THE LUMLEIAN LECTURES

ON THE PATHOLOGICAL RELATIONS OF THE VOICE AND SPEECH.

Delivered at the Royal College of Physicians of London.

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LECTURE II.

MR. PRESIDENT AND GENTLEMEN,—In my last lecture I discussed the mechanical and acoustical principles of voice and speech. I pointed out the importance of the chest and its contents as a collective organ for the regulated discharge of air over the vocal cords, and through the articulating cavities of the mouth and nose. I considered the action of the larynx, first, in allowing the escape of silent breath; second, in imparting to the expired air that toneless flutter which is the basis of whispered speech; third, in the production of the musical sounds of the natural voice; and, lastly, in the causation of falsetto notes. And, in conclusion, I discussed the means by which articulate sounds are uttered, the various characters of these sounds, and their mutual relations.

The complexity of the combined processes concerned in phonation, and necessarily, therefore, of those concerned in articulate utterance, is confessedly very great. It is remarkable, even if regarded from the point of view of the number of separate parts whose co-operation is needed for their performance. But from this point of view the respiratory mechanism might seem more complicated than that of the larynx, and the latter more complicated, perhaps, than that by which articulation is effected. But the reverse of this is the fact, and, indeed, but little consideration is required to make it clear that complexity of mechanism and multiplicity of parts are by no means correlative conditions. The variations in the capacity of the chest, on which respiration depends, are due simply to the alternate actions of antagonistic groups of muscles, under the influence of special groups of nerves. The thoracic framework is of complex structure, and the muscles and nerves regulating its movement are very numerous and apparently of highly complicated arrangement; but the entire mechanism is such, and the combined movements of which it is capable are so few and simple, that it would seem an easy problem to collect, so to speak, into the hands of some central power the strings by which the several component parts may be brought into harmonious action. In fact, the respiratory acts, notwithstanding the very delicate gradations of force of which they are susceptible, and their marvellous precision in association with speech and music, constitute one of the simplest examples of co-ordinated movements. The centre for their co-ordination is known to be situated in the medulla oblongata, but (for the purposes of voice and speech) this is clearly the agent of some higher co-ordinating centre, which brings its actions into due relation with those of these associated functions.

Again, the movements of the larynx, in spite of the perfection of its mechanism and the infinite series of graduated sounds to which it may be adjusted, are only very slightly more complicated than those of the thorax. They consist essentially in the opening and closing of the glottis and the stretching and relaxing of the chordæ vocales; the latter actions, on which the variations in the pitch of the voice depend, being determined simply by the regulated contraction of particular groups of muscles. It is clear therefore that, in this case as in the last, apparent complexity becomes, on analysis, comparative simplicity, and that the co-ordination of the laryngeal movements for song and speech, as a motor problem, presents but little difficulty. The centre for the combined movements of the larynx is situated in the medulla; but it is certain that, in the utterance of notes in musical sequence, it is subordinate to some centre of higher attributes.

The muscular actions on which the production of articulate sounds depends are different from both of those groups which have just been discussed; forasmuch as, while they seem to demand less nicety of adjustment in the contraction of the different muscles engaged, they involve a much wider range of motor combinations. That less nicety of muscular action is needed for speech than for phonation or for the regulation of the discharge of air from the lungs, is obvious when we consider how, in one case, the force with which the air has to be expelled has to be adjusted accurately, not only to the different degrees of loudness of the voice, but to the different degrees of obstruction which it

encounters in the larynx and mouth, and how in the other case the smallest variations in the force which the muscles exert on the vocal cords are attended with appreciable differences in the pitch of the resulting notes, while the different articulate sounds, though requiring special arrangements of the organs of speech, admit, within certain limits, of great variety in the details of these arrangements. But it is quite certain that they involve a much greater variety of motor combinations; for while the actions of the thorax are simply those of inspiration and expiration, and those of the larynx, so far as simple phonation is concerned, merely relate to the more or less tension of the vocal cords, every literal sound or element of spoken language is characterised by its special arrangement of the organs of speech. The number of these distinct motor combinations, however, is much less formidable than might at first sight be supposed. It will be remembered that in my last lecture I enumerated fourteen distinct vowel-sounds as existing in English, and half a dozen others which are peculiar to certain other European languages, together with twenty-four distinct consonantal sounds characteristic of our mother-tongue, and about five more of foreign birth. I do not mean to imply that these forty-nine distinct sounds include all possible articulate sounds, or even all that competent authorities recognise among European languages, or that there may not be, as some maintain, articulate sounds in our own language, to which I have given no place in my scheme. But I am sure that the specifically distinct articulate sounds in English, and probably in any other language, are at any rate less than fifty. If, indeed, we eliminate the surd letters, which, so far as their oral manufacture is concerned, are the same as their several sonant varieties, the articulate sounds of our own language become reduced to twenty-nine. But it is certain that the exercise of the art of speech involves much greater difficulties than the mere distinct utterance of twenty-nine or even fifty different sounds. Letters have to be associated in words in innumerable combinations, and the passage from the position of the organs for one letter to that of their position for any other letter has to be accomplished with readiness and precision. The difference, indeed, between the mere capability of uttering so many different letters and the art of readily combining them in speech is very much like the difference between simply striking single notes of a musical instrument and the playing upon it in orderly sequence by the hand of the skilled musician. That the centre for the co-ordination of those movements of the mouth, tongue, and fauces which are concerned in mastication and deglutition is situated, as are those for respiration and the ordinary action of the larynx, in the medulla oblongata, is doubtless true. But at any rate it is probable that the centre for the co-ordination of the movements of articulation is situated in some different and higher region of the encephalon, probably the corpus striatum. At the same time there are good grounds for believing that the supreme centre for spoken language, the centre from which the impulses to express our thoughts in words start, is only indirectly concerned in the co-ordination of the groups of movements which, by their sequential association, determine speech. In other words, it is probable that when the mind wills to express itself in articulate language it does so automatically, not by acting directly from the speech-centre on the nerve-nuclei of the nerves distributed to the organs of speech, but on some other centres, which govern the specific movements for the utterance of articulate sounds and their facile combination.

I have thus far considered, though imperfectly, the processes by which intellectual and musical conceptions and recollections, arising in the superficial grey matter of the brain, become expressed respectively in spoken language and vocal music. It may be interesting, on the other hand, to consider briefly the converse processes by which musical and articulate sounds are carried to the supreme centre for the reception and cognisance of auditory impressions. The modes in which the peripheral ends of the sensory nerves receive impressions, and these impressions are conveyed to the central organs, and there become modified into perceptions, are doubtless in most respects identical. It will be allowable, therefore, to argue from the eye, as the better understood organ, to the ear, as an organ the functions of whose parts have hardly yet been clearly determined. The peripheral ends of the fibres of the optic nerves appear to be severally connected with a special end organ—a rod or cone—which is adapted to receive and transmit impressions made by the rays of light which impinge upon it. We have no reason to think that any one of these end-organs does more, when exposed to its proper stimulus, than receive a single impression of light of a certain quality or intensity, or individually transmits to the sensorium anything beyond that single formless and limitless impression. The knowledge derived through the eye of the size and shape and other visual attributes of objects, depends on the fact that cones of light emanating from minute yet definite points of their surface are brought individually focus by the optical arrangements of the eye upon the ends of the appr

priately situated rods and cones. The retina is a mosaic, of which each element receives a single elementary impression, which, taken alone, has no meaning beyond the fact that there is light of a certain intensity and colour, but which, taken in connection with the simultaneous impressions made on the artificially arranged elements which surround it, carries to the mind, simultaneously, but piecemeal, an accurate representation of the picture formed on the retina. That is, the picture of any object which impresses itself on the mind as a concrete whole, and which is only resolved into its simpler elements by a mental effort, is actually in its passage to the sensorium divided by the retina into numberless bits, and carried inwards in numberless distinct streams, of which, individually, the mind has no separate cognisance, but which collectively produce a compact impression or conception. The transmission of auditory impressions follows, no doubt, the same general law; but in this case geometrical relations become unimportant, while those of time and the qualities of impressions rise into special importance. Acoustic vibrations are waves of alternate contraction and rarefaction. Those which cause musical sounds are rhythmical, pitch being directly proportionate to the rapidity with which the vibrations follow one another. The different qualities of musical sounds depend on the association with fundamental vibrations of rhythmical vibrations of greater rapidity which are in harmonic relation with them, and these associated groups of vibrations differ largely in relative intensity and in number in different cases; so that definite musical notes, with their associated harmonics, present in many cases extreme complexity. Sounds which are not musical obey no such definite rule. They are, however, due to vibrations, which may be solitary, or, if grouped, are irregular in sequence and loudness, or are rhythmical, but follow one another too slowly to blend into a musical sound. Moreover, many sounds, like those of articulate language, which are not really musical, owe their distinctive qualities to groups of resonances or harmonic tones, which the fundamental sounds of the letters waken into being. Now how are these groups of variously compounded vibrations, which even the uneducated ear distinguishes as the product, in one case of the harp, in another of the organ, in another as a literal sound, and in yet another as the voice of a friend or relation, taken up by the essential parts of the ear, how are they carried to the sensorium, and how do they become or produce those sonant perceptions which reveal their several sources? We know that every impulse or wave which falls on the membrana tympani produces a corresponding backward and forward movement in that membrane; that every musical wave, with all the subordinate vibrations that attend it, is accurately represented in its vibrations; and, further, that concurrent acoustical impulses from different sources produce in the tympanic membrane apparently tumultuous oscillations, which are, in fact, the mean of all the motor influences which are acting upon it. We know, also, that the impulses which affect the membrana tympani are imparted through the chain of ossicles and fenestra ovalis to the perilymph, and that these, still blended and apparently confused, sweep across the keys of the cochlea. I do not know that it has yet been ascertained positively how sonorous impulses affect the peripheral terminations of the auditory nerves; but there are, in the anatomical details of the cochlea and in the analogies afforded by other senses, good grounds for believing that every series of simple musical vibrations is caught up, as it were, by its own special portion of the cochlear mechanism, and carried thence by a particular nerve or group of nerves to some part of the central nervous apparatus. According to this view, every compound vibration, every group of compound vibrations, which falls upon the membrana tympani, and is carried thence in a concrete form to the essential part of the ear, becomes analysed there and reduced to its simplest elements, each of which is carried separately along its specific route to the sensorium, there to be combined with its fellows into a single specific perception.

My purpose, in the foregoing remarks, has been to show that in the same way as when we will the performance of some special act, such as the utterance of a word, the concrete impulse, which alone exists in the brain, is transmitted along special fibres to special co-ordinating centres, from these to a wider range of subordinate centres, and thence to the innumerable nerve-fibres which act directly and in due proportion on the various muscles whose function it is to combine in the performance of the particular duty required of them; so, conversely, the objects of our sensations, which are presented in a concrete form to our organs of sense, are analysed with extraordinary minuteness, and conveyed with infinite subdivision by the corresponding sensory fibres to their nuclei of origin, and thence to co-ordinating centres, whence they are transmitted to the sensorium, where again they concrete into single pictures or conceptions, where the untravelling threads of sensory impressions are again woven into the patterns from which they were derived.

I apologise for whatever in the foregoing observations may appear to be trivial, irrelevant, or erroneous. I acknowledge that some are crude,

and that I have been tempted now and then to enter into discussions which I might have done well to avoid. Still, I trust there are some things among them which will be found to have a more or less direct relation to the pathological questions which I am about to consider.

