June, 1957 a high speed film was shown at Baden-Baden, which also disproved some of HUSSON'S findings, i.e. vocal fold vibration and phonation only occurred, when there was a subglottal air supply. (cf. personal correspondence with R. Luchsinger, Zurich, June, 1957.)

Long before HUSSON published his experimental results, I had theoretically assumed that the vocal folds are centrally "steered" or initiated. To this conclusion one comes most logically, if one is familiar with the integrative action of the neuro-muscular system*. HUSSON is no doubt right in his idea of neuro-chronaxy of the vocal folds. One cannot help visualizing the recurrent chronaxy acting like an electric motor on the phonation process. But in all acts of normal phonation subglottal functions must be taken into consideration as much as laryngeal functions. The synthesis of infra-laryngeal, laryngeal and supra-laryngeal functions makes up normal phonation.

It would be a misjudging of the integration and synchronization of psycho-physical functions to say that the vocal mechanism modifies (or even steers) the breathing or, vice versa, that the breathing modifies the voice functions. In the normal individual the balanced interaction of all functions is the standard. In an abnormal situation we get an unbalanced interaction. If a person is suddenly thrown into an unusual emotional upheaval, his voice will be affected and so will be his breathing. The same applies in an abnormal physical situation. If a person has to run two miles without stopping, his breathing will

* It should be remembered that both nerve and muscle are developed from previously undifferentiated neuro-muscular tissue (cf. C. L. Meader and J. H. Muyskens: *Handbook of Biolinguistics*, Toledo, 1950, IV, p.57.)
 **Research on sobbing might prove interesting in this connection. In the spasmodic interaction of diaphragm and larynx in sobbing it is impossible to allot a predominant role to either function.

be affected, and, in trying to speak or sing, his voice will be equally affected. We cannot separate breathing and voice in phonation**. They are both neurogenic and act upon each other, whatever occasional time-lag in synchronization may occur.

Whether we accept HUSSON'S ideas or not, his publications are very stimulating; they invite a repetition of his experiments and further researches in the field of normal and abnormal voice production, e.g. voice studies during puberty, male falsettos, hysterical dysphonics and aphonics and subliminal phonation. It is to be expected that the chronaxic measurement of the recurrent nerve will not remain a study for research only, but may become as much a routine examination in the practice of the Logopedician and Phoniatician as laryngoscopy and laryngostroboscopy. It can serve as a periodic examination to check up on the progress of therapy. It may lead the way e.g. to a new type of specific relaxation therapy, which will take the question of hand dominance into consideration.

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