THE LUMLEIAN LECTURES

ON THE

PATHOLOGICAL RELATIONS OF THE VOICE AND SPEECH.

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LECTURE I.—March 28th.

MR. PRESIDENT AND GENTLEMEN,—When, some months ago, I was offered the honourable post of Lumleian Lecturer, I naturally thought that my many years' experience would supply me with numerous topics of interest, on any one of which I might presume to discourse, even before this distinguished audience; and I accepted it without misgiving. When, a little later, I was required to specify definitely the subject of my course, and had to decide which I would select out of several groups of ideas which had been gradually acquiring distinctness in my mind as suitable for my purpose, I was determined in my choice mainly by the consideration that I had at various times given special study, if not original thought, to several points in connection with the physiology and pathology of voice and speech; and for the second time I committed myself with a light heart. It is only since I have taken it seriously in hand, that all the difficulties of my task have confronted me, and only since I have looked at it from all points of view that I have fully learnt how little I really know of the subject on which I was hoping to throw some gleams of light. I have to confess, therefore, with some disappointment, that my lectures will be less worthy of the College than I had hoped to make them; and to crave indulgence beforehand for their incompleteness and inequality, and especially for the inadequate treatment in them of questions of supreme interest, while what may perhaps be regarded as matters of trivial detail are discussed at inordinate, if not at wearisome, length.

Having relieved my mind by this apology, I shall proceed at once to the subject-matter of my course, merely premising that, on the present occasion, I shall treat mainly of the physiological aspects of the voice and speech, and that the discussion of their pathological relations will be reserved for my second and third lectures.

I need scarcely remind you, gentlemen, that articulate utterance comprises three factors, namely: (1) the emission of breath, due to the regulated action of the lungs and associated respiratory mechanism; (2) the production either of musical notes or of a rustling sound, determined by the passage of the breath through the rima glottidis; and (3) the formation of articulate sounds, which is the special function of the mouth and the other organs anterior to and above the larynx.

The due action of the respiratory apparatus is, of course, of fundamental importance in the production of both laryngeal and oral sounds. Without previous inspiration, expiration would be impossible; without expiration, there could be neither voice nor vocal speech. It is, in fact, the more or less forcible yet graduated expiratory blast which wakes the latent music of the larynx, and which later becomes moulded, so to speak, into articulate language. The larynx is a musical instrument of extraordinary perfection and charm. It is generally considered to be a reed instrument, and is, no doubt, more closely related to this than to any other variety of musical apparatus. But whether it is to be looked upon as a stringed instrument, or as a reed instrument, or as a combination of both, is, after all, a very subordinate matter. What is of real importance to understand is its mode of action; and on this point our knowledge (excepting in one or two particulars) appears to be pretty complete. The essential elements of the vocal apparatus are the chordæ vocales, the cartilaginous framework to which they are attached, and the muscles which regulate the action of these several parts. The vocal cords are two elastic strings, of which each is attached anteriorly to the posterior aspect of the thyroid cartilage, and posteriorly to the processus vocalis of the corresponding arytenoid cartilage, covered above, below, and on the inner side with mucous membrane, and connected externally with the lateral walls of the larynx, and especially with the thyro-arytenoid muscle. Thus they form the inner edges of two elastic laminae, constituting the lateral boundaries of the rima glottidis; which, in virtue of their connection with the arytenoid cartilages, are capable of

being widely separated from one another behind, so as to allow of the unimpeded passage of the breath, or of being brought into absolute contact in their whole length, so as to completely close the laryngeal aperture; and which, in dependence mainly on the vertical rotatory movement of the thyroid on the cricoid cartilage (effected by certain muscles which I need not specify), are capable of being stretched or relaxed at will, so as to minister to the production of all the musical notes included in the compass of the voice.

