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OBSERVATION, ITS MEANING AND IMPORTANCE*

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The Medical Society of London is approaching the second century of its foundation, and the Annual Oration has been given by an unbroken succession of orators for close on 180 years. I am deeply conscious of the honour you have done me in inviting me to share in this distinguished succession and to pay my tribute to the great founders of the society. I feel that I cannot better discharge my debt than by a consideration of that faculty of which they were all supreme exponents, the faculty of observation. Since their day the whole art of medicine has changed and a science of which they knew nothing has claimed it for its own. But still to-day we can admire the clinical insight which could unravel difficult problems unaided, and I would urge that, with all the wonderful resources we possess, the most indispensable resource of all is direct clinical observation.

Consciously or unconsciously we all spend a great part of our lives in observation and we are all agreed on its importance, but we rarely consider the mechanism by which the outside world presents itself to our observation or the mechanism within ourselves by which our observation is effected. Yet surely such an inquiry is essential to any real appreciation of the world around us, for only by such an inquiry can we form any opinion upon how far the apparent world of our experience really exists, how much of it is real, and how much of it is coloured or even created by our own imagination. With the profound philosophical problems involved, with which philosophers have amused themselves since the beginning of history, I do not propose to deal, and indeed I should be quite incompetent to do so. I propose to sketch for you only the physical and physiological mechanisms of observation and perhaps to devote a little time to the consideration of certain practical conclusions.

Our contact with the world and the possibility of our observing depend upon our five senses. Of these, touch demands actual contact, taste and smell involve the assimilation of particles, possibly of only molecular dimensions, while sight and hearing have a wider range and enable us to observe objects at a distance by the radiations of light and sound which they emit. The last two faculties so far transcend the others in interest, though perhaps not in importance, that I shall confine myself to these and limit inquiry to the two questions—How do we see, and how do we hear?

Observation by Sight

We are enabled to see objects by the light which falls on them or is emitted by them. Light itself consists of groups of electro-magnetic waves which travel across space with almost inconceivable velocity, the waves themselves so small that from two thousand to four thousand would occupy only a millimetre. Where we see objects by illumination the waves are absorbed by the atoms of the object and then emitted by these atoms in a modified form. Let us examine these statements a little more closely.

Light is not the only kind of radiation with which we are acquainted. It forms, in fact, only one octave in the vast complex of vibrations with which space is filled. Some of these other vibrations we use, and through this room are passing hundreds of wave-groups radiating from transmitters, which we could detect through suitable receivers, from cosmic rays which arose somewhere in distant space to the programme of the B.B.C. All these are examples of electro-magnetic waves, and we are familiar with more than sixty octaves of such vibrations. But only one of these octaves constitutes light, and to this octave we are indebted for all that we see, whether we are reading the pages of a newspaper or watching a glorious sunset, or looking through a telescope at a distant star. Perhaps it is as well that for only this minute fraction of a vast complex have we any means of perception.

Let us, however, look for a moment at the origin of these waves of light, at the atoms from which they arise, and about whose characters they tell us. In the modern view each atom consists of a nucleus around which circulate a number of electrons. In its normal state the number of electrons is fixed for the atom of each element and is in fact the distinguishing characteristic of the element. Hydrogen has one electron, helium two (Fig. 1), lithium three, and so on up to uranium with 92. Moreover, the electrons revolve in orbits whose measurements are known with great accuracy.

FIG. 1.—Hydrogen (A) and helium (B) atoms.

The orbits are not always the same, for if an atom absorbs energy it does so by the displacement of an electron to a wider orbit; when the electron returns to its normal

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orbit the same energy is given out, perhaps as a group of waves of light. Moreover, the energy is absorbed or given out not in a continuous stream but in little packets of chains of waves termed photons. The absorption and emission of energy by an atom are thus the outward signs of the displacement of an electron from its orbit and of its return. The absorption and emission of light and energy are entirely the business of these electrons. If energy is absorbed certain electrons move to wider orbits, and when they drop back to their normal circuit the same energy is given out again.

It will be seen, then, that from the strictly physical aspect any observation depending on the use of light is an affair of extreme complexity, and though the observation may seem to us the simplest thing in the world it is in fact based on vast assumptions for the validity of which we can only cite our general experience. But what relation our observations bear to the profound reality which lies behind we have no means whatever of knowing, and it is quite certain that it would be utterly beyond our comprehension.

