The physiological & pathological relations of the voice and speech / by John Syer Bristowe.

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PHYSIOLOGICAL & PATHOLOGICAL RELATIONS

OF THE

VOICE AND SPEECH

BY

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Being the Lumleian Lectures, delivered before the Royal College of Physicians, in March and April, 1879.

LONDON:
DAVID BOGUE,
PUBLISHER TO THE ROYAL COLLEGE OF SURGEONS,
3 ST. MARTIN'S PLACE, TRAFALGAR SQUARE.
1880.

LONDON
PRINTED BY STRANGEWAYS AND SONS
Tower Street, Upper St. Martin's Lane.

TO

JAMES RISDON BENNETT, M.D., F.R.S.

PRESIDENT OF THE ROYAL COLLEGE OF PHYSICIANS,

This Volume is Inscribed,

IN

TOKEN OF THE ESTEEM AND AFFECTION

ENTERTAINED FOR HIM

BY

HIS OLD PUPIL.

PREFACE.

THE following lectures were not intended to be exhaustive of the subjects discussed in them. But certain matters in relation to the voice and speech were selected for consideration, to which the Author had from time to time given special attention, and upon which he had contributed papers to the St. Thomas's Hospital Reports, and to the *Transactions* of the Clinical Society, and had delivered himself to some extent in his work on *The Theory and Practice of Medicine.* The articles referred to, however, have only been partly reproduced, and the opinions originally entertained have been carefully reconsidered, and in many instances considerably modified. The notes to the first lecture are quoted almost *verbatim* from a paper of the Author's *On the Mechanism of Articulate Speech*, published ten years ago.

Among the authorities whose works were largely consulted for the purposes of that paper, and to whom

he is still chiefly indebted for information relating to articulate sounds, must be especially enumerated :—

Helmholtz, *Die Lehre von den Ton-empfindungen als Physiologische Grundlage für die Theorie der Musik.* French translation, 1868, corrected up to that date by its Author ; J. Müller, M.D., *Elements of Physiology,* translated by Baly ; Professor Max Müller, *Science of Language,* 1864 ; and Mr. A. J. Ellis, various publications on Phonetics.

11 Old Burlington Street,
February, 1880.

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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 venture to discourse, even before this distinguished audience; and I accepted it without misgiving. When, a little later, I was required to specify definitively the subject of my course, and had therefore 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 connexion with the phy-

siology and pathology of the 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 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.

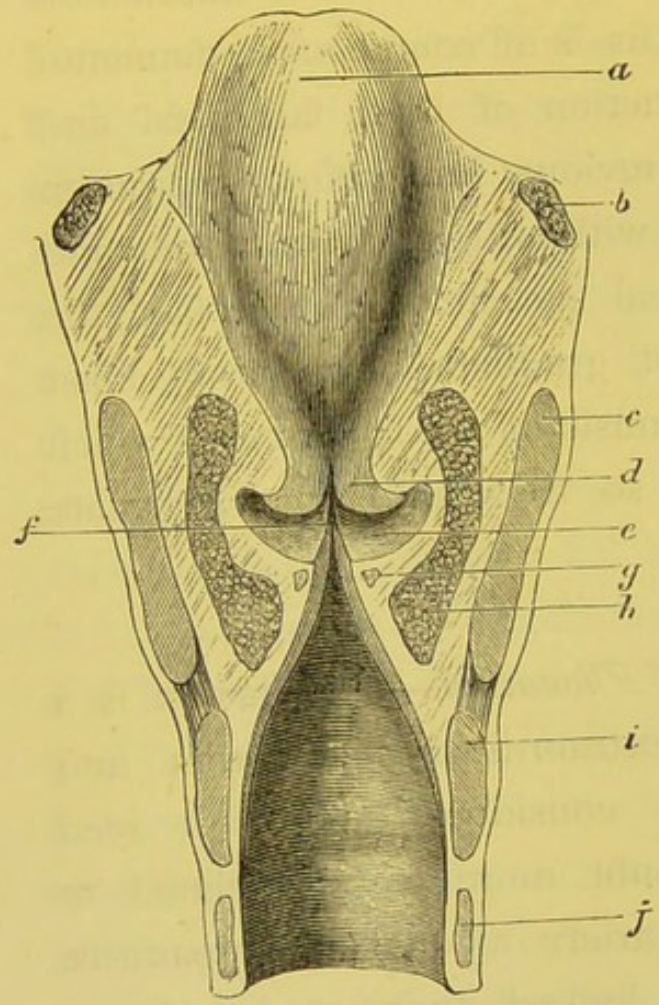
I need scarcely remind you, gentlemen, that articulate utterance comprises three factors: namely, 1st, The emission of breath, due to the regulated action of the lungs and associated respiratory mechanism; 2nd, The production either of musical notes or of a rustling sound, determined by the passage of the breath through

the rima glottidis; and 3rd, The formation of articulate sounds, which is the special function of the mouth and other organs anterior to and above the larynx.

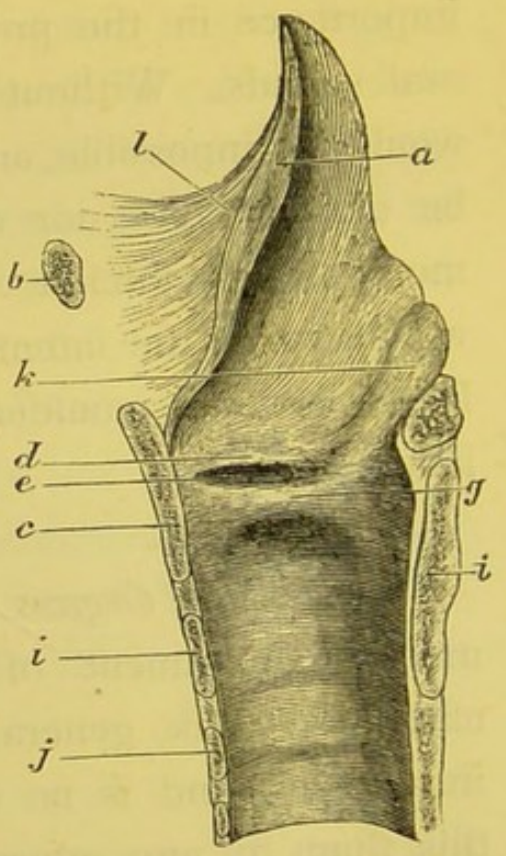
1. *Action of Organs of Respiration.*—The due action of the respiratory apparatus is of course of fundamental importance in the production of both laryngeal and oral sounds. Without previous inspiration expiration would be impossible, and without expiration there could be neither voice nor vocal speech. 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.

2. *Action of Organs of Phonation.*—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 actions 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, is covered above, below, and on the



VERTICAL TRANSVERSE SECTION OF LARYNX.

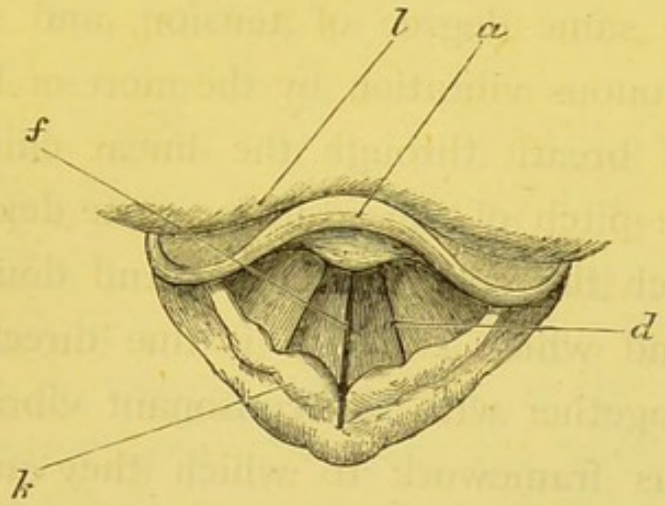


VERTICAL ANTERO-POSTERIOR SECTION OF LARYNX.

a Epiglottis.
b Hyoid bone.
c Thyroid cartilage.
d False vocal cord.
e Sinus.
f Rima glottidis.
g Vocal cord.
h Thyro-arytenoid muscle.
i Cricoid cartilage.
j First ring of trachea.
k Arytenoid cartilage.
l Base of tongue.

inner side with mucous membrane, and is 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 laminæ, constituting

the lateral boundaries of the rima glottidis; which in virtue of their connexion 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



UPPER ORIFICE OF LARYNX SEEN FROM ABOVE, DURING UTTERANCE OF A HIGH NOTE.

a Epiglottis.
d False cord.
f Glottis with vocal cords on either side.
k Summits of arytenoid cartilage.
l Base of tougue.

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.

(*a*) *The natural or chest 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 rhythmical puffs through the constricted glottis; and it is especially from this fact that the larynx is regarded as a reed instrument. Under any circumstances, the different notes which the same voice utters depend upon corresponding variations in the rate of vibration of the 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 thrice 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; if it be three times as long, it will oscillate at only one-third its rate. Further, other things being equal, the rates of vibration of strings are 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 vibrations which they execute in a given time must (in obedience to the first of these laws) become more and more numerous 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 quoted above, 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 16mm., and that they can by powerful voluntary

effort be stretched to 20mm., 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 100 vibrations in the second, and his highest note consequently one of 800 vibrations in the same time. Now, if vocal pitch were dependent solely on relative length of cords, the voice should become deeper as the chords became elongated; and, assuming that the note emitted by the cords in their shortest condition to be one of 100 vibrations, that due to them in their state of greatest elongation would, under the circumstances, be one of 80 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, namely 16mm., vibrated in the production of every one of the notes of his voice; and if, further, the force of tension varied from 1 at the lower end of the scale to 100 at the upper end of the scale; the lowest note would still be characterised by 100 vibrations in the second, but the highest would be one of 1000 vibrations. But if we assume, as is in fact the case, that tension and elongation of the cords are going on concurrently, and that the highest and lowest notes, and *a fortiori* all intermediate notes, are resultants of these two conditions, we shall find that the note due to the greatest elongation of the cords, instead of being one of 80 vibrations only, and that the note due to the greatest tension of the cords, instead of being one of 1000 vibrations, become, in accordance with our

original hypothesis, blended, so to speak, into a note of 800 vibrations—the 1000 vibrations in a second, due to the cord of 16mm., becoming, according to the laws regulating the vibration of strings of different lengths, 800 vibrations in the second in the cord of 20mm.

If tension and length were the only points to be taken into consideration in determining the ratio of the musical adjustments of the vocal cords, the problem would be easy of solution. But this simple view of the case is not admissible; for it must be recollected that, during their varying degrees of elongation, the cords undergo variations, necessarily in thickness, and perhaps even 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 outwards 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 due 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 hitherto spoken of the notes of the voice, as

though they were due simply to vibration 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 individual voices present qualities by which they are 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 thus assemblages of harmonic tones or overtones are superadded to the fundamental note, whatever it may be, and become acoustically blended with it.

(*b.*) *The falsetto voice.*—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.

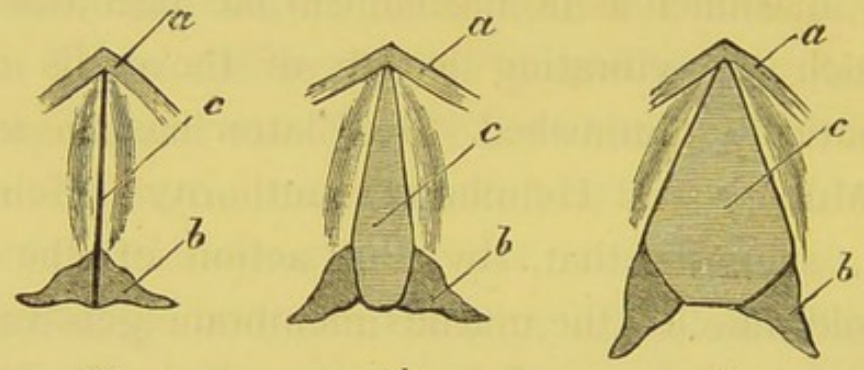
There are only two conceivable ways in which the vocal cords can be made to vibrate more rapidly, and, consequently, to evolve higher notes, than should result

from the extreme application of the ordinary tensile force. The one is that by some mechanical means the cords may be prevented from vibrating in their whole length; the other is that by some peculiar mechanism or manœuvre the musical vibrations of the cords may be limited to their extreme edges, which, being thinner than the rest, would vibrate with proportionately greater rapidity. The former of these explanations 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, indeed, suggests that, by the action of the thyro-arytenoid muscles, the mucous membrane gets retracted from the lower part of the cords, which thus become attenuated.

It is asserted by Garcia that the glottis is partly 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 unvocalised 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-note, 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 had recently 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.

(*c.*) *The whispered voice.*—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



4*a*. 4*b*. 4*c*.

DIAGRAMS OF GLOTTIS:

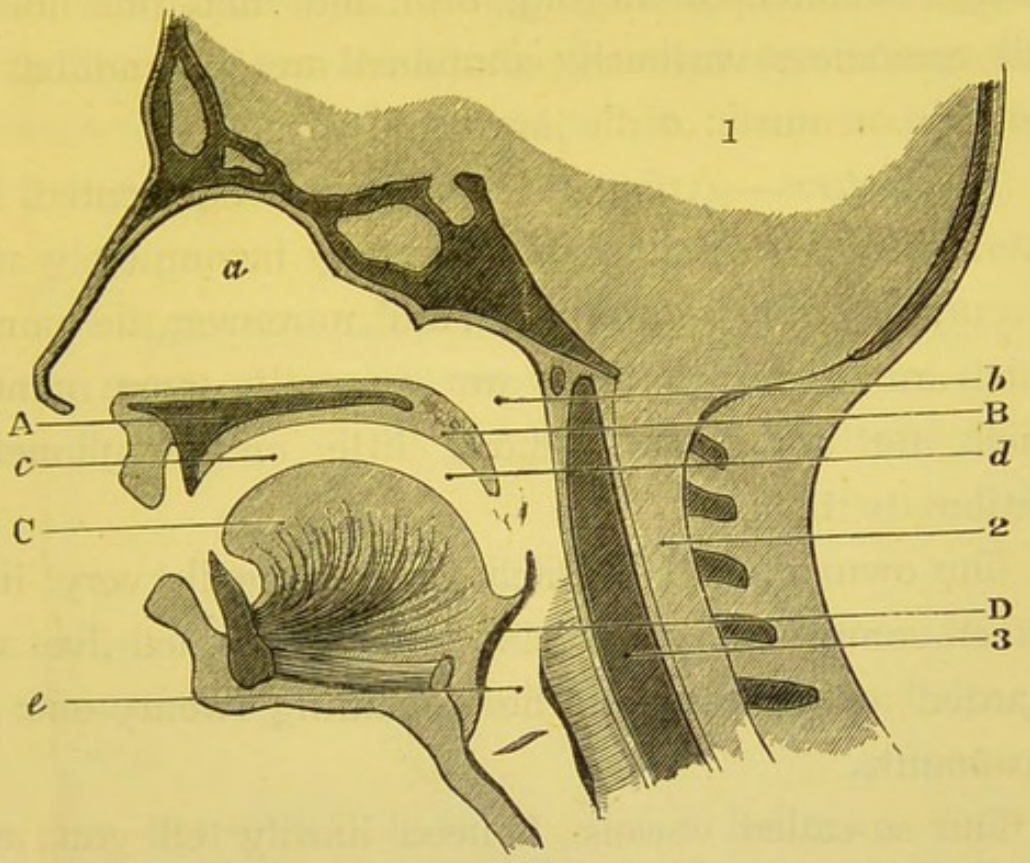
4*a* During utterance of a musical note. 4*b* In quiet inspiration or whispering. 4*c* During deep inspiration.

a Thyroid cartilage.
b Arytenoid cartilage.
c Glottis, with vocal cords and faint indication of false vocal cords on either side.

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.

3. *Action of organs of articulation.* — 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,



DIAGRAMMATIC ANTERO-POSTERIOR VERTICAL SECTION OF FACE, NECK, AND SKULL, SHOWING IN ITS UNSHADED PARTS THE CAVITIES OR CANALS CONCERNED IN PHONATION AND SPEECH.

A Hard palate.
B Soft palate and uvula.
C Tongue.
D Epiglottis.
a Cavity of nose.
b Pharynx.
c Cavity of mouth.
d Fauces.
e Larynx.
1 Cavity of skull.
2 Spinal canal.
3 Bodies of vertebræ.

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 on breath which has undergone vocalisation in the larynx, or at any rate on breath which has been thrown into audible vibra-

tions 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 checked in a greater or less degree by obstructions of different kinds, and made to pass through channels of varying form, and that thus noises and resonances variously combined are superadded to the noise or music of the laryngeal voice.

(*a.*) *Letters.*—Articulate sounds are represented by letters, but to a great extent are very incompletely and inaccurately thus represented; and, moreover, the names which are given to them are generally mere names, which not unfrequently have little or no phonetic relation to them.

Our own alphabet, which is confessedly very imperfect, comprises twenty-six letters; of which five are regarded as vowels, and the remaining twenty-one as consonants.

Our so-called vowels, I need hardly tell you, are *a*, *e*, *i*, *o*, *u*. Of these, according to their names, *a*, *e*, and *o*, are 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 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.

The following table comprises in its first column all, or, at any rate, all the more obvious, simple vowel-sounds of our language; and shows in the subsequent columns by what various single vowel-signs they may severally be indicated.

TABLE I.

THE VOWEL SOUNDS.	DIFFERENT VOWEL-SOUNDS WHICH THE SEVERAL VOWEL-CHARACTERS MAY REPRESENT.					
	a	e	i	o	u	y
far	*path*	*Der(by)*				
fat	*hath*					
fell	*man(y)*	*met*				
fail	*bathe*					
fill	...	*Eng(land)*	*slim*	*wo(men)*	...	*crypt*
feel	...	*mete*	*(ob)lique*	...	...	...
fur(rier)	*(ide)a*	*(mil)ler*	*(O)phir*	*dove*	*hut*	*(mar)tyr*
fur	...	*herb*	*first*	*world*	*cur*	*myrrh*
fol(ly)	*what*	...	...	*not*		
fall	*wrath*	...	...	*snort*		
foal	...	...	...	*note*		
full	...	...	...	*wolf*	*put*	
fool	...	...	...	*to*	*rule*	

Most of the vowel-sounds included in the table are also frequently indicated by conventional arrangements of letters.

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 *ur* (in *fur*).

I shall not discuss the names of our one-and-twenty consonants further than to draw attention to the facts, that while many of them do consist simply of their own proper sounds conjoined to a vowel; others, such as *c* and *g*, stand severally for at least two distinct sounds, of which one, like the sound of *c* (in *cat*), or *g* (in *get*), has no relation whatever to the actual consonantal name; others, such as *h* and *w*, are mere names; and others, again, of which *y* is an example, actually have appropriated to them names which should belong to 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 both insufficient and superfluous. For, in the first place, we have several distinct consonants in our language which have no specific literal representatives; the best-known of which are the sounds of *ng* (in *tongue*), of *th* (in *the*), of *th* (in *thing*), of *sh* (in *she*), and of *z* (in *azure*). And, in the second place, several of our consonants are double letters, and therefore simple luxuries: namely, *q*, which in its name is a compound of the essential sounds of *k*, *y*, and the vowel-sound represented by *oo*, but in its pronunciation in words is a compound of *k* and *w*; *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 *c* and the soft *g*, are mere duplicates of *s* and *k*, and of *j*, respectively.

Of the consonants, some (excepting when, as occasionally happens, they are silent, or when in certain combinations the combined letters are the sign of some conventional sound distinct from each) never stand for any other articulate sound than that single sound which each specially represents. These consonants are, *b*, *k*, *l*, *m*, *p*, *r*, *v*, *w*, and *y*. But most of the remainder do duty, according to circumstances, for one or other of two or more elementary sounds, or for two such sounds in combination.

The following table, from which the letters above enumerated, together with the double letters, *j*, *q*, and *x*, have been excluded, shows at a glance the several values of the consonants here referred to.

TABLE II.

ASSUMED PRIMARY SOUND OF LETTER.	SIMPLE SECONDARY SOUNDS OF LETTERS IN FIRST COLUMN.								DOUBLE DO. DO.	
	k	s	t	v	z	sh	zh	ng	tsh	dzh
c ... *ace*	*cat*	...	...	...	(*dis*)*cern*	(*o*)*cean*	...	...	...	...
d ... *do*	...	...	(*cough*)'*d*	...	...	...	...	...	...	...
f ... *fee*	...	...	...	*of*	...	...	...	...	...	...
g ... *get*	...	...	...	...	...	...	...	...	...	*gem*
n ... *no*	...	...	...	...	...	...	...	*sink*	...	...
s ... *sat*	...	...	...	...	*as*	*A*)*sia*	(*vi*)*sion*	...	...	...
t ... *to*	...	...	...	...	...	*a*)*tient*	...	...	(*ques*)*tion*	...
z ... *maze*	...	(*chint*)*z*	...	...	...	...	(*a*)*zure*	...	...	...

As regards the double letters, it may here be pointed out, that *q*, as in the word *quit*, for the most part implies the combined sounds of *k* and *w*, but that occasionally it has the value of *k* simply, as in *oblique*; and that *x* stands not only for *ks*, as in *axiom*, but sometimes represents *gz*, as in *exist*, sometimes *ksh*, as in *anxious*, and sometimes *z*, as in *xerxes*.

Sh, *zh*, and *ng*, as interpreted in the table by the pronunciation of the words below them, represent, as before pointed out, simple definite sounds. But *zh*, in writing, is always indicated by *s* or *z*; *sh* is represented not only by *c*, *s*, or *t*, but often by the combination *sh*, as in *ash* and *shine*, sometimes by *ch*, as in *chaise*, and sometimes by *sc*, as in *conscious*; *ng* is indicated, either by *n* before *k*, or hard *g*, or by the combination *ng*, as in *tongue* and *sting*.

