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PART I.
ORIGINAL COMMUNICATIONS.

ART. XVI.—*On Double and Single Vision.* By ROBERT J. GRAVES, M. D., M. R. I. A., King's Professor of the Institutes of Medicine.

BUFFON, Doctor Gall, and many other authors, have noticed the common observation, that under certain circumstances an object appears double when viewed with both eyes; these circumstances are detailed with precision by Dr. Arnott, in the following passage of his work on the Elements of Physics.*

“When the two eyes are directed to any object, their axes meet at it, and the centres of the two retinæ are opposite to it, and all the other points of the eyes have perfect mutual correspondence as regards that object, giving the sensation of single vision; but the images formed at the same time, of an object nearer to or farther from the eye than the first supposed, cannot fall on corresponding points, for an object nearer than

* Vol. ii. p. 217.

where the axes meet, would have its images on the outsides of the eyes, and an object more distant would have its images on the insides of the eyes, and in either case the vision would be double. Thus, if a person hold the two forefingers in a line from his eyes, so that one may be more distant than the other, by then looking at the nearest, the more distant will appear double, and by looking at the more distant, the nearer will appear double."

In making this experiment it is singular that no one has noticed the very remarkable difference which exists between the relative position of the images in the two cases here spoken of. Thus, when the object is nearer than where the axes meet, the image on the left hand is that seen by the right eye, and that on the right hand belongs to the left eye; whereas, when the object is more distant than where the axes meet, the left hand image is seen by the left eye, and the right hand image by the right. The annexed diagram will enable the student to understand this experiment and its explanation. (*See Plate 2, Fig. 1.*)

Let both eyes be directed to the object a , at which therefore their axes may be supposed to meet, (if produced,) then a nearer object, b , also visible to both eyes, will have its picture on the retina of each at some point to the other side of the axis from itself; but as b is inside each axis, its picture will consequently be outside each, say at b' , b'' . Now, as every object is seen in a direction perpendicular to the point of the retina on which its picture falls, the object b will be seen in the direction $b'x$ for the right eye, and $b''z$ for the left; and consequently as these directions cross each other, the image seen by the right eye is to the left of that seen by the left eye.

If the object c be beyond the point to which both eyes are directed, then it is plain that being outside both axes, its images will be inside them, as at c' , c'' , and they will appear in directions $c'x''$ and $c'z''$, which do not cross each other; therefore in this case the image seen by the right eye is to the right of that seen by the left eye.

We have here supposed the objects placed between the

axes before or after their intersection ; if, however, they be in any other place, the same rule still applies, as may be demonstrated both theoretically and experimentally. These experiments are strongly corroborative of the accuracy of those who maintain *that every object is seen in a direction perpendicular to the point of the retina on which its picture falls*, for otherwise the results of the experiments just spoken of, could not be always accurately predicted ; the student will at once perceive the importance of this law, and the beauty of its operation, when he considers that each visible object, as *a*, (*Plate 2, Fig. 2*.) (here represented as a point,) is painted on the retina by means of a number of rays which the refracting powers of the eye cause to converge to form its picture *a*. Now, if every ray, *b a*, *c a*, *d a*, *e a*, converging to *a*, were to produce a sensation in its own direction, the object would be seen in as many different directions as there are converging rays, (for each of these arrives at the retina in a different direction,) and thus not only would the true direction of the object be mistaken, but each of its images would be very indistinct, being produced by only a single ray.

In consequence of the law of visible direction, however, these inconveniences are obviated, and all the converging rays are made to unite in producing the desired effect. It may be remarked, that the sense of touch presents us with something analogous, for no matter what has been the direction of a moving point, when it arrives at the skin, it excites a sensation unconnected with that direction, and apparently perpendicular to the skin at the point of contact.

This law of visible direction is fully explained, and its importance pointed out, in the *Library of Useful Knowledge*,* and Dr. Brewster, in his admirable *Treatise on Optics*, published in Dr. Lardner's *Cabinet Cyclopædia*,† has established the same law of visible direction, and by its means has fully succeeded in explaining the cause of single vision with two

* Page 42, Article, *Optics*.

