THE

NATURAL HISTORY

OF

MAN.

SECT. VI.

Of the Senſe of Seeing.

WE have already deſcribed the parts of which the human body conſiſts; and ſhall now proceed to examine thoſe curious organs by which ſenſations are conveyed to the mind. In this inveſtigation, we ſhall endeavour to point out the uſes of the different ſenſes, and to mark thoſe errors to which we are, in ſome meaſure, ſubjected by Nature.

In the human fœtus, the eyes are early formed; in the chicken alſo, they are the firſt double organs which make their appearance; and, in the eggs of lizards, and of ſeveral ſpecies of birds, I have remarked, that the eyes were more prominent and advanced in growth than any other double parts of the body. In viviparous animals, it is true, and particularly in the human fœtus, the eyes are not ſo large, in proportion,

as in the oviparous; but ſtill they are more quickly expanded than the other parts of the ſyſtem. The ſame remark applies to the organ of hearing. The ſmall bones of the ear are fully formed before the other bones of the body have acquired any degree of ſolidity or bulk. In the ſeventh month, the whole bones of the ear are perfectly ſolid, and have acquired all the denſity they poſſeſs in the adult ſtate. It is, therefore, apparent, that thoſe parts which are furniſhed with the greateſt quantity of nerves, are firſt formed and expanded. We formerly remarked, that the veſicles which contain the brain and cerebellum, and that which contains the ſpinal marrow, appear firſt. The ſpinal marrow is a fundamental and eſſential part of the body, and is therefore firſt formed. Hence the nerves exiſt before any of the other parts of the body, and thoſe organs which are moſt amply ſupplied with them, as the ears and eyes, are moſt quickly expanded.

Upon examining the eyes of an infant ſome hours after birth, it is eaſy to perceive that it can make no uſe of them: This organ not having acquired a ſufficient degree of conſiſtence, the rays of light make a confuſed impreſſion only on the retina. About a month after birth, the eye ſeems to have acquired that tenſion and ſolidity which are neceſſary for the proper tranſmiſſion of the rays of light; but, even then, infants are incapable of fixing their eyes upon any object:

object: They roll and move them to all ſides, without being able to diſtinguiſh the objects to which their eyes are directed. In ſix or ſeven weeks, however, they begin to fix their attention upon luminous objects. But this exerciſe tends only to fortify the eye, without conveying any exact perception of different objects; for the firſt great error in viſion, is the inverted repreſentation of objects upon the retina: And, till children learn the real poſition of bodies by the ſenſe of feeling, they ſee every object inverted. A ſecond error in the viſion of infants ariſes from the double appearance of objects; becauſe a diſtinct image of the ſame object is formed on the retina of each eye. It is by the experience of feeling bodies only, that children are enabled to correct this error. By the frequent handling of objects, they gradually learn that they are neither double nor inverted; and cuſtom ſoon makes them imagine they ſee objects in the order and poſition in which they are repreſented to the mind by the ſenſe of touching. Hence, if we were deprived of feeling, our eyes would deceive us, both with regard to the poſition and number of objects.

The inverſion of objects is a reſult of the ſtructure of the eye; for the rays which form the images of theſe objects, cannot enter the pupil without croſſing each other. This admits of an eaſy proof: When light is tranſmitted through

a ſmall hole into a dark chamber, the images of the objects from without are repreſented on the wall in an inverted poſition; becauſe all the rays reflected from the different points of the object cannot paſs through this ſmall hole, in the ſame extent and poſition as they proceed from the object, unleſs the hole be of equal dimenſions with the object. But, as every part of the object reflects images of itſelf on all ſides, and, as the rays which form theſe images proceed from every point of the object as from ſo many centres, none of them can paſs through the hole but thoſe that arrive at it in different directions. Hence the hole becomes the centre of the whole object, at which the rays flowing from the lower, as well as the higher parts of the object, arrive in converging directions; and, of courſe, they muſt croſs each other at this centre, and repreſent the picture of the object on the oppoſite wall in an inverted poſition.