The first of those which I had proposed to myself has already been adverted to by my friend Dr. Stone. I mean the subject of the auscultation of the voice and speech. Bronchophony, pectoriloquy, and egophony are the names which are applied to the different varieties of sound, due to articulate and vocal utterance, which reach the ear of the listener when applied directly or by means of the stethoscope to the chest. The meaning of egophony is well understood. The word signifies a tremulous or bleating high-pitched modification of bronchophony, generally heard in cases of moderate pleuritic effusion over the lower part of the back of the chest. It is, Dr. Reynaud says, "merely a remote bronchophony"; and its peculiarities are due, as Dr. Stone has shown, to the fact that, from some special cause interfering with the uniform transmission of sound (in pleuritic effusion, the presence of a layer of fluid between the lung and chest-walls), the deeper and coarser vibrations of the fundamental tones of the voice are arrested in their transit, while the finer and closer vibrations of their harmonics filter through, and either alone or mainly reach the ear of the auscultator. But what are bronchophony and pectoriloquy? Most practical physicians profess to know; and yet I make bold to say that scarcely anywhere will be found an intelligible, or at any rate accurate, statement of the distinctions which exist between them. That Laennec himself recognised a clear practical difference between them, few, I think, can doubt; yet his descriptions of these conditions are so confused that, after perusing them, one is tempted, with Skoda, to assume that Laennec's pectoriloquy and bronchophony represent one and the same phenomenon. His descriptions are evidently vitiated by two facts: the one, that from an early date he adopted the theory that pectoriloquy is heard only over cavities, and is due to the resonance of the voice in cavities, while bronchophony is developed in the course of tubes; the other, that he had no clear conception of the real distinctions which exist between simple laryngeal vibrations and the articulate utterances of the mouth and parts associated therewith. He had a tendency, therefore, to call all those increased vocal resonances heard over presumed cavities pectoriloquy, and all those heard over solid lung permeated by tubes bronchophony. And his descriptive difference between the two conditions amounts to this: that in pectoriloquy the voice appears to come directly from the chest and to pass wholly through the central tube of the stethoscope, while in bronchophony the voice seems to pass only in part through the stethoscope. It need scarcely be said that his theory is erroneous, and that his descriptions are inaccurate and fanciful. Nevertheless, I incline to think (though agreeing so far with Skoda as to believe that he constantly confounded the two conditions) that, in the typical cases of pectoriloquy to which he originally gave this name, he meant to imply that he actually heard the patient's articulate utterances as well as his laryngeal sounds. But he evidently managed to confound loudness of laryngeal intonation with distinctness of articulation.

Skoda affirms that Laennec's pectoriloquy and bronchophony represent the same phenomenon, and consequently regards the former word as unnecessary; but he divides bronchophony into two varieties, namely, the loud and the weak. The loud variety he subdivides into the loud clear form in which, he says, "the thoracic voice is either as loud as or louder or somewhat weaker than the laryngeal voice, the articulation being at the same distinguishable"; and a loud dull form, "in which the voice produces a concussion in the ear, but the articulation, and consequently the words spoken, are not recognisable". By weak bronchophony, he does not signify "a mere humming, but a clear and audible voice, which produces little or no concussion in the ear, the articulation of the words being generally distinctly heard". But it will be observed that, notwithstanding his criticism of Laennec's views, he incidentally allows the existence of that very distinction which, I repeat, I am inclined to think Laennec intended; namely, that in certain cases of his bronchophony the actual words may be recognised, while in other cases there is only a confused though possibly loud humming. I suspect Laennec would have termed Skoda's loud clear bronchophony pectoriloquy, and would have regarded Skoda's loud dull bronchophony and weak bronchophony both as bronchophony, notwithstanding that in the last case the conveyance of the patient's articulate utterances to the ear constitutes an essential factor of the phenomenon.