There are three distinct kinds of voice which most persons, at any rate most men, are capable of uttering—namely, the natural or chest voice, the falsetto or head voice, and the whispered voice. In the production of the natural voice (which comprises, in different individuals, from one to three octaves), the vocal cords lie parallel with one another in their whole length, are in close contiguity or absolute contact, have each exactly the same degree of tension, and are thrown into synchronous vibration by the more or less forcible emission of breath through the linear chink between them. The pitch of the resulting note depends on the rate at which the cords oscillate, and doubtless some of the sound which is heard is due directly to their vibration, together with the consonant vibration of the cartilaginous framework to which they are attached. But it is certain that the great bulk of the sound is referable to the concurrent escape of the imprisoned air in rhythmic puffs through the constricted glottis; and it is especially from this fact that the larynx is regarded as a reed instrument. But, under any circumstances, the different notes which the same voice utters depend upon equivalent variations in the rate of vibration of the same vocal cords; and it is well, therefore, to understand on what these variations depend. The laws which regulate the vibration of strings, to which the vocal cords are usually compared, are few and simple. In the first place, in strings of equal length, thickness, and density, the vibrations executed in a given time are proportional in number to the square roots of the weights or forces by which the strings are stretched; and hence if three such strings be rendered tense by forces represented by one pound, four pounds, and nine pounds respectively, the second string will vibrate twice as rapidly, and the third three times as rapidly, as the first. In the second place, in strings of equal thickness, density, and tension, the rates of vibration are inversely as the lengths of the strings; so that if one such string be twice as long as another, it will oscillate with half its frequency; and if it be three times as long, it will oscillate at only one-third of its rate. Further, other things being equal, the rate of vibration of strings is in inverse proportion to their thickness, and in direct proportion to the square roots of their density. It is evident, then, that if the vocal cords follow the same laws as strings, the number of vibrations which they execute in a given time must, in obedience to the first of these laws, become more and more rapid according as the force employed in stretching them increases; while, on the other hand, since the more powerfully they are acted on by this force the longer they become, it is obvious that, under the operation of the second of the laws I have quoted, there will be a concurrent tendency to a reduction in the rate of vibration due to their elongation. In order to make my meaning clear, I will take an imaginary example. I will assume that the length of the vocal cords in the adult male at the time of their greatest relaxation, and when they are in a condition to sound the gravest note of which his voice is capable, is sixteen *millimètres*; and that they can, by powerful voluntary effort, be stretched to twenty *millimètres*, at which degree of tension they are in a condition to utter the highest note of his natural register. I will assume further that the compass of his voice is three octaves, and that his lowest note is one of one hundred vibrations in the second, and the highest note consequently one of eight hundred vibrations in the same time. Now, if vocal pitch were dependent solely on relative length of cords, the voice should become deeper as the cords become elongated; and assuming still the note emitted by the cords in their shortest condition to be one of one hundred vibrations, that due to them in their state of greatest elongation would, under the circumstances, be one of eighty vibrations only. If, on the other hand, the differences of the uttered notes were determined by tension only, and consequently the same length of cords vibrated in the formation of every one of the notes of his voice; and if, further, the force of tension varied from one at the lower end of the scale to one hundred at the upper end of the scale, the lowest note would still be characterised by one hundred vibrations in the second, but the highest would be one of one thousand vibrations. But if we assume, as is the case, that the tension and elongation of the cords are going on concurrently, and that the highest and lowest notes, and *à fortiori* all intermediate notes, are a resultant of these two conditions, we shall find that the note due to the greatest elongation of the cords, instead of being one of eighty vibrations only, and that the note due to the greatest tension of the cords, instead of being one of one thousand vibrations, become, in accordance with our original hypothesis, blended, so to speak, into