It is equally eaſy to ſhow that we ſee all objects double: If, for inſtance, we look at an object with the right eye, we will find that it correſponds with a certain point of the wall; if we look at the ſame object with the left, it then correſponds with a different point; and, laſtly, when we look at it with both eyes, it appears in the middle between theſe points. Thus an image of the object is formed on both eyes, one of which appears on the left, and the other on the

the right; and we perceive it to be ſingle and in a middle ſituation, becauſe we have learned to correct this error of viſion by the ſenſe of touching. In the ſame manner, if we look with both eyes at two objects, nearly in the ſame direction, by fixing our eyes on the neareſt, we perceive it to be ſingle; but the fartheſt appears to be double; and, if we fix our eyes on the fartheſt, it appears to be ſingle, while the neareſt is perceived to be double. This is an evident proof, that we ſee all objects double, though we conceive them to be ſingle; and that, though we form an accurate idea of their real ſituation, yet we actually ſee them where they are not. If, therefore, the ſenſe of ſeeing were not conſtantly rectified by that of touching, we would be perpetually deceived as to the poſition, number, and ſituation of objects; we would perceive them to be inverted, double, and to the right or left of their real ſituations; and, inſtead of two, if we had 100 eyes, we would ſtill conceive objects to be ſingle, though they were in reality multiplied a hundred fold.

Thus a ſeparate image of every object is formed in each eye; and, when the two images fall on correſponding parts of the retina, or thoſe parts which are always affected at the ſame time, objects appear ſingle, becauſe we are accuſtomed to judge of them in this manner. But, when the images of objects fall upon parts of the retina which are not uſually affected at the ſame

time, they then appear double, becauſe we have not acquired the habit of rectifying this unuſual ſenſation.

Mr. Cheſſelden, in his anatomy *, relates the caſe of a man who had been affected with a ſtrabiſmis, in conſequence of a blow on the head. This man ſaw every object double for a long time. But he gradually learned to correct this error of viſion, with regard to objects which were moſt familiar to him; and, at laſt, he ſaw every object ſingle as formerly, though the ſquinting of his eyes were never removed. This is a proof ſtill more direct, that we really ſee all objects double, and that it is by habit alone we learn to conceive them to be ſingle. If it ſhould be aſked, why children ſooner acquire the faculty of correcting this deception than adults whoſe eyes have been diſtorted by accident? it may be replied, that children, having acquired no oppoſite habits, leſs time is, of courſe, neceſſary to correct the errors of their ſenſations; but that adults, who have for many years been accuſtomed to perceive objects ſingle, becauſe their images fall upon correſponding parts of the retina, have a contrary habit to oppoſe, and, conſequently, muſt require a long time before they can obviate its effects.

The ſenſe of ſeeing conveys no idea of diſtances. Without the aid of touching, all objects would appear to be within the eye, becauſe it is

* P. 324.

there

there alone that their images exiſt: And an infant, who has had no experience of the ſenſe of touching, muſt conſider all external bodies as exiſting in itſelf: They appear larger or ſmaller only, according as they approach or recede from the eye. A fly, when near the eye, will ſeem larger than an ox or a horſe at a diſtance. Thus an infant can have no idea of the relative magnitude of objects, becauſe he has no notion of the different diſtances at which he views them. It is only after meaſuring ſpace by the extenſion of the hand, or by tranſporting their bodies from one place to another, that children acquire correct ideas concerning the diſtances and magnitudes of objects. Before this period, they can form no judgment of the diſtance or magnitude of an object, but by the image painted on the retina. Their ideas of magnitude entirely reſult from the angle formed by the extreme rays reflected from the ſuperior and inferior parts of the object: Of courſe, every near object muſt appear to be large, and every diſtant object ſmall. But, after having acquired, by touch, ideas of diſtances, the judgment concerning magnitude begins to be rectified: They truſt not alone to the apparent magnitude conveyed by the eye: They endeavour to inveſtigate the diſtance; they try, at the ſame time, to diſtinguiſh the object by its form; and then they judge of its magnitude.