Mechanism of Sight

Let us now turn to the other side of the picture and study the mechanism by which light makes an impression upon us—the means, in fact, by which we see. You are all familiar with the eye as an optical instrument in which an image is formed on the sensitive retina (Fig. 2). Developmentally the retina is an extension of the brain, and it consists of a vast forest of cells of two special forms—rods and cones—with the unique property of being sensitive to light. In each retina there are some seven million cones and 100 million rods, and although small groups may share one conducting fibre there are many million fibres, each with its own insulating sheath, in each optic nerve.

The optic nerves, carrying the whole of the light impulses from the two retinæ, pass backwards to the optic chiasma,

FIG. 3.—Optic chiasma.

and here the nerve fibres which form the two nerves are redistributed in a very remarkable way. The fibres from the left-hand sides of both retinæ join to form the left optic tract, while those from the right-hand sides of both retinæ form the right optic tract (Fig. 3). The effect of this is that the whole of the right visual field is served by the left optic tract, while the left visual field is served by the right optic tract.

The two optic tracts pass backwards beneath the brain to certain relay stations, from which they are again distributed. The true visual fibres are relayed by the optic radiations to the visual cortex of the two occipital lobes,

where are situated the primary cortical centres for sight (Fig. 4). Other relays serve centres for eye movements, focusing, and the pupil reflex, all of which are essential to accurate vision. It will thus be realized that a large part of the light which enters the eyes is absorbed in the operation of a very elaborate mechanism of whose action we are almost completely unconscious, and that only a small portion is actually relayed to the visual cortex.

The visual cortex appears to present an exact point-to-point correspondence with the retina, so that one can regard the retinal image as actually transferred to the visual cortex, with, however, one very remarkable difference. On each retina the whole visual field is received, but each occipital lobe receives only the contralateral half of the field. Yet we are entirely unconscious of any such division, for the image has not yet reached a level in the brain at which it can be appreciated. From the visual cortex the image is transferred by well-marked tracts of fibres to many regions in the brain where it can take its share in many reflex activities. In the angular gyrus it adjoins the sensory cortex, where it makes contact with the sense of touch; and here the meaning of objects is recognized—the difference, for example, between a pencil and a penknife. Transference to the speech centre enables printed or written words to be recognized, and, further on in the motor centres, to be reproduced in speech or writing. Connexions with the auditory centre enable us to interpret the sound represented by printed words or music. Finally, a massive band of fibres conveys the image to the frontal lobes, the region probably of higher psychic analysis.

It is clear, then, that the image focused by our eyes is distributed to almost every portion of the brain and that there it fuses with other impulses to form a whole series of collateral effects. In every region it is confronted with earlier memories, until the whole forms a complex utterly defying analysis. Yet of all this complicated process we are entirely unconscious, and its detail is brought to our notice only when some item fails. Some of you may suffer from migraine and are familiar with the dazzling fortification lines, followed perhaps by a complete blackout of one-half of the visual field. If so, you have had the opportunity of observing the effects of spasm of one of the arteries supplying the occipital lobe. It may console you that you have had definite proof that your arteries are still young and elastic.

When we look at a scene I suppose that most of us imagine that it is reproduced in our brain very much as it would be reproduced on the film of a camera, but what

The Visual Paths

FIG. 4.—Diagram showing the visual paths.

actually happens is very different. The scene is in fact formed as an image on the retina of each eye, but these images are first split into left and right, then each pair combine on opposite sides of the brain, then these split images are re-combined and brought into relation with impulses from many other sources and filtered through a whole mass of memories. The final complex is what we see, and it is only after this infinity of preparation that the scene reaches our consciousness. Is it not amazing that what we see bears any relation at all to the facts and that on the whole the visual sensations of different individuals correspond so closely?

Observation by Sound

Let us turn to another of the means by which we make contact with the outside world, our sense of sound. Like light, sound is propagated by waves, but of a very different nature—by means of compression and rarefaction of the air. The waves are produced by the vibration of solid objects, and if the sound is musical in character the waves must recur in regular periods, though they may be of any form. Upon the number of waves per second depends the pitch of the sound; upon the form of the wave depends its

character—from the simple wave emitted by a tuning-fork to the complex wave of the oboe (Fig. 5).

Sound waves have two remarkable properties. In the first place, they

are capable of infinite variety, so that the most complex sound produced by a modern orchestra can be embodied in a succession of wave forms, and indeed it is only as such that it can affect our ears. But even more remarkable is the fact demonstrated by the great mathematician Fourier that these wave forms, however complex, can by a suitable analysis be reduced to a group of simple harmonic vibrations such as a tuning-fork emits. Moreover, this analysis, one of the great feats of mathematical skill, is carried out automatically by our ears, and it is the analysed wave, broken up into its constituent fractions, and not the crude wave of sound, which is transmitted to our brains. And apparently, so far as the mechanism of the ear is concerned, this analysis has nothing to do with musical appreciation, and indeed may be just as perfect in a cat as in a virtuoso.

