

## S E C T. VII.

*Of the Sense of Hearing.*

THE sense of hearing, like that of seeing, conveys perceptions of distant objects; it is, of course, subject to similar errors, and must deceive us, when we have no opportunity of rectifying, by the touch, the ideas it excites. The sense of hearing communicates no distinct intelligence of the distance of sonorous bodies. A great noise at a distance, and a small one when near, produce the same sensation; and, unless we derive aid from the other senses, we cannot distinguish the distance of the one from that of the other.

When we hear an unknown sound, we can neither judge of the distance, nor of the momentum of the stroke which gives rise to it. But, whenever we can ascertain the species of any individual sound, we are able to guess both at the distance and momentum of the stroke. If, for example, we hear the report of a cannon, or the sound of a bell, we compare them with those of the same kind which we have formerly heard, and form a gross judgment both of their distance and momentum.

Every

Every body that impinges on another produces sound: This sound, in non-elastic bodies, is simple, but multiplied in those which are elastic. When we strike a bell, a single stroke produces a sound, which is successively repeated as long as the sonorous body continues to vibrate. If, therefore, we had not acquired the habit of judging every sound to be single which is produced by one stroke, we would conceive all sounds to be multiplied. On this subject, I shall relate an incident that happened to myself. When lying in bed half asleep, my clock struck, and I counted five strokes of the hammer on the bell, which I heard distinctly. I immediately rose, and, upon examination, found, that it was only one o'clock, and that one stroke only had been struck on the bell; for there was not the smallest derangement in the machinery. After a little reflection, I concluded, that, if we knew not from experience that a single stroke should produce but one sound, every vibration of a bell would be heard as a separate sound, and as if several strokes had successively been repeated on the sonorous body. When I heard the clock strike, I was in the same situation with a person who had heard for the first time, and who, having no idea of the manner in which sound is produced, would judge only by the impression made on the ear; and, on this supposition, he would hear as many distinct sounds as there were successive vibrations.

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It is the number of vibrations excited in elastic bodies which constitutes the tone of sound. There is no tone in a simple sound. The report of a gun, or the crack of a whip, produce different sounds; but they have no tone. It is the same with every instantaneous sound. Tone consists in the duration of the same sound for a certain time. This duration of sound may be effected in two different ways: The first, and most common, is the succession of vibrations in elastic and sonorous bodies. But the same effect may be produced in non-elastic bodies by a quick repetition of strokes; for a succession of vibrations acts upon the ear in the same manner as if each vibration were a separate stroke.

By considering, in this view, the production of sound, and the different tones which modify it, we shall find, that a repetition of equal strokes is necessary to produce a tone from bodies incapable of vibration. If the number of equal strokes be augmented in the same time, the tone will only be rendered more equal and perceptible, without changing either the sound or the tone produced by the strokes. But, if the force of the equal strokes be augmented, the sound will be stronger, and the tone may be changed. For example, if the force of the stroke be doubled, it will produce a sound doubly strong; and if the tone of the former was an octave, that of the latter will be doubly grave.

May

May not elastic bodies, when set a vibrating by a single stroke, be regarded as bodies whose figure and length precisely determine the force of the stroke, and limit it to the production of a certain sound only? If one stroke on a bell have only half the force of another, it will not be heard at so great a distance, but it will still produce the same tone. It is the same with the string of an instrument; the same length gives always the same tone. Should not this lead us to think, that, in the explication of the production of different tones by the greater or smaller number of vibrations alone, we mistake the effect for the cause? For, the vibrations of sonorous bodies being nothing else than what is produced in non-elastic bodies by a frequent repetition of equal strokes, a greater or lesser number of vibrations should have no more influence, with regard to tones, than the quicker or slower repetition of strokes made upon bodies which do not vibrate. Now, this quicker or slower repetition of strokes produces no change; neither ought the frequency of vibrations; and the tone, which, in the first case, depends upon the force of the stroke, depends, in the second case, upon the volume of the sonorous body. If it be double the thickness, and of the same length, or double the length, and of the same thickness, the gravity of the one will be double, in the same manner as the tone of a non-elastic body is doubly grave,

grave, when struck with a double weight or force.

If we strike a body incapable of vibrating, with a double force, or a double mass of matter, it will produce a sound doubly grave, or an octave lower; for it is the same thing as if we struck with two equal masses instead of one of them, which would necessarily double the intensity of the sound. Suppose, then, that two non-elastic bodies are struck, the one with a single mass, the other with two, each of them equal to the first; a sound would be produced by the first body, whose intensity would be only one-half of that produced by the second. But, if we strike one of these bodies with two masses, and the other with three; in this case, the first body would produce a sound, the intensity of which would be one-third less than that produced by the second. In the same manner, if we strike the one body with three equal masses, and the other with four, the former will produce a sound, the intensity of which will be one-fourth less than that produced by the latter. Now, in comparing numbers, we comprehend them most easily in the proportions of one to two, one to three, one to four, &c.; and, of all the proportions comprehended between the single and the double, those which we perceive with the greatest facility, are two to one, three to two, four to three, &c. Thus, in judging of sounds, the octave corresponds best with the original

original sound, then the fifth, and then the fourth; because these sounds are in the above proportion. For, if we suppose the small bones of the ear to be hard unelastic bodies, which receive strokes of equal masses of matter, we would more easily refer the sound produced by one of them to a certain standard, if the other sounds were produced by masses that were proportioned to the first, as 1 to 2, 2 to 3, or 3 to 4; because these are the proportions which the mind recognises with the greatest facility. Thus, in considering sound as a sensation, the pleasure arising from harmony appears to consist in the proportion between the fundamental sound and the others by which it is succeeded. If these other sounds measure exactly the fundamental sound, they will be always harmonious and agreeable; but, if they are incommensurable, they will be harsh and discordant.

It may be asked, why should one proportion, when it is exact, be more agreeable than another, which is less exact? I answer, that the cause of pleasure originates from this justness of proportion; for, whenever our senses are acted upon in this manner, an agreeable sensation is the result; and disproportion, on the contrary, is always disagreeable. We may recollect what was said concerning the blind man who received his sight from the dexterity of Mr. Cheselden. When he began to see, regular objects were more agreeable to him than those which were rough and irregular. It is, therefore, unquestionable,

able, that the idea of beauty, and the pleasing sensations we receive by the eye, originate from regularity and proportion. It is the same with the sense of touching: Smooth, round, and uniform bodies, afford us more pleasure than those which are rough and unequal. Thus the pleasure arising from the sense of touching, as well as from that of seeing, is founded in the proportion of objects. Why, therefore, should not the pleasures of the ear proceed from the proportion of sounds?

Sound, like light, is not only propagated at a distance, but is capable of being reflected. The laws which regulate the reflection of sound are not indeed so well understood. All we know is, that sound is reflected when its motion is interrupted by hard bodies: A mountain, a house, a wall, reflect sound, and sometimes so perfectly, that we imagine it proceeds from a direction opposite to that of its original motion. Smooth concave surfaces, as vaults, hollow rocks, &c. produce the most distinct echoes. The internal cavity of the ear is fitted for reflecting sound in the most perfect manner. It is hollowed out of the hard part of the temporal bone, like a cavern in a rock. In this cavity sounds are repeated and articulated; this repetition of sound excites vibrations in the solid parts of the lamina of the cochlea, which are communicated to the membranous part of the lamina; and this membranous part is an expansion of the auditory nerve,

nerve, which conveys these different vibrations to the mind. As the osseous parts are solid and insensible, they can receive and reflect sounds only; the nerves alone are capable of producing sensation. Now, in the organ of hearing, the only nervous part is a portion of the spiral lamina; all the rest is solid; and hence I have made this part the immediate organ of hearing, which may be further proved by the following reflections.

The external ear is only an accessory to the internal. Its concave windings may augment the quantity of sound; but we can hear very well without the external ears, as appears from dogs and other animals, which have had these organs cut off. The membrane of the tympanum is not more essential to the perception of sound than the external ear; for many persons have heard distinctly after this membrane was either entirely or partly destroyed. Some persons can make the smoke of tobacco, silk cords, lead plates, &c. pass from the mouth to the ear, and yet they hear as well as other men. Neither do the small bones of the ear seem to be essential to hearing. It has frequently happened, that these bones have been curious, and have even come out of the ear, without destroying the sense of hearing. Besides, birds have no such bones; and yet they have most delicate ears. The semicircular canals appear to be more necessary. They are a kind of winding tubes in the os petrosum,

that seem to direct and conduct the sonorous particles to the membranous part of the cochlea, upon which sound acts, and the sensation of it is produced.

Deafness is incident to old age; because the density of the membranous part of the lamina of the cochlea augments in proportion as we advance in years. When this part becomes too solid, the person grows dull of hearing; and when it is entirely ossified, deafness is the consequence; because there is no longer any sensible part of the organ capable to transmit the sensation of sound to the mind. A deafness proceeding from this cause is incurable. But, when it proceeds from a stuffing of the auditory canal with wax, or other viscid matter, it may be removed by syringing, or even by instruments. We may easily ascertain whether deafness be occasioned by any external or internal cause, by putting a repeating watch into the person's mouth. If he hears it strike, he may be assured that his deafness is effected by an external cause, and that it, in some measure, admits of a remedy.

I have often remarked, that men who have unmusical ears, and bad voices, hear better with the one ear than with the other. I formerly observed, that squinting was occasioned by an inequality of strength in the eyes: A person who squints sees not so far with the distorted eye as with the other. From this analogy I was led

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to make some experiments on men who sung falsely; and I uniformly found that they heard better with the one ear than with the other. Through each ear they receive a different sensation, which produces a discordance in the total result; and thus, by always hearing false, they necessarily sing false, without perceiving any defect. Persons of this kind are likewise often deceived as to the quarter from which a sound comes. If their best ear be the right one, sounds will more frequently seem to proceed from the right than from the left. I speak here of such persons only as are born with this imperfection; for, though a man advanced in life may, by accident, have one ear duller than another; yet, as he was formerly in the habit of receiving just perceptions of sound, neither his ear nor his voice will be affected by the change.

Trumpets or funnels employed to assist the hearing, answer the same end as convex glasses to old or decayed eyes. The parts necessary to hearing, as well as those necessary to vision, become blunt and insensible with age; and, therefore, each of them equally requires the assistance of art to augment the quantity of the medium through which their peculiar sensations are transmitted. Trumpets for facilitating hearing might be rendered as extensively useful to the ear, as telescopes are to the eye; but these trumpets could not be employed with advantage, except in solitary and silent places; for neighbouring

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sounds are uniformly collected and blended with those at a distance, and produce in the ear nothing but a confused noise.

The sense of hearing is of more importance to man than to any other animal. In the latter, it is only a passive quality of receiving impressions from distant objects; but, in man, it is not only a passive quality, but becomes active by the use of speech. It is by this sense that we are enabled to carry on the business of society, and to form a mutual communication of our sentiments. The organs of the voice would be entirely useless, if they were not excited to motion by the sense of hearing. A man deaf from his birth is necessarily dumb, and has no idea of abstract and general knowledge. We must not omit, in this place, a singular account of a man who, for the first time, suddenly acquired the use of hearing, when he was at the age of 24 years. His history, of which the following is an abridgement, is recorded in the *Memoirs of the French Academy* \*.

‘ A young man, of the town of Chartres, aged about 24, who had been deaf from his birth, began, all at once, to speak, to the utter astonishment of all who knew him. He informed his friends, that, for three or four months before, he had heard the sound of bells; and that he was extremely surpris’d at this new and unknown sensation. Some time

\* *Année 1703, p. 18.*

‘ after,

‘ after, a kind of humour issued from his left ear, and then he heard distinctly with both. ‘ During these three or four months, he listened to every thing; and, without attempting to speak aloud, he accustomed himself to utter softly the words spoken by others. He laboured hard in acquiring the pronunciation of words, and in learning the ideas annexed to them. At length, thinking himself qualified to break silence, he declared that he could speak, though still imperfectly. Soon after, he was interrogated by some able divines concerning his former condition. The principal questions turned upon God, the soul, and moral good and evil. But of these subjects he seem’d not to have the smallest conception. Though he was born of Catholic parents, attended mass, was instructed to make the sign of the cross, and to assume all the external marks of devotion, he comprehend’d nothing of their real intention. He had form’d no distinct idea of death; and exist’d purely in an animal state. Wholly occupied with sensible objects, and with the few ideas he had acquired by the eye, he drew no conclusions from them. He did not want parts; but the understanding of a man, when deprived of the intercourse of society, has so little exercise or cultivation, that he never thinks but when sensible objects obtrude themselves on his mind. The great source of

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'human ideas arises from the reciprocal intercourse of society.'

It is possible, however, to communicate ideas to deaf men, and to give them precise notions of general truths, by writing and by signs. A man deaf from his birth may be taught to read, to write, to communicate even the most complicated ideas, and to understand words by the motions of the lips. Nothing can be a stronger proof of the great resemblance between the different senses, and how far one may supply the place of another.

On this subject, it may not be improper to relate a fact, of which I was an eye-witness. M. Rodrigue Pereire, a native of Portugal, having long studied the most effectual methods of teaching the use of language to the deaf and dumb, brought a young man to my house, aged about 19, who had been deaf from his birth. M. Pereire undertook to learn him to speak, read, &c. At the end of four months, the young man could pronounce syllables and words; and, after ten months, he knew, and could pronounce about 1300 words. His education, so happily commenced, was interrupted, for nine months, by the absence of his master, who then found that the young man had forgot a great part of what he had formerly learned. His pronunciation was extremely bad, and most of his words had escaped his memory. M. Pereire renewed his instructions in the month of

February

February 1748, and from that time has never left him, (June 1749). This young man was presented before one of the meetings of the French Academy, where several questions were put to him in writing. His replies, which he made both in writing and in words, were extremely distinct. But his pronunciation was slow, and the tone of his voice was harsh. These defects, however, were unavoidable; for it is by imitation alone that we bring our organs gradually to form precise and well articulated sounds: But a deaf man cannot imitate what he does not hear. The shortness of the time employed by the master, and the surprising progress of the pupil, who was not deficient in ability, fully evince that persons born deaf and dumb may, by the assistance of art, be taught to hold intercourse with society; for I am persuaded, that, if this man had begun to be instructed at the age of seven or eight, he would have attained as many ideas as mankind generally possess.\*

\* This conjecture is now fully verified by the labours of the ingenious Mr. BARTHOLOMEW of Edinburgh, who has, for many years, taught, in his academy, great numbers of pupils, who had been born deaf, to speak, to read, to converse by observing the motions of other men's lips, and to understand grammar, morals, religion, and even the most abstract sciences.