Walshe in the main appears to follow Laennec, and divides bronchophony into simple, pectoriloquous, and egophonic. In bronchophony, he says, the sound conveyed to the ear of the listener is ringing and distinct, but unattended with appreciable articulation of the words spoken. Of pectoriloquous bronchophony, he observes that its nature

and significance are still *sub judice*. But he believes, as I do, that Laennec meant by pectoriloquy the specific propagation of articulate sounds to the ear; though I repeat that I do not think that Laennec ever says this expressly. Walshe himself likens it to the voice heard over the larynx, and says that it appears to pass directly through the stethoscope into the ear, and may throw the concha and even neighbouring parts of the skull into more or less strong vibration. He goes on: "Limited generally to a small and accurately defined space, it may have a hollow or ringing character, or not. Though as a general fact loud, this is a wholly unessential property of pectoriloquous bronchophony, depending in great measure on the power of the laryngeal voice. The hollow and ringing character, the insulation of the phenomenon, and its transmission in an articulated form through the stethoscope, may be distinctly marked, even when the speaking voice is almost destroyed. When the physical conditions of its production exist in a patient thus reduced almost to a state of aphonia, it becomes peculiarly characteristic: low muffled whispers pass distinctly into the ear, articulated sometimes with as much, if not more, precision than the laryngeal voice." He also says of laryngophony, to which he compares pectoriloquous bronchophony, that the voice is transmitted imperfectly articulated; and of natural bronchophony, of which he regards morbid bronchophony as simply a variety, that the articulation is very imperfect, showing apparently (as would also appear from his selection of names) that he regards pectoriloquy and bronchophony as mere grades of the same phenomenon.

The last writer to whom I shall refer is Dr. Gee, who, in what is on the whole a very good account of these conditions, observes that pectoriloquy is nothing but a very clear bronchophony; and who evidently, therefore, like Walshe, Skoda, and many others, appears to regard pectoriloquy as being acoustically the same thing as bronchophony, but as bronchophony in its most perfect form, or the sound of the voice as it is heard over the larynx.

I do not venture to say that I have done justice to the accounts which the eminent writers I have quoted have given of pectoriloquy and bronchophony. There is much in what they have written which, taken separately from the context, might seem to show that their views are in the main identical with mine; yet, on the other hand, there is much in them, and especially in their general tenour, which leads me to the opposite conclusion. It seems to me that none of them has, in relation to this matter, fully realised the importance of clearly distinguishing between the sounds made at the rima glottidis and the articulated utterances developed in the mouth, nose, and fauces. But it is clear that these two varieties of sound, though blended with one another and inseparable as they issue from the lips, are essentially distinct from one another in their seats of development and in their relations to the cavity of the chest. Sounds developed at the rima glottidis are, owing to that very circumstance, in a condition not only to be carried outwards with the expiratory blast, but to be carried inwards, and also to be increased by resonance in the trachea and its tributary air-passages; while sounds originating in the mouth, as a rule, are of themselves not only much less loud and musical than laryngeal sounds, but, being developed beyond the larynx, have, in order to reach the ear applied to the neck or chest, to be carried backwards against the breath-stream, and, further, to pass the barrier of a more or less perfectly closed glottis. In fact, it may, I think, be asserted that, for the most part, the laryngeal sounds accompanying speech are alone carried back into the air-passages, and thence to the auscultator's ear. This I regard as bronchophony. There are cases, however, in which, in addition to laryngeal sounds, articulate utterances are transmitted from the chest-walls to the stethoscope. This is pectoriloquy. Bronchophony means the conveyance to the ear of sounds produced at the rima glottidis; pectoriloquy, the similar conveyance of sounds developed above the rima glottidis. The two conditions appear to me distinct, and, though often (possibly in some degree always) united, never to run into one another in the sense of being different grades of the same phenomenon.

