

POERKSEN: So you thought likewise that the external object determines what happens inside the organism.

MATURANA: Quite right. I expected to be able to demonstrate an unambiguous correlation between the colour and the activities of the pigeon retina because I had already shown in comparable experiments that the activities of certain cells could, in fact, be correlated with specific shapes. I performed numerous experiments – nevertheless, I simply could not confirm the correlation I had predicted. It was impossible to find specific cells or cell groups that would react in a determinate manner to given spectral compositions.

WHY THE NERVOUS SYSTEM IS CLOSED

POERKSEN: So we face here an exemplary situation of all the researchers who are trying to test a hypothesis. They will usually carry on along the same lines, change their assumptions within the given framework, or develop a completely different and new hypothesis. What did you do?

MATURANA: At first I thought that my recordings were not yet accurate enough so I tried to refine them and to improve my recording instruments. My procedure was as follows: While the pigeons were shown colour tables, the activities of their retinal cells were recorded by means of fine electrodes. Numerous continually re-designed experiments only showed, however, that all the cells more or less reacted to all the different spectral compositions. No significant correlation between the activities of certain cells or cell groups and the spectral composition of the colours could be read off the minimally different modes of the cell reactions. The marginal differences in the modes of reaction were not significant.

POERKSEN: Comparing this experiment on the colour perception of pigeons with the striking behaviour of the manipulated salamanders, we find ourselves facing the same situation: the problem of the determination of what is inside by external determinants – coloured objects or moving worms.

MATURANA: That is the point. Furthermore, it becomes apparent that every experiment contains a particular view of the world, a complete epistemology, or cosmology, a bundle of expectations and premises, which guide our operations. One day, however, I realised that my expectations might possibly never be fulfilled because a correlation between the external stimulus and the internal reaction just could not be established. Only then I began really to appreciate Roger Sperry's experiments and their hidden epistemology, and to envisage the nervous system of an organism as a closed system. That was the turning point which gave me my thinking a new direction.

POERKSEN: What precisely brought about that transformation of your views? What was the reason? You could simply have accepted the failure of the original hypothesis and moved on to a new topic.

MATURANA: And that is precisely what did not happen because I managed to bring about a re-orientation that demolished the framework within which a transformation would still have been acceptable. The customary way of slightly modifying one's assumptions and procedures would have consisted in creating ever-finer instruments of measurement and in continuing to carry out new experiments in the hope of producing productive results, in the end. I opted for something entirely new, however, which made some of my university colleagues seriously doubt my sanity. Perhaps I should, I said to myself, deal with the strange question whether the activity of the retina could be shown to be connected with the names of colours, which represent a certain experience; whether there might be an internal correlation between the activities of the retina and the names of colours, i.e. between different states of activity within the nervous system. The consequence was a momentous change with regard to the goal of my research and the traditional point of view. Suddenly I found myself outside the established traditions of perception research. Suddenly I was confronted by epistemological questions: What does it mean to know if we consider the nervous system as a closed system? How can the process of cognition be understood at all?

POERKSEN: Your key idea to correlate colour names and retinal states does indeed seem somewhat strange and rather curious. Names and

designations of colours are, after all, merely arbitrary products of convention.

MATURANA: People naturally thought I was crazy. It even led to people laughing about me behind my back during my lectures when I had turned to the blackboard to write something. A friend of mine told me one day. I knew very well, of course, that names are arