REITH LECTURES 1950: Doubt and Certainty in Science

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Lecture 4: The Establishment of Certainty

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In one of his poems A E Housman expresses a feeling we sometimes have; a feeling of being lost in the Universe, of not belonging there:

I, a stranger, and afraid,
In a world I never made.

A world I never made? But the researches outlined in my last two lectures show that the brain of each one of us does literally create his or her own world. To explain this I must answer the question: How does each brain set up its own characteristic rules? How do those regular patterns of activity in the cells of the brain which I described in my last lecture develop? This is he process that I call the establishment of certainty and it is a process which we may consider as beginning in each human being at the moment when, as a newly born baby, his eyes open on to the world. He will have received some stimuli before this, but now his brain begins to receive a flood of information from all the senses. From that moment the incoming stimuli begin to leave their mark on the brain, its rules begin to be established. We have no means of examining and recording all that happens in the brains of babies and very young children. But we can learn a great deal that is helpful from the reports of people with certain rather rare forms of blindness who, though born blind, have later been operated on and received their sight. This is a specially favourable opportunity by which we may examine, as it were, the phases of childhood being passed through in a person who can talk.

What would such a person see, what would he say, on first opening his eyes on a new world? During the present century, the operation has been done often enough for systematic and accurate reports to be collected. The patient on opening his eyes for the first time gets little or no enjoyment, indeed, he finds the experience painful. He sees only a spinning mass of- lights and colours. He proves to be quite unable to pick out objects by sight, to recognise what they are, or to name them. He has no conception of a space with objects in it. But remember, he knows all about objects and their names by touch. ‘Of course’, you will say, ‘he must take a little time to learn to recognise them by sight’. Not a little time, I am afraid, but a very, very long time, in fact years. His brain has not been trained in the rules of seeing. We are not conscious that there are any such rules; we think that we see, as we say, naturally. But we have in fact learned a whole set of rules during childhood. If our blind man is to make use of his eyes he, too, must (rain his brain. How can this be done? Unless he is quite clever and very persistent he may never learn to make use of his eyes at all. At first he only experiences a mass of colour, but gradually he learns to separate shapes. When shown a patch of one colour placed on another he will begin to see that there is a difference between the patch and its surroundings. What he will not do is to recognise that he has seen that particular shape before, nor will he be able to give it its proper name. For example, one man when shown an orange a week after beginning to see said that it was gold. When asked, ‘What shape is it?’ he said, ‘Let me touch it and I will tell you!’ After doing so, he said that it was an orange. Then he looked long at it and said, ‘Yes, I can see that it is round’. Shown next a blue square, he said it was blue and round. A triangle he also described as round. When the angles were pointed out to him he said, ‘Ah. Yes, I understand now, you can see how they feel’. For many weeks and months after beginning to see, the person can only with great difficulty distinguish between the simplest shapes, such as a triangle and a square. If you ask him how he does it, he may say, ‘Of course if I look carefully I see that there are three sharp turns at the edge of the one patch of light, but four on the other’. But he may add peevishly, ‘What on earth do you mean by saying that it would be useful to know this? The difference is only very slight and as you can see it takes me a long time to work it out, I can do it much better with my fingers’. And if you show him the two next day he will be quite unable to say which is a triangle and which a square.

The patient often finds that the new sense brings only a feeling of uncertainty and he may refuse to make any attempt to use it unless forced to do so. He does not spontaneously attend to the details of shapes. He has not learned the rules, does not know which features are significant and useful for naming objects and conducting life. Remember that for him so far shapes have been named only after feeling the disposition of their edges by touch. However, if you can convince him that it is worth while, then after weeks of practice he will name simple objects by sight. At first they must be seen always in the same colour and the same angle. One man having learned to name an egg, a potato, and a cube of sugar when he saw them, could not do it when they were put in yellow light. The lump of sugar was named when on the table but not when hung up in the air with a thread. Still such people can gradually learn. If sufficiently encouraged they may after some years develop a full visual life and be able even to read.