Bronchophony may be vocal or whispered. In the former, which alone is usually understood by the term, the phenomenon accompanies the natural tones of the voice, and, other things being equal, varies in loudness, quality, and pitch according to the strength, quality, and pitch of the voice; and also, other things being equal, the deeper and stronger the voice, the more unpleasant will be the vibration which it causes in the ear, and the more distinct the accompanying vocal fremitus. Whispered bronchophony, taken by itself, is little, if anything, more than expiratory tubular breathing, divided into lengths which correspond to the words the patient speaks. What we hear with the stethoscope is the unmusical rush of air through the partly open glottis, on which the patient's whispered words are moulded. The sound does not correspond exactly in duration to the articulate sounds themselves; for after some letters, and especially after the explosive consonants, a short

supplemental rush occurs, which, although almost inaudible in ordinary conversation, is very loud and obvious on auscultation. Whispered bronchophony is unattended with the sensible vibrations which vocal bronchophony inflicts on the ear, and often also on the hand. Since speech always depends on vocal or whispered laryngeal sound, pectoriloquy cannot be present apart from bronchophony; but whenever the articulate utterances of the mouth can be heard through the stethoscope, then pectoriloquy is present. I regard it as a rare phenomenon, and think that generally, when it is supposed to be heard, either the patient's articulate sounds reach the auscultator through the air, and blend unconsciously to him with the sounds conveyed through the stethoscope, or that the inarticulate expiratory gusts of whispered bronchophony are taken for the articulate sounds which the patient utters to dictation, or for those which are expected and given in reply to a leading question. Still I am satisfied that we occasionally meet with it, and mainly in connection with the whispered voice, in the production of which the glottis remains partly open, and the conditions best suited for permitting the sounds of articulation to enter the trachea are present. I do not intend to discuss the significance and importance of pectoriloquy and bronchophony; but I am inclined to believe that pectoriloquy is chiefly heard over cavities.

[To be continued.]

ABSTRACT REPORT OF LECTURES ON THE COMPARATIVE ANATOMY OF MAN.

Delivered at the Royal College of Surgeons of England.

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LECTURE IV.—THE INHABITANTS OF THE ANDAMAN ISLANDS.

ATTENTION was first drawn to the fact that the proportions of the different segments of the limbs might differ in various races by the announcement in 1799 by White of Manchester, since amply confirmed, that the forearm of the Negro is proportionally longer than that of the European. Relative lengths of bones are far more difficult to estimate on the living than on the skeleton; but, unfortunately, skeletons of most races are so rare in collections, that we have at present but few reliable data on the subject. One or two examples are of little or no use, as in all races there are great individual modifications. It is only when a sufficient number can be obtained on which to found a fair average, that any satisfactory law can be established. The numbers in the case of the Andamanese are sufficient, at all events, for very good approximation, though slight modifications in the average may have to be made with further augmentation of materials.

The first ratio or index is that obtained by the comparison of the entire upper and lower limbs with each other: the *intermembral index*, or the length of the humerus and radius added together, as compared with that of the femur and tibia, the latter being taken as 100. This ratio in the nineteen Andaman skeletons is 68.3; in fourteen Europeans, measured in the same manner, 69.2, showing a slight diminution in the length of the arm of the former as compared with the latter. This has also been found by Broca to be the case with African Negroes. The *femoro-humeral index* is the ratio of the humerus to the femur, the latter being taken as 100. In Europeans, according to Professor Flower's and Broca's measurements, this is 72 to 73; in Negroes, according to Broca, 68.9; in the Andamanese, 69.8, showing that in both the latter races the humerus is relatively shorter than the femur. The *femoro-tibial index* is the length of the tibia to the femur, the latter being 100. In Europeans, this is 82; in Negroes, according to Professor Humphry, 84.7; in the Andamanese, almost exactly the same, 84.5. The *humero-radial index* or the length of the radius compared to the humerus is, perhaps, the most important, as being subject to greater variations in different races. In nine Europeans measured by Broca, it is 73.9; in fourteen Europeans in the College Museum, it is exactly the same; in fifteen Negroes measured by Broca, 79.4; in the nineteen Andamanese, 81.0. These figures show that, in all points in which the proportions of the long bones of Negroes differ from those of the white races, the Andamanese agree with the former, the differences being in most cases somewhat exaggerated. The differential characters of the Andamanese as compared with Europeans, in respect to the proportions of the limb-bones, lie mainly,