The nerve impulses which arise from the sound, each representing a single term in the Fourier analysis, are conveyed to the brain by the auditory nerve, each apparently by a separate nerve fibre, and after suitable relays are conveyed to the temporal lobe on the opposite side of the brain. Just as the occipital lobes provide the receptive cortex for sight, so do the temporal lobes provide the receptive cortex for hearing, but this is still far from the level of consciousness. Numerous fibre tracts connect the auditory cortex with the other regions of the brain, with areas of touch, of sight, of motion. Thus without any actual involvement of consciousness we may turn to see whence a sound comes or spring aside to avoid danger. Beyond these areas, again, lies the level of consciousness where we can analyse the nervous impulses and compare them with our memories. It is here in the hidden recesses of the brain that the power of the musician lies, and almost certainly not in the actual mechanism of the ear itself.

Beethoven was stone deaf when he wrote the music of his last and greatest phase, and it is indeed to this that we owe his finest pianoforte sonatas, for no pianoforte then existed capable of producing their majestic power. It is said that when he conducted the first performance of the Choral Symphony the audience rose to their feet to applaud at the conclusion. But the conductor remained facing the orchestra, till the leading soprano came forward and took him by the hand to turn towards the audience the only man who had not heard a single note.

Musicians tell me that when they read the score of a symphony they hear the harmonies as clearly as if they were listening to an orchestra. With these fortunate people sound memories and the visual pictures of notes are so combined that the eye can almost replace the ear. To Beethoven the movement of the bows of the violins brought back the memory of his creation so vividly that I do not for one moment suppose that he realized his deafness and that no sound could penetrate his ears. His vast genius lived again in the world of its own inspiration.

Composite Pictures

I have tried to show you something of the mechanism by which waves of light and of sound gain access to the brain and how they are distributed and fused with stimuli arising from other sources. So much is this the case that it would scarcely be an exaggeration to say that every region of the brain is affected by every stimulus which reaches the level of consciousness.

The interlocking of all the regions of the brain generally passes unnoticed, but occasionally some unusual effect calls for our attention. Many years ago on a holiday in the Black Forest I heard the Kreutzer Sonata being studied by two young musicians. Two years later I heard it again in Oxford, and with the great opening chord passage I was overwhelmed by the smell of pines. I was so astonished that it was some moments before I remembered my summer in the pine forest of Germany. You could scarcely have a more dramatic illustration of the diffusion of stimuli through the brain.

We have thus reached the conclusion that whenever we make any observation we build up in our brain a set of

FIG. 5.—Sound waves of oboe and flute.

FIG. 6.—Cortical localization.

composite pictures in each of which are united groups of impulses which have entered the brain through different ports of entry. So far we are in the realm of ascertained fact, and we even know the region of the brain where these primary composite pictures are formed (Fig. 6). Moreover, the nerve stimuli which form these images are all identical in nature and differ only in the situation of the particular

cells affected. For example, in the region of the angular gyrus certain cells receive messages from the visual cortex, others from the sensory cortex, but all these messages, however varied their meaning, now give rise to cell activities identical in nature and differing only in position. And these activities, so different in origin, are here combined and passed to other cells for transmission to other regions of the brain.

The brain contains some ten thousand million nerve cells, and these are of many types and no doubt serve many special functions, but the point I wish to make is that so far as we can discover these cells transmit activity by similar processes and to them it is a matter of complete indifference whether the message entered initially by the eye, or the nose, or the ear.

But although we cannot follow the stimuli further into the anatomy of the brain we can appreciate other stages in analysis which may well have an anatomical basis. For example, one recognizes a square as a square, or a circle as a circle, whatever its position, and this is something beyond the capacity of the initial regions of combination such as the angular gyrus. But this capacity is very limited, as you may easily satisfy yourself by trying to read a book upside down. Possibly a higher development of such a faculty may explain the vagaries of the futurist.

Memory, an Essential Basis

We have traced the passage of nerve impulses from their varied origin as far as we can penetrate into the dim regions of their final synthesis. The passage is accompanied by a by-product which is for us of vital importance. It is a fundamental law of all nerve activity and transmission that each occurrence facilitates the next similar occurrence. Why or how this happens we do not know, but it is a simple and recognized fact which indeed forms the physiological basis of our lives. You see it in perhaps its most perfect form in the musician who practises a simple figure until it becomes subconscious and automatic. On the more extended scale this facility, acquired by the recurrent passage of similar stimuli, is the basis of memory. Moreover, as I have shown you, a single stimulus from one source—for example, a sound or a smell—may arouse a whole complex of forgotten memories.