If we judge by the eye alone, and have not acquired the habit of apprehending the ſame ob-

jects to be equally large, though viewed at different distances, the first soldier, in a file of 20, must appear much larger than the last. But we know the last soldier to be equally large with the first; and hence we judge him to be of the same dimensions. And, as we have the habit of considering the same object to be of equal magnitude at all ordinary distances, we are never deceived on this head, except when the distance is too great, or when the interval is in an uncommon direction. A distance ceases to be familiar to us whenever it is too large, or rather when the interval is vertical instead of horizontal. The first ideas of the comparative magnitude of objects we acquire either by measuring their relative distances by the hand, or by moving the whole body. But all the experiments by which we commonly rectify the errors of vision, with regard to distances, are made horizontally. We have no acquired habit of judging of the magnitude of objects which are elevated above, or sunk below us; because we are not accustomed to measure in this direction by the touch. Hence, when viewing men from the top of a tower, or when looking up to a cock or a globe on the top of a steeple, we think these objects are much more diminished than if we viewed them at equal distances in a horizontal direction.

Though a small degree of reflection be sufficient to convince us of the truth of these positions, it may still be of use to relate the facts

which confirm them. The celebrated Cheſſelden couched cataracts in both eyes of a youth of 13 years of age, who had been blind from his birth. The operation ſucceeded; and Mr. Cheſſelden carefully obſerved the manner in which the young man was affected by the ſenſe of ſeeing. Theſe obſervations he publiſhed in the Philoſophical Tranſactions *. This young man was not abſolutely blind: Like other perſons affected with cataracts, he could diſtinguiſh night from day, and even black from white; but he had not the moſt diſtant conception of the figure of bodies. The operation was firſt performed in one eye. When he ſaw for the firſt time, he was ſo far from judging of diſtances, that he believed every object touched his eyes in the ſame manner as every thing he handled touched his ſkin. Objects of a regular figure, and having plain ſurfaces, were moſt agreeable to him, though he was ſtill incapable of forming any judgment as to their form, or telling why they afforded him more pleaſure than others. His ideas of colours before the operation were ſo faint, that, after receiving his ſight, he was unable to diſtinguiſh one from another. He inſiſted that the colours which he then ſaw were not the ſame he was formerly acquainted with. He knew not the figure of any object; nor could he diſtinguiſh one from another, however different in form and in magnitude.

* See Phil. Tranſ. No. 402. and Tatler, Art. 55.

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When preſented with things which were formerly familiar to him, he obſerved them with attention, that he might be able to know them afterwards. But, as he had too many objects to recogniſe at once, he forgot the greateſt part of them; and, from his commencing to diſtinguiſh objects, he did not retain in his memory one out of a thouſand. Thoſe objects and perſons which were formerly moſt beloved by him, he was aſtoniſhed to find that they were not alſo the moſt agreeable to his ſight. It was more than two months before he could perceive that pictures were the repreſentations of ſolid bodies. Previous to this period, he conſidered them only as plain ſurfaces diverſified by different colours. But, after he began to perceive that pictures repreſented ſolid bodies, he expected to recogniſe their ſeeming inequalities by touching the canvas; and was perfectly aſtoniſhed when he found the whole uniformly ſmooth. He aſked, whether the deception aroſe from the ſenſe of feeling or that of ſeeing? He was then ſhown a miniature portrait of his father, contained in his mother's watch-caſe. He recogniſed the reſemblance of his father: But he inquired with amazement how ſo large a countenance could poſſibly be contained in ſo ſmall a compaſs; for it appeared to him equally ſtrange, as that a buſhel ſhould be held in a pint veſſel. At firſt, his eye could ſupport a ſmall quantity of light only; and every object ſeemed much larger than

than the life: But, after he had ſeen objects of large dimenſions, former objects appeared to be proportionally diminiſhed. He had no conception that any objects exceeded the limits of thoſe he had already ſeen. He knew that his own apartment was only a part of the houſe, and yet he was unable to comprehend how the houſe ſhould be larger than his chamber. Before the operation, he expected not much pleaſure from the acquiſition of the new ſenſe that had been promiſed him, except what ſhould ariſe from his being enabled to read and write. He alledged, for example, that he could receive no new ſatisfaction from walking in the garden, becauſe he already knew every corner of it, and could walk there with great eaſe and freedom. He had even remarked, that his blindneſs gave him the advantage of walking in the night with more confidence and ſecurity than thoſe who enjoyed the benefit of ſight. But, after he began to have the proper uſe of this new ſenſe, he was tranſported beyond meaſure. He declared that every new object afforded a freſh delight; and that the pleaſure he felt exceeded the powers of expreſſion. About twelve months after the operation, he was conducted to Epſom, from which there is a beautiful and extenſive proſpect. He was charmed with the view; and he called this landſcape a new mode of ſeeing.