It takes at least a month to learn the names of even a few objects. Gradually the patient leaves out the laborious counting of the corners and comes to identify things so quickly that, as in an ordinary person, the process by which he does so is not apparent. So it is not that all along the eyes or brain were incapable of acting normally. The real point is that what these people lack is the store of rules in the brain, rules usually learnt by the long years of exploration with the eyes during childhood. They have no models with which to compare the input, no mould or filter that can be used to select the significant features of visual experience and produce appropriate words and other motor responses. A normal person learns the rules of seeing by connecting some parts of the sensory input with motor acts that lead to satisfaction, for instance naming and the fulfilment of communication.

We do not know exactly what happens in the brain as it learns to react to shapes during that period of training. At first the eyes wander at random over the visual field. So probably learning to move the eyes in certain ways is an important part of the process. Compare this with a very young animal wandering at large in the woods with no clue as to where to find food. Each time he moves in a direction that results in satisfaction of his hunger a link is formed in his brain. This link makes him tend to repeat the movement on a later occasion. Similarly, when the once blind man is told that what he has so far seen as only a patch of light is in fact an orange, he learns that the movements of running his eyes round its outline are useful. His brain subsequently makes his eyes follow outlines, he becomes able to name objects by sight, with all the advantages of that communication.

Brain and Eye

So we can believe that the brain gradually comes to act in certain special ways. One of the earliest of these habits gives us the tendency for the eye to sweep not in all directions at random but along lines. Connections between the cells in the brain are built up, such that each time the eye rests on a point it tends to follow any lines away from that point. Thus we come to pick out and name the significant objects in the field of vision, neglecting vague shadows.

Certain difficulties familiar to everybody give hints of the way the brain is organised. There is no difficulty in learning that the words ‘right’ and ‘left’ refer to horizontal and ‘up’ and ‘down’ to vertical directions. But every child has some difficulty in distinguishing ‘up’ from ‘down’. On the other hand ‘in’ and ‘out’ are easily learned. Even as adults many of us have trouble with ‘left’ and ‘right’ and incidentally also east and west. These difficulties all suggest that the brain is organised in such a way that although our eyes readily sweep either from side to side or up and down, yet these two sets of movements are quite distinct. o we never confuse ‘up’ or ‘down’ with ‘right’ or ‘left’. But there is no such deep distinction between sweeping from left to right and from right to left, and therefore we have difficulty in correctly naming these directions. We do not know what arrangement of the brain cells makes us select lines in this way, but we are beginning to suspect that there is such an arrangement.

From following lines an early step is to learn to attend to circles. There is certainly something about a circle that very readily attracts our eyes. We pick it out from a mass of other input reaching us. Study advertisement hoardings and you will see that their pictures often contain one or several circles. Those who produce advertisements have excellent reasons for finding out what patterns attract the human eye.. Designs of circles have played a prominent part in many art forms— look at any rose window in a church, for example. Evidently there is something about lines and circles that fits easily into the rules of our brain. When we see a line that makes three parts of a circle, or even less, we at once complete it and call it a circle. Do you see what I mean when I say that our brain cells are so arranged that their rules make a model or mould that selects certain parts of the input for attention and naming?

In the case of the man born blind, you see, he had at first only a lot of colours to look at, but no rules, no models to help him to abstract, to select significant features. Like all those who have not learned the point of abstracting, he could not believe that it was worth while trying to work out anything significant about these coloured patches. They did not seem to mean anything to him. So the paintings of Picasso mean nothing to his angry critics. The once blind man was like all of us in this. He already had his own rules, his own ways of selecting and communicating, using his sense of touch. He was content with these ways and could not see the point of trying to find others. ‘And why not?’ you may say. ‘Why must anyone seek for new ways of acting?’ The answer is that in the long run the continuity of life itself depends on the making of new experiments. As we go on with these lectures I hope it will become plain how the continuous invention of new ways of observing is man’s special secret of living. There is a limit to the extent to which this invention can go on in any one head. But the continuity of life of the whole race will only be preserved if the individual contributes his new invention to the rules that he passes on.