It is obvious, from the above analysis of our alphabet, that we have a small number of vowel-signs, of which each may stand for several distinct vowel-sounds, and of which several may represent the same sound; that among our consonantal signs several stand for two or more consonantal sounds, while several are superfluous; and that we have consonantal sounds which can only be represented conventionally by combinations of letters, or by letters to the proper sound of which they have no kind of relation.

(*b.*) *Classification of letters.*—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*, and *h*. Or they may be classified according as their pronunciation admits of indefinite prolongation, or is of momentary duration only; the latter class comprising the explosive consonants *b*, *d*, hard *g*, *p*, *t*, and *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 the 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.

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 com-

binations, habitually play the part of vowels, as shown by the words a-*ble*, lit-*tle*, mai-*den*, spo-*ken*, sea-*sons*, pick-*led*, 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. And, further, the contact, if not the actual blending, at certain points between vowels and consonants, is even more markedly shown 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 appear 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 (for on this point I am not quite clear), that whereas the fundamental sounds of the vowels are produced at the rima glottidis, either in a whisper or in the ordinary voice, the fundamental or essential sounds of the consonants are developed within the mouth, at the point at which an impediment is offered to the escape of breath by the lips, tongue, or teeth.

(*c.*) *Vowels.*—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 their 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 for 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 their 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

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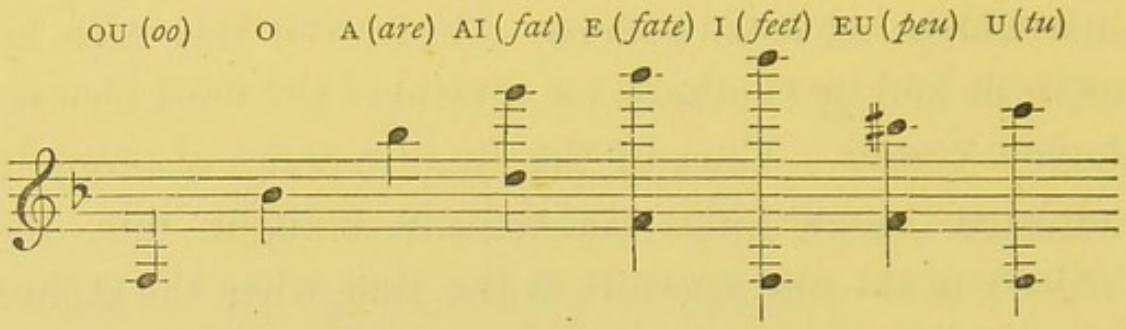
* Helmholtz discovered that the resonance of the mouth for the vowel OU (*oo* in *fool*) is fa_1, that for O (*o* in *note*) $si\flat_2$, that for A (*a* in *are*) $si\flat_3$ or re_4, that for AI (? *a* in *fat*) re_3, that for E (*a* in *fate*) fa_2, that for I (*e* in *feel*) fa_1, that for EU (*eu* in *jeu*) fa_2, and that for U (*u* in *tu*) fa_1. And he discovered, partly by the aid of tuning-forks, but partly by his ear, that in those vowels during the utterance of which the dorsum of the tongue approaches the roof of the mouth so as incompletely to divide the oral cavity into an anterior and a posterior chamber, the posterior chamber acted as an additional resounding cavity, resounding in every case a special but (as might be supposed) a higher note. The vowels here referred to are those just represented by the signs AI, E, I, EU, and U; the resonance of the posterior part of the mouth for AI is represented by sol_4, that for E by $si\flat_4$, that for I by re_5, that for EU by $ut\sharp_4$, and that for U by sol_4.

The following notes represent the resonances of the mouth corresponding to the different vowels:

the knowledge thus obtained, he was able, by simultaneously sounding selected groups of tuning-forks in



In the whispered voice, when the basis of the vowel-sounds is a mere unmusical breezy whiff derived from the passage of the breath through the narrowed, but not completely closed, orifice of the glottis, the differences between the vowel-sounds depend doubtless upon the fact that each sound becomes modified by resonance in its transit through the mouth, in exact accordance with the statement which has just been made; the vowels, of which the notes are above given, acquire then their distinctive characters, in virtue of the characteristic resonances which are there shown to belong to them. But when the vowels are uttered with laryngeal intonation, or, in other words, are produced by the modification of a musical note, it is obvious that the above scheme cannot represent the groups of harmonic sounds which then characterise each vowel; because, assuming that, as in ordinary conversation, they are all uttered on the same fundamental note, the sound of each must comprise, in the first place, the sound of that fundamental note, and in the second place, no other sounds than those which are in harmonical relation with it, that is to say, sounds which are produced by two, three, four, five, or more times as many vibrations in a given time as the fundamental. It may be added, however, that whenever the fundamental tone includes among its higher harmonics one which is identical with, or near to that particular note which the cavity of the mouth is at the moment regulated to resound, this becomes singled out, as it were, and evolved with great force.

By using a series of glass vessels regulated to resound each a particular note, Helmholtz was enabled to analyse, to some extent,

harmonic relation with one another, to reproduce combinations of fundamental tones and harmonics, which were severally recognisable as specific vowels.

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the voice of a singer when uttering the various vowel-sounds, and thus to detect some of the harmonics accompanying the fundamental note, and the fact of the specially loud evolution of those harmonics which were in accordance with the resounding properties of the oral cavity. Again, by having a series of tuning-forks so related to one another that the numbers of their vibrations executed in a given time were in the proportion, 1, 2, 3, 4, 5, and so on, or, in other words, produced respectively the fundamental tone and its immediately succeeding series of harmonics, he was enabled, by sounding simultaneously, by means of electricity, groups of them selected more or less in accordance with the results of his analysis of the vocalised vowels, to imitate with considerable success several of the vowel-sounds. In the first instance he experimentalised by means of eight tuning-forks, yielding respectively the notes $si\flat$, $si\flat_1$, fa_2, $si\flat_2$, re_3, fa_3, $la\flat_3$, $si\flat_3$. And he found, that by sounding the first alone, or still better, by sounding the first strongly and the second and third feebly, he obtained the sound of OU ; that by sounding the first somewhat less strongly than in the last case, the fourth very strongly, and the second, third, and fifth feebly, he obtained the sound of O ; and that by sounding the last four powerfully, the first four feebly, he got a good A. With regard to the other vowel-sounds, however, which are characterised by more acute tones, his success with the above apparatus was naturally not very great ; he produced, however, a somewhat imperfect AI, when he sounded loudly the fourth and fifth forks, and sounded feebly the three graver ones, and he succeeded also in evolving a still less perfect E. He subsequently employed a similar series of forks, ranging from $si\flat_1$, to $si\flat_4$; and with these produced OU by sounding the first fork alone ; O, by sounding the first fork moderately, the second strongly, and the third more feebly ; A, by adding to the sound of the first fork, those of the second and third feebly, and those of the fourth and fifth strongly ; AI, by adding to the sound of the first, those of the second and

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 superadded oral resonances, the specific characters 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 in-

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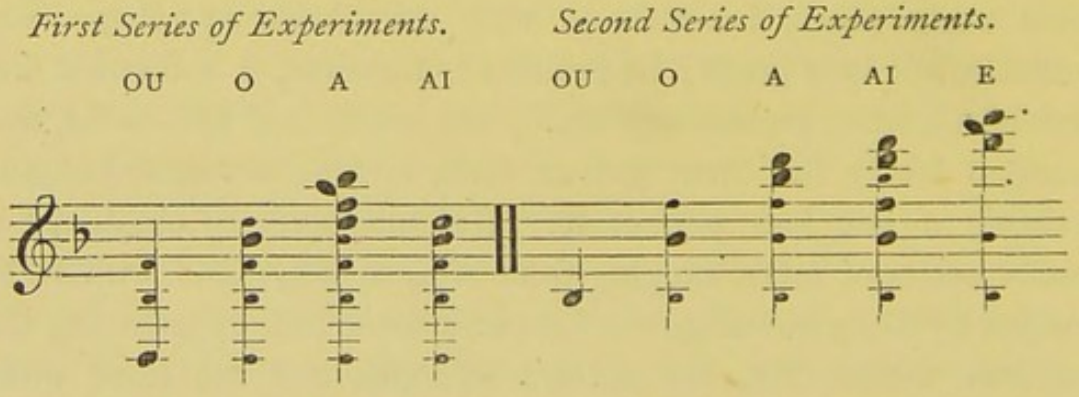
third strongly, that of the fourth weakly, and those of the fifth and sixth very strongly ; and E, by sounding the first and second pretty strongly, and the sixth, seventh, and eighth, very strongly.

The following notes, in which relative intensity is indicated by difference of size in the dots, show at a glance the synthesis of the vowel-sounds, according to the above experiments.



In the foregoing note, I have represented the vowel-sounds as they are given in the French translation of Helmholtz's work ; but I have given them in capital letters so as to avoid confusion.

numerable, 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, thirteen 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 *pate*), *i* (in *pit*), *e* (in *peat*), *au* (in *pauper*), *o* (in *pot*), *o* (in *potent*), *u* (in *put*), *oo* (in *boot*), *u* (in *pur*), and *u* (in *putty*). And to these may be added the French *u* (in *tu*), which is also a German vowel, as (in *Kühnste*), 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 *donc*, *dans*, *un* and *fin*.*

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* Kempelen, many years ago, gave the following statement of the relative sizes of the oral opening and canal during the utterance of the following vowels, pronounced in the German fashion, the size of the oral canal being determined by the position which the tongue assumes :—

a (*past*)	...	5	size of oral opening	...	3	size of oral canal.
e (*pate*)	...	4	,,	,,	...	2	,,	,,
i (*peat*)	...	3	,,	,,	...	1	,,	,,
o (*potent*)		2	,,	,,	...	4	,,	,,
u (*boot*)	...	1	,,	,,	...	5	,,	,,

This determination, so far as it goes, is probably not very far from

I shall not weary my audience by discussing the vowel-sounds in minute detail, but shall simply draw

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the truth; but it relates only to five out of the twenty vowels just enumerated. 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.

According to my own observations (made some years ago in relation to ten only of the thirteen vowels recognised in the text), the labial aperture, in ordinary conversational utterance, diminishes in size gradually from the pronunciation of *a* in *far* to that of *u* in the French word *vu*, according to the following sequence:—1, *a* in *far*; 2, *a* in *fat*; 3, *a* in *fate*; 4, *a* in *all*; 5, 'ur vocal' in *fur*; 6, *e* in *mete*; 7, *o* in *note*; 8, *eu* in the French word *jeu*; 9, *oo* in *fool*; 10, *u* in *vu*. But these differences are not invariable in respect of all the vowels. In the five vowels included under the numbers 1, 3, 5, and 6, the tendency which I have indicated is, I think, undoubted; yet these may all be uttered (with perfect distinctness, though a little muffled in tone) through the closed teeth, under which circumstances little or no change takes place in the size or form of the labial aperture in passing from the sound of one of these vowels to that of any other of them; again, they may all be pronounced between the separated teeth with no more enlargement of the labial orifice than that which the production of the *e* (in *mete*) requires; and, lastly, they may all be uttered, scarcely modified in sound, with the mouth widely open, or, at all events, so widely opened as permits of the requisite relationship between the tongue and the upper teeth and palate. There is a little tendency in the pronunciation of *a* (*far*) to draw the angles of the mouth outwards, or rather, perhaps, to separate the lips in the whole of their extent, a peculiarity which becomes progressively more evident in the formation of the vowel-sounds of *a* (*fat*), *a* (*fate*), and *e* (*mete*). For 'ur vocal,' on the other hand, the mouth stands at ease—if I may use the expression—the lips are just so far apart as they are in the habitual quiescent open condition of the mouth,

attention to some points in connexion with the subject which appear important or interesting.

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being still in contact with one another near the angles. The vowels, which I have numbered 4, 7, 9, and 10, are also characterised by the gradual diminution of the labial aperture in passing from the pronunciation of the first onwards to the last. For the whole of this series the transverse diameter of the mouth is notably contracted, and the under lip occupies a sensibly higher position in relation to the lower teeth than it does in the pronunciation of any of the former series; the lip, moreover, is a little protruded or shot out. In the pronunciation of these vowels the form and size of the labial aperture are of essential importance; still, within certain limits, a good deal of variation in size is compatible with the correct production of the sound of *a* (*fall*); and a little variation is compatible with the development of the sound of *o* (*note*). The very small orifices through which the sounds of *oo* (*fool*) and *u* (*tu*) are normally emitted admit, however, of very little modification. In forming the remaining vowel, *eu* (*jeu*), the eighth on the list, the labial aperture is also small; but it appears to me that the lower lip is neither so distinctly raised relatively to the teeth, nor so distinctly protruded, as in the last series of vowels. The form of the mouth, indeed, seems to me to be simply intermediate between that which it assumes in the pronunciation of 'ur vocal' and that of gentle closure.

The variations in the position of the tongue are considerable. Judging from observations upon my own, the tip is retracted from the anterior surface of the lower incisors, in the pronunciation of the several vowels, to the following extent; in *a* (*all*) 1·5 inch, in *a* (*far*) 1·3 inch, in *o* (*note*) and *oo* (*fool*) 1·2 inch, in 'ur vocal' 1·0 inch, in *a* (*fat*) ·7 inch, in *a* (*fate*) and *eu* (*jeu*) ·6 inch, and in *e* (*mete*), and *u* (*tu*) ·5 inch. The degree of elevation of the tongue above the floor of the mouth increases generally with the advance of the tip; it is, however, most depressed for *a* (*far*), and then gradually rises for *a* (*all*), 'ur vocal,' *o* (*note*), *oo* (*fool*), *a* (*fat*), *a* (*fate*), and *e* (*mete*), and *u* (*tu*); for both of which latter the sides of the tongue are pressed against the upper teeth, and a vertically

It seems to me, then, that (excluding for the present the French nasal modifications) the fifteen vowels before

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narrow, but somewhat broad aperture alone is left for the passage of air between the tongue and the fore-part of the palate. But here again it appears that although there are certain positions which the tongue naturally assumes during the utterance of the several vowels, these positions admit of a good deal of variety within certain limits with little or no detriment to correct enunciation. Thus, provided the general form of the oral cavity due to each vowel be maintained, it is quite possible to pronounce all, or nearly all of them with the tip of the tongue touching the lower incisor teeth ; and again (to take a particular example), although in the ordinary mode of producing the sound *e* (m*e*te), the anterior part of the tongue is rounded from above downwards and forwards, and so placed that while its tip touches, or almost touches, the lower incisors, the anterior portion of the dorsum slopes obliquely upwards to the anterior upper bicuspids and the lateral portions of the hard palate between them, it is quite possible to sound a very good *e* by reverting the tip of the tongue so as to make it extend across the upper part of the mouth from one bicuspid to its fellow, and thus exposing, through the oral aperture, the under instead of the upper surface of the organ. The fact seems to be that it is essential in the production of the vowel-sounds to have a certain form and size of some special part or parts of the oral cavity for each vowel, but that it is a matter of secondary or of comparatively little importance by what means these peculiarities are attained, or what modifications are given to regions not thus specially engaged.

'Ur vocal,' 'the natural vowel of the reed,' 'the voice least modified,' may be taken as the starting-point from whence to describe the conditions of the oral cavity in the formation of the several vowel-sounds. In pronouncing this letter (as, indeed, in pronouncing all the vowels with the exception of the French nasal vowels) the communication between the fauces and the nose is closed by the ascent of the soft palate ; there is no apparent modification in the form of the fauces, and the tongue lies some-

specified may be arranged in three tolerably distinct, yet parallel, series. In the first series I should include

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what rounded (as at rest) on the floor of the mouth, with its tip removed about an inch from the front teeth. I pass from this vowel to a series the members of which, I think, are in some measure related to one another; the series includes *a* (*far*), *a* (*fat*), *a* (*fate*), and *e* (*mete*). For the first of these the tongue is retracted somewhat further from the teeth, than it is for 'ur vocal;' and it is at the same time considerably more depressed upon the floor of the cavity, and I think a little more expanded laterally. For the second, the point of the tongue is considerably advanced in a rounded form; its dorsum, convex in its general shape, approaches by its posterior half the posterior half of the palate, and, widened out, touches with its edges the last two upper molar teeth on each side, extending, indeed, in this situation into the interval between the upper and lower teeth. In front of this the dorsum, sloping gently forwards and downwards, retreats both from the palate and from the upper teeth. Thus a somewhat flattened tube is formed, extending from the fauces to the situation in which the tongue leaves the upper teeth, where it becomes continuous with the general cavity of the mouth. For the third, *a* (in *fate*), the position of parts remains unchanged, except that the tongue both advances and ascends a little, so that the sides of the organ touch the anterior molar teeth, and the tube between the tongue and palate is rendered a little longer and a little narrower. For the last, *e* (in *mete*), these changes are carried a step further, the tube is rendered still longer and more contracted, and the sides of the tongue rest against the upper teeth, as far forward as the anterior bicuspids. The next series of vowels includes, I think, *a* (*fall*), *o* (*note*), *oo* (*fool*), and *u* (*tu*). In framing the cavity of the mouth for the pronunciation of the first of these, the tongue occupies very nearly the same position that it does in the pronunciation of *a* (*far*); but it is a little more retracted, the posterior part of its dorsum is a little more elevated, and, as a consequence, the pharynx below the soft palate, and the fauces, are somewhat more contracted in their antero-posterior diameter, while the cavity of the mouth is made

in successive order *a* (in *past*), *a* (in *pat*), *e* (in *pet*), a (in (*pate*), *i* (in *pit*), 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*), *ur* (in *fur*), and *eu* (in *jeune*).

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proportionately more capacious. In the production of the second sound, that of *o* (*note*), the dorsum of the tongue becomes considerably more elevated, at the same time its point is slightly advanced, and the general form of the tongue, especially towards its point, becomes somewhat quadrilateral, instead of being expanded laterally, as it is in the pronunciation of vowels of the other series. In pronouncing *oo* (*fool*), the tongue occupies nearly the same position that it does during the utterance of the last vowel, its tip rests as nearly as possible in the same spot, but the organ, which also presents a quadrilateral form, is a little more elevated, and thus nearer to the roof. In the pronunciation of *u* (*tu*), the tongue occupies the same position that it does in pronouncing *e* (*mete*), the different sounds of the two vowels depending wholly on the difference of form and size of the oral aperture. The vowel-sound *eu* (*jeu*) seems to me, judging by the ear, to be in some degree related to *e* (*mete*) on the one hand, and to *u* (*tu*) on the other; it has also, I fancy, a very definite relation to 'ur vocal.' Indeed, it is not very distinct in sound from the 'ur vocal' uttered with a contracted oral aperture. I think, however, that the tongue is a little more advanced, and at the same time a little more elevated, and its sides are in contact with the posterior teeth of the upper jaw.

TABLE III.

SCHEME OF VOWEL-SOUNDS.

FIRST SERIES.		SECOND SERIES.		THIRD SERIES.	
ORAL.	NASAL.	ORAL.	NASAL.	ORAL.	NASAL.
p-A-st *p-A-t* *p-E-t* *p-A-te* *p-I-t* *p-EA-t*	*d-AN-s* *f-IN*	*p-O-t* *p-AU-per* *p-O-tent* *p-U-t* *b-OO-t* *t-U-toyer*	*dONc*	*p-U-tty* *p-U-r* *g-OE-the*	*UN*

The vowels of the first series seem to me to be related to one another, not only in sound, but because 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 depressed and retracted in the utterance of *a* (in *past*), becomes progressively more and more elevated and projected forwards 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 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 elevation and projection of the tongue forwards nearly into the position which it occupies in the enunciation of *e* (in *peat*).

Not only, however, have the vowels of each series affinities among themselves, but there are distinct cross relations between certain vowels of the several groups. Thus, *a* (in *past*), *ur* (in *fur*), or *u* (in *putty*), and *au* (in *pauper*), are all distinctly related to one another, in that for each the oral cavity is large, the tongue is retracted, and the oral aperture is freely if not widely opened. And again, there is a specially-marked affinity between *e* (in *peat*), *eu* (in *jeune*), and *u* (in *tu*), in the circumstances that in the utterance of all of them the tongue is more markedly elevated, and the tip more nearly approximated to the incisors, than they are in the utterance of any of the other vowels. Moreover, there is a distinct likeness between their sounds.

It may possibly be objected that the fifteen vowels which I have enumerated are not all distinct vowels. It has been maintained (and I confess that I formerly held this opinion) that several of them are merely unaccentuated or rapid utterances of others that have been more generally recognised. Thus, *a* (in *pat*) has been regarded as a shortened *a* (in *past*); *e* (in *pet*) as a shortened *a* (in *pat*); *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 all be pronounced independently, and prolonged in their pronunciation without merging into any other vowel; but their characteristic sounds certainly cannot be so readily recognised under these 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.

Again, it may perhaps be objected that I have omitted from enumeration certain well-recognised vowel-sounds. It is held, for example, that the *a* in *fare* is distinct from the *a* in *fate*, and an independent vowel-sound. I believe, however, that in this word, as in many other somewhat similar cases, we have to do, not with vowels, but with combinations of vowels, or diphthongs. There is, in fact, a great tendency for some of our vowels to be converted, while pronouncing them, into diphthongs. Thus the sound of *a* in *fate*, when prolonged, is usually merged into that of long *e;* and the sound of *o* in *potent*, under similar circumstances, is apt to glide into that of *oo*. And the sound of *a* in *fare* and other words that rhyme with it is not, I think, the sound of *a* in *pate*, but a sequence of the sounds of *a* in *pat* and *ur* in *fur*.