About a year after the firſt operation, the cataract on the other eye was couched with equal ſucceſs. With this ſecond eye he perceived objects to be much larger than with the other, but not ſo large as when he firſt received ſight; and when he viewed the ſame object with both eyes, he ſaid that it appeared to be twice as large as with the firſt eye alone. But, after he procured the uſe of both eyes, he did not ſee objects double, or, at leaſt, Mr. Cheſſelden could not be certain that he did.

Mr. Cheſſelden records ſeveral other examples of blind men, who had no remembrance of light, reſtored to viſion by the ſame operation; and he aſſures us, that, when they firſt obtained the uſe of their eyes, they expreſſed their perceptions in a ſimilar manner, though not ſo minutely: And he remarks upon the whole, that as, during their blindneſs, they had no occaſion to move their eyes, it coſt them much difficulty, and a conſiderable time, before they could acquire the faculty of directing them to the objects they wiſhed to examine *.

As, from particular circumſtances, we can have no juſt idea of diſtance, and, as we cannot judge concerning the magnitude of objects, but by the largeneſs of the angle or image formed in the eye, we muſt neceſſarily be ſubject to deceptions with regard to theſe articles. Every body knows how liable we are, when travelling in the night, to miſtake a buſh that is near us

* See Lettre ſur les aveugles, a l'uſage de ceux qui voient.

for

for a tree at a diſtance, or a diſtant tree for a buſh which is at hand. In the ſame manner, if we are unacquainted with the figure of objects, we cannot form any idea either of their diſtance or magnitude: A fly paſſing with rapidity at ſome inches from the eye, would, in this caſe, appear like a bird at a conſiderable diſtance; and a horſe ſtanding in the middle of a plain, would not ſeem larger than a ſheep. But, as ſoon as we knew it to be a horſe, it would inſtantly appear as large as the life, becauſe we have the power of correcting this deception of viſion.

Whenever, therefore, we are benighted in a part of the country with which we are unacquainted, being unable, on account of the darkneſs, to judge of the diſtance or figure of objects, we are every moment liable to all the deceptions of viſion. This is the ſource of that dread which moſt people feel in the dark, and of thoſe ſpectres and terrible figures which ſo many perſons tell us they have ſeen in the night. Though ſuch figures, it is commonly aſſerted, exiſt in the imagination only; yet they may have a real exiſtence in the eye; for, whenever we have no other mode of judging of an unknown object but by the angle it forms in the eye, its magnitude will uniformly increaſe in proportion to its propinquity. If it appears, when at the diſtance of 20 or 30 paces, to be only a few feet high, its height, when within two or three

feet

feet of the eye, will be many fathoms. An object of this kind muſt naturally excite terror and aſtoniſhment in the ſpectator, till he approaches and recogniſes it by actual feeling; for the moment a man knows an object, the gigantic appearance it aſſumed in the eye inſtantly diminiſhes, and its apparent magnitude is reduced to its real dimenſions. But if, inſtead of approaching ſuch an object, the ſpectator flies from it, he can have no other idea of it but from the image which it formed in his eye; and, in this caſe, he may affirm with truth, that he ſaw an object terrible in its aſpect, and enormous in its ſize. Thus the notions concerning ſpectres is founded in nature, and depend not, as ſome philoſophers affirm, upon the imagination alone.

When we are unable to form an idea of the diſtance of objects by the knowledge of the ſpace between them and the eye, we endeavour to judge of their magnitude by diſtinguiſhing their figures. But, when the figures are not diſtinguiſhable, and when we view a number of objects of the ſame from, we conceive thoſe that are moſt brilliant to be neareſt, and thoſe which are moſt obſcure to be at the greateſt diſtance. This mode of judging gives riſe to deceptions of a ſingular nature. When a multitude of objects are diſpoſed in a right line, as the lamps on the road from Verſailles to Paris, of the proximity or remoteneſs of which we can only judge by the different quantities of light they tranſmit to the eye,