These most interesting observations on the difficulties of people born blind show that we have to learn from others how to see. The visual receiving system in its untrained state has only very limited powers. We are perhaps deceived by the fact that the eye is a sort of camera. Contrary to what we might suppose, the eyes and brain do not just simply record in a sort of photographic manner the pictures that pass in front of us. The brain is not by any means a simple recording system like a film. Recognition of this fact of our relativity is one of the most revolutionary developments of the thought of the present time. Its importance is only now dawning upon us very gradually, and it is a main purpose of these lectures to show you what the change means. Many of our affairs are conducted on the assumption that our sense organs provide us with an accurate record, independent of ourselves. What we are now beginning to realise is that much of this is an illusion; that we have to learn to see the world as we do. These ways of acting that we learn give us a rhythm of behaviour. Remember the brain is not a passive mass of tissue. Through all waking life it drives along. Woken in the morning by some stimulus, it immediately begins to run through sequences of activities, according to the rules that it has learned. These sequences produce the actions by which the body lives. They are partly touched off by outside stimuli, but, once started, they may run by themselves as independent trains in the brain, each combination starting another one.

The life of the new-born child consists largely of sleep, periods, that is, in which numbers of brain cells are firing in unison. We know this because electrical records show that in a baby there are very large and regular brain waves. This unison or synchrony becomes broken up by the nerve impulses arising from the receptor organs, internal or external. The receptors are so arranged as to alert the organism that its needs are not satisfied; it must be up and doing. The hungry baby wakes and cries, giving the sign stimulus that brings the mother’s attention. At first it kicks and clutches at random until it obtains the milk. When the stomach is filled, the hunger impulses from it stop, the brain returns to its simple synchronous activity, and the baby goes to sleep. But in the course of each waking episode there are changes going on in its brain. Actions, at first random, develop into little sequences, according to patterns developed during previous wakings. These have become printed or otherwise recorded in the brain.

How a Baby Behaves

Meanwhile the world does not stand still. The mother becomes gradually less co-operative and the child has to learn to get what it needs by ways other than crying. The eye movements are used to discriminate between faces, cups and other objects, so th the output of the brain leads to the making of appropriate noises, the giving of names that produce satisfactory actions by others, that establish communication. The effect of stimulations, external or internal, is to break up the unison of action of some part or the whole of the brain. A speculative suggestion is that the disturbance in some way breaks the unity of the actual pattern that has been previously built up in the brain. The brain then selects those features from the input that tend to repair the model and return the cells to their regular synchronous beating. I cannot pretend to be able to develop this idea of models in our brain in detail, but I believe it to have great possibilities in showing how we tend to fit ourselves to the world and world to ourselves. In any case the brain initiates sequences of actions that tend to return it to its rhythmic pattern, this return being the act of consummation, or completion. If the first action performed fails to do this, fails that is to stop the original disturbance, then other sequences may be tried. The brain runs through its rules one after another, matching the input with its various models until somehow unison is achieved. This may perhaps only be after strenuous, varied and prolonged searching. During this random activity further connections and action patterns are formed and they in turn will determine future sequences.

As the child grows, therefore, the brain acquires a series of ways of acting, of laws as it were, for dealing with the situations that occur to it. The sequence of natural events around us is rhythmic. Night succeeds day and night is a poor time for an animal that mainly depends on its eyes. Therefore we normally sleep by night and wake by day. But notice that this rhythm has to be learned by the child and can be modified and if necessary reversed in the adult.

The actual process of association between two inputs to the brain is probably performed rather rapidly in all animals. I mentioned earlier that an octopus learns after only one or two trials to avoid a white square from which it has received a shock. In birds there is a process of quick learning just after birth by which a young animal learns to react properly to members of its own species. Some feature of the earliest object seen can be imprinted upon the brain of the newly hatched chick and never thereafter forgotten. A German scientist, Dr. Lorenz, found that a young goose, freshly hatched, who saw the doctor before it saw any other goose, thereafter acted in every way as if Dr. Lorenz was a goose, following him around and so on. In this type of learning, therefore, a rather elaborate pattern must be printed somehow on the brain; this pattern thereafter acts as a model and moulds behaviour. The way in which the system of rules is built up in the brain is also shown in the famous experiments of the Russian Professor Pavlov on what he called conditioned reflexes. By ringing a bell just before giving meat to a dog on several occasions Pavlov found that the bell alone soon came to produce a flow of saliva, which did not occur before. In further experiments it was found to be possible to use the method to train dogs to discriminate between two notes by giving meat with one note but not the other. If the difference between the notes was made too small the dogs became very excited and they refused to stand still and attend to the experiments as they usually did. Pavlov compared this condition with neurosis in man.