The French nasal vowels are characterised essentially by the peculiarity that, while for all other vowels the soft palate closes the aperture of communication between the nose and 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* (*donc*), *a* in *pat* (*fin*), and *ur* in *fur* or *u* in *putty* (*un*).

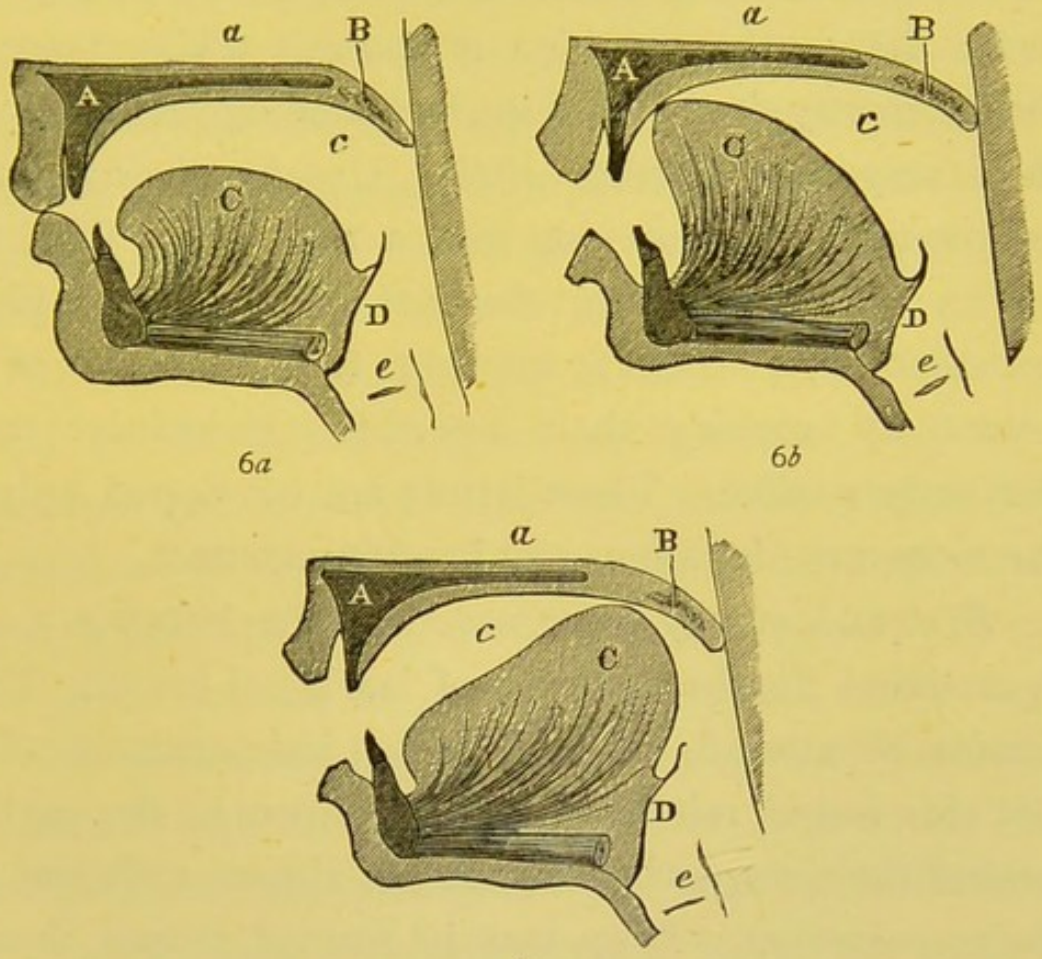
(*d*) *Consonants* differ from vowels in being unmusical sounds, or noises (as Max Müller terms them), formed by the interposition of checks or barriers to the free passage of air through the oral cavity, or at any rate by the interposition of more complete barriers than those which are formed during the evolution of the vowel-sounds; at which barriers, instead of in the larynx, their fundamental sounds are produced. The fundamental sound in the case of some consonants is associated with laryngeal intonation or sound, while in the case of others there is absolute laryngeal silence; when present, however, this is always coloured by the characteristic resonances of the cavity or cavities which the barrier limits or divides. In some instances, the barrier to the transmission of air is complete, and the consonantal sound is of limited duration, and produced only or most distinctly at the moment of opening or closing the barrier; these are the explosive consonants. In other instances the barrier to the passage of air through the mouth is complete, but the communication between the nose and mouth remains open, so that their characteristic sounds, which originate at the chink between the posterior edge of the soft palate and the back of the pharynx, through which the breath is transmitted into the nose, may be indefinitely pro-

longed; these are the nasal consonants or nasal continuants. In other instances, again, the check to the passage of air through the mouth is incomplete, so that these, like the last, admit of indefinite prolongation; they comprise letters of various denominations, such as sibilants, trills, semi-vowels, but, collectively, may conveniently be termed oral continuants.

The explosive consonants are *p*, *b*, *t*, *d*, *k* and *g* (hard), the last of which I shall hereafter represent by the Greek letter γ. In the production of the first two the barrier to the escape of breath is formed by the lips, the position of the tongue being immaterial, provided only it does not interpose another complete check. In the production of the next two, the barrier is formed by the tongue, which is flattened out and so placed that while its apex touches the hard palate immediately behind the incisor teeth, its sides, sloping downwards and backwards, first press against the upper canines and bicuspids, then against the upper molars, and lastly against the folds extending, behind the teeth, between the upper and lower jaws. In the production of the last two the barrier is formed by the contact of the base of the tongue with the palate at the line of union of its hard and soft portions. They thus form three series, of which *p* and *b* are termed labial, *t* and *d* lingual, *k* and γ guttural.

Of these letters, *p*, *t*, and *k* resemble one another in the fact that they can only be pronounced with the glottis wide open, or, in other words, with unvocalised breath. If it be attempted to utter them with laryngeal

intonation, or even with that breezy laryngeal sound which forms the basis of whispered language, they become converted respectively into *b*, *d*, and *γ*. They



6*a* 6*b* 6*c*

DIAGRAMMATIC REPRESENTATIONS OF POSITIONS OF ORAL PARIETES AND TONGUE IN PRONUNCIATION:

6*a* Of labial explodents; 6*b* Of lingual explodents; and 6*c* Of guttural explodents.

In the pronunciation of their respective nasal equivalents the soft palate, which in the diagram forms a septum between the nose and fauces, assumes the position given to it in the diagram on page 13.

A Hard palate.
B Soft palate and uvula.
C Tongue.
D Epiglottis.

a Cavity of nose.
c Cavity of mouth.
e Larynx.

may be formed, indeed, altogether independently of the breath by the sharp closure, or still better by the sharp opening, of their respective barriers; and obviously,

therefore, are caused essentially, as the crack of a whip or an electric spark, by the sudden displacement of air consequent on sudden, impulsive movements. Their mutually distinctive characters, however, are clearly due to the different superadded resonances taking place in the differently sized and shaped resounding cavities which their respective barriers limit. Usually these sounds are produced in connexion with a rush of air from the larynx; and although (as has been shown) this rush is not essential, it no doubt improves the articulation of the letters, by making their associated resonances more distinctly audible. These letters are developed only at the moments of making and breaking contact.

B, *d*, and *γ* may be regarded as the letters *p*, *t*, and *k*, modified by the presence of laryngeal sound. They cannot be uttered, as *b*, *d*, and *γ*, independently of it. But this sound, reinforced by resonance in the cavities behind their respective barriers, is almost sufficient for their production. They may be formed, indeed, though somewhat imperfectly, during the closed condition of the cavities, and may be thus uttered as continuous sounds so long as the limits to the distension of the cavities by the admission of air from the larynx are not transgressed. They commence, however, with the closure of their respective barriers, and terminate when they open, and are undoubtedly increased in force and distinctness by the addition of the sounds of these impulsive actions.

The characteristic differences then between the labial, lingual, and guttural explosive consonants

depend upon the specific resounding qualities of the cavities in connexion with which they are severally formed; and the characteristic differences between the several surd or voiceless explodents, and their sonant or vocal varieties, depend on the fact that the sounds upon which the letters are, as it were, moulded, are due in the former case to the impact or separation of the barriers alone, in the latter case to the sonant action of the glottis associated with that of the barriers.

The nasal consonants, *m*, *n*, and *ng*, are closely related to the labial, lingual, and guttural explosive consonants respectively. Everyone knows that if he endeavours to pronounce the words *m*outh, *n*ose, to*ng*ue, while his nares are stopped from catarrh or by artificial means, he says instead *b*outh, *d*ose, t*ug*. The only differences between the formation of the nasal consonants and that of the explosive consonants to which they severally correspond are, that in the former case the soft palate is so arranged as to leave a narrow passage between the nose and the back of the mouth, while in the latter case this passage is closed; and that in the former case the fundamental sound of the consonants results from the passage of air through the naso-pharyngeal chink, whereas in the latter case it arises in the mouth by the action of the barriers. The recognised nasal consonants are, like *b*, *d*, and *γ*, sonant, and their distinctive sounds, therefore, are reinforced by the laryngeal voice. They receive, however, their specific colourings from the combined resonances of the oral and nasal cavities. The qua-

lities which distinguish them from one another are due to the resonances of the oral cavity; those, on the other hand, which distinguish them especially from *b*, *d*, and γ, are due to the resonance of the nasal cavities.

But besides the recognised forms of *m*, *n*, and *ng* (which are sonant), voiceless or surd varieties of them can be formed. These do not, so far as I know, exist either in the English or in any other language as acknowledged letters; and, indeed, from the absence of laryngeal sound and from the extreme feebleness and close resemblance among themselves of the resonances which attend their utterance, they are scarcely, if at all, distinguishable from one another.

The remaining consonants are sometimes termed oral continuants. They are all produced by the passage of the breath past, or through, an incomplete barrier, and are therefore all, like the last group, continuous. But in their utterance the septum between the nose and mouth is completely, at any rate practically, closed. Further, like other consonants, and especially like the explosive consonants, they form two parallel series — one consisting of the surd or voiceless letters, of which *f*, *th* (in *thing*), *s*, and *sh* are examples; the other consisting of their respective sonant modifications, *v*, *th* (in *the*), *z*, and *zh* or *z* (in *azure*). The surds, as in other cases, can only be uttered with unvocalised breath, the association of breath carrying sound from the larynx converting them at once into their sonant equivalents.

In the utterance of the English *f* and *v*, the parts in the interior of the mouth have the same position that

they present during the pronunciation of *p* and *b*; but the lips are slightly parted, the upper teeth rest on the lower lip, and the breath is driven with some degree of force through the lower portion of the interdental spaces, and between the teeth and lip.

In pronouncing *th* (in *thing*), and *th* (in *the*), or (as it may be more conveniently represented) *dh*, the tongue is flattened, and the margins of its upper surface are pressed against the whole semicircle of the upper teeth, its edge projecting even a little beyond into the interval between them and the teeth of the lower jaw. The sounds of these letters are evolved by driving the breath through the intervals between the upper front teeth, and between these and the tip of the tongue.

To form the sounds *s* and *z*, the organs of articulation must occupy almost exactly the same position that they do in the utterance of *d* and *t*. The only differences are: first, that the tip of the tongue, instead of resting against the hard palate immediately behind the incisor teeth, is slightly withdrawn from the palate in this situation, so as to leave there a narrow chink for the passage of the breath; and, second, that the labial aperture is diminished in size and somewhat modified in shape, partly in consequence of the lower lip being a little elevated and pouted, and (as in whistling) rendered concave in the mesial line, partly from elevation and arching of the middle portion of the upper lip.

In order to effect the pronunciation of *sh*, and *z* (in

azure), or (as it may be more appropriately represented) *zh*, the teeth are usually brought a shade nearer together than they are in pronouncing *s* and *z*, and the lips are more obviously protruded, the oral aperture, however, presenting the same general form and size. The tongue is brought very nearly into the same position that it occupies when long *e* is sounded ; but the passage between its anterior half and the corresponding portion of the palate is more contracted, in consequence of the greater degree of elevation of this part of the tongue ; which organ becomes, therefore, a little less flattened and a little more cuboidal than it is during the utterance of the vowel.

The remaining oral continuants have features of more or less special interest ; and I shall discuss them briefly, but in no particular order.

The letter *l* presents two distinct varieties : one the ordinary *l* of our own and Continental languages, which is sonant ; the other the Welsh *ll* (in Llanberis), which is unknown in English, but which is simply the voiceless form of the common *l*, and as such uttered without accompanying laryngeal sound. In order to pronounce either, the point of the tongue is pressed against the palate just behind the upper incisors, but an interval is left on either side between the tongue and the double teeth, through which the air is made to pass. But for this lateral separation of the tongue from the teeth, the position of the organs of articulation in sounding *l* is identical with the position they assume for the utterance of *t*.

The English *r* presents two very obvious varieties, the one being the trilled, the other the untrilled *r*. For the former, as it is usually sounded (in the word *error*, for example), the lips and teeth being well separated, and the tongue having generally the same position that it has in the pronunciation of *t* or *s*, its tip, anterior to the front bicuspids (with which it is in contact), is stretched horizontally forwards towards the upper incisors, remaining separated from them, however, by a widish semilunar interval. Then by a very forcible expulsion of vocalised breath this edge is thrown into slow, irregular, and very visible vibrations—slow, that is to say, in comparison with the rate of vibrations which for the most part produce musical tones. Donders has estimated them at thirty in the second. For the untrilled *r*, as it occurs in the word *rain*, the tongue is arched in such a manner that its upper surface is rendered concave from before backwards, while its tip, which is a little reverted, points to the highest part of the palatal arch. The sound of this letter is due to the passage of the breath through the narrow aperture which is left between the tip of the tongue and the palate, but in no degree, as in the other case, to coarse vibrations of the tongue.

Although these two varieties of *r* are represented by the same sign, and are to a considerable extent employed indifferently in speech, it is obvious that there is a real and marked difference between them: and, indeed, the untrilled *r* has at least as close an

affinity to certain vowels, as *a* (in *far*), and *a* (in *all*), and especially to *u* (in *fur*), as it has to the trilled *r*. I believe that the untrilled *r* has much the same relation to the '*ur* vocal' that the consonant *ng* has to the French nasal vowels, or (to adduce yet more apposite examples) that the consonant *w* has to the vowel *oo*, or the consonant *y* to the vowel *e*. The curious tendency which uneducated persons show to confound these several groups of sounds seems to me to be a confirmation of this peculiar relation. I need scarcely call attention to the frequency with which the untrilled *r* is dropped in conversation, and to the frequency with which it is unconsciously added to the '*ur* vocal' when this ends a word followed by another vowel, as in the combinations idea-*r* of, yelle-*r* ochre, and the like.

The varieties of *r* above considered are sonant, but each has its unvocalised or surd representative; and these were not improbably the aspirated *r* (ῥ) of the Greek alphabet. They are not English letters.

The true labial and guttural continuants are specially interesting, among other reasons, because they include *y* and *w*, which have been classified as semi-vowels, and have severally a very close relationship to certain vowels. By many grammarians and physiologists, indeed, they have been regarded as vowels, or perhaps rather as the primary factors of certain diphthongal sounds, which it is assumed they make with the aid of the vowels which succeed them. Thus *w* is intimately related to *oo*, and *y* to long *e*; and it has been

assumed that such words as *w-ail*, *w-eed*, and *w-ind*, might properly be spelt *oo-ail*, *oo-eed*, and *oo-ind*; and such words as *y-acht*, *y-outh*, and *y-oke*, be spelt *e-acht*, *e-outh*, and *e-oke*. It must be admitted that, in passing rapidly from the sound of *oo* or *e* to that of some other vowel, there is a very great tendency in the organs of articulation to utter, in the one case the distinctive sound of *y*, in the other that of *w*. But that the consonantal sounds of *w* and *y* are really distinct from those of *oo* and *e* is obvious, when we compare the sounds of *w-oo* and *y-e* with those of their supposed equivalents *oo-oo* and *ee-e*, or when we contrast such words as *ooze* and *woos*, and *ear* and *year*. There can be no doubt, indeed, that *w* and *y* do really represent true and peculiar consonantal sounds.

The true labial continuous consonants are the English *w* and the German *w* and *v*, which latter are respectively very closely related in sound to the English *v* and *f*.

In the utterance of the German varieties of *v* and *f* the lips are brought into close approximation, leaving only a longish linear chink between them, through which the breath is emitted with sufficient force to produce a manifest rustling sound. The *v* (the German *w*) is a sonant letter; the *f* (the German *v*) is its surd modification.

The sound of the English vocal *w* differs from that of the vowel *oo* mainly in the fact that the fundamental vowel-sound is produced in the larynx, and receives its colouring from the oral cavity, while the distinctive

sound of the consonant, though also coloured by the resonance of the oral cavity, is manufactured at the labial orifice; it differs from the sound of the German *w* in its less sibilant character, and from both vowel and consonant in its mode of production. In the pronunciation of *w* the lips have an intermediate position between that which they assume in uttering the German *w* and that which they present in sounding the vowel *oo*. They are a little less pouted, and the orifice between them is considerably narrower from above downwards, than for *oo*; but the orifice is neither so narrow nor so elongated as it is for the German letter. The common English *w* is sonant, but a distinct surd variety exists, which, though common among the Irish in such words as *which* and *what*, is falling into disuse amongst Englishmen.

The true guttural continuous sounds are probably four in number. The two best known and most agreeable of the group are the German *ch*, or (as it may be preferably represented) *kh*, and our own *y*. *Kh* and *y* are, as regards their mode of formation, mere modifications of *k* and *γ*. The general arrangement of the organs of articulation is almost identical in both cases; but in the utterance of *kh* and *y* the base of the tongue and the back of the hard palate, instead of being in contact, leave between them a narrow aperture by the sharp passage of the breath through which the special sounds of the consonants are produced. The sound of *kh*, as in the German *ich*, is generally considered to be absent from the English language. Its presence, how-

ever, has been recognised by several writers (and there is no doubt of their correctness) in the initial sound of such words as *hew* (which might properly be spelt *ch-y-oo*), *huge*, and *Whewell*. As regards *y*, I feel no doubt that it is, as J. Müller, Max Müller, and several other writers maintain, simply the sonant form of the surd *ch* or *kh*.

The other two guttural sounds are, I believe, the surd Scotch *ch* in *loch*, which seems to be much rougher and less musical than the German *ch*, and to be produced, as Max Müller observes, between the base of the tongue and the uvula, or further back than the German *ch*; and the sound of *g* in the German word *tage*, which is sonant and certainly related to *y*, but is rougher in sound, more guttural than it, and, like the Scotch *ch*, seems to be produced far back in the throat.

Other consonantal sounds besides those which have been considered no doubt exist or can be uttered; but they are, probably, little more than modifications of them. Thus, *p*, *b*, and *m* can each be pronounced, though with some impairment of character, with the upper teeth resting, as for *f* and *v*, upon the lower lip, or with the upper lip resting on the teeth of the under jaw. So, again, *t*, *d*, and *n* can be uttered, slightly modified, either with the tongue in the position which it assumes when *th* or *dh* is pronounced, or by bringing the tongue into contact with the roof of the mouth somewhere between the normal point of contact for *t* and that for *k*. Further, other trills can be effected

besides the ordinary trilled *r*: one, for example, with the lips, which has a natural affinity to *w*, but more especially to the German *w* and *v* and to *b*; another at the back of the mouth, produced apparently between the uvula and the tongue, which is very rough and disagreeable, and is evidently specially related to the *g* (in *tage*); and one also (if it may be termed a letter) due to the coarse vibration of the aryteno-epiglottidean folds.

The so-called consonant, *h*, I have reserved for special consideration. It is the spiritus asper or true aspirate, and is generally regarded as a simple unvocalised rush of air through the glottis opened to its full extent, which, in our own language, and more or less in other languages, is under certain circumstances made to precede the utterance of vowel-sounds. It is also said to precede the sounds of certain consonants, as in the occasional pronunciation of *wh-ich* and *wh-at*, and in the Greek ῥ. In our own language the letter *h* standing at the beginning of a word or syllable usually indicates the aspirate, but when present in other situations is either silent or has a conventional value. The aspirate necessarily ceases at the moment at which the sound of the letter it ushers in commences.

A little consideration, however, will show that the letter *h* is not a mere unvocalised rush of air, but that it is an unvocalised rush of air which acquires sound and character as it passes through the mouth; and, further, that for every vowel, and indeed for every consonant, which it precedes, it is attended with a special arrangement of the oral canal, tongue, and lips—an arrangement

which is, in fact, that of the particular vowel or consonant with which it is associated.

In other words, the aspirate which precedes an ordinary or sonant vowel is the surd, voiceless, or aspirated form of that vowel; and the aspirate which precedes a voiced or sonant consonant is the surd or voiceless representative of that consonant. In this point of view, the letter *h* placed before a vowel implies that two vowels are sounded consecutively: namely (first), the unvoiced vowel, which, by the closure of the glottis in the progress of its utterance, becomes converted into (second) its vocal equivalent, or that which alone is usually regarded as a vowel.

Further, it implies, that whenever a consonant is supposed to be aspirated, its sonant form is simply preceded in utterance by its surd form, or in some cases, perhaps, that the surd form of the consonant is alone pronounced. Thus, in the case of the aspirated *which* or *what*, the *wh* is either the surd *w* followed by the sonant *w*, or the surd *w* alone; and in the case of the word *hew*, which I have previously shown should be spelt phonetically by the consonant represented by the German *ch*, *y*, and the vowel indicated in English by *oo*, the sound which *h* represents is in reality that of *ch*, or the surd equivalent of the *y*, which in the pronunciation of the word follows it. I am not aware that any other consonants are aspirated in English; but all other continuous consonants admit of aspiration in the sense of having the sonant consonant preceded by its surd variety. It is thus, I think, in regard to the Welsh *ll*

as ordinarily uttered, and it was probably thus that the Greek ῥ was pronounced. It is stated that in Sanskrit consonants were often followed by aspirates; and it need scarcely be said that, though such combinations are unknown amongst ourselves, it is just as easy to continue the pronunciation of a sonant vowel or consonant into its surd equivalent, as it is to convert in the course of its utterance a surd into its correlative sonant.

(*e.*) Having now pointed out the mechanical processes by which the sounds of consonants are produced; and in some degree how consonants fall into groups, partly from resemblances in their modes of formation, partly from resemblances in sound, and partly from a combination of these conditions; it will be convenient to tabulate them, so that the affinities which I have endeavoured to establish may be recognised at a glance. A reference to the table will show that I have arranged consonants in three vertical groups—the labial, the lingual, and the guttural; and have placed beneath each the vowel which seems to me to have a special affinity with it. Each of the groups comprises explosive, nasal continuous, and oral continuous consonants, together with trills; of which all present (indicated by small letters) surd or voiceless, and (indicated by capitals) sonant or vocal varieties; and of which all the sonant, excepting the explosives, may, like the vowels, be aspirated, or, in other words, be associated in continuous pronunciation with their respective surd equivalents. It will be observed, that of those letters for which no specific characters exist, some I have represented by

TABLE IV.

SCHEME OF CONSONANTAL SOUNDS.*

	Labial.		Lingual.			Guttural		
	Lips.	Lips and Teeth.	Tongue and Teeth.	Tip of Tongue and Palate.	Back of T. and Palate.	Base of T. and Palate.	Base of T. and Uvula.	
Explosive Consonants.	*p*	...	...	*t* ...	...	*k*	...	Voiceless or Surd.
	B	...	...	*D* ...	...	Γ	...	Vocal or Sonant.
Nasal Continuous Consonants.	*m*	...	...	*n* ...	...	*nγ*	...	Voiceless.
	M	...	...	*N* ...	...	*N*Γ	...	Vocal.
	m-M	...	...	*n-N* ...	...	*nγ-N*Γ	...	Aspirated.
Oral Continuous Consonants.	*w* *v* (G)	*f*	*th*	*s* *r*	*sh*	*kh* (G)	*kh*	Voiceless.
	W *W* (G)	*V*	*DH*	*Z* *R*	*ZH*	*Y*	Γ*H*	Vocal.
	w-W *v-W* (G)	*f-V*	*th-DH*	*s-Z* *r-R*	*sh-ZH*	*kh-Y*	*kh-*Γ*H*	Aspirated.
	,,	...	...	*ll* (W) ...	...	...	...	Voiceless.
	,,	...	...	*L* ...	...	...	...	Vocal.
	,,	...	...	*ll-L* ...	...	...	...	Aspirated.
Trills.	Trill	...	...	... (Trill)	...	...	(Trill)	Voiceless.
								Vocal.
								Aspirated.
Vowels of each Group.	*OO*	...	...	*Ur* Vocal	...	Long *E*	...	

* In the Table, G in brackets, thus (G), stands for German; W in brackets, thus (W), for Welsh.

the combinations of letters which commonly stand for them, while to others I have assigned combinations which may be assumed from analogy to represent them; and that the aspirated sonant letters have placed before them, in small letters, their surd equivalents, which, as I have explained, I regard as their proper aspirates.

Among labial consonants, *p*, *b*, and *m* have an easily recognised and generally acknowledged connexion; and the letters *f* and *v* are frequently regarded as the oral continuous modifications of *p* and *b* respectively. It is clear, however, that there is a closer relation between the German *v* and *w* than there is between the English *f* and *v* and these explodents, inasmuch as the German letters, like the explosives, are formed simply with the lips. The surd and sonant forms of the English *w* equally are true labial sounds. I have therefore placed the German modifications of *f* and *v* (*v* and *w* respectively), and the English *w*, in the same linear series with *p*, *b*, and *m*; and the English *f* and *v*, which are formed by the lips and teeth, I have put in a subordinate collateral—the labio-dental—group.

Among lingual consonants, *t*, *d*, and *n* have a universally admitted affinity; and the sounds represented by *th* and *dh* are usually taken for their oral continuant representatives. But the relations of the other consonants which I have placed among the linguals have generally been less distinctly defined. I venture to regard as the true linguals those consonants in the formation of which the tip of the tongue is brought into contact or close relation with the anterior portion of the

palatal arch; and as nearly allied series (first) those letters which are formed by the approximation of the tip of the tongue to the teeth, and (secondly and thirdly), those which are produced by the convergence severally of the anterior and of the middle portion of the tongue to the summit of the palatal arch. The principal and most complete of these series comprises obviously *t*, *d*, and *n* and (and as having the same relation to *t* and *d* that the German *v* and *w* have to *p* and *b*) the sibilant sounds *s* and *z*, together with the consonant *l*, which has no equivalent in any of the other groups. The first of the lingual sub-series is the linguo-dental, comprising the consonants *th* and *dh*, which are evidently related in character to our *f* and *v*, and in the utterance of which the tip of the tongue is applied to the upper teeth. The second sub-series includes the untrilled and the trilled *r*; and the third sub-series consists of *sh* and *zh*, in enunciating which the position of the tongue approaches to that characteristic of *y* and *kh*, and of which the sounds have a very close resemblance to those of these guttural letters.

The guttural consonants, *k*, *γ*, and *ng*, again, are obviously in close relation; and the consonantal sounds indicated by *kh* and *y*, clearly belong to the same group. Of the harsher varieties of these continuous guttural sounds I have made a sub-series.

Finally, in each series I have included trills, which I regard as mere modifications of certain letters which I have already specified.

LECTURE II.

Recapitulation—Complexity of Motor Processes in Respiration: in Phonation: in Articulation—Transmission of Sensory Impressions to Brain—Auscultation: Ægophony: Bronchophony and Pectoriloquy—Loss or Impairment of the Laryngeal Voice—Paralysis of the Recurrent Laryngeal Nerve—Cases—Paralysis and Spasm of Organs concerned in Articulation—Bulbar Paralysis: General Paralysis, &c.—Chorea and Stammering.

In my last lecture I discussed the mechanical and acoustical principles of the functions of voice and speech. I pointed out the fundamental importance of the chest and its contents as a collective organ for the regulated discharge of air over the vibratile vocal cords and through the articulating cavities of the mouth and nose. I considered briefly 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, and at much greater length, I discussed the means by which articulate sounds are uttered, the various characters of these sounds, and their mutual relations.

1. *Complexity of motor processes.*—The complexity of the combined processes concerned in phonation, and *à fortiori* of those concerned in articulate utterance, is confessedly very great. It is remarkable, even if we regard it from the point of view of the number of separate parts whose co-operation is needed for their due performance. But from this point of view the simple respiratory mechanism would seem more complicated than the mechanism of the larynx, and the latter more complicated perhaps than that by which articulation is effected. The reverse of this, however, is undoubtedly 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.

(*a*) *In respiration.* The variations in the capacity of the chest, on which inspiration and expiration depend, are due simply to the alternate actions of antagonistic groups of muscles under the influence of special groups of nerves. And although the thoracic framework is of complex structure, and the muscles and nerves which determine its movements are very numerous, and apparently highly complicated in their arrangement, the entire mechanism is of such a character, and the combined movements of which it is capable are so few and simple, that it should be an easy problem to collect, so to speak, into the hands of some central power the strings by which the various co-operant parts may be brought into harmonious action. Indeed, the respiratory acts, notwithstanding the extremely 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.

Their co-ordinating centre is well known to be situated in the medulla oblongata; but this (for the purposes of speech and voice) is clearly under the influence, or the agent, of some higher co-ordinating centre, which brings its actions into due relation with those of these associated functions.

(*b*) *In phonation.* The movements of the larynx, again, despite the perfection of its mechanism and the infinite series of graduated sounds to which it may be adjusted, are only in a slight degree 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 vocal cords; the latter actions, on which alone the variations of the pitch of the voice depend, being determined simply by the regulated contraction of certain groups of muscles. It is clear, then, in this case as in the last, that 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 seated in the medulla; but it is obvious that for the utterance of notes in musical sequence it is subordinate to some centre of higher attributes.

(*c*) *In articulation.* The muscular actions on which the production of articulate sounds depends are different

from either of those groups which have just been considered; inasmuch 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 required for speech than for phonation, or for the regulation of the discharge of air from the lungs, seems obvious, when we consider, how in expiration the force with which the air is expelled has to be adjusted accurately not only to the different degrees of loudness of the voice, but to the different degrees of obstruction occurring in the larynx and mouth; and how in phonation the minutest variations in the amount of force which the muscles exert upon the vocal cords are attended with appreciable modifications 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 much variety in the details of these arrangements. But that they involve a much greater variety of motor combinations is quite certain. For while the actions of the thorax are simply those of inspiration and expiration, and those of the larynx, so far as mere phonation is concerned, relate merely to the more or less tension of the vocal cords, every single literal sound or element of spoken language is characterised by a specific 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 recollected that in my

last lecture I enumerated thirteen distinct vowel-sounds as existing in English, and half-a-dozen more which are special to certain other European languages, together with twenty-four distinct consonantal sounds characteristic of our mother tongue, and about five others of foreign birth. I do not by any means intend to imply, that these forty-eight distinct sounds include all possible articulate sounds, or even all those which competent authorities recognise among European languages; or that there may not even be, as some assert, articulate sounds in our own language to which I have given no place in my scheme. But I am satisfied that the specifically distinct articulate sounds in the English, and probably in any other language, are, at any rate, under fifty. If, indeed, we eliminate the surd letters, which, so far as their oral manufacture is concerned, are identical with their several sonant varieties, the articulate sounds of our own language become reduced to twenty-eight.

It is certain, however, that the exercise of speech as an art involves much greater difficulties than the mere distinct utterance of twenty-eight, or even fifty, different sounds. Letters have to be associated in words in almost endless combinations, and the passage from the position of the organs for one letter to their position for any other letter has to be effected with readiness and precision. The difference, in fact, between the mere capability of uttering so many different letters and the art of readily combining them in speech, is very much the difference between simply striking solitary notes of

a musical instrument with the finger and the playing upon them 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, with those for respiration and the ordinary actions of the larynx, in the medulla oblongata, is doubtless true. But it is at least probable that the centre for the co-ordination of the movements concerned in articulation is situated in some different and higher part of the encephalon, probably the corpus striatum. At the same time, there are many reasons for believing that the supreme centre for spoken language—the centre whence the impulse to express our thoughts in words starts—is only indirectly concerned in the co-ordination of those groups of movements which by their sequential association determine speech. In other words, it seems probable that, when the mind wills to express itself in articulate language, it effects its object automatically—not by acting directly from the speech-centre on the nerve-nuclei of the nerves distributed to the organs of speech, or even on the co-ordinating centre for the simple acts of mastication and deglutition, but by influencing them indirectly through the agency of some intermediate centre which governs the specific movements for the utterance of articulate sounds and their facile combination.

2. *Transmission of Sensory Impressions to Brain.*—

I have thus far considered, imperfectly I admit, the processes by which intellectual and musical conceptions and recollections arising in the superficial grey matter of the cerebral hemispheres become expressed respectively in spoken language and in vocal music. It may be interesting, on the other hand, to consider briefly the converse processes by which musical and articulate sounds are conveyed to the supreme centres for the reception and cognisance of acoustical impressions.

The modes in which the peripheral ends of the different sensory nerves receive impressions, and these impressions are conveyed to the central organs, and thus become modified into perceptions, are doubtless in many 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 scarcely yet been clearly determined.

The peripheral ends of the fibres of the optic nerves appear each to be connected with a special end-organ—a rod or cone,—which is adapted to receive and transmit impressions due to 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 and intensity, or transmit to the sensorium anything beyond that single formless and limitless impression. The knowledge which we derive through the eye of the size and shape and other visual attributes of objects depends upon the fact, that cones of light emanating from minute yet definite points of

their surface are brought individually to focus by the optical arrangements of the eye upon the ends of appropriately-situated rods and cones. The retina, in fact, is a mosaic of which each element receives a single elementary impression; which, taken alone, has no meaning or significance beyond the fact that there is light of a certain intensity and colour; but which, taken in connexion with the simultaneous impressions made on the definitely-arranged elements which surround it, carries to the mind simultaneously, but piecemeal as it were, an accurate representation of the picture formed on the retina. That is to say, 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 progress to the sensorium divided by the retina into innumerable bits, and carried inwards in innumerable distinct streams, of which individually the mind has no separate cognisance, but which collectively produce a compact impression or perception.

It is essentially the same, no doubt, in regard to the transmission of auditory impressions. But here geometrical relations become unimportant, while those of time, and the qualities of the impressions, rise into special importance. The vibrations which produce sound are waves of alternate condensation and rarefaction. Those which cause musical sounds are rhythmical, the pitch of notes being directly proportional to the rapidity with which the vibrations follow one another. The different qualities of musical sounds depend on the association

with the fundamental vibrations (or those which determine the pitch of notes) of rhythmical vibrations of greater rapidity, 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. As regards sounds which are not musical, no definite rule can be stated of them, except that they are 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 become blended into a musical note. It will be recollected, moreover, that many sounds, like those of articulate utterance, which are not necessarily musical, owe their distinctive qualities to groups of resonances or harmonic tones which their fundamental sound, be it what it may, wakes into being.

Now, how are these groups of variously-compounded vibrations, which even the comparatively 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, absorbed, so to speak, by the essential parts of the ear? How are they carried to the sensorium? And how do they there become or produce those concrete perceptions which reveal their several sources?

We know, in the first place, 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 waves which accompany it, is accurately represented in its vibrations; and, further, that concurrent acoustical impulses from different sources produce in the membrana tympani apparently tumultuous oscillations, which are, in fact, the mean of all the motor influences which are acting upon it. We know, in the second place, that the impulses which affect the membrana tympani are imparted through the chain of ossicles and fenestra ovalis to the perilymph, and thus, still blended and apparently confused, sweep over the keys of the cochlea. I am not aware that it is even yet known positively how sonorous impulses affect the peripheral terminations of the auditory nerve; but, at any rate, there are in the anatomical details of the cochlea, and in the analogies afforded by the other senses, good grounds for the belief 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.

If this view be correct, 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 parts of the ear, becomes there analysed and reduced to its simplest elements, each of which is carried separately along its particular route to the sensorium, there to be reunited with its fellows into a single specific perception.

The object I have had in view in making these latter

remarks has been to show that, just as when we will the performance of some special act (say the utterance of a word), the concrete impulse which alone exists in the brain is transmitted along special fibres to special co-ordinating centres or agents, 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 duty it is in combination to perform the specific 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 by them with extraordinary minuteness, and are carried with infinite subdivision by the corresponding sensory nerves to their nuclei of origin and to co-ordinating centres, and thence to the sensorium, where they concrete again into a single picture or perception—where the unravelled threads of sensory impressions are again woven into the patterns from which they were derived.

I ask pardon 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 here and there to diverge into discussions which I should probably have done well to avoid. Still, there are, I trust, some things among them which will be found to have a more or less direct relation to those pathological questions which I now proceed to consider.

1. *Auscultation.*—The first of these which I had proposed to myself has already been adverted to by my friend, Dr. Stone, in his suggestive Croonian lectures—I mean the subject of the auscultation of the voice and speech. I have hesitated whether, under the circumstances, I should introduce it here; but, for reasons which I need not specify, reconsideration has decided me to adhere to my original programme.

Bronchophony, pectoriloquy, and ægophony, 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, applied directly, or through the intervention of the stethoscope, to the chest.

(*a*) *Ægophony.*—The meaning of ægophony is well understood. It signifies a tremulous or bleating high-pitched modification of bronchophony, generally audible in cases of moderate pleuritic effusion over the lower part of the back of the chest. It is, as Dr. Reynaud holds, 'merely a remote bronchophony;' and its peculiarities are due, as Dr. Stone has, I think, distinctly shown, to the fact that from some special causes interfering with the uniform transmission of sound (in pleuritic effusion to the presence of a layer of fluid between the lung and chest-wall) the deeper and coarser vibrations of the fundamental tones of the voice are arrested in their transit, while the finer and closer undulations of their harmonics filter through, and either alone or mainly reach the ear of the auscultator.

(*b*) *Bronchophony and Pectoriloquy.*—But what are the meanings of the terms 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, I think, undoubtedly exist between them. That Laennec himself recognised a clear practical difference between pectoriloquy and bronchophony, few, I should think, can doubt. At the same time, 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, however, are evidently vitiated by two circumstances: one being that from a very early period he adopted the hypothesis 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 being that he had no clear conception of the essential distinction which there is between simple laryngeal intonation and the articulate utterances of the mouth and associated parts. He consequently had a tendency to call all those increased vocal resonances which were heard over presumed cavities pectoriloquy, and all those which were audible over solid lung permeated by tubes bronchophony. And his descriptive difference between the two conditions amounts simply to this—that in pectoriloquy the voice appears to come directly from the chest, and to pass wholly through the central canal of the stethoscope, while in bronchophony the voice seems to pass only in part through

the stethoscope. It needs scarcely be said that his hypothesis was wrong, and that his descriptions as they stand are inaccurate and fanciful. Nevertheless, I am inclined 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 confounded, in some way or other, loudness of laryngeal intonation with distinctness of articulation.

Skoda affirms that Laennec's pectoriloquy and bronchophony represent one and the same phenomenon, and consequently discards the use of the former word as unnecessary. But he divides bronchophony into two varieties, the loud and the weak. The loud variety he subdivides into the loud, clear form, 'in which,' he says, 'the thoracic voice may be either as loud as, or louder or somewhat weaker than, the laryngeal voice, the articulation being at the same time distinguishable;' and the 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 designate 'a mere humming, but a clear and audible voice, which produces little or no concussion in the ear; the articulation of the words uttered being generally distinctly heard.' It will be observed, however, that, notwithstanding his criticism of Laennec's views, he seems incidentally to allow 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 articulate words may be recognised, while in other cases there is only a confused, though possibly loud, humming. I suspect that Laennec would have termed Skoda's loud, clear bronchophony pectoriloquy; and that he 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 auscultator's ear is described as being an essential factor of the phenomenon.

Walshe, in the main, appears to follow Laennec. He divides bronchophony into simple, pectoriloquous, and ægophonic. As regards 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 do not think with Walshe that Laennec ever says so expressly. And he himself likens it to the voice heard over the larynx, and says that it appears to pass directly through the stethoscope into the observer's ear, and may throw the concha, and even neighbouring parts of the skull, into more or less strong vibration. He continues: '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 characters, 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 directly into the ear, articulated sometimes with as much, if not more, precision than the laryngeal voice.' He says elsewhere of laryngophony, to which he compares pectoriloquous bronchophony, that the voice is transmitted *imperfectly articulated;* and of natural bronchophony, of which bronchophony in disease is simply a variety, that the articulation is *very imperfect;* showing apparently (as is confirmed by his selection of names) that in his view pectoriloquy and bronchophony are mere grades of the same phenomenon.

The only other writer to whom I shall refer is Dr. Gee, who, in what, on the whole, is 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, seems 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 normally over the larynx.

Now, I cannot venture to say that I have done full 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 and mine are in the main identical; 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 evolved at the rima glottidis and the articulate utterances which are 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 produced at the rima glottidis are, from that very circumstance, in a condition not only to be carried outwards with the expiratory blast, but also to be conveyed inwards, and it may even be to get increased by resonance in the trachea and its tributary air-passages; while, as a rule, sounds developed wholly in the mouth are not only much less loud and much less 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 also to pass the barrier of a more or less perfectly closed glottis.

Indeed, 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, then, means the conveyance to the ear of sounds developed at the rima glottidis; pectoriloquy the similar conveyance of sounds developed above the rima glottidis. The two conditions appear to me to be quite distinct, and though often (possibly in some degree always) united, never to run into one another in the sense of being different gradations of the same phenomenon.

Bronchophony may be either vocal or whispered.

In the former variety, which alone is ordinarily 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, under the same conditions, the deeper and stronger the voice the more unpleasant will be the vibration which it causes in the ear, and the more distinct the vocal fremitus which attends it.

Whispered bronchophony, taken by itself, is little if anything more than expiratory tubular breathing divided into lengths which correspond to the words the patient utters. What we hear, in fact, with the

stethoscope is the unmusical rush of air through the partially open glottis, on which the patient's whispered words are moulded. The sounds uttered do not correspond accurately in duration to the words themselves; for after some letters, and especially after the explosive consonants, a short supplementary rush occurs, which, though almost inaudible in ordinary conversation, is peculiarly loud and distinct on auscultation. Whispered bronchophony is unattended with the sensible vibration which vocal bronchophony inflicts on the ear and often on the hand.

Since speech is always dependent on vocal or whispered laryngeal sound, pectoriloquy cannot be present without bronchophony; but whenever the articulate utterances of the patient can be distinguished through the stethoscope, there pectoriloquy is present. I believe it to be a rare phenomenon; and that most frequently where 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 the inarticulate expiratory gusts of whispered bronchophony are taken for the articulate sounds which the patient utters to dictation, or for those which are given and expected in answer to some leading question. Nevertheless I feel satisfied that it is sometimes met with, and mainly, if not exclusively, in connexion with the whispered voice, in the production of which the glottis is partly open, and the conditions best adapted

for permitting the sounds of articulation to enter the trachea are present.

I do not propose to discuss the significance and importance of pectoriloquy and bronchophony. I am inclined, however, to believe that pectoriloquy is heard mainly over cavities.

2. *Loss or impairment of the laryngeal voice* is one of the common incidents of many diseases which involve the larynx itself or its ministerial nerves. It is a usual temporary consequence of catarrhal and other inflammations affecting the vocal cords and surrounding parts; it is a frequent and often abiding result of syphilitic or tubercular destruction of the vocal apparatus, or of involvement of the same parts in different forms of neoplasms. But the most interesting causes of pathological modifications of the voice are those which are referable to affections of the nerves and nerve-centres concerned in the actions of the larynx. Diphtheria and hysteria often induce paralysis of the motor, and less frequently of the sensory, nerves distributed to this part, the muscles which govern the tension of the cords being those which are most apt to suffer. It is not usual for the movements of the vocal cords to be compromised in cerebral hemiplegia, yet occasionally, no doubt, in such cases the voice becomes enfeebled and monotonous. Much more frequently the central causes of laryngeal paralysis are such as involve the medulla oblongata, and especially, therefore, glosso-labio-laryngeal palsy, disseminated sclerosis, progressive muscular atrophy, and the

development of tumours, syphilitic or other, in or about this centre. Further, any lesion implicating one of the pneumogastric trunks in the neck, or its superior or recurrent laryngeal branch, or any of the subdivisions of either of these branches, necessarily leads to paralysis of the muscle or group of muscles to which the affected nerve is distributed. The whole of this subject is one of great interest and importance, and might well repay analytical investigation. I shall confine my observations, however, to a single point, which to the general physician is probably the most interesting of all—namely, paralysis in the domain of the recurrent laryngeal.

It is well known that this nerve, from its long and tortuous course and peculiar relations to certain important structures, is specially liable to be compressed, stretched, or involved in the progress of material diseases of the root of the neck and upper part of the chest. Among these may be included inflammations of the pericardium and pleura, and especially of the connective tissue in the locality referred to, and goitrous tumours. But the commonest and by far the most important are aneurysms of the aorta or innominate artery, and tumours of malignant character.

Recurrent laryngeal paralysis is generally unilateral, and involves loss of motor power in all the muscles supplied by the nerve: namely, all the intrinsic muscles, excepting the crico-thyroid, which is specially the tensor of the vocal cords, and as such is concerned in the production of the higher notes of the voice. The powers of

adduction and abduction are lost to the cord, as also is so much of its permanent tension as is due to the action of the thyro-arytenoid. If a larynx in this condition be examined laryngoscopically, the paralysed cord will be seen to remain passive about midway between the position it should assume in phonation and that characteristic of ordinary respiration, and motionless, except in so far as it is affected by the air passing over it during inspiration and expiration. The other cord, however, will be seen to execute its accustomed movements, and probably in phonation (being unopposed by its fellow) will be observed to revolve even beyond the median line, so as to come into actual contact with the paralysed cord—the glottis assuming an oblique position, and the healthy corniculum probably passing in front of that of the other side.

In the bilateral form of the disease both vocal cords are of course paralysed, both assume the position characteristic of this affection, and the aperture of the glottis, which is open to about half the extent that it should have in quiet respiration, acquires, as von Ziemssen appropriately expresses it, the cadaveric position.

The symptoms of recurrent laryngeal paralysis are well marked, and, in association with the results of laryngoscopic examination, leave no room for doubt as to their cause. In the case of bilateral paralysis there is usually complete aphonia, in consequence of the permanently patent state of the glottis and the want of effective tension of the vocal cords. Accordingly the voice is reduced to a whisper, and even that is accom-

plished with undue waste of breath and consequent difficulty. From the same cause the acts of coughing and expectorating are impaired in effectiveness. In unilateral paralysis the voice is also affected, but it is not necessarily reduced to a mere whisper. It becomes weak, impure or husky, and of heightened pitch; conditions explained by the combination, of a nearly closed glottis (which, while it permits of the escape of air in vocal puffs, permits also of more or less escape of unvocal breath); of vocal cords which are in different degrees of tension, and therefore cannot vibrate in unison so as to produce a true note; and of a vocal cord (the healthy one) which, on account of the increased effort which the patient makes to speak, is apparently rendered more tense than it would be under ordinary circumstances, and so tends to vibrate with unwonted rapidity. The voice sometimes acquires a falsetto character.

There has been a general belief, I think, among English physicians, that difficulty of breathing also is one of the symptoms due to affection of the recurrent laryngeal nerves. At any rate, it has been maintained, and is, I believe, still commonly believed, that not only the loss of voice, but the paroxysmal cough and dyspnœa, which are so often observed in aneurysm of the arch of the aorta, are the conjoint consequences of implication of the recurrent laryngeal nerve.

It is now eight or nine years ago that several cases came under my care which satisfied me that this view is erroneous, and that the paroxysmal cough and dyspnœa occurring in these cases own a different origin to the

loss of voice with which they are so frequently associated. Especially I had under treatment, within a very short period of one another, two middle-aged men who were suffering from carcinoma, and had also unilateral laryngeal paralysis.

Case 1.—The first patient had cancer of the œsophagus, commencing a little below the situation of the thyroid body and extending for some distance downwards. He had also a few enlarged and hard glands in the lower part of the neck. In addition to the usual symptoms of œsophageal stricture, he suffered from hoarseness of voice, which had only come on recently, and was unattended with soreness of throat or cough. On laryngoscopic examination, the cords were seen to be structurally healthy; but the right one moved freely, while the left was motionless, nearly in the position of closure. The patient remained under treatment for nearly three months, and then died suddenly from hæmorrhage, due to perforation of the left common carotid. At the *post mortem* examination the left recurrent laryngeal was found to be entirely destroyed in a good inch of its course by involvement in the carcinomatous growth; yet he had had no difficulty of breathing from first to last.

Case 2.—In the second case the patient had carcinoma of the retro-peritoneal glands, stomach, and liver, to which the symptoms in the earlier part of his illness were mainly due. Subsequently the lungs became

affected ; and the immediate cause of death was intercurrent pneumonia. On admission into the hospital his voice was a hoarse whisper, and it had been so for six weeks ; but he had not had, nor had he then, either cough or dyspnœa. The right vocal cord acted well, but the left was motionless in the position of almost complete closure. The paralysis of the left vocal cord and the feebleness and hoarseness of voice were persistent up to his death, which occurred three months after admission ; yet, although during the last three or four weeks of his life symptoms of pulmonary disease, with cough and expectoration, got developed, he never suffered from dyspnœa, far less from severe paroxysmal attacks of it. During the last two months he had a manifest difficulty in swallowing fluids, which had a tendency to pass into his windpipe. At the *post mortem* examination, the lungs, trachea, and œsophagus were found healthy ; but the left recurrent laryngeal was involved and lost in a carcinomatous tumour about as large as a filbert.

Now in both of these cases there was clear proof afforded by the autopsy that the patients were the subjects of complete destruction of the recurrent laryngeal ; and it is certain that during life they had suffered from those symptoms which *à priori*, I think, we should be inclined to attribute to that lesion—namely, impairment of laryngeal intonation, and (at any rate, in one of them) difficulty in preventing the entrance of fluids into the trachea ; but there was no trace of dyspnœa, either persistent or paroxysmal.

Case 3.—The next case I shall venture to quote is that of a patient of mine, a man thirty-seven years of age, who died in the hospital about six years ago from aortic aneurysm. His illness was of six months' duration, the last three weeks of which time were passed in the hospital. In the beginning he supposed he had caught cold; and he had from that time up to the day of admission steadily increasing dyspnœa and cough, attended latterly with expectoration. He was a spare man, with some duskiness of face and anxiety of aspect. The local indications of an aneurysm springing from the aorta about the point at which the innominate is given off were quite obvious. His chief sufferings for some little time before he came into the hospital, and during the whole time he was under treatment, arose from difficulty of breathing, which was constant, but liable to sudden terrible exacerbations; during which he had a harsh, metallic cough, lasting until his face became extremely livid, and relieved by the expectoration of muco-purulent fluid. His respiration was markedly stridulous; but there was never any tendency for food to go the wrong way; short-breathed though he was, his voice maintained from first to last its natural quality; and, indeed, there was no indication whatever of paralysis of the vocal cords. His death was due mainly to pulmonary congestion, with lobular pneumonia, consequent in great measure on long-continued laryngeal obstruction. At the *post mortem* examination both recurrent laryngeals were found unaffected; but the trachea opposite the site of the tumour (which was of the size of a small orange,

and arose from the transverse arch of the aorta at the point of origin of the innominate) was much compressed and narrowed ; and already ulceration preparatory to the opening of the aneurysm into the trachea was considerably advanced.

Case 4.—Another case of great interest has recently been under my care. The patient was a ship's steward, twenty-seven years of age, who came into one of my beds at the end of March, 1878, and died on the 1st of February, 1879. He had had syphilis, but no other illness. About four months previously he strained himself in lifting a heavy cask, and a fortnight afterwards was attacked suddenly in the night-time with loss of voice. For this he went under treatment in the Valparaiso Hospital for six weeks. At first he was believed to be suffering from laryngeal catarrh, and was treated accordingly ; but before he left he was told that his malady was not what it had been supposed to be, but aneurysm.

When admitted into St. Thomas's Hospital there was distinct evidence of the existence of an aneurysm, in the presence of dulness and pulsation over a limited area beneath the inner part of the right clavicle, burning pain in the same situation, distension of the jugular veins on the right side, pain down the right arm and up the corresponding side of the neck, and weakness, impurity, and elevation of pitch of voice, associated with paralysis of the right vocal cord. There was no difficulty in swallowing, no dyspnœa of which the

patient complained, and only slight cough, which aggravated the intra-thoracic pain.

I shall not weary you with a detailed statement of all the varying phases of his illness, but will simply enumerate the more important points which it presented. About a week after admission he had a sharp and severe attack of pericarditis, in which for a time his life was despaired of. From this he recovered in the course of two or three weeks. About a month afterwards he had most intense abdominal pain, followed by diarrhœa. These symptoms lasted for three or four days, and recurred a few weeks later. For several months subsequently to the pericardial attack he considered that he was getting better; he felt, at any rate, easier on the whole. The pain in the arm, neck, and chest diminished, and his appetite and spirits improved. But the disease was extending; a systolic murmur, which had not been noticed at first, was detected beneath the inner extremity of the right clavicle; the aneurysmal dulness and pulsation gradually increased in area, and extended beneath the manubrium to the left side; the right radial pulse became smaller and smaller, until it was almost imperceptible; the veins in the neck got larger, and slight œdema of the face appeared. Moreover, though he did not usually complain of shortness of breath, his breathing was manifestly stridulous when hurried or deep drawn. Sometimes also he had to sit up in bed, and had attacks in which he feared he should be choked. Occasionally he complained of a little diffi-

culty in swallowing, and a tendency to choke when drinking quickly.

At the latter part of December (by which time the aneurysm had extended markedly to the left, and had caused prominence of the manubrium, with some infiltration and thickening in the lower part of the neck), he began to complain of pain down the left arm. And, although he had had cough, with occasional shortness of breath and sense of choking, for some months previously, it was now especially that he began to suffer from marked dyspnœa with stridulous breathing, and paroxysmal attacks coming on at first at intervals of two or three days, but subsequently several times a day, and lasting from a few minutes to an hour or more. In these he was compelled to sit up in bed, sometimes sat on the edge of the bed, struggled for breath with frantic efforts, got livid in the hands and face, with prominent and starting eyes, and an expression of the utmost horror; his pulse became imperceptible; perspiration poured from the forehead and face; and occasionally insensibility supervened. These attacks were attended or followed by cough, and more or less abundant expectoration. His death occurred quietly some hours after one of them.

At the *post mortem* examination, an aneurysm of the innominate artery, of the size of a cocoa-nut, and partly filled with clot, was found to have caused erosion of the manubrium, to have obliterated by pressure the right innominate vein, and in some degree to have obstructed the left; to have involved in its parietes and

destroyed the right recurrent laryngeal nerve; and to have compressed and eroded both the trachea and the œsophagus. These tubes communicated freely with one another, and with the interior of the aneurysm, through ulcerated openings, which were obstructed (so far at any rate as that of the aneurysm was concerned) by the protrusion of laminated clot. The aorta was much diseased; and there were found at least three aneurysms besides: one, the size of half a walnut, in the transverse arch, which caused considerable stretching of the left recurrent; another, somewhat smaller, in the ascending arch; and another in the lower part of the thoracic aorta, which was obliterated by laminated coagulum. The right common carotid was completely obstructed, but the subclavian was pervious. The pericardial cavity was effaced by moderately firm adhesions.

In the former of the above cases of aneurysm it will be observed, that the recurrent laryngeals were not in the least implicated, and consequently there was no affection of the glottis, and no impairment of voice; but that the trachea was compressed by the tumour, and the patient suffered from paroxysmal attacks of cough and dyspnœa of the most aggravated character. In the latter case, on the other hand, almost the first symptom of which the patient complained was aphonia due to affection of the right recurrent; but it was not until after some months that he began to show manifest signs of difficulty of breathing, which signs were

evidently connected with the gradually increasing pressure of the aneurysm on the trachea. Nor was it until a later period still, at a time when doubtless the direct implication of the trachea had attained serious proportions, that paroxysmal attacks of dyspnœa and cough arose.

The several cases which have just been narrated show, in the first place, that destruction of the functional activity of one recurrent laryngeal nerve is attended with, of course, paralysis of the corresponding vocal cord (which can be recognised by means of the laryngoscope), with impairment of the musical quality of the voice, and apparently with some difficulty of swallowing, owing to the tendency of food to slip into the trachea, but is certainly not necessarily attended with stridor or dyspnœa; and, in the second place, that compression of the trachea involves stridor, and dyspnœa, which is often paroxysmal, and is liable to end in sudden death, but does not itself interfere with intonation or phonation, excepting in so far as it may render the voice weak by diminishing the supply of wind to the vocal organ. The exacerbations of dyspnœa, occurring in narrowing of the trachea, may be due in some measure to spasm of the muscular fibres of the affected part; but doubtless are referable mainly to accumulation of mucus in or below the point of narrowing, with difficulty in dislodging that mucus in consequence of the mechanical impediment existing there to the performance of an effective cough, and to temporary swelling of the mucous membrane.

The above discussion leads up to a question of some practical importance: namely, as to how far it is advisable, or not advisable, to perform tracheotomy for the relief of patients suffering from difficulty of breathing dependent on the pressure of an intra-thoracic tumour. Dr. Gairdner some years ago advocated this operation for the temporary relief of the dyspnœal attacks which so often complicate thoracic aneurysm; and I believe his opinion has been largely adopted and acted upon. Now, on the assumption that the difficulty of breathing in these cases depends on pressure upon the recurrent laryngeal, and occurs therefore at the laryngeal orifice, tracheotomy is not only a justifiable measure, but one that it becomes our duty to the patient to urge upon him. But if it be clear that the impediment is not there, but in the trachea at a point below the lowest possible point of operation, the question assumes a very different aspect. In most such cases my own vote would certainly be given against its performance.

3. *Paralysis and spasm of organs concerned in articulation.*—I now proceed to make a very few observations in reference to some of those affections of speech in which the mechanical operations on which articulation depends are interfered with by paralysis, spasm, or other conditions.

As a general rule, the greater the skill we attain in the art of so combining and adjusting the movements of particular groups of muscles as to make them the

ready instruments of our will for special purposes, the more automatic do those movements become, and the less their need of the direct guidance of the mind; and the perfection of such skill is reached by the performer only when, losing sight of all intermediate processes, he becomes conscious of nothing, in relation to his performance, save the will to execute and the actual execution. Indeed, the greater the direct attention we bestow on our own mechanical operations the less will probably be the accuracy of the immediate result.

Thus, no healthy man has difficulty in maintaining his balance, and in walking evenly under ordinary circumstances; but there are few who manifest equal steadiness and precision when the having to walk over a narrow plank placed across an abyss diverts their attention from the end in view to the movements of their legs and the actions needed for the maintenance of equilibrium. And thus the accomplished pianiste executes the most difficult passages with consummate skill so long as she thinks simply of the music to which she is giving life; but when, from nervousness or the mere desire to play with special accuracy, her attention becomes divided between the music and her fingers, she is only too apt to become inaccurate and to stumble. The same rule applies to the orator, whose fluency is liable to be checked, and whose language to become confused, when his mind wanders from the subject-matter of his speech to the grammatical construction of his sentences and the careful selection of

appropriate words; and to the ordinary speaker when his attention is diverted from the words he wishes to utter to the organs on whose action utterance depends. It is due to this that soreness, and other like temporary conditions of the mouth, are often attended, not simply by a little thickness of utterance, which is their natural consequence, but by a tendency to leave out or transpose letters or syllables, and to stammer. It is due, in some measure, to this fact that the stammerer's peculiarity of speech becomes aggravated when he is under observation, or is at special pains to speak well, or is nervous. And there is no doubt that the enforced attention which they, whose organs of speech are more or less paralysed, give to the enunciation of their words, brings with it a tendency to blundering enunciation and to stammering.* It may be assumed, I think, that the condition here referred to is a more or less important factor in the defects of articulation which are manifested by all persons who suffer from paralysis or spasm directly interfering with the mechanical performance of speech.

(*a.*) *Paralysis.*—It is curious to observe how little comparatively hemiplegic paralysis of the organs of articulation, or even one-sided paralysis of these organs, due to disease of the motor nerves supplied to them, or of their several nuclei of origin, interferes with the function of articulate utterance. In either of these

* For an interesting discussion on the above subject, see a paper by Dr. Ord ('Notes on Cases of Nervous Disorder'), in the *St. Thomas's Hospital Reports*, vol. iv.

cases the patient can usually pronounce every literal sound without difficulty, but he manifests, perhaps, a slight degree of thickness or want of clearness in their articulation in connexion with one another. Doubtless, also, in some cases close attention will discover traces of the peculiarities of utterance which habitually attend the different forms of bilateral palsy.

It is very different, however, when there is bilateral paralysis of any of the organs concerned in articulation. Thus when, in diphtheria, or from other causes, the soft palate is paralysed; not only is food apt to enter the nose during the act of deglutition, but a distinct nasal quality is added to the articulate utterances, and more especially to the explosive consonants, which become changed more or less completely into their nasal equivalents. And thus, when both facial nerves are implicated, the labials are no longer capable of being pronounced. Quite recently an interesting case of this kind came under my observation in the person of an intelligent young man who had fallen from a height on to the top of his head, and had presumably fractured the base of the skull. At the end of some months he had recovered his intelligence, though he remained emotional, and slightly paralysed in the left arm; but he was nearly absolutely deaf in both ears, and had uniform and nearly total loss of power in both facial nerves. He could not shut his eyes, or close his mouth, and his face was expressionless and almost immovable. He could speak well in other respects, but was absolutely unable to articulate the labial sounds

of *w*, *f*, *v*, *p*, *b*, and *m*, the last three of which were replaced in conversation by the corresponding linguals, and the *f* and *v* by *th*.

One of the most striking forms of general paralysis of the organs of speech is that, which comes on gradually in the so-called 'glosso-labio-laryngeal,' or bulbar palsy, and which may be developed more or less suddenly in hæmorrhage and other acute morbid conditions of the medulla oblongata. In the first stage of the one affection, and in the last stage of the other, the patient may lose absolutely all power over the muscles concerned in phonation and articulation, and may become incapable also of the acts of mastication and deglutition. In glosso-labio-laryngeal palsy, the loss of speech is gradual, and varies in the order of its loss according as the lips, tongue, or fauces are first implicated. It is easy, of course, to understand, that if the lips be paralysed, the labial consonants will be difficult or impossible of utterance; that if the tongue suffer, those which need the use of that organ will succumb; that if the soft palate cease to act, a nasal quality will be given to the voice; that if the laryngeal muscles be implicated, phonation will be annulled or modified in character.

I am bound, however, to say that in this case, and in allied forms of disease which I have carefully examined in regard to articulation, I have often found that, even at a time when the patient's speech was a confused inarticulate babble, which only those who were in constant attendance on him could interpret,

when the lips were scarcely capable of voluntary motion, and the tongue could not be protruded beyond the teeth, and deglutition and phonation were alike affected, he could still, when asked to repeat them, utter with fair distinctness and power all the separate articulate sounds which in combination he found it impossible to evolve. The utterance of the separate sounds, however, has generally been somewhat uncertain, so that I have left the patient's bed at one time with the impression that the labial consonants or some other class of letter-sounds were specially defective, and on my return have found them perhaps more distinctly pronounced than any others.

I may point out that in testing patients who cannot pronounce complex groups of letters, and whose organs are not quite within their control, it is important to make them utter the letter-sounds pure and simple or in easy combinations carefully devised for the occasion, and not to ask them to repeat the names of letters which, like those of *z*, *h*, *w*, and *y*, and many others, are not letters at all, but words compounded of several letters. There is generally a tendency, however, for the explosive consonants to be converted into the corresponding oral or nasal continuous consonants, and for an undue expenditure of breath, which adds a sibilant or wheezy character to all their utterances.

Other well-known affections attended with paralytic impairment of articulation are, tabes dorsalis, disseminated sclerosis, general paralysis, and Sir W. Gull's

cretinoid condition, occurring mainly among women. The peculiarities of utterance which attend these are not unlike those displayed in bulbar paralysis; nor do I think that there is any trustworthy distinctive difference in respect of speech between themselves. In all of them there is feebleness and indistinctness of utterance, which becomes more apparent, and probably blundering, when the patient gets excited or tries to speak rapidly. In all there is more or less liability of the lips to tremble during speech and immediately preceding speech, and for fibrillar tremblings or (if I may use the expression) amœboid movements of the tongue to take place when that organ is protruded. In all of them also there is a manifest difficulty in beginning words and syllables, which sometimes leads to imperfect utterance and slurring of the letters, but which also leads (especially when the patient tries to speak distinctly and to read aloud) to the divided or scanning enunciation which is so characteristic of some of these cases, and even to explosive enunciation. The attempt to speak distinctly involves, not only scanning enunciation, but increased effort on the part of the patient to put his muscles of articulation in motion; which reveals itself, sometimes by needless violence and amplitude in the movements of the lips, sometimes by a curious general elevation of the upper lip attending the opening of the mouth, associated with deepening of the naso-labial sulci, elevation of the alæ nasi, and it may be with yet more extensive co-operation of the facial muscles. Further, there is a common tendency

for such patients to speak with little modulation, and even in a monotone.

Of course, in these, as in other cases, implication of the soft palate imparts a nasal quality to the voice, implication of the larynx leads to more or less complete aphonia, and difficulty of swallowing is liable to supervene.

I do not, by the above remarks, intend to imply that there are no clinical differences as regards speech between the different paralytic affections here grouped together. I believe that in many cases such differences exist; but I think that for the most part they are rather differences of degree than of kind, and not to be regarded as of specific value.

Nevertheless, it is worthy of observation that, in the case of general paralysis of the insane, tremors in the organs of articulation, and a tendency to rapid annulment of the capability of articulation, are specially noticeable; and that in the same affection there is apt to be present a tendency to chatter with the teeth (as if cold) when speaking, a tendency to stammer, and a tendency also for the facial muscles generally, even those of the forehead and eyelids to tremble simultaneously with those of articulation. I have now under my care a young man suffering from general paralysis, but in whom as yet no mental phenomena have manifested themselves, whose face when he speaks breaks out into universal muscular ripples, whose lips tremble violently, whose teeth chatter, and whose words, otherwise well enunciated, come out as they would do from

a person shivering with cold. Some little time back, also, a patient of mine, an elderly Frenchman, who had general paralysis, attended with depression of spirits, and whose case proved very rapidly fatal, presented some peculiarities of speech. At first he had simply the usual tremors; but before many weeks had passed, and while he still retained good intelligence, his lips in the attempt to speak would move as though he were sobbing, then after a minute or two, he would perhaps utter the first syllable of the word in his mind, which would be repeated less and less distinctly in stuttering form until he shook his head and desisted from the attempt.

(*b*) *Spasm.*—The most interesting of the spasmodic affections implicating speech are chorea, and that condition, or those conditions, to which stammering or stuttering is due.

In *chorea* there is generally distinct affection of speech, which in different cases may depend on spasm of the lips, tongue, larynx, or respiratory muscles, or on several or all of these factors combined. Thus the words are sometimes more or less indistinctly articulated, sometimes drawled out, sometimes uttered with explosive impetuosity, sometimes unfinished—being interrupted by a sudden spasm of the lips or tongue, some sucking or other sound effected in the mouth, a grunt or croak developed at the glottis, or a sudden inspiration or expiration. In rare cases, speech is altogether abolished.

Recently I have had under my care a fairly

intelligent little girl of seven, who, while suffering from severe general chorea, lost for at least three weeks all capacity to utter articulate sounds and to phonate. Though understanding quite well everything that was going on around her, she remained absolutely dumb. During the same period she had unusual difficulty in retaining food within the lips, and also in deglutition.

Stammering is a too well-known disorder, coming on usually in childhood, but occasionally at later periods of life, probably in consequence of some sudden impression either on the general system or on the nervous organism. It is characterised by a sudden hitch in the act of speaking—a momentary or longer arrest in the flow of sounds. It is generally held, that it is at the explosive consonants, *b*, *p*, *d*, *t*, *k*, and hard *g*, that the sufferer comes to grief; that the continuous consonants are for the most part pronounced readily; and that vowels are freely uttered.

These statements, however, by no means express the whole truth in relation to the matter. For a little examination of a series of stammerers will show that, while some will perhaps halt especially at the labial, others especially at the lingual, and others especially at the guttural explosive consonants, all, or nearly all, are liable at times to stumble not only at any one of the explosive consonants, but even at those which are continuous, and some even will manifest an impediment to the utterance of simple vowels. When the check occurs at the lips, the evolution of the labial sounds is arrested by a sudden spasmodic closure of the mouth;

when at the point of the tongue, this gets fixed in the position belonging to the utterance of lingual sounds; when at the base of the tongue, this becomes spasmodically approximated to the palate. In some instances, and especially when the vowel-sounds are implicated, the spasm takes place at the glottis. And not unfrequently the stammering, whether occurring in connexion with vowels or consonants, is due to a sudden inspiration. But whatever part the spasm may affect primarily, the arrest may consist either in a sudden, simple, more or less prolonged spasm, or in a series of such spasms in rapid sequence, during which the implicated literal sound undergoes more or less frequent repetition. And, further, there is generally a tendency, especially if the spasm be prolonged, for a greater or less number of other groups of muscles to be involved. So that if, for example, the spasm commences at the base of the tongue, we may find in some cases that the mouth opens widely and remains in that position, the muscles of expression work convulsively, the glottis contracts, respiration becomes arrested, and finally spasmodic movements of remote parts become also excited.

It would be easy to write a detailed description of some of these cases, and to show how individual examples differ from one another; but the final result would be, I think, to prove that their resemblances are far more important than their differences, and that the pathological explanation is the same in all. Speech, as I have shown, is, even in its mechanical details, a

very complicated art; it requires, for its perfect performance, not only that the respiratory apparatus, the laryngeal instrument, and the organs of articulation shall uniformly co-operate with the greatest nicety under conditions which are ever varying; but, as regards the last organs especially, that they shall pass from one arrangement to another arrangement with unfailing ease, certainty, and rapidity. It is generally in connexion with complicated, rapidly varying muscular combinations, which are rendered easy of performance and more or less automatic by long practice, that momentary spasms or hitches are liable to occur and mar the performance.

It is thus that occasionally, the swordsman's arm becomes arrested in some particular attitude, the pianist has to give up his playing because of some recurring sudden inco-ordination, and the scribe especially is seized during his work with momentary spasm or cramp which checks or spoils his writing.

And it is, doubtless, thus that spasm in the utterance of articulate language takes place, and that this spasm (although it may commence in any of the three mechanisms concerned in speech) almost always begins either in the organs of articulation themselves or in connexion with the mutual co-ordination of the several factors of speech—respiration, phonation, and articulation—and at the commencement of words or syllables.

It has been asserted that stammering does not occur when the sufferer whispers or when he sings or intones.

Neither of these statements, however, is accurate. Whispering is frequently attended with stammering, and, although the singing voice is usually free from it, even in aggravated cases, it undoubtedly sometimes suffers.

In concluding this subject, I may remark that I do not pretend to throw any light on the treatment of this affection. Inasmuch, however, as it does not depend on any structural defect of the organs concerned in speech, local remedies, with the possible exception of the continuous galvanic current, are not likely to be of any service. It may, however, be improved, if not cured, by close attention to the management of the breath in speaking, by carefully practising those combinations of letters which are specially liable to give rise to stammering, and by the adoption of a deliberate and carefully balanced method of enunciation.

LECTURE III.

Cerebral Localisation of Speech — Broca's Views — Bastian's, Broadbent's, Ferrier's, and Kussmaul's Observations — Cases.

I PROPOSE in to-day's lecture to confine my attention to those affections of speech which are dependent on lesions of the higher nervous centres—affections which are commonly included under the term 'aphasia.'

Cerebral localisation of speech.—I need not repeat the well-worn story of how Gall and his pupil Bouillaud first localised the faculty of speech in the anterior cerebral lobes; how MM. Dax (father and son) demonstrated, as the result of long-continued observation, that disturbances of speech occurred mainly, if not wholly, in dependence on lesions of the left cerebral hemisphere; and how M. Broca, at a later period, identified the posterior third of the left third frontal convolution, together with perhaps a portion of the adjoining second frontal convolution, as the special centre for articulate speech.

Notwithstanding the striking observations on which this last conclusion was based, and the rapid accumulation of facts which, on the whole, tended strongly to confirm its truth, many distinguished physicians, having

regard to the important exceptions to the rule which occasionally presented themselves, and from a disinclination to believe in the localisation of cerebral functions, hesitated for a time to accept it.

But this localisation, to which many pathological as well as physiological considerations had long pointed, on which Hughlings-Jackson had especially insisted, and which Bastian and Broadbent, in their writings on aphasia (now some years old) had assumed, has during the last few years been established beyond the possibility of doubt by the experimental researches of Fritz and Hitzig and of Ferrier. And some, at any rate, of the apparent exceptions have been in the case of left-handed persons, in whom, we have now ample reason to believe, the functional importance of the cerebral hemispheres, as well as that of the limbs, is transposed.

There are few, therefore, now who, in the main, do not acquiesce in Broca's generalisation that the posterior part of the left third frontal convolution, together possibly with some neighbouring tracts, is the special centre for the expression of the thoughts in language, and who do not also accept his explanation that the predominance of the left side of the brain over the other side is connected with the predominant use of the right arm and leg, and due to a special aptitude of the left hemisphere to take the lead in self-education, in determining actions which require special skill, and in the higher mental operations.

Broca himself, however, regarded the spot here indicated, not as the intellectual centre of speech, but

as the supreme centre for the motor processes of speech, as the agent of the mind for the automatic expression of the thoughts in articulate language, and in writing —a view which Hughlings-Jackson adopts when he speaks of it as being 'the way out' for speech.

Apart from the pathological consequences of disease of this area, there are several considerations which tend to establish the truth of Broca's inference. One is that, in the case of many of the lower animals, experimental injury to the posterior part of the third frontal and lower part of the ascending frontal convolution on one side causes, according to its character, paralysis or spasm of the opposite side of the tongue and lips— a fact which evidently implies a direct connexion through the motor tract between this particular part of the brain and the muscles which subserve articulation. Another is the anatomical fact, that all that region of the cerebral surface which is anterior to the fissure of Rolando, together with the ascending parietal gyrus situated behind that fissure, and therefore Broca's convolution, is specially connected with that part of the corona radiata which springs from the corpus striatum, and the portion of the internal capsule derived from the crusta of the crus cerebri—in other words, with the motor tract. This region, moreover, as M. Betz has shown, is characterised by the possession of giant cells, like those which distinguish the anterior or motor horns of the grey matter of the cord.

If, then, Broca's convolution is to be regarded simply as the centre for the motor processes of speech,

it is clear that it forms a part only of the cerebral mechanism concerned in speech. Dr. Bastian, in his able article before referred to, published ten years ago, insists with great clearness that there are in the cerebral surface 'perceptive centres.' 'It seems almost certain,' he says, 'that impressions from the organs of sense to the perceptive centres in the cerebral hemispheres travel along different routes, although we may be more or less ignorant as to what these routes are, and also as to the extent and situation of the ground occupied in the cerebral hemispheres by the several perceptive centres.' He goes on to say: 'We may be sure that such centres are in connexion with afferent fibres, bringing them into connexion with ganglionic masses, existing nearer the base of the brain and the medulla oblongata; that upon these lower ganglionic masses sensory impressions, travelling along their respective nerves, impinge, and that each there undergoes that first modification of the series which is to convert the primary stimulus into a distinct perception, after the final action of the cells of the cortical substance in the corresponding perceptive centre.'

And the view which he puts forward is as follows:— That spoken words caught up by the ear are carried as acoustic impressions by a definite route to a supreme acoustic centre, where they become perceptions, and get stored up in memory, ready to be revived during thought, and to be translated into articulate speech through the agency of commissural fibres leading from this acoustic centre downwards to the corpus striatum

which he appears to regard as the co-ordinating centre for the motor processes of speech; but that, while written words striking the eye are similarly conveyed to a superior visual centre, there to be converted into visual perceptions capable of revival in thought, writing is effected primarily by the revival of the auditory impressions of words, which then automatically revive the visual impressions of the letters composing words, and thence evoke, through the agency of the corpus striatum, the muscular co-ordinations involved in writing. He assumes also that there is a free intercommunication by fibres between the several perceptive centres and all others; and, adopting Herbert Spencer's view, he regards the power of naming (which is an essential factor of language) as being dependent on the integrity of the memory, and the capability of performing the simplest acts of inference, and its loss, therefore, as apparently the consequence of a general weakening or failure of intellect, rather than of any lesion occupying a definite site.

Dr. Broadbent, in a very ingenious paper read three years later, adopts Bastian's views with some modifications. He assumes, with Bastian, that there are distinct perceptive centres in the convolutionary surface of the brain connected with each of the special senses, in which impressions received from the several organs of sense become perceptions. He assumes, that the centres connected with audition occupy the marginal convolutions of each hemisphere, that words are revived in these as remembered sounds, and that the outlet for 'intellec-

tual expression in spoken words,' or the supreme centre for the motor processes of speech, is situated where Broca places it, in the posterior part of the third frontal gyrus, the cell-groups for spoken words being seated in the corpora striata. He assumes further that, in simple parrot-like repetition or speech, auditory perceptions or remembered sounds originate, in the auditory perceptive centre, a stimulus which acts directly on those groups of motor cells in the corpus striatum, which co-operate in the production of the corresponding articulate movements. But he also maintains, that the perceptive centres fulfil only a subordinate mental function; that in them the perceptive acts are rudimentary only; that they take cognisance merely of those attributes of objects which affect the particular sensory nerves which are in relation with them, and of the causes which underlie them; and that there is a higher centre still, with which all the perceptive centres are in intimate relation, in which are combined the perceptions of these several perceptive centres, and in which a conception or idea of an object as a whole is obtained. This also he regards as the naming centre. And he holds that speech as an intellectual function takes its start, not from the auditory perceptive centre, but from this higher ideational centre, operating through Broca's convolution (which determines the exact combinations of words in which ideas are to be clothed) on the appropriate cell-clusters in the corpus striatum, which by influencing the subordinate nerve-nuclei call forth the combined movements on which articulate language depends.

Broadbent, without discussing the matter at any length, indicates also that other perceptive centres, and notably that connected with vision, have similar relations with that of hearing to the ideational centre, and somewhat similar relations with it to language—at any rate to written language.

The practical difference between these writers seems to me to be: that, whereas Bastian assumes the presence of perceptive centres in which verbal impressions are received and revived in thought, and which in all cases, so to speak, play directly on the keys for verbal enunciation situated in the corpus striatum; Broadbent holds that the processes which Bastian enumerates, and the routes which he indicates, belong solely to words as acoustic impressions and reflex motor reproductions, and that for language as an intellectual function there is a higher centre to which all the perceptive centres converge, and from which, when wishing to express our thoughts in language, impulses proceed first to Broca's convolution (which in the former case is avoided) where the suitable selection of words is made, and thence to the corpus striatum, where, as also in the case of simple reflex speech, the cell-groups which represent articulate sounds and words are called into action. The difference, however, is hardly so great as it seems (excepting in the clear recognition by Broadbent of the linguistic importance of Broca's convolution); for Bastian assumes the presence of some higher mental powers than those which he expressly discusses, and which are concerned in naming and remembering, but he regards

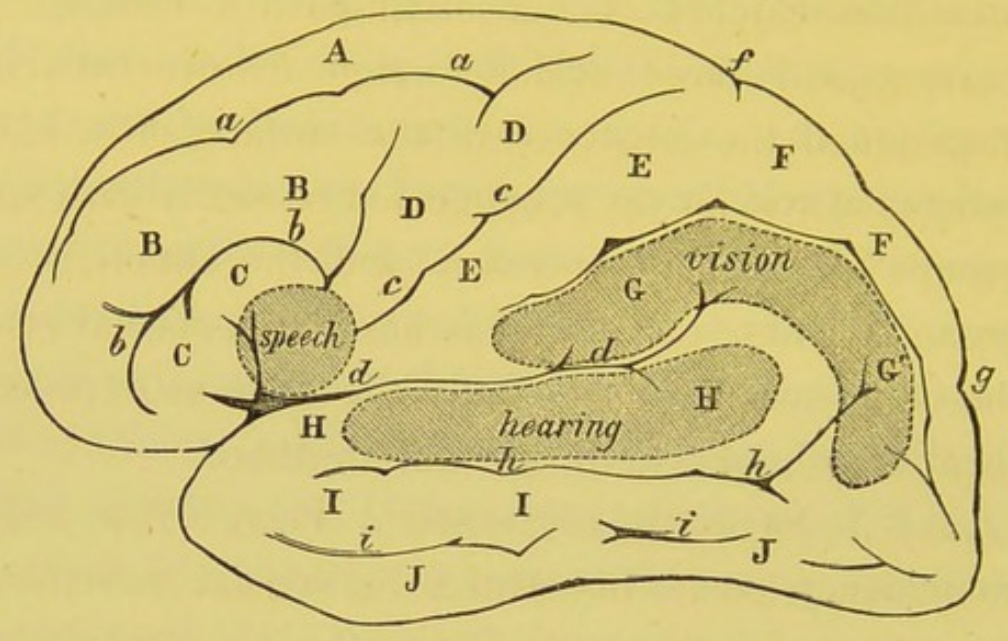
them as functions of the general intellect, and does not, therefore, venture to localise them.

The above views were formulated before the experimental researches of our distinguished colleague, Dr. Ferrier, and those of his foreign fellow-workers, had determined the existence in the surface of the hemispheres of specific areæ, connected severally with specific groups of motor processes, and the different sense-organs. These recent researches give a special value to the older speculations; and while they help to correct them they help also to substantiate them.

As I have already shown, Ferrier, by a happy coincidence, places his centres for special movements of the tongue and lips as nearly as possible in the posterior third of the third frontal convolutions. Immediately above and behind them he recognises centres for the elevation, depression, and retraction of the mouth; and closely adjoining these—namely, in the ascending parietal convolutions—are the areæ connected with specific movements of the hands and wrists. Thus, according to this gentleman, we have on each side a group of centres comprised within a comparatively small area, which would seem to have some specific relation with those movements of the organs of articulation and of the organs concerned in writing which are determined by mental operations.

Again, Ferrier shows, that the perceptive visual centre, the centre connected with the upward termination of the visual tract, occupies the whole extent of the supra-marginal convolution, and the pli-courbe; and

that the perceptive acoustic centre, to which auditory impressions are directly conveyed, corresponds to the whole length of the first temporo-sphenoidal convolution.



LATERAL VIEW OF LEFT HEMISPHERE OF BRAIN, SHOWING PRINCIPAL SULCI AND CONVOLUTIONS; TOGETHER WITH FERRIER'S CENTRES FOR VISION, FOR HEARING, AND FOR MOVEMENTS OF LIPS AND TONGUE, OR FOR THE MOTOR PROCESSES OF LANGUAGE (AS NEARLY AS POSSIBLE BROCA'S CONVOLUTION).

Fissures.—*a* Superior frontal; *b* Inferior frontal; *c* Fissure of Rolando; *d* Fissure of Sylvius; *e* Inter-parietal; *f* Fronto-parietal; *g* Parieto-occipital; *h* First temporo-sphenoidal; *i* Second ditto.

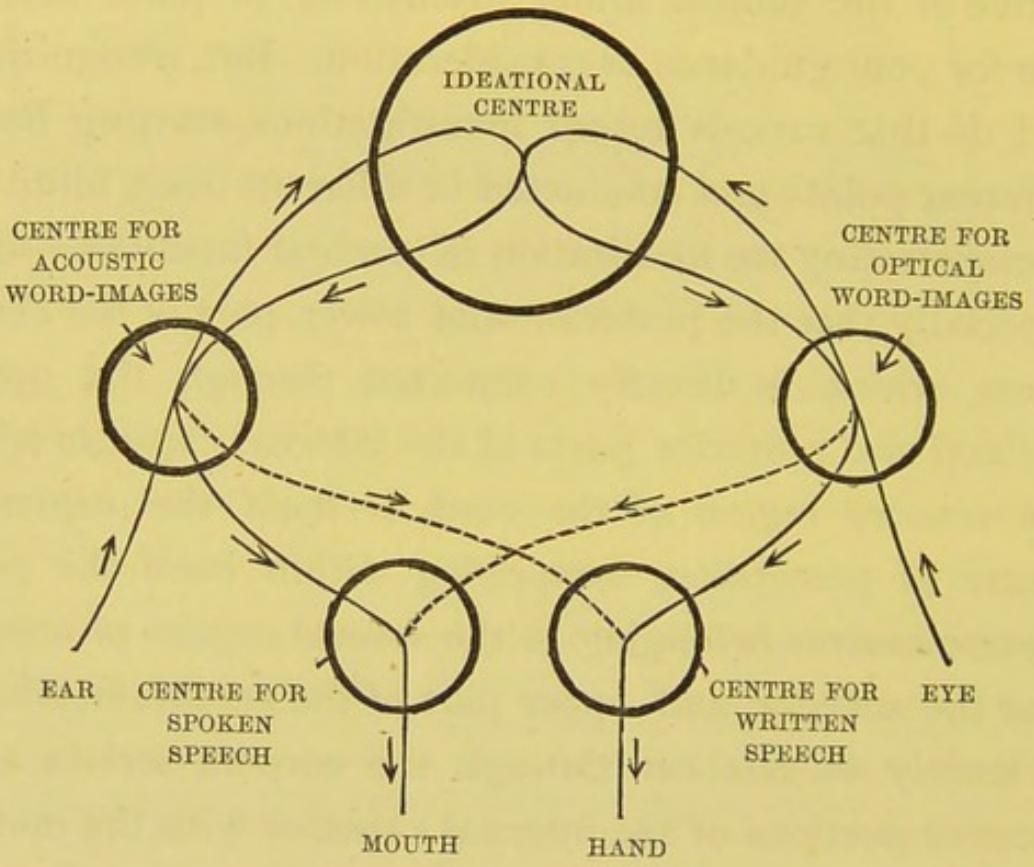
Convolutions.—A First frontal; B Second ditto; C Third ditto; D Ascending frontal or anterior parietal; E Ascending parietal; F Superior parietal; G Supra-marginal; G Pli-courbe; H First temporo-sphenoidal; I J Second and third ditto.