note of eight hundred vibrations; the one thousand vibrations in a second, due to the cord of sixteen *millimètres* becoming, according to the laws regulating the vibration of strings of different length, eight hundred vibrations in a second in a cord of twenty *millimètres*. If tension and length were the only points to be taken into consideration in determining the ratio of musical adjustment of the vocal cords, the problem would be easy of solution; but this simple view of the case is not admissible. It must be recollected that, during the varying degrees of elongation, the cords undergo variations necessarily in thickness, and perhaps in density; and that these constitute more or less important factors in the determination of their rates of vibration. And it must especially be recollected that the so-called vocal cords are not really cords free to vibrate between their extreme points, as true cords are, but that they are adherent along one side; and not only so, but that, starting from their free edges, they gradually increase in thickness and become modified in structure as they pass onwards to blend with the lateral walls of the larynx. There can be no doubt that these latter conditions materially modify the action of the laws of vibration which I have particularly discussed. Yet there can equally be no doubt, from a full consideration of all the facts of the case, that variations of tension of the vocal cords are still in some definite ratio the essential cause of variations in the pitch of the laryngeal sounds. I have spoken hitherto of the notes of the voice as though they were due simply to vibrations of the cords in their whole length. Of course the cords do vibrate at all degrees of tension in their whole length, and thus produce the deepest tones of which, under such conditions, they are capable—in other words, their fundamental notes. But the human voice presents qualities of tone by which it is distinguishable from all other musical instruments, and each voice presents qualities by which it is recognised from all other voices. These, which are referable structurally to differences of form, size, and quality in the vocal cords and surrounding parts, are due acoustically to the fact that the cords, while vibrating in their whole length, divide into harmonic lengths, which vibrate independently; and that hence assemblages of harmonic tones or overtones are superadded to the fundamental note, whatever it may be, and become acoustically blended with it.

The nature of the falsetto voice is not even yet, I believe, thoroughly understood. That it is not produced in precisely the same way as the natural voice is obvious; for not only is there, in passing from the one voice to the other, a manifest effort, but there is a marked difference in the quality of the two voices; and, moreover, the two registers not unfrequently overlap, so that some persons can sing several specific notes indifferently with either voice. There are only two conceivable ways in which the vocal cords can be made to vibrate more rapidly, and consequently to give higher notes than should result from the extreme application of their ordinary tensile force. The one is, that by some mechanical means the cords are prevented from vibrating in their whole length; the other is, that, by some peculiar mechanism or manœuvre, the musical vibrations of the cords are limited to their extreme edges, which, being thinner than the rest, vibrate with proportionally greater rapidity. The former explanation is unsatisfactory, inasmuch as no mechanism has been discovered by which the vibrating length of the cords can be systematically diminished. The latter has the sanction of J. Müller's and Helmholtz's authority. Helmholtz suggests that, by the action of the thyro-arytenoid muscles, the mucous membrane becomes retracted from the lower part of the cords, which thus become attenuated. It is asserted by Garcia that the glottis is partially open during the utterance of the falsetto voice. I am disposed, however, to question the accuracy of this statement; partly because, if this were so, the escape of unvoiced air would affect the purity of the notes evolved; partly because a falsetto note may be sustained for an equal length of time with its corresponding chest notes, which implies that there is no greater waste of air in the one case than in the other; and partly because, in a case which I recently had the opportunity of observing, there was no visible separation of the cords when falsetto notes were being produced. Still, whatever explanation be adopted, there is no doubt that the different notes of the falsetto voice, like those of the natural voice, are determined mainly by differences of longitudinal tension. In the whispered voice, the larynx remains partly open, the breath traversing the rima glottidis with a more or less distinctly audible breezy or sighing sound. The extent to which the glottis is patent varies, no doubt, considerably; but in any case there is such a relation between the force with which the breath is expired and the size of the laryngeal orifice as to cause an audible flutter in the air as it traverses it. The sound is in no degree musical, and is probably wholly independent of any vibration of the vocal cords. On the other hand, it is distinct from the ordinary simple expiratory sound, during which the glottis is widely open, and which is often scarcely audible even by means of the stethoscope.

Articulate sounds, which by their combinations make words and sentences, and which are consequently the acoustic factors of spoken language, are the especial product of the mouth, fauces, and nose, inclusive, of course, as special agents in their production, of the soft palate, tongue, teeth, and lips. They are all framed, so to speak, on breath emitted from the lungs through the glottis, and for the most part of breath which has undergone vocalisation in the larynx, or, at any rate, of breath which has been thrown into audible vibration in its passage through that tube; and their several specific characters are due to the facts that the breath in its transit from the rima glottidis to the external air is arrested in a greater or less degree by obstructions of different kinds, and made to pass through channels of varying forms, and that thus noises and resonances variously combined are superadded to the noises or music of the laryngeal voice.

Articulate sounds are represented by letters, but to a great extent they are very imperfectly thus represented, and the names which are given to them are generally mere names which not infrequently have little or no phonetic relation to them. Our own alphabet, which is confessedly very imperfect, comprises six-and-twenty letters, of which five are regarded as vowels, and the remaining twenty-one consonants. Our so-called vowels, I need hardly remind you, are *a, e, i, o, u*. Of these, *a, e*, and *o* are, according to their names, undoubtedly well defined vowel sounds, but *i* is a diphthong, formed by the sequence of *a* in "far" and *i* in "hit", and *u* is a word compounded of the consonant *y* and of the vowel represented by *oo* in "fool". The names by which we know them, no doubt, are unimportant, provided we have a definite knowledge of what the characters themselves mean; but unfortunately these are employed not only with the greatest laxity, so that there is scarcely any one among them which does not in certain positions have the force of any one of the other four, but the five nominal vowels have to do duty for more than a dozen distinct vowel sounds which are contained in our language. If the five so-called vowels were to be limited in use to the sounds represented by their own names, we should have no signs whereby to indicate the other equally distinct vowel sounds represented by *a* in "fall", *a* in "far", *a* in "shall", *oo* in "fool", *e* in "pet", *i* in "pit", and several others, but above all *u* in "fur", which is the commonest and yet the least generally recognised of all our vowels. I shall not discuss the names of our one-and-twenty consonants further than to show that, while many of them do consist simply of their own proper sounds conjoined to a vowel, some of them, like *c* and *g*, stand for at least two distinct sounds, of which one of each, namely, *c* in "cat", or of *g* in "get", has no relation whatever to the actual consonantal name; others, such as *k* and *w*, are mere names; and others again, of which *y* is an example, have actually appropriated to them the names of other letters. The name of *y* is compounded of the letter *w* and the diphthong *i*. But here again, as in the case of the vowels, the characters are insufficient; for we have several distinct consonants in our language which have no literal representatives. The best known of these are the sounds of *ng* in "tongue", of *th* in "though", of *th* in "thing", of *sh* in "she", and of *z* in "azure". Further, several of our consonants are double letters, and, therefore, simple luxuries; namely, *q*, which is a compound of *k* and *g*, *j* which is a compound of *d* and *z* in "azure", and *x* which is made up of *k* and *s*; while several others, such as *s* and the soft *g* are mere duplicates of *s* and *k*, and of *j* respectively. I have made the above remarks not with the intention of giving an exhaustive criticism of the imperfections of our alphabet, but simply to show that it is so far imperfect that it can scarcely be made a basis for the discussion of literal sounds.

It is easy to arrange letters in groups in accordance with certain striking peculiarities which they present. Thus they may be divided into two classes, according as they are attended with vocal sound, or are uttered independently of such sound—the former class, which is termed sonant or voiced, including such letters as *b, d, hard g, v, z, m, n*, and *l*, together with the vowels; the latter class, termed surd, voiceless, or aspirate, comprising among others *p, t, k, f, s, h*. Or they may be classified according as their pronunciation admits of indefinite prolongation or is momentary only; the latter class comprising the explosive consonants *b, d, hard g, p, t, k*, together with perhaps some of the so-called short vowels; the former embracing all the remaining letters which are sometimes called continuants. Or again they may be grouped into those in the pronunciation of which the septum between nose and mouth remains open, and which have consequently a nasal quality, and those in which this quality is absent. To the former class belong the letters *m, n*, and *ng* in "tongue", as also the French nasal vowels. But it has always been customary among grammarians to make the primary division of letters into vowels and consonants; the former, according to the general statement, admitting of perfect independent utterance, the latter needing for the full development of their peculiar sounds to be associated with some vowel. That there is a real and

fundamental difference between vowels and consonants is, I think, quite certain. But the distinction which has just been quoted is obviously neither accurate nor sufficient; for the great majority of consonantal sounds may be produced perfectly without vowel aid; while some, in certain combinations, habitually play the part of vowels, as evidenced by such words as "a-ble", "little", "maiden", "spoken", "seasons", "pickled"—in each of which the last syllable, though written with a vowel, is pronounced without one, the *l* or *n* serving the purpose of a vowel. Further, the contact, if not the actual blending, at certain points between vowels and consonants is even more marked in the acknowledged relationship which exists between the long *e* and the consonant *y*, and between the vowel represented by *oo* in "fool" and *w*. The essential differences between them appears to be—first, that in the pronunciation of the vowels there is a much less interrupted passage of air through the oral cavity and aperture than there is in the pronunciation of consonants; and perhaps, secondly, that whereas the fundamental sounds of the vowels are produced at the rima glottidis either as a whisper or in the ordinary voice, the fundamental or essential sounds of the consonants are fully developed within the mouth, at the point at which an impediment is offered to the escape of breath by the lips, tongue, or teeth.

It was first suggested by Wheatstone, and has since been shown by Helmholtz, that the vowel-sounds differ from one another in the fact that the note emitted by the vocal cords in the process of the utterance (assuming this note to be the same for each) is modified in its passage through the mouth by the superaddition to it of groups of harmonic tones which are determined by the form and size which the different parts of the oral cavity assume, and are specific of each vowel; in other words, that the vowels are merely *timbres* or qualities due to oral resonance of the inarticulate laryngeal sounds. He proved this both by analysis and by synthesis for several of the most characteristic vowels. Thus, by the use of a series of properly adjusted tuning-forks successively brought into the vicinity of the oral aperture at the time when the organs of articulation were pronouncing, or were in the position to pronounce, various vowel-sounds, and by observing in each case which of these had its notes reinforced by resonance, he was enabled to detect the chief oral resonances characteristic of the particular vowels under investigation; and subsequently, under the guidance of the knowledge thus obtained, he was able, by sounding simultaneously selected groups of tuning-forks in harmonic relation with one another, to reproduce combinations of fundamental tones and harmonics which were severally recognisable as specific vowels. The above theory of the causes of the vowel-sounds is confirmed by their mode of production by Willis and others. Willis evoked them by means of an artificial larynx which yielded the fundamental note, and by resonant tubes of variable length placed in front of or above this larynx, which modified the quality of the fundamental note, and thus converted it, according to the special conditions of the experiment, into one or other of the five principal vowel-sounds. It may be admitted, then, that the recognised vowel-sounds are the product of vocalised or whispered breath and of super-added oral resonances; the specific characteristics of which are determined by the differences of capacity and form which the oral cavity and aperture assume for each. And since such differences are theoretically innumerable, it might even be assumed, with Max Müller, that the possible vowel-sounds are infinite in number. But, on the other hand, the fact that the recognised vowel-sounds of most, if not of all, languages are, with occasional characteristic and easily recognisable exceptions, identical, or nearly so, renders it not improbable that most of the vowel-sounds which the ear could readily distinguish from one another have already been utilised. The vowels of the English language are, I believe, fourteen in number: namely (to give them in selected words, so that they may admit of ready comparison), *a* in "past", *a* in "pat", *e* in "pet", *a* in "hate", *i* in "hit", *e* in "peat", *au* in "pauper", *o* in "pot", *o* in "potent", *u* in "put", *oo* in "boot", *u* in "fur", and *u* in "putty". And to these may be added the French *u* in "tu", which is also a German vowel, as in "Künste" and an English provincialism; the French *eu* in "jeune", and the equivalent German *oe* in "Goethe"; and the French nasal vowels, of which there are four, as exemplified in the words "done", "dans", "un", and "fin". Kempelen, many years ago, gave a statement of the relative sizes of the oral opening and canal during the utterance of vowels pronounced in the German fashion. This is so well known, that I need not recite it. This determination, so far as it goes, is probably not very far from the truth, but it only relates to five out of about twenty vowels. Further, as regards the oral orifice, size is not the only element to be considered; and, as regards the oral canal, it is important to consider not merely size, but the peculiarities of position of the tongue, and the consequent peculiarities in the form of the canal. I shall not weary you by discussing this matter in minute detail, and shall simply draw