The doctrine that learning is all of a conditioned reflex type had had an immense vogue in Russia and is said to be a basic part of the theory of Soviet education. Like all systematisations it has some advantages over no systematisation at all. But somehow we feel that Pavlov's analysis leaves out some essential feature of learning as it occurs in man. or at least man as we know him. I believe that because of the limitation of his method, he actually took elaborate precautions to rule out the very phenomenon he should have studied. He did not include the random trial and error behaviour by which an animal or man searches for actions that shall produce satisfactory solutions for his needs. The Russian Government built him a wonderful laboratory with every room sound-proof and complicated arrangements to ensure that the dogs should stand quite still and be educated. With his outlook this seemed the right thing to do. It was the right thing to do to get that sort of result. But study by this method will not include the most useful forms of human behaviour.

Random Behaviour

If my attempt to show how patterns of action grow up in the brain has been successful, you may now perhaps begin to see how this is going to help us on in our search for the nature of scientific enquiry. I hope to be able to show in later lectures that in this system of brain action lie clues for understanding the development of man as a communicating, family, social, religious, and scientific animal. At all stages we find first random behaviour, or what we call experiment, doubting. Then the making through observations of connections between features that occur repeatedly. This is the recognition of similarities and recurrences, the establishment of laws, of certainty.

But we must notice that this process of replacing randomness by law, is a one-way, non-reversible process. The cortex of the new-born baby has perhaps few innate traits, it is in the main a blank sheet of possibilities. But the very fact that it becomes organised minute by minute, day by day, throughout the years, reduces progressively the number of possible alternative ways of action. Learning the laws of behaving in certain ways makes it increasingly difficult to learn others. We know surprisingly little about what determines the stability of the systems that get built up in our brains. They can certainly be to some extent reversed by new circumstances. We may forget, or learn new ways of speaking about the world. Some people manage to go on learning new ways much longer than others. Probably a part of their secret is that they constantly seek new circumstances. The temptation to go on relying only upon the rules already used year in year out is very strong. But a really useful and interesting brain is always starting off on new ways. But it is a common experience that this gets more difficult as we grow older.

Every night when we are asleep we certainly receive some relief from our rules and wake up that much more alert and ready to observe in new ways. Within limits the longer we sleep the fresher we become. We do not know how far the unison beating of the nerve cells during the night breaks down the patterns of action of the day. The basic patterns are probably laid down, as I have discussed, in the sizes and connections of the very fibres of the brain. These can perhaps also be changed, but only with long practice.

There seems to be a limit beyond which new patterns and new connections are no longer easily formed. As we grow older the randomness of the brain becomes gradually used up. The brain ceases to be able to profit from experiment; it becomes set into patterns of laws. The well-established laws of a well-trained person may continue to be usefully applied to situations already experienced, though they fail to meet new ones. Here we see with startling clearness the basis of some of the most familiar features of human society, the adventure, subversiveness, inventiveness and resource of the young; the informed and responsible wisdom of the old. At each stage, in fact, of the development of our brains we have a special contribution to make, particularly if at each stage we realise that this is not the only stage, that doubt and certainty must be properly balanced.

In this lecture we have seen that each brain has to learn its rules of acting. It can then experiment with these rules, finding useful ways of modifying them. In man the brain rules are largely concerned with providing means of communication, we each learn the accepted way of communicating and this determines our view of the world. We also contribute to the evolution of the race if we improve that system and pass on ways of observing and describing that are a little more powerful than the ones we received. If it is true that each brain has a limited store of randomness, then clearly this process can only go on indefinitely for the race as a whole. To recognise the implications of this evolutionary process is perhaps to see a deeper meaning in the rhythm of birth and mortality.