eye, it frequently happens, when viewed at the diſtance of an eighth of a league, that the lamps appear to be on the right hand, in place of the left. This deception is an effect of the cauſe above mentioned; for, as the ſpectator has no other criterion to judge of the diſtance of the lamps, but the quantity of light they emit, he thinks the moſt brilliant of them is neareſt to his eye. Now, if the firſt two or three lamps ſhould happen to be moſt obſcure, or, if one in the whole range was more brilliant than the reſt, that one, to a ſpectator, would ſeem to be the firſt, and all the others, whatever might be their real ſituation, would ſeem to be placed behind it. This apparent tranſpoſition could not be effected by any other means than a change of ſituation from left to right; for in a long range of objects, we cannot apprehend what is really behind to be ſituated before any one of theſe objects, without ſeeing on the right what is on the left, or on the left what is on the right.

I have thus mentioned the principal defects of the ſenſe of ſeeing; and ſhall now proceed to examine the nature, properties, and extent of that admirable organ by which we are enabled to have a communication with the moſt diſtant objects. Sight is a ſpecies of touching, but very different from the common ſpecies of that ſenſe. Before we can touch any object, we muſt either approach it with ſome part of our body, or it muſt approach us. But, with the eye, we can touch

touch any object, however distant, if it transmits a sufficient quantity of light to make an impression on, or if its picture forms a sensible angle in the eye. The smallest visible angle is about one minute. This angle, when an object is viewed at the greatest distance of vision, is about the 3436th part of the diameter of that object. An object, for example, of a foot square, ceases to be visible at the distance of 3436 feet. A man of five feet high is not visible beyond the distance of 17,180 feet, when the sun shines.

But, with regard to the extent of human vision, an observation occurs, which seems to have escaped all the writers on optics: The extent of our sight diminishes or augments in proportion to the quantity of light that surrounds us, supposing the illumination of the object to remain the same. If the same object which we see during the day at the distance of 3436 times its diameter, were equally illuminated during the night, it would be visible at a distance 100 times greater. A candle is visible in the night at the distance of more than two leagues; that is, supposing the diameter of the luminary to be one inch, it would be visible at the distance of 316,800 times the length of its diameter. But, in the day, this candle would not be discernible beyond ten or twelve thousand times the length of its diameter. The same remark is applicable to all objects, when viewed during the day or the night,

night. We may, therefore, conclude, that the extent of our vision is much greater than our first supposition; and that the reason why we are often unable to distinguish distant objects, is less owing to a defect of light, or to the smallness of the angle under which they are painted in the eye, than to the profusion of rays reflected from intermediate objects, which, by their brilliancy, prevent us from perceiving the fainter and more diverging rays that proceed from distant objects. The retina of the eye is like a canvas upon which objects are painted. The colour of those pictures are bright or obscure in proportion to the distances of the objects represented. When objects are very remote, their pictures on the retina are so faint, that they are entirely obliterated by the vigorous and lively impressions made by nearer objects, with which we are every where environed. But, when the intermediate objects emit a feeble light only, compared with that which proceeds from remote objects, as, for example, when we view a luminous body in the night-time, then the distant object makes a distinct picture on the retina, and becomes perfectly visible. It is a consequence of these facts, that a man, by placing himself in the dark, and employing a long tube, may make a telescope, which will have a considerable effect even during the day. For the same reason, a man at the bottom of a deep pit can see the stars at noon; and this fact was not

unknown to the ancients, as appears from the following paſſage of Ariſtotle: 'Manu enim 'admota, aut per fiſtulam, longius cernet. Qui- 'dam ex foveis puteiſque interdum ſtellas con- 'ſpiciunt.'

We may, therefore, affirm, that the human eye is capable of being affected with objects which ſubtend not an angle above a ſecond, or leſs, even when they reflect no more light than when they were ſeen under an angle of one minute; and, conſequently, that the powers of this organ are greater than was formerly imagined. But, if objects, without forming a greater angle, were furniſhed with a more intenſe light, we would ſee them at ſtill greater diſtances. A ſmall taper, when vivid, is ſeen much farther than a flambeau that emits a dim light. In order to determine the utmoſt diſtance at which an object can be rendered viſible, three things muſt be conſidered: 1. The largeneſs of the angle formed in the eye: 2. The degree of light with which the neighbouring and intermediate objects are illuminated; and, 3. The intenſity of the light proceeding from the object itſelf. Viſion is affected by each of theſe cauſes; and it is only by eſtimating and comparing them, that we can determine the diſtance at which any particular object can be diſcerned. The following is a demonſtrative proof of the influence of intenſity of light upon viſion. Teleſcopes and microſcopes are known to be inſtruments of the