attention to some points in connection with it which appear important or interesting. It seems to me that, excluding for the present the French nasal modifications, the sixteen vowels which I have alluded to may be arranged in three tolerably distinct yet parallel series. In the first series, I should include in successive order *a* in "past", *a* in "pat", *e* in "pet", *a* in "hate", *i* in "hit", and *e* in "peat"; in the second series, *au* in "pauper", *o* in "pot", *o* in "potent", *u* in "put", *oo* in "boot", and *u* in "tu"; and in the third series, which I should place intermediately between the other two, *u* in "putty", *u* or *ur* in "fur", and *eu* in "jeune". The vowels of the first series seem to me to be related to one another, not only in sound, but in the fact that, in their utterance, the lips are separated from one another in their whole extent; and the differences between them appear to depend partly on the fact that, with slight modifications, which on the whole are of no great importance, the lips become approximated more and more closely, and the aperture between them more and more elongated, as we enunciate them in their order from the first to the last, but mainly on the fact that the tongue, which is much retracted in the utterance of *a* in "past" becomes progressively more and more elevated and projected forward in the utterance of the others, until, in the pronunciation of *e*, the dorsum of the organ leaves only a narrow channel between it and the palate, and the tip approaches within half an inch of the lower incisor teeth. The vowels of the second series also seem to me to be mutually related, both in sound and in the circumstance that, in their enunciation, the oral aperture assumes a rounded form. And the distinctive differences between them are determined mainly by the fact, that the oral orifice becomes more and more contracted in all its dimensions in passing from the pronunciation of the first to that of the last; but importantly also by the fact that in this, as in the former case, the tongue, which is depressed and retracted during the utterance of the first, progressively rises towards the palate and approaches the anterior teeth as the remainder of the series are in turn pronounced. In the articulation of the vowels of the third series, the labial aperture is not rounded as in the last case, or opened in its whole width as in the first case, but the lips are separated with little or no appreciable effort, and in their central portions only, as they often are in quiet respiration, or when a person is about to speak. Indeed, in the pronunciation of *ur*, which is probably effected with the least effort of all the vowels, the position of the tongue, which lies somewhat rounded on the floor of the mouth, with its tip removed about an inch from the front teeth, and the form which the oral aperture assumes, are precisely those which attend ordinary quiet respiration. This vowel I should place in the middle of its series, the *u* in "putty" occupying the first place, with a somewhat wider opening of the mouth and greater depression of the tongue; and the *eu* in "jeune" occupying the last, with a much contracted oral orifice and an elongation and projection of the tongue forwards, nearly into the position which it occupies in the utterance of *e* in "peat".

It may possibly be objected that the sixteen vowels which I have enumerated are not all distinct vowels. It has been maintained—and I confess that I formerly held this opinion in regard to some of them—that several of the so-called short vowels are merely unaccentuated or rapid utterances of others that have been more generally recognised. Thus *a* in "fat" has been regarded as a shortened *a* in "past"; *e* in "pet" as a shortened *e* in "fate"; *i* in "pit" as a shortened *e* in "peat"; *o* in "pot" as a shortened *au* in "pauper"; *u* in "put" as a shortened *oo* in "boot"; and *u* in "putty" as a shortened *ur* in "fur". And it may be admitted that, while the so-called long vowels can be readily pronounced independently, the so-called short vowels are best distinguished from one another when their pronunciation is terminated by a consonant. There is no doubt, however, I think, that they can be pronounced independently, and prolonged in their pronunciation, without merging into any other vowel; but their characteristic sounds can certainly not be so readily recognised, under those circumstances, as those of the stronger vowels. I may add that the vowel *ur* is probably the most common of all our vowels, and is certainly one of the most characteristic.

The French nasal vowels are characterised essentially by the fact that, while for all the other vowels the soft palate closes the aperture of communication between the nose and the mouth, in the pronunciation of these that opening remains patent, so that the emitted breath escapes partly through the nose and partly through the mouth. The four nasal vowels are apparently modifications of *a* in "past" (*dans*), *o* in "pot" (*done*), *a* in "pat" (*fin*), and *ur* in "fur", or *u* in "putty" (*un*).

[To be concluded.]

THE quarantine imposed on arrivals in Marseilles from the Black Sea, the Sea of Azoff, and the Levant has been reduced from seven to three days.