It is an important anatomical fact, that all the motor areæ are comprised within that part of the brain-surface which has a special relation with the motor region of the corona radiata; and that the sensory areæ occupy that portion of the surface which is similarly related to the upward extension of the sensory tract. It is also an important fact that the several motor and sensory areæ above referred to are nearly conterminous,

and therefore so placed as to admit of easy intercommunication; and that they are all included in the district supplied by the middle cerebral artery, and consequently liable to common implication when that vessel is obstructed.

I do not claim to be in any degree a metaphysician; and I have no personal speculations of any value, elucidative of the subject under discussion, to place before you for your guidance or consideration. But, recognising as I do that various recent investigations, starting from different points and conducted in different lines, unite in demonstrating the localisation of cerebral functions—and especially that the posterior and lower part of the cerebrum, which is directly connected through the optic thalami and posterior parts of the internal capsules with the sensory region of the cord, is itself the supreme centre of perception, comprising within itself the perceptive centres belonging to the several organs of sense; that the anterior and upper part of the cerebrum, which is mainly in relation through the corpora striata and anterior portions of the internal capsules with the motor region of the cord, is the supreme centre for the co-ordination of those movements which are directed by the mind, and includes within it subordinate centres which have specific motor functions; and that thus just as the sensory and motor tracts of the cord are in horizontal connexion with one another so that afferent impressions made upon the former are translated to the latter as motor impulses, and just as the optic thalamus and corresponding corpus striatum present similar mutual

relations, so there is reason to believe that impressions made or revived in the sensory areæ of the brain evoke through the corresponding motor areæ special combinations of movements—I am bound to say that I recognise, if not literally, at any rate essentially, some such localisation of the several processes of speech as that represented in the accompanying diagram.



Without binding myself to accept it in detail, I am inclined to think that this diagram, which is simplified from that furnished by Kussmaul in his article on 'Disturbances of Speech,' in Von Ziemssen's *Cyclopædia*, fairly well represents the conclusions that may be accepted provisionally in regard to the arrangement and connexions of the areæ concerned in speech.

He assumes, as will be seen, a sensory centre for

acoustic word-images, and a similar centre for optical word-images, which are presumably, as we have shown, the first temporo-sphenoidal gyrus and the supra-marginal convolution (with the pli-courbe) respectively; he also assumes a motor centre for the co-ordination of sound-movements into spoken words, and one for that of strokes produced in writing into written words, which latter would seem to be situated in or near the third frontal convolution; and he further assumes, with Broadbent, a higher ideational centre, where articulate sounds and the visual images of objects blend, where ideas are formed, and whence the impulses to express oneself in language, whether by the mouth or by the hand, or in any other way, emerge.

And he considers that mere imitative speech either is effected directly in spoken language through the conjoint agency of the acoustic centre and the centre for the speech-movements of the lips and tongue, or indirectly in written characters through the acoustic centre and the centre for expression in writing; or else is evolved directly in written characters through the conjoint agency of the visual centre and the centre for expression in writing, or indirectly in spoken language through the visual centre and that for speech-movements.

And, further, he considers that spoken or written speech as an intellectual operation is evoked in the ideational centre by the action of the perceptive centres, or by the ideas which originate within itself, and that it becomes expressed through the agency of one or other of the co-ordinating centres for word-movements.

The main points of this scheme on which I am disposed to be critical are: first, that I do not recognise any need for assuming that the ideational centre in evoking word-movements should have to act upon the motor centres through the perceptive centres, unless, indeed (as it probably should be), the ideational centre be regarded as merely the diagrammatic differentiation of a special cerebral function which has no exclusive anatomical seat; second, that it seems to me that the diagram ought to have attached to it subordinate co-ordinating centres—namely, on the motor side the corpus striatum, and on the sensory side the optic thalamus; and, third, that the diagram represents the arrangements of only one side of the brain.

It is obvious, indeed (a point on which Broadbent has not been forgetful), both on anatomical and on physiological grounds, and judging from the effects of the destruction of the organs of sense, that the perceptive centres of one side of the brain have little or no preponderance in importance over those of the other side of the brain; and that they differ, therefore, in this respect from the supreme motor centres, and probably also from the ideational centres connected with them, which, so far at any rate as speech is concerned, are potent on the left side, but remain in practical abeyance on the right. So that, consequently, while words seen with either eye or heard with either ear can be perceived in their respective perceptive centres, they not improbably in any case evoke distinct ideas only when they are taken cognisance of in the left side of the brain, and certainly,

as a general rule, only evoke spoken or written language when they act on the special motor organs through the motor centres of that side. As regards the subordinate centres — namely, the corpora striata and optic thalami,— I am inclined to think, with Broadbent, that the motor cell-groups for literal sounds, and probably also those for the mechanical details of writing, are placed in the former ganglia; while on analogical grounds I am disposed to think with Bastian that subordinate sensory co-ordinations take place in the optic thalami.

It is, at any rate, not difficult, with the aid of some such plan, to explain many of the clinical phenomena presented by aphasic patients. Thus it is conceivable, that if the auditory perceptive centres be implicated or their communications with the ideational centre divided, the patient would, as Broadbent urges, fail to understand the meanings of the words which he hears, and probably of those which he utters; that if the visual perceptive centres be affected, or their communications with the ideational centre cut off, the patient would fail to understand written language, and probably lose the power of writing; that if the left corpus striatum or the fibres between this and Broca's convolution be destroyed, there would be at least temporary loss of power of uttering articulate sounds; that if Broca's convolution itself be injured, the capacity for verbal utterance, and probably also that for expression in writing, would be impaired or lost; and that if the ideational centre be the seat of lesion, the patient would no longer be able

to recall words or perform many of the higher mental operations connected with language.

By means of such a plan, moreover, it is easy to understand how persons who have lost the power of recollecting names may yet be able to repeat words dictated to them; and how persons who have lost the art of writing, either to dictation or spontaneously, are yet sometimes able not only to write a copy, but to translate printed words into their written equivalents. It is evident, however, that the close neighbourhood of the several centres above referred to, their intimate and complicated relations with one another by nerve-fibres, the association with the predominant side of the brain of the other side, which probably co-operates with it, though in an uncertain and feeble way, and the fact that the affections of the brain implicating speech, though generally paralytic, are sometimes irritative, collectively render it exceedingly improbable that we shall often meet with typical cases of any simple disorders of speech. Cases that come before us are almost always complicated, and yet the grouping of the phenomena which they present is often curious and suggestive.

It seems to me probable that there is an important difference between the co-ordination of the organs of articulation for articulation and that of the hand for writing. In the former case the different positions which the organs assume are determined, even from the beginning, neither by sight nor by touch, but simply by the nature of the sounds evolved as recognised by the ear; and it is likely therefore that if the

special groups of cells for the co-ordination of the necessary movements should fail to act, the patient might lose absolutely, at least for a time, the power of articulate language, even though he retained the voluntary use of his tongue for other purposes. In the latter case, although, not improbably, a similar series of co-ordinations is developed in the process of learning to write, and might conceivably be destroyed by disease, it is clear that so long as the patient retains the general use of his hand, he must still be able, under the guidance of sight and touch, to copy what is set before him to copy, or, if he remembers the forms of letters, to reproduce them in their proper shapes. It would, of course, be different if the supreme centres for the combined movements of writing were the seat of disease.

From this tedious and, I fear, somewhat barren, disquisition, I proceed to narrate several cases which have been under my care, and are illustrative in a greater or less degree of some of the physiological points that have just been discussed.

Before entering upon my first case, which I have already published in the *Transactions* of the Clinical Society, and which is one of equal rarity and interest, I proceed to cite an analogous case given in Trousseau's *Clinical Medicine.* He says :—'I received one day in my consulting-room a carrier of the Paris Halles, very young, and having the appearance of a man enjoying excellent health. He made signs that he could not speak, and handed me a note in which the history of

his illness was detailed. He had written the note himself, with a very steady hand, and had worded it well. A few days previously he had suddenly lost his senses, and had been unconscious for nearly an hour. When he came round he exhibited no symptoms of paralysis, but could not articulate a single word. He was ineffectually galvanised for a fortnight; but without any special treatment he completely recovered his speech five or six weeks after the invasion of the complaint. It is very remarkable, however, that during the whole course of this singular affection he could manage all his affairs by substituting writing for speech.'

Case 5.—My own case was that of a Canadian, thirty-six years of age, a steward on board a steamer plying between India and China. Having previously enjoyed good health, he was attacked on the morning of March 7th, 1868, while in the Straits of Banca, with headache and feverishness, which were followed a few hours later by a series of violent epileptic fits. He remained unconscious for several hours, and, on coming to, found himself lying on the floor of the cabin; and he soon discovered that, although he could see and understand everything that was going on, he was totally unable to move a limb, had entirely lost the power of speech, and was 'stone deaf.' He could not hear a pistol fired off close to his ear.

He remained in this condition up to the time of his arrival at Singapore on March 20th. He was then transferred to the General Hospital. At that time

his right leg and arm were still weak; his left limbs were numb and quite powerless. He had pain and tenderness of the scalp. He was still perfectly deaf and dumb, and had, further, considerable difficulty in masticating his food, which was due in some degree to pain in the back of the head provoked by the movements of mastication. He gradually improved. In the first week he regained complete use of his right side, and audition so far returned that he could hear when spoken to loudly. His hearing was restored by April 22nd. He also regained to a large extent the use of his left arm, and improved remarkably in his general health.

In the middle of June he left the hospital, and started for England in a sailing vessel. At this time he was still incapable of articulation, had difficulty of mastication, the left leg was useless, and the left arm was so weak that he could not use a crutch which had been provided for him. His voyage lasted four months, and he was received into St. Thomas's Hospital on November 1st.

On admission, he complained of numbness in the left leg, with loss of power and tremors in it when he tried to use it. He could walk totteringly with a stick, dragging the leg after him. The left arm was slightly affected, but there was no paralysis of the right side of the body, and he had (as he had had all along) perfect control over the rectum and bladder. His hearing, sight, and other special senses were healthy. He complained, of pain and tenderness in the scalp, but there was nothing abnormal to be felt there; and of some

pain at the back of the head and neck on the right side, a little behind the mastoid process. He seems also at this time to have had a little difficulty in mastication, yet he could eat solid food, and swallowed with ease. He was unable to speak, but appeared perfectly sensible. There was no sign of heart, lung, or kidney disease.

Three days after admission I saw the patient for the first time. I found that he was quite intelligent, that he understood everything that was said to him, that he could read to himself and comprehend everything that he read, and that he could maintain a conversation of any length—he writing on a slate and his interlocutor speaking. He wrote, indeed, with remarkable facility, a very excellent and legible hand, expressing himself with point and accuracy, except for an occasional error of spelling or construction, due evidently to defective education. But he could not speak; he could not utter a single articulate sound. I ascertained, however, that he could perform, with his lips, tongue, and jaws, all varieties of voluntary movements, and also that he was capable of vocal intonation. I think he could hum a tune, but I could not get him to make the attempt.

No change took place in his condition up to about the 25th of November; at which date, having spoken to him casually from time to time during my periodical visits (for he was not my own patient), I had come to the conclusion that his inability to speak was probably due to his having forgotten how to combine automatically the movements of his organs so as to obtain from them the elementary sounds which in combination constitute

articulate speech, and I had determined to make the attempt to teach him.

I explained to him my view of his case, which he appeared to understand perfectly; and I gave him my first lesson, which lasted five or ten minutes. I showed him that ordinary vocal sounds are compounded of two factors: namely, laryngeal intonation, which he was already capable of producing, and articulation effected by the lips, tongue, and associated parts, of which he was as yet totally incapable. I then got him to sound a laryngeal note; and subsequently, by explaining to him and showing him how to modify the shape and size of his oral passage and aperture, and getting him at the same time to expire either with or without laryngeal intonation, made him sound, both in a whisper and in a loud voice, several of the more simple and obvious vowel-sounds—*a* (in gate), *a* (in art), *a* (in all), *e* (in feel), *oo* (in root), *o* (in hole), and (*ur* vocal). I do not mean to say that he learnt at once to articulate these letters accurately; but he so far succeeded that those about him easily identified his attempts, and he himself fully recognised his success.

At my next visit, three or four days afterwards, I found that he had by practice completely mastered the sounds which I had taught him; and I set to work to teach him the labials—*p*, *b*, *f*, *v*, and *m*. I may as well, perhaps, explain minutely in reference to these letters the method of instruction which I pursued. I closed my lips firmly and then opened them with a sudden smack, and got him to do the same. We both thus

pronounced the essential sound of *p*. I asked him if he did not recognise it as such, and I made him repeat the sound until he recognised it fully. I then explained to him that in order to make the sound perfectly clear, it was necessary that a vowel-sound should be prefixed to or added after it. And I got him to follow up the sound of *p*, as above pronounced, by a vocalised *e*. In his first efforts the two sounds were uttered at a considerable interval one after the other; but gradually he approximated them until he succeeded in making them very nearly continuous. There remained, however, even at the end of the lesson, a slight but quite appreciable fault. Next, closing my lips as before, I produced laryngeal intonation without allowing air to escape through my nose, and whilst producing this sound in my throat, opened my mouth. I made him perform the same acts, and recognise that he had thus, almost without knowing it, articulated the letter *b*. Again, still setting him the example, I got him to place his upper teeth upon his lower lip, and simply blow between them. He thus uttered the sound of *f*, and perceived clearly that he had done so. Then, by repeating the same actions, with the addition of a musical laryngeal note, he sounded and recognised that he had sounded the letter *v*. Finally, I got him to close his lips, and, without opening them again, to make a continuous laryngeal sound—in other words, to allow the air passing between his vocal cords to escape by the nose. The essential sound of *m* was the result. I need scarcely add that not only in the first, but in every

other case, as soon as I had got him to see that he had really articulated the letter-sound I was teaching him, I endeavoured to make him associate its pronunciation with that of some prefixed or appended vowel, and in every case with considerable though not absolute success.

At subsequent visits I taught him, by the same process, the lingual and guttural consonantal sounds; and thus, in the course of four or five lessons, each of about ten minutes' duration, given within less than a fortnight, he acquired the power of articulating all the simple vowel-sounds and all the simple consonantal sounds, including those of *th* (in thing) and *th* (in this), *ng* (in tongue), *sh*, and *z* (in azure).

On December 4th he wrote on his slate: 'I don't feel very well this morning. I got a fall last Thursday night (accidentally); one of my crutches slipped, which gave me a severe shaking. My back is rather painful, and a great deal of pain in the head from the fall. Can pronounce all the vowels now, except *i* and *u*. Can't pronounce *g*, *h*, *j*, *q*, *w*, and *y*.' The truth, however, was, as stated above, that he could pronounce all the elementary articulate sounds, but he could not yet combine sounds which he had not been taught to combine, and therefore he could not utter the names of the letters which he enumerated. It is scarcely necessary for me to remind you that *i* and *u* represent compound vowel-sounds, and that the name of each one of the other letters is made up of at least three distinct literal sounds.

At the end of a fortnight from the beginning of my

treatment I began to teach him to combine letters. Selecting certain consonants, I made him pronounce them in conjunction with the various vowel-sounds. I found little difficulty now in making him do this; and I recommended him to practise new combinations for himself, for which purpose I suggested that a child's spelling-book might be useful to him; and he got one. I think it was at my next visit, three or four days afterwards, that he greeted me for the first time with a somewhat slowly and carefully uttered 'Good morning, sir.' His progress was now marvellous in its rapidity. Within ten days he was able to talk well, except perhaps that he spoke somewhat slowly, and evidently had to give more thought to the pronunciation of his words than healthy people need to do. He improved subsequently in readiness of speech, but even when he left the hospital spoke with apparent effort and slowly. This manner may, however, have been natural to him, for when his speech was restored he spoke with his original American accent.

The lessons which I gave him were, as I have shown, few and short. But he himself, as soon as he had realised the fact that he had organs capable of evolving articulate sounds, supplemented my instruction by the most zealous practice. Thus the vowel and consonantal sounds, which he uttered somewhat imperfectly during a lesson, were learnt accurately by my next visit; and as soon as he had begun to combine sounds he practised them in various combinations with great industry, the sister of the ward, the nurses, and more especially three

or four intelligent patients who were friendly with him, and interested in his progress, giving him constant assistance.

Before he could articulate at all, and in the earlier period of his recovery, he often wrote, 'There is a sort of difficulty I cannot explain which prevents me from speaking;' and always during his earlier attempts he complained of a pain at the back of the right side of the neck and head attending them—pain apparently of the same kind and in the same place as that which had formerly attended the act of mastication. This disappeared, however, before long.

Whilst his recovery of speech was in progress he gradually regained also the use of his left arm. There was no improvement in the condition of the leg, however, up to the end of December. About that time treatment by faradism was commenced, and was continued with rapid success. He could walk without a stick in about a week, and left the hospital apparently well on June 18th, 1869.

Where the lesion was situated which caused the interesting combination of phenomena presented by this case is, of course, only a matter of inference. But all the early incidents of the case, and many of the later ones, point distinctly to implication of the region lying between the floor of the fourth ventricle and the surface of the pons Varolii. That the lesion was a small one, and effected very little permanent damage, is evident; but it must have occupied such a position as, for a time, to have obstructed completely the usual route along

which the co-ordinated impulses for the movements of articulation find their way.

The affection of speech here was a simple and uncomplicated one, and one that may readily be explained by an interruption of the fibres anywhere between the supreme centre for the movements of spoken language and the specific groups of nerve-nuclei whence the several nerves concerned in speech emerge.

I have only once since had a case under my care where I have made the attempt to instruct the patient in articulation. The failure to articulate, however, which was incomplete, was associated with other aphasic phenomena, so that my success was only partial, and not permanent.

Case 6.—The next case I shall quote is also one that interested me very much, and to which I gave considerable attention. It is that of a butcher, aged twenty-one, who was brought to the hospital on January 13th, 1871, having just been thrown from a cart on to his head, and stunned.

On admission he was insensible; both pupils were dilated, especially the right, which also responded less readily to light than the other. There was a lacerated wound on the right temple just above the eyebrow; the right eyelids were swollen, and a little blood was oozing from the nostrils; no discharge from either ear; pulse slow and full; skin cool; respiration normal. He became partially conscious in a few hours, and remained thus until the 17th, when he had a slight fit, attended

with twitching of the face (chiefly on the right side) and rolling of the eyes. This was succeeded by a series of fits, occasionally following one another at very short intervals, until the afternoon of the 19th. In most of these the arms were said to have been stiff, and the left arm and leg convulsed. Between the fits he lay in a semi-conscious condition.

On the morning of the 19th erysipelas appeared in the wound. This proved to be a severe attack; but had subsided by the 31st, when his general health seemed rather better than it had been previously, and his intelligence had decidedly improved. He appeared to understand what was said to him, protruded his tongue when asked to do so, and answered questions imperfectly. About this time a case or two of small-pox broke out in the hospital, and this patient took it. He passed through a mild attack, and it was after this that he came under my care.

When I first saw him he seemed to be in very good health, and wholly without trace of paralysis. He could use his limbs freely; his organs of sense seemed all perfect; he could masticate, swallow, and articulate with facility. He evidently understood everything that was said to him, did in a moment anything he was asked to do, knew as well as he had ever known persons and things, and played quite well at dominoes with other patients; and, indeed, if not required to talk, read, or write, appeared to be a perfectly sound man, both mentally and bodily, except that he was somewhat inclined to be morose and ill-tempered at times. I may

mention here, that he had had a very fair education ; that he could repeat accurately and readily every word that was dictated to him ; that he retained the power of whistling and singing (or rather humming) tunes ; and that, having perfect use of his fingers, he could copy (in the sense of drawing) with pen or pencil whatever was placed before him as well as ever he did, and necessarily also the forms of letters. His inability to express himself in words was very great, and, although by slow degrees he improved in this respect, he was still at the time of leaving the hospital markedly aphasic.

At the early part of my intercourse with him he scarcely recalled the name of anything which was shown to him ; and, when asked to give a name, would sometimes shake his head, at other times utter a word which had no relation whatever to the object before him, recognising, however, almost invariably the error he had made. On close examination it seemed to me that it was not simply in the names of things that his memory was defective, but that there was at least equal defect in availing himself for conversation of verbs, adjectives, and other parts of speech. He spoke, not in single words, but in short sentences, and I noticed that when he endeavoured to talk, there was a tendency to harp upon certain formulæ and to use the same words in the same combinations to express utterly different things. But here, again, even in the process of speaking, he appeared obviously to recognise that he was talking nonsense, would check himself, try to correct himself, and then come to a stop with a puzzled air and gesture of annoyance.

The following examination, conducted some little time after he came under my observation, and after he had improved to some extent, will illustrate some of his peculiarities. A pencil was shown him, which he named correctly. A quill-pen he called after some hesitation a 'pencil,' then, knowing he was wrong, added, 'I used to keep a lot of them.' He recognised the name 'quill-pen' when it was uttered. He could not name a jug, but knew it was not a dog or a plum-pudding, and picked out the word 'jug' when it was repeated with several other words. He failed to name a hat and several other articles of dress, but identified the names unerringly when he heard them. After a short time he was re-examined on the same subjects, and still failed in almost every case to recall the appropriate names. When shown the jug he could not name it, but said, 'I broke it,' not meaning, however, that he did actually break it. He could say some of the letters of the alphabet consecutively, but could not remember even a fragment of the Lord's Prayer, or any text out of the Bible, or verse of poetry. When asked how old he was, he said, after thinking for at least a minute, 'price,' but when asked a second time, answered correctly 'twenty-one.' He was told to count, and immediately, beginning at one, counted correctly up to forty. He was then stopped and asked to begin at one hundred, from which he went on correctly until he was again stopped. He said twice two was thirty. Asking him something about his family, he replied that his 'sister came in at two,' meaning that she died when he was two. He was then

requested to name (without giving him much time to think or any opportunity of correcting errors) the letters of a sentence in a newspaper. The letters and the values which he assigned to them are as follows :—

Letters : When about thirty years ;

Values : Mhth hthtt thwht7 h2ht7.