Now, memory has two sides. We can create memories by repetition, but we use those memories in the appreciation of fresh stimuli. Without these memories the world around us would be meaningless, for we should have no basis of comparison. It would be a book written in a language of which we did not even know the characters. Memory is the essential basis of observation. If this view is correct it follows that a baby has at birth no true power of observation, for it has none of the memories on which alone observation can be based. In one sense its brain is a clear tablet ready to receive impressions, although of course it possesses latent traits inherited through the ages.

We have reached the fundamental point which I wish to make, that the value of any observation is entirely conditioned by the mass of recorded observations which form the stock-in-trade of our personality. In an orderly brain these form a library of reference in which every new fact is filed. Most of our observations pass through along well-worn paths without raising a ripple, but every now and then one of them does not quite fit in and we look at it again. We may be on the brink of a great discovery. But notice that it is the content of the observer's brain, the slow accumulation of years of toil, that has made possible this moment of triumph.

Comparison of Old and New Perceptions

I suppose that for countless aeons of time men watched the stars stream across the sky before one of these men noticed that one of the stars had moved from its place. But that man himself must have watched the stars for years till their permanent relation was fixed in his mind and he was startled to find that one had changed its place. You can imagine that he kept the secret to himself and watched night after night to see if it were really true. And if he were a wise man the more certain he became the more closely would he guard such a revolutionary discovery.

From this standpoint observation consists in the comparison of the new picture with the old. Agreement generally passes unnoticed or may give a certain sense of satisfaction. Disagreement induces a feeling of unrest and a desire for solution. But I believe that the matter goes deeper than this, and that such agreement is the physiological basis of pleasure. We all know the pleasure of familiar scenes, of well-known music. But here the basis of pleasure is too complex for analysis. The resolution of a chord or the fusion of two geometrical patterns are simpler examples, the complex in each case resolving into the simpler form. There is, however, one curious example where we can actually watch the comparison and ultimate fusion of two pictures in the brain—in stereoscopic vision. Here different but complementary pictures are presented to the two eyes and after a moment of confusion are fused in the brain, forming now one picture with the quality of solidity. The moment of fusion is accompanied by a feeling of satisfaction which may under certain circumstances have all the subtle qualities of pleasure.

In the modern view the brain consists of a vast number of neurones, varying in detailed structure but of the same general type, each capable of receiving impressions and of transmitting these, perhaps greatly reinforced and probably modified, to other and perhaps distant regions of the brain. I do not know which is the more astonishing—the simplicity of the neurone as a unit or the vast complexity of the combination of these simple units in the brain. Up to a certain point we can follow our observations through this forest, but they are lost long before they have reached their final goal and even before they have become apparent to our consciousness. So far we can follow their physiological course, but where and how do they reach us? That is for ever beyond our ken, but at a certain level in the brain the passage of nerve impulses affects our consciousness, and, moreover, at this level we have some power of controlling them. It is easy to see how at lower levels constant repetition may produce facility, but how is that repetition ordered and how is it controlled? That we shall never know.

External Aids

You will see by now that the most trivial observation, far from being a simple process, involves mechanisms of unimaginable complexity. The mechanism of the outer world by which it makes itself known to us is complex enough, but this is simple when compared with the mechanism in our bodies by which we receive these impressions. Yet it is only through this strange and incomprehensible machine of our own that we make contact either with the outside world or with one another. Its proper use is of vital importance to our understanding, and is, of course, the aim of education. But, regarding it solely as a machine, can we improve its services? We can correct certain physical defects by such means as spectacles and auditory aids. We can extend its powers by the use of telescopes and microscopes, which indeed open up for us

new worlds. Although heaven has limited our vision to one octave of light waves, by cunning devices such as radar and wireless we can extend our observations over vast fields of space and time. In such ways we do indeed increase our powers of observation, but sometimes with rather disconcerting effects.

Powerful telescopes enable us to see into regions of space where all the physical conditions are utterly outside our experience, but few of us ever realize the strangeness of the world into which we peer. We can study the moon in quite minute detail, but can we really grasp the fact that we are looking at an arid desert devoid not only of water but of air, where the temperature is either far above boiling point or a hundred degrees below freezing? We look at Jupiter and think of the glory of its moons, but can we ever realize that its dead and frozen surface is for ever hidden from us by vast clouds of ammonia?