† Page 292.

eyes,* as well as the cause of erect vision from an inverted image.† The real cause of erect vision has been also recognized by other writers, as Dr. Mayo in his *Outlines of Human Physiology*. It is therefore to be regretted that neither this important law, or the conclusions to which it leads, have been even noticed by Professor Lloyd in his able *Treatise on Light and Vision*,‡ a book deservedly in high repute in our University, and much read by the students. Mr. Lloyd indeed offers no explanation whatsoever of erect vision, and has adopted that of the justly celebrated Mr. Herschel on the subject of single vision, viz. that it is entirely the result of habit.

Mr. Herschel thus expresses himself:§ “As we have two eyes, and a separate image of every external object is formed on each, it may be asked why we do not see double; and to some the question has appeared to present much difficulty. To us it appears, that we might with equal reason ask, why, having two hands and five fingers on each, all endowed with equal sensibility of touch, and equal aptitude to discern objects by that sense, we do not feel decuple?”

With all the deference due to so high an authority as Mr. Herschel, I do not think that the inference he draws from facts connected with the sense of touch, can with justice be extended to the sense of sight. Indeed there are points of difference between the two cases so material, as almost entirely to destroy the force of the analogy. Thus, when we look at a single object with both eyes, we at once perceive it to be single; the perception of its being so is in every case decided and certain, and

* l. c., p. 300.

† l. c., p. 294.

‡ The following is the only sentence in Mr. Lloyd's Chapter on Vision, which conveys the least intimation of such a law: “From all this it manifestly follows, that the only thing necessary to enable us to judge of the position of external objects by sight, is, that there should be a steady correspondence between their positions and the impressions which the rays proceeding from them produce on the retina.”

§ *Encyclopædia Metropolitana*, Part 19.

so far as our sight is concerned, no further experiment is required to convince us, that this our first judgment is correct. But with regard to the sensation imparted to us by two fingers, or ten fingers, it is altogether different. Here no positive knowledge is conveyed to the mind concerning the matter touched, as to whether it is in one mass or in several, whether it is a single object or many, two objects or ten.

Nor can experience here, as it is said to do in the case of vision, instantly correct a sensation in itself erroneous, and derive from it an accurate perception ; nor can we by its intervention at once decide whether we are feeling one, two, or ten bodies, in the same way that, by the aid of experience, (according to Mr. Herschel,) we instantly correct the perception derived from our two eyes concerning a single body. Let any one, for instance, apply the tops of all his fingers simultaneously to ten small pieces of ice, and undoubtedly he will receive ten distinct impressions, one from each finger. It is exactly the same when we apply our fingers to one large piece of ice, and consequently here we actually feel decuple. But as our previous experience has warned us against the errors consequent on conclusions drawn from such data ; we immediately commence a further investigation of the matter, and institute several successive examinations with our fingers, we feel the intervals between the parts first touched, ascertain whether they are separate or continuous, and thus, finally, by the aid of the sense of touch alone, arrive at an accurate conclusion. Again, if we touch ten pieces of metal of very different temperatures, each is distinctly felt at the same moment, and if it were possible to heat a piece of metal in narrow zones to different temperatures, the feeling being exactly similar, would induce us to think that we were feeling ten pieces, not one, we would feel decuple. It is thus we always judge : when the surfaces felt by our different fingers produce sensations in every respect similar, we infer that they proceed from one and the same body, but when they are dissimilar, we guess that they are caused by different bodies,

and beyond this, our experience is no service as a guide. To be accurate, we must in every case institute a further examination, and there the case differs materially from the perception of a single object imparted to us by our two eyes, a perception correct in the first instance, and requiring not the aid of further experiment. There is likewise another point connected with Mr. Herschel's argument to which I cannot assent; he says, "the case is exactly the same with the sense of touch; lay hands on a globe and handle it; it is *one*; nothing can be more irresistible than this conviction. Place it between the first and second fingers of the right hand in their natural position; the right side of the first, and left of the second finger feel opposite convexities; but as habit has always taught us that two convexities so felt belong to one and the same spherical surface, we never hesitate or question the identity of the globe or the unity of the sensation. Now, cross the two fingers, bringing the second over the first, and place the globe on the table in the fork between them, so as to feel the left side of the globe with the right side of the second finger, and the right with the left of the first. In this state of things the impression is equally irresistible that we have two globes in contact with the fingers, especially if the eyes be shut, and the fingers placed on it by another person. A pea is a very proper object for this experiment."

To prove that the sensation produced by the pea placed as above described, in the fork of the crossed fingers, has nothing to do with its convexities, as Mr. Herschel supposes, it is only necessary to make the experiment with a flat body instead of a pea. Thus, if a rectangular piece of card in breadth equalling the diameter of a pea, be used, its two corners will give an impression of two separate bodies not less distinct than that derived from the pea. In both cases, the experiment admits of a very easy explanation quite unconnected with the shape of the body; the inside surface of each finger so constantly touches bodies at the same moment in contact with the outside of its

neighbour, that impressions derived simultaneously from both these surfaces, are habitually considered as proceeding from one and the same body. In this case experience has taught us to look upon the double sensation excited by the double point of contact as the sign of the presence of but one body ; but when the fingers are crossed, two surfaces, not thus habitually associated in feeling a single object together, are now brought into contact with it, and consequently the first impression, that there is a separate object for each point of contact, predominates, and we seem to feel two bodies, not one.

In support of the influence of habit in producing single vision with two eyes, Mr. Herschel observes, "those who have one eye distorted by a blow, see double, until habit has taught them anew to see single, though the distortion of the optic axes still exists."

The case to which Mr. Herschel here probably alludes, is quoted by Buffon, from the works of Cheselden ; and other similar cases have been recorded, but admit, in my opinion, of a very different explanation.

Although the assertion of some physiologists, that we always look with one eye alone,* cannot be admitted, yet it is true that

* Gall and Spurzheim, *Physiognomical System*, p. 299, observe on this subject, "There is no doubt that we look with one eye alone ; if we place a small stick, a pencil, a goose quill, or another thin body between our eyes and the light, if we keep both eyes open, and point out the right line between our eyes, the stick and light, then if we looked with both eyes the stick should occupy the diagonal, and its shadow should fall upon the nose. But the shadow falls always upon one eye, upon that of which the person who repeats the experiment ordinarily makes use of in looking with attention."

There is certainly a most happy confusion of ideas and absurdity of expression in this passage ; he must have accurate notions of the properties of a right line, who, placing a stick and candle before his face, expects to find, and be able to point out, *a right line between our eyes, the stick and light !!* as to what *diagonal the stick ought to occupy if we look with both eyes*, I must confess myself totally in the dark. The experiment in question is extremely simple, although it does not afford a shadow of evidence in favour of the conclusion drawn from it by Messrs.

we all do so occasionally, and under the influence of certain circumstances, this habit may even become permanent.

Thus experienced sportsmen attend only to the right eye in taking aim, although the left remains open, and persons who acquire a squint suddenly, soon learn to attend only to the impressions they receive from the sound eye; at first, that is as long as they attend to, or see the images suggested to the mind by the contorted as well as the sound eye, they see double, because they are unable to direct both eyes to the same object; this error they find cannot be corrected except by attending solely to what they see with one eye, and they invariably prefer using that whose motions are unimpaired; hence, persons with a bad squint, such as the man alluded to by Mr. Herschel, are enabled to see single by force of habit, but it is to be observed, that in producing this effect, habit does not operate in the way Mr. Herschel supposes, for single vision is gradually acquired in such cases, not by new points of both retinas becoming associated together, or rendered *corresponding*, as it is termed, but by so complete a cessation of all association and correspondence between both retinas, that the mind receives impressions from the one but none from the other. Indeed (it seems to me) the phrase, corresponding points of the retinas, ought to be abandoned altogether, for it seems probable that no such points exist; a picture of a given object on one retina can never produce an image coincident with that produced by its fellow picture on the other, unless both pictures happen to fall at the extremities of the optic axes; therefore no other points of the retinas are corresponding; no others can ever become by habit, or any other means, so associated, that similar impressions made on both together are perceived by the mind

Gall and Spurzheim. In fact, it proves nothing more than the practicability of placing a small object between one eye and a distant candle, in such a manner as to intercept its light and prevent its being seen by that eye. To place the object so as to be between both eyes and the candle is impossible. When its shadow falls on the nose, it will not to either eye appear to cover the candle.

as one. Indeed, facts are not wanting to prove that single vision with two eyes, so far as we enjoy it, is totally independent of habit. Thus, Cheselden operated on a young man blind from his infancy, and gave him the sight of one eye. At the expiration of a year, a similar operation put him in possession of the sight of the other eye likewise. And what was the consequence? According to Mr. Herschel's theory, double vision ought to have been then produced; but it was not; an apparent increase in the size of objects, probably owing to the increased vividness of the impression, was the only result.

All these considerations induce us to join Drs. Gall, Mayow, and Brewster, in the opinion, that single vision with two eyes has nothing to do with previous experience,* and that in this case the sense of sight owes nothing to that of touch. Indeed, the power we possess of correcting the errors of vision by means of the sense of touch, has been much exaggerated. If we look at one of our fingers through a multiplying glass, it will *appear* to the eye many fingers, not one finger, notwithstanding the thorough conviction we have that it is but one. If we put the finger into water, it will appear to the eye to be bent at the surface of the fluid, *though we feel* that it is not so; and no matter how often such experiments are tried, the contradictions between these two senses will remain as strong as ever. In connexion with this subject, I may observe, that the sense of touch has been said to give more accurate ideas of shape than those derived through the medium of vision. A globe, at a distance, it has been remarked, may appear to the eye flat, or a flat surface properly shaded may appear globular; and thus vision may induce us to form erroneous conclusions, which the sense of

* Dr. Gall observes very judiciously, "Moreover, nobody recollects to have seen objects double in his infancy; no person born blind who has recovered his sight by the operation for the cataract has seen objects double. We have also never observed or heard that animals take single objects for double ones. Animals which live a short time, and which never can rectify their vision by touch, are not deceived by the number of objects."

touch afterwards corrects. This mode of considering the subject is evidently incorrect; for in the first place, we cannot by the touch alone decide as to the globular or flat shape of the surface in question until we have felt it all over, until we have applied our finger to it on every side; now, if we take similar pains with regard to the evidence derived from vision, if we approach the surface, and regard it in various positions, in fact, if we look at it not merely in front, but in profile, we shall be at no loss to distinguish what is flat from what is globular.

But to return to our subject. From what has been stated, it appears that no object is seen single except both eyes be directed to it, in other words, except it be placed at the intersection of the optic axes. When an object is so placed, it seems to the right eye to be exactly in the same place as to the left eye, and consequently, its two images perfectly coincide, and appear but one. If the object be moved out of this position, its two images no longer overlap each other; and if it be very small and bright, it will very soon appear double. From this it follows, that in truth we only enjoy single vision in its perfection with both eyes with respect to one object at a time, and that all the remaining objects within the field of view common to both eyes are seen with their images not perfectly coincident, but more or less overlapping each other, or else completely separate; and consequently, such objects appear, if I may use such an expression, more or less, or completely, double. To most persons this assertion will appear paradoxical; they will consider it impossible that so curious a circumstance should have escaped their notice; nay, they will at first disbelieve it altogether, as contradictory to their previous experience; but, nevertheless, the fact is so, and we only fail to perceive it because *no object but the one is ever seen distinctly by the eyes at one time*. Thus, when we look at a printed page, we only see one letter distinctly; the letters on each side of it are seen, but much less distinctly, and those at a considerable distance excite no accurate perception of their shapes whatsoever. The

amazing rapidity with which the motions of the eyes are performed, it is true, prevents us from feeling any practical inconvenience from this indistinctness of objects seen obliquely, and the attention we always for the moment bestow upon the object directly before our eyes, prevents us from perceiving the comparative indistinctness of all other objects within the field of view. It is obvious, also, that objects near the intersection of the axes are not seen double, for their images, although not coincident, still very nearly overlap each other. To be seen truly double, therefore, an object must be removed to a certain distance from this intersection, and in proportion to this distance, it is less and less attended to; and consequently, the circumstance of its appearing double is entirely overlooked, unless our attention be forcibly drawn to the fact.

ART. XVII.—*Remarks on some Properties of the Hydracids.*

By ROBERT J. KANE, M. R. I. A., Professor of Chemistry to Apothecaries' Hall, &c.

THE terms acid and base are applied to two great classes of chemical substances, which, endowed each with powerfully active properties, have a great tendency to combine, and by their combination, to give rise to the formation of the various salts. These salts are seldom very energetic in their action upon other substances; the violent affinities of the acids and bases appear to be destroyed by their combination; they, as it is termed, neutralize each other; and the fact of the annihilation of the several powers of the acids and bases by their being put in contact with each other, has been beautifully explained by the discovery that these bodies exist naturally in opposite states of electricity.

The bases are all combinations of a metal with oxygen:*

* The basis of the ammoniacal salts is here supposed to be the combination of ammonia with an atom of water, i. e. of 1 ammonia + 1 oxygen + 1 hydrogen, the hydrogen and the ammonia forming the metal ammonium, $N + 4 H$, and the oxygen the oxide.