He was really, as I shall presently show, more skilful at recognising letters than the result just given would lead one to suppose ; but this hurried examination illustrates, though with some exaggeration, the tendency he had to repeat words and passages which were, so to speak, ready to hand. Before he left the hospital he had learnt the names of a good many common things round about him, but his powers of joining in conversation and of expressing his meaning in sentences had improved on the whole but little.

He was always very fond of trying to write letters. But there was little difference in them, and they were always failures. He usually commenced by writing 'My' pretty correctly, followed by 'dear ;' and then, as a rule, lapsed into a meaningless combination of letters or up and down strokes. He could not write to dictation, and he could not read ; but he could copy with ease written words that were placed before him.

On one occasion I opened a large Prayer-book, and pointing to a verse of one of the Psalms, asked him to read it. This he could not do ; and I then asked him to copy it letter by letter—meaning, of course, that he should copy the actual forms of the letters. To my sur-

prise, he translated it accurately, and without hesitation, into written characters in his proper handwriting. The verse was, 'Plead thou my cause, O Lord, with them that strive with me.' I now asked him to read what he had written; and, after careful study, the only words which he attempted were, 'O Lord' and 'them,' the latter of which he called 'then.' I then spelt each word in succession for him, asking him to name them; and again he only recognised 'Lord,' and 'them.' Subsequently I asked him to name each of the printed letters of the verse he had copied, and afterwards each of the letters he had written. The result was as follows:—

Names of printed letters: Plehr thor mr chust O loht hath ther that stroue with he.

Names of written letters: Plea- ther he cahst O lort woth then thet c-nile wish he.

On several occasions I repeated this latter kind of examination, and always with the same result.

He now and then pored over the newspapers; and on one occasion he had a paper with a long account of the opening of St. Thomas's Hospital. I tried to ascertain if he had any understanding of what he appeared to have been reading about. I need scarcely say, perhaps, that he could not read this out loud better than he had read the Prayer-book; but it struck me that he might nevertheless understand the words which he could not utter. He certainly seemed to look through the columns with interest. To test him, I asked him to point out in the report where certain statements (selecting

such as might be supposed to have some interest for him) were to be found. It seemed to me, however, that his condition was very much like that of a person trying to read a book in a foreign language, of which he only knows a few words. He singled out, for example, the names of certain persons connected with the hospital, and pointed out here and there a sentence, the meaning of which he either understood or had a glimpse of. I feel sure he had no general understanding of what he was reading.

The only other point in regard to which I examined him carefully was his knowledge of figures and arithmetic. I have already mentioned that he could count correctly; he could also, when I first saw him, write down figures correctly from dictation. Further, he could do simple addition sums. In doing addition of money, he was less accurate; and, curiously would often name the right figure while writing down a wrong one, or conversely, would name a wrong figure, but write down the proper one. He left the hospital in July.

The points of chief interest in this case seem to me to be comprised in the association, of greatly impaired power of recalling words and their elements, of speaking and writing them, of repeating vocally and of understanding written or printed language, and of writing to dictation; with the perfect capability of repeating all sounds dictated to him and of understanding them, the perfect capability of copying any writing that was placed before him, and even of translating printed words into their written equivalents without however

understanding them, the retention of the musical faculty and in some measure that of calculation, the survival of memory for other things than words, and apparently perfect comprehension of all that was going on about him. It is of course a matter of speculation as to where the cerebral lesion was in this case. There were no paralytic phenomena to guide us. The injury to the right side of the head, associated as it was with subsequent erysipelatous inflammation and aggravation of head symptoms, might seem to point to lesion of that side. On the principle of *contrecoup*, however, it is extremely probable that the part actually injured was the surface of the left cerebral hemisphere, somewhere in the region supplied by the middle cerebral artery—in other words, in that area which includes the several centres presumably concerned in speech. Broca's convolution was probably involved directly. Beyond this I shall not go, excepting to remark that it is easy, with some such diagram as I have placed before you, to explain theoretically most of this patient's mental and linguistic peculiarities.

Case 7.—T. R——, a man thirty-nine years of age, was admitted under my care on Jan. 29th, 1872. He had been attacked about ten weeks previously with a fit, due, I believe, to extravasation of blood, from which he emerged completely paralysed on the right side, and utterly unable to speak even a syllable. In the course of a fortnight he had improved so far as to be able to walk with assistance, and later he began to say a few

words ; but up to the time of admission he remained unintelligible. His words were few and misapplied ; he could not spell out words, for his friends tried him with a box of letters ; and his attempts to write with the left hand resulted, it is said, only in the repetition of the word 'the' over and over again.

When I first saw him his paralysis was incomplete, and he could not employ the right hand for any useful purpose. He understood very imperfectly what was said to him, although he put out his tongue when asked. He could not repeat words to dictation, but had a series of words ready to hand, which he uttered with more or less earnestness and volubility when he wished to speak or answer a question : they were—''stablish,' 'can't,' 'simple,' 'can't afford it,' 'opposite,' 'can't see,' 'yes,' and 'no.' He did not attempt to name, and probably could not name, any object which was placed before him ; nor could he write.

For some little time after he came in there was gradual improvement. His vocabulary extended ; and this extension was partly due to persistent instruction on the part of the sister of the ward, who taught him to say a variety of words and sentences, such as 'good morning,' 'glass of wine,' 'St. Paul's,' 'Prince of Wales,' and 'Princess.' But he had a tendency to curtail or alter the words, so that 'Prince of Wales' became 'iss of Wales,' and 'Princess' 'concess' and 'cess.' He learnt also to say 'sank you, sir.' As he improved in other respects, his power of repeating words dictated to him likewise improved ; but there was always more or less

uncertainty in this respect. And even when he left the hospital, at the end of April, although he had managed to learn and retain a good many words that had been taught him by constant repetition, and although he could often name common objects readily, he more often failed, and failed even to some extent to recognise that a suggested word was erroneous. Thus, a few days before he left, he named a watch, spectacles, hat, and coat, but could not name a cap; and when asked if the sister's cap was a nightcap, assented, and then looked sheepish; called my nose 'spectacles;' could not name a pen or an inkstand or a key, and when asked if the last was a lock, replied 'yes.' When puzzled, he would frequently exclaim, 'Oh dear, oh dear!'

There were a few additional points of interest in his case. At first he did not appear to be able to write at all, but once or twice I got him to make the attempt to copy with his left hand. I drew a geometrical figure, for example, and tried to explain to him that I wanted him to imitate it. On the first occasion he simply drew a series of indefinite and meaningless lines. Subsequently, however, he reproduced it with an obvious attempt at imitation, but imperfectly, as a young child might do. I drew also a capital Roman 'A' and one or two other easy letters, which he copied, as one might have expected, with moderate success. I then drew a hasty caricature, consisting of a couple of circles for the head and body respectively, with straight lines for the arms and legs, and asked him to copy it, which he did. He was sitting at a table at the time, with a good many

students and other persons around him, and, on the impulse of the moment, I suggested to him to take the portrait of some one standing opposite. He at once drew such a figure as he had drawn before, and then, with a sudden twinkle in his eye, added one or two strokes which gave some point to the caricature.

Latterly, though he could not write spontaneously, or to dictation, he reproduced in writing two words out of a sentence in the Prayer-book which was placed before him.

When first admitted he did not appear to recollect anything that he had learnt; but when he had recovered the use of language to some extent I found that he was able to count up to ten or twelve, and that he could repeat the Lord's Prayer in a fashion; that is to say, he would utter a kind of jargon which was, for the most part, meaningless, but in which could be detected here and there actual words of the prayer, and here and there words or sounds which were imperfect or remote reproductions of the actual sounds. At any rate, the ear could follow him, and it was generally possible to recognise the particular sentence he was uttering.

I do not think he could read: at any rate, he could not point out letters or words; and although on one or two occasions he apparently read the Lord's Prayer in the same manner that he repeated it, I am inclined to think he said it chiefly from memory; for once, after completing the prayer which was before him, he added

to it (as though he were reading it) the doxology, which was not before him. Shortly before he left the hospital he sang, at my request, 'God save the Queen.' The tune was satisfactory; the words, of course, were inaccurate, and only partly distinguishable.

There are some striking resemblances, and, at the same time, some important distinctions between this case and the previous one. In both there was marked inability to express themselves in spoken words, to read and to write; and in both the capacity to sing survived, at any rate, to some extent. But whereas in the former case the patient could speak unerringly to dictation, and always knew the right word when he uttered it or heard it, and had a clear comprehension of everything that was said, and of all that was going on about him; in the latter case there was a difficulty, even at his best, in repeating words, he frequently used words in an entirely wrong sense without appearing to know it, and there seemed to me to be also a marked failure of his general intelligence. He could not, I think, do simple arithmetical sums as the other did; but he recollected much better than he, not, perhaps, the actual words of the Lord's Prayer, and of other things which he had learnt, but rather the general sound or rhythm, as a young child will sometimes do.

As I stated at first, I have reason to believe that the patient was suffering from the results of hæmorrhage into the left hemisphere, which was probably situated as usual in and external to the corpus striatum, and so affected the surface of the brain, not so much directly

as by pressure and interruption to the fibres passing from the surface to the central ganglia.

Case 8.—S. A. L——, a married woman, aged about fifty, came under my care on the 12th of July, 1878. Her history was imperfect; but it appeared that she had been abroad, that she was a person of some education, and that for three months she had been confined to the house with rheumatism. On the day of admission she had a fit, and was brought to the hospital in a state of almost complete unconsciousness.

It was ascertained, that there was a systolic murmur at the apex of the heart; that there was complete right-sided motor paralysis and hemianæsthesia; and that the left pupil was contracted. At this time the face was turned strongly to the left side. During the next few days consciousness returned to a considerable extent, and she began to recognise those about her; but the right arm and leg remained absolutely without power of voluntary motion; hemianæsthesia was complete up to the middle line; reflex action could, however, be readily excited by touching the hand, foot, or eyelid; the right pupil remained more dilated than its fellow, though both acted to light, and it was determined, beyond all doubt, that she was totally blind of the right eye. She understood very imperfectly what was said to her, and did not attempt to utter articulate sounds, or even to protrude the tongue beyond the teeth.

About three weeks after admission she began to suffer severe pain in the right arm, especially when it

was moved, and frequently screamed out. There was no rise of temperature at this time. A day or two later she spoke for the first time, replying to all interrogations 'stomach,' 'stomach.' From this period there was gradual recovery of sensation in the right side, associated with gradually increasing rigidity and pain in the arm and leg on passive movement, and the sight of the right eye returned; but there was no restoration of voluntary power. She certainly improved in mental condition, yet she continued to say 'stomach,' and occasionally 'no,' in answer to all questions. Sometimes she would pause and apparently strive to use other expressions, but it always ended by the word 'stomach' slipping out.

I shall not pursue the history of this case in chronological order; and may at once say, that she remained under my treatment until late in February, 1879, when she was discharged at her own request; that during this time the paralysis of the arm and leg continued absolute, associated with rigidity and pain on movement; that her general health remained good; and that, although rapid improvement took place in her power of speech for a short time after improvement began, it reached only a certain point, and for the last four or five months there was very little appreciable change in this respect.

Her difficulty in naming things was always very great. She could only rarely designate correctly things that were shown to her, and almost invariably failed to name her thumb, fingers, nose, eyes, and ears. On one

occasion, when shown a pen, she called it a 'sixpence;' on another she misnamed it 'thumb;' and when asked its use, answered, 'write a pen with,' but still could not name it; and on another she made no apparent attempt, but exclaimed, 'gone out of mind,' 'stupid.' Once when I asked her to name her nose, she called it 'eyes;' when, however, I pointed to her eyes, she also replied 'eyes;' subsequently she called nose 'bears.' At the same time she became puzzled about her teeth, lips, tongue, &c., and presently exclaimed, 'I've lost those faculties.'

But it was curious that on several occasions when I showed her well-pronounced colours she named them with scarcely a mistake, and that generally she was equally accurate as regards the designation of pieces of money. Proper names were always a special difficulty with her. On asking her her own name she generally could not give it. Not unfrequently, however, she would answer 'Sarah Ann,' which were her Christian names, and then stop. Occasionally by a sudden impulse she would add 'Harris' (this being her maiden name), or L——, the name of her present husband. Much more commonly she could not think of these words, and generally forgot them a few seconds after she had said them. When her former and present surnames were mentioned to her at the same time, she was often in doubt as to which of them was the right one. Once she said her name was 'tablespoon.'

She was often very talkative, and would sometimes utter long sentences which were quite appropriate,

sometimes expressions which were altogether wide of the mark, and still more frequently an unintelligible gabble which appeared to be divided into words and sentences, and which came out with extreme volubility. It was interesting, that she would often talk nonsense, or continue her gabble for a considerable length of time, with great earnestness, under the evident impression that she was expressing her thoughts in intelligible language, and yet that she would occasionally check herself, and apparently recognise that what she was saying was meaningless.

In November she was selected as one of the subjects for clinical examination by candidates for the degree of M.B. of the University of London, and was removed for that purpose in a lift from her own ward to the one above it. This excited and alarmed her very much, and when I saw her after her return, she poured out a flood of incoherent sounds, among which could occasionally be detected such expressions as 'Lord 'a mercy,' 'never shall forget it.' It is worth noticing that the candidate to whom she was allotted, after investigating her case for some time, came to the examiner and said he could make nothing of her, for she was a foreigner, and he did not understand her language. On one occasion when she was thus speaking unintelligibly, I interrupted her by asking if she called that English; to which she replied, 'I don't think it is, but I can't read.' At another time, when asked how she was, she said at once, 'I feel awfully cold, and you look as though you were cold.'

I tested her several times in regard to letters and numerals. On one occasion she counted up to seven, and then stopped; she also said the first three letters of the alphabet, then added *e* and came to a standstill. I asked her how much 10 times 10 was, when she exclaimed, 'Oh, dear! too long; you astonish me!'

I then tried to make her repeat the alphabet after me. Many of the letters she said correctly, but many she mispronounced; in place of some she said 'yes,' 'no,' 'one,' 'two,' or some other word; and at times, instead of repeating the letter I dictated, she went on to the next. I subsequently examined her on the Lord's Prayer. I asked her if she could say it. Her reply was, 'I can't see to-night; I never could.' I urged her to try, and she said, 'Lord, and of the—oh! I can never get through it.' I then suggested, 'Our Father,' which she repeated, added a quantity of unintelligible stuff, and wound up with 'I am sure I can't.'

Her difficulty and uncertainty in reading and distinguishing letters were quite as great as those in speaking. Once I showed her a ticket printed in large type, to the following effect: 'St. Thomas's Hospital.—No article of food is to be brought into the ward or given to any patient without the permission of the sister,' &c. She said, 'No medicines brought into the gallery without.' Subsequently she read the word 'Thomas.' But she did not recognise all the words, and could not point to a single letter or name one. Shortly before she left the hospital, I printed her name and my own, together with several other words, in large capitals,

and placed them before her. She picked out her own name and read it, 'Sarah Ann L——.' But a day or two afterwards, she read the same words as 'Sarah Ann Harris.' She made out the 'Dr.' prefixed to my name, but could not read the name itself. She knew, however, that it was my name. At another time, when trying to read unsuccessfully, she exclaimed, 'I have it in my head, but I cannot say it,' and several times exclaimed, 'Oh dear! oh, dear!' with a look of perplexity and annoyance.

On one occasion I tried to find out if the flavours of things would recall their names, and I placed successively on her tongue sugar, salt, and mustard. She did not at all approve of the experiment, which failed; and when she tasted the mustard, she exclaimed vehemently, 'stinking stuff!' I several times asked her to try and sing, and at length prevailed on her to strike up 'God save the Queen;' the words were imperfect, and there was a total absence of musical inflexion.

I must add that, although she evidently understood a good deal of what was said to her, there was, even to the last, much uncertainty in this respect; that only two or three days before her discharge she was hopelessly puzzled with respect to the actual meanings of the words 'nose,' 'eyes,' 'ears,' 'lips,' 'tongue,' 'teeth,' and 'hair;' and that, although she could generally put out her tongue when told to put it out, she would often point to her nose or eyes when asked to point to her tongue.

As regards the morbid anatomy of this case, there is good reason to suspect, not only from the mental

symptoms, but from the association with complete motor hemiplegia of hemianæsthesia and loss of sight in the right eye, that the middle cerebral artery was obstructed at its commencement, and that consequently a large extent of cerebral substance, including Broca's convolution, and the acoustic and optic perceptive centres, had undergone softening. The patient's symptoms, which were much like those of the case last described, were in many respects such as might be expected under the circumstances; especially if it be assumed that the functions of this part of the brain were impaired but not absolutely destroyed, or, what is more likely, that the functions of these parts being to a large extent annulled, their linguistic duties were supplemented by the inefficient correspondingly situated region of the right hemisphere. She had difficulty and uncertainty in understanding both spoken and written words, and in repeating words dictated to her. She had a similar difficulty and uncertainty in naming things which were shown to her; and although she at times uttered appropriate groups of words, she much more frequently used erroneous words or spoke a senseless jargon, without knowing that she was talking nonsense. Her general intelligence was much less seriously impaired than her knowledge of language might have led one to suppose.

The last case which I shall venture to narrate is chiefly interesting from the fact that it adds one to the list of cases in which left-sided hemiplegia in a left-

handed man was attended with typical aphasic symptoms.

Case 9.—J. W——, twenty-six years of age, came under my care on the 17th March, 1874. He had been attacked with rheumatism between four and five weeks before. A fortnight later, when his rheumatism had subsided, he was seized suddenly with loss of speech and incomplete paralysis of the left side. He could walk from the first, and from the first could only say the words 'little,' 'yes,' and 'no.'

On admission he presented partial paralysis of the left side. He could walk, but the leg was weak and dragged; he could not grasp so strongly with the left hand as with the right; the mouth was drawn to the right and the tongue protruded to the left; there was no impairment of sensation. A well-marked systolic murmur was audible at the apex of the heart, and bronchitic râles were abundant over both lungs. His vocabulary was limited to 'yes,' 'no,' and 'little, little,' which he repeated volubly and with energy in reply to all questions. For the most part he failed to repeat words which were dictated to him, but occasionally short easy ones, such as 'blue' and 'red' slipped out as if by accident. He did not understand all that was said to him; laughed when I asked him if he was one hundred years old, and said 'No;' but replied 'Yes' seriously when I inquired of him if he was two. When told to put out his tongue he put it out, but when asked to grasp my hand or to shut his eyes, he still put out his tongue. He could not name any object. I ascertained

that he had not learned to read or write, and that he was left-handed. I tested this latter statement repeatedly by making him use a knife and fork in my presence, when, invariably, notwithstanding the comparative weakness of his left hand, he used that for cutting.

He improved in respect of speech from the time of admission onwards. He gradually acquired the power of uttering a few sentences, and of counting, but to the last had scarcely any power of naming; moreover he had a marked tendency to mispronounce consonants, and especially to replace those situated at the beginnings of words and syllables by *l* or *b*. He also became more ready in repeating words dictated to him, with the exception that *l* and *b* largely replaced other consonants. In saying the alphabet to dictation, most of the explosive consonants were called *b*. Latterly he appeared to understand everything that was said to him.

Unfortunately, while the patient was improving mentally and as regards speech, symptoms referable to his valvular lesion rapidly developed. These became serious about the 4th of April. Pulmonary apoplexy with hæmoptysis and difficulty of breathing, enlargement and tenderness of the liver with jaundice and vomiting, albuminuria, and general dropsy successively supervened, and he died on the 27th.

The *post mortem* examination was made on the following day. The lungs were congested, and contained several recent apoplectic clots. The liver was rather small and soft, but somewhat bile-stained, and in

a nutmeg condition. The spleen contained one or two hæmorrhagic blocks. The kidneys were hyperæmic, especially in their medullary portions, and one presented an old depressed block. The heart was hypertrophied, especially on the right side; and recent vegetations, forming in some places pendulous masses, were attached to both the aortic and the mitral valves. The aortic valve prevented regurgitation, but the mitral orifice was contracted, and the valve incompetent. A secondary branch of the right middle cerebral, near a bifurcation, was obstructed by an embolus, which was as large as a pin's head, and the region to which the obstructed system of vessels led was yellow and soft, while the pia mater over it was thickened, opaque, and adherent. The affected region included the posterior part of the third frontal convolution, a small portion of the second frontal above it, the lower parts of the anterior and posterior ascending parietal convolutions, a small patch of the supra-marginal convolution, and a good deal of the adjoining first temporo-sphenoidal, together with the convolutions of the island of Reil. The right corpus striatum was a little yellower than the other, and possibly softened. But the changes presented by this body were very slight.

In this case, as generally occurs in cerebral embolism, and as might have been supposed from the linguistic symptoms presented during life, a somewhat extensive area of the surface of the brain had undergone softening. The diseased area included, in fact, not only the recognised speech-centre, but also a portion of the centre for

visual perceptions, and a considerable extent of the auditory centre. His symptoms were much like those exhibited by S. A. L——, in whom also there is reason to believe that the cerebral affection was due to embolic softening, and was of wide distribution.

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