The new 200-inch reflector in California enables us to explore unimagined regions of space, and one of the first photographs taken with it was of a distant nebula. This nebula probably consists of millions of stars and may be as extensive as the whole of our own stellar system, but the point of interest is its distance and the time its light has taken to reach us—no less than a thousand million years. Now astronomers assert that the whole age of the stellar universe is certainly less than four times this period, and it is quite certain that when those rays of light started on their way our solar system did not exist. Moreover, the nebula we see to-day is the nebula of a thousand million years ago, and for all we can know it may long ago have vanished.

Or again, we look through a microscope and see the exquisite form and perfect arrangement of the cells of some tissue. Do we always quite grasp that we are looking at an artifact which has only a remote connexion with reality? The beautiful colour, the sharp outlines which delight us, we owe to the skill of the technician who made the preparation and to tissue reactions which have no connexion whatever with the life of the tissue as part of a living organism.

You will see, then, that these external aids, valuable though they are, carry with them certain illusions which we must appreciate if we are to use them to advantage. It is indeed a fatal mistake to accept as gospel all the technical detail with which science can furnish us without first correlating it with our own unaided observation and fusing it all into one coherent whole. This is true even of observation in the physical universe, but how much more is it so in the complex world of the human body?

Internal Mechanism

We can indeed improve our observation by external means, but far transcending these in importance is the power we undoubtedly possess of improving our own internal mechanism by its exercise and by the storing of memories. For the physical basis of memory is only a path along which messages can flow more freely so that our observations move along well-worn channels with a minimum resistance and a maximum effect. But the mere casual accumulation of memories is not enough. They must be accurate, they must be connected, and they must be arranged in coherent groups. May I give you an example?

A physician is standing by a child's bedside; his fingers are on its wrist. He feels the dry hot skin. He notes the racing pulse and estimates its power, its quality, its

regularity. He sees the flushed face with its tinge of blue; he sees the nose expanding at each quick intake; he hears the hurried respiration and characteristic grunt. And he knows that he is faced with a case of acute pneumonia with a certainty which nothing but direct clinical observation can afford. His long experience has gathered together a great number of separate impressions into one clear picture. He is a trained clinical observer, and all his impressions are grouped together subconsciously into one observation which sweeps away irrelevant detail and grasps the one essential fact.

If observation is of such importance can we by any means develop and improve it? As regards the primary organs of sensation—our touch corpuscles, our taste buds, our ears, our eyes—we have probably very little, if any, power of modifying them at all. But in the higher centres of reception and co-ordination we have very great powers of development. Touch can be developed to distinguish variations of thickness of a thousandth of an inch; the trained musician can perceive variations in pitch which most of us could not distinguish. We can, in fact, in every field develop our power of primary perception.

But of far greater importance is our immense capacity for developing the combination of primary perceptions, for, as I hope that I have shown you, every observation we make has two aspects. On the one hand its character and its value depend on a vast train of preceding observations reaching back to our earliest infancy. On the other hand it leaves behind an impress which will affect every fresh observation we make into the distant future. Every observation is actually a conditioned reflex. By our observations and our memories we really create new worlds for ourselves through which we can wander at our pleasure. The historian can live again in the past; the musician can explore the limitless world of sound, of balanced periods, and of subtle harmonies; the mathematician can explore all the vast fields of space and time—perhaps, like Newton, “for ever voyaging through undiscovered fields of space alone.”

The world of observation is a wonderful world, limitless in its possibilities, absorbing in its vast opportunities. And yet if we are really to enter it and to enjoy it to the full we must carry with us a spirit that seems its very contradiction—the spirit of adventure, of freedom from the restraint imposed by experience, the happy irresponsible spirit of a child. For there is another world which we may well envy, which perhaps only a child can enjoy in all the wonder of freedom, untrammelled by the bounds of convention, limitless in its imagination, inhabited by strange and delightful monsters and by fairies who sweep away all difficulties with the wave of a magic wand. Is their world the real one, or is ours? Can we still believe in fairies?

The classification of hospital posts used by the Central Medical War Committee differs from that used by the Ministry of Health in its Terms and Conditions of Service of Hospital Medical Staff. The Ministry has therefore sent a circular to hospitals asking them to use dual descriptions in advertisements for the next few months. They are as follows:—House-officer posts: House officer—first post (A) (second or third post (B2), as the case may be); or house-physician (or surgeon, etc.), salary £350 (A), £400 or £450 (B2) a year according to experience. Registrar posts: Junior registrar (B1); registrar (B1); senior registrar (B1). Junior hospital medical officer (B1). The Ministry hopes that it will be possible to discontinue the old classification into A, B2, and B1 by September 30.