ſame kind, each of them increaſing the viſible angle of objects, whether they be really minute, or appear ſo on account of their diſtance. Why then do teleſcopes with difficulty magnify objects a thouſand times, when a good microſcope magnifies more than a million? This difference, it is apparent, proceeds from the degree of light only; for, if we could illuminate diſtant objects with an additional quantity of rays, they would appear infinitely clearer, though ſeen under the ſame angle; and teleſcopes would have the ſame effect upon diſtant objects as microſcopes have upon thoſe which are minute. But this is not a proper place for expatiating on theſe ſubjects.

The diſtance at which any object can be ſeen is ſeldom the ſame in both eyes. There are few men who have both eyes equally ſtrong. When this inequality is great, the ſtrongeſt eye is moſt generally employed, which is the cauſe of ſquinting, as I have elſewhere proved *. When both eyes are equally ſtrong, and directed to the ſame object, one ſhould imagine that the viſion would be doubly diſtinct; but the difference has been found by experiment to be only one 13th part †; and this phænomenon may admit of the following ſolution. The two optic nerves, near the place where they come out of the ſkull, unite, and then ſeparate by an obtuſe angle, before they

* See Mem. de l'Acad. année 1743.

† See Jurin's eſſays on diſtinct and indiſtinct viſion.

enter the eyes. The motion communicated to theſe nerves by the impreſſion of objects on the retina, cannot be tranſmitted to the brain without paſſing the united part. Hence theſe two motions muſt be combined, and produce a ſimilar effect, as when two bodies moving upon two ſides of a ſquare, and impinging on a third, make it move in the diagonal. Now, if the angle were about 115 or 116 degrees, the diagonal would be to the ſide as 13 to 12, which is the ſame ratio that the ſenſation reſulting from both eyes bears to that which reſults from one. The angle formed by the two optic nerves being nearly equal to that ſuppoſed above, the loſs of ſenſation may be attributed to this poſition of the nerves; and this loſs will always increaſe in proportion to the greatneſs of the angle.

Short-ſighted perſons are generally ſuppoſed to ſee objects larger than other men. But the reverſe is the truth; for they actually ſee them diminiſhed. I myſelf am ſhort-ſighted, and my left eye is ſtronger than my right. I have a thouſand times examined the ſame objects, as the letters of a book, at the ſame diſtance, firſt with the one eye, and then with the other, and uniformly found that objects appeared both cleareſt and largeſt to the left eye; and, when I diſtorted one of my eyes to make an object appear double, the image preſented to the right eye was leſs than the other. I cannot, therefore, heſitate in pronouncing, that the more ſhort-ſighted any man

man is, he ſees objects proportionally diminiſhed. I examined ſeveral perſons who had eyes unequal in ſtrength, and all of them declared that they ſaw objects larger with the ſtrong than with the weak eye. This phænomenon is perhaps the effect of habit; for ſhort-ſighted people, being accuſtomed to approach cloſe to objects, and to view a ſmall portion of them only at a time, their eyes acquire a ſtandard of magnitude much leſs than other men, who can take in at once all the parts of large bodies.

Short-ſightedneſs has been often aſcribed to a roundneſs or prominence of the eyes. But this cauſe is not ſatisfactory; for ſome have ſuddenly become ſhort-ſighted, as the young man mentioned by Mr. Smith in his optics *, who became ſhort-ſighted on coming out of a cold bath, and who, from that period, was always obliged to uſe a concave glaſs. It cannot be ſuppoſed that the cryſtalline and vitreous humours were all at once inflated to ſuch a degree as to produce this difference in viſion. Short-ſightedneſs may as well proceed from the reſpective poſition of the different parts of the eye, and eſpecially of the retina, as from the form of the humours; it may proceed from a leſs degree of ſenſibility in the retina, from a ſmallneſs of the pupil, &c. In the two latter caſes, it is true, concave glaſſes would be uſeleſs, and even hurtful; in the two former, they may be employed with advantage.

* Vol. ii. p. 10.

But ſtill, objects ſeen through theſe glaſſes are neither ſo diſtinct, nor perceived at ſuch a diſtance, as other men ſee them with the naked eye; becauſe ſhort-ſighted perſons, as formerly remarked, ſee the pictures in a diminiſhed form, and concave glaſſes diminiſh them ſtill farther: Whenever, therefore, theſe pictures become ſo ſmall as to make too faint an impreſſion on the retina, they ceaſe to be viſible; conſequently, people who labour under this defect, ſee not ſo far with the aſſiſtance of glaſſes as other men do with their eyes.

As the eyes of infants are leſs than thoſe of adults, they muſt likewiſe ſee objects leſs; becauſe the greateſt angle which an object can form in the eye muſt always be proportioned to the dimenſions of the retina: If the field of the retina, where the pictures of objects are formed, be ſuppoſed to be half an inch in adults, it will not exceed a third or a fourth of an inch in infants. Children, of courſe, cannot ſee ſo far as adults; for, as objects appear leſs to them, they muſt ſooner become inviſible. But as, in infants, the pupils are larger, in proportion to the ſize of their eyes, than thoſe of adults, they may derive ſome ſmall advantage from this circumſtance.

Old men, as the humours of their eyes are ſaid to be dried up, ought to ſee nearer than young men: But the reverſe is true; for old men

men ſee beſt at a diſtance. This alteration can not proceed entirely from a diminution, or a flattening of the humours of the eye, but rather from a change of poſition between its parts, as between the cornea and the cryſtalline, or between the vitreous humour and the retina. This may be eaſily underſtood, by ſuppoſing that the cornea becomes more ſolid as we advance in years, and, conſequently, that it cannot readily aſſume that convexity which is neceſſary in order to ſee near objects; and, as it muſt be flattened by drying, this circumſtance alone is ſufficient to make old men ſee beſt at a diſtance.

Clear and *diſtinct* viſion, though different in their nature, are terms very generally confounded by writers on optics. We ſee an object *clearly*, whenever it is ſufficiently illuminated to enable us to form a general idea of its figure; but we ſee it not *diſtinctly*, till it be ſo near that we can examine all its parts. When we view a diſtant tower, we ſee it clearly as ſoon as we perceive it to be a tower; but we ſee it not diſtinctly till we approach ſo near as to be able to determine not only its general dimenſions, but to diſtinguiſh the parts of which it is compoſed, as the order of architecture, the materials, the windows, &c. We may, therefore, ſee an object clearly without ſeeing it diſtinctly, and we may ſee it diſtinctly without ſeeing it clearly; becauſe

diſtinct viſion implies a ſucceſſive examination of the different parts of objects. Old men ſee clearly, but not diſtinctly: They perceive large or luminous objects at a diſtance; but they are unable to diſtinguiſh ſmall objects, as the characters of a book, without the aſſiſtance of magnifying glaſſes. Short-ſighted perſons, on the contrary, ſee ſmall objects diſtinctly; but they have no clear viſion of large objects, unleſs they are diminiſhed by concave glaſſes. A great quantity of light is neceſſary for clear viſion, and a ſmall quantity is ſufficient for diſtinct viſion. Hence ſhort-ſighted people ſee better in the night than other men.

When an object is too brilliant, or when the eye fixes too long upon the ſame object, the organ is injured or fatigued, viſion becomes indiſtinct, and the image of the object, having made an impreſſion too violent, or remained too long on the retina, ſeems, for ſome time, to be painted on every body we look at. But I will not enlarge on this ſubject, becauſe I have elſewhere given a full explication of it *. I ſhall only obſerve, that nothing perhaps is more deſtructive to the eye than too great a quantity of light. Blindneſs is exceedingly frequent in the northern regions, where the ſnow, illuminated by the rays of the ſun, obliges travellers to cover their eyes with crape, to prevent the

* See Mem. de l'Acad. année 1743.

dangerous,

dangerous, and often ſudden, effects of too much light. In the ſandy deſerts of Arabia, the reflection of the light is ſo violent, that the eyes are unable to ſupport it. Such perſons, therefore, as are obliged to write or read long at a time, ſhould beware of uſing a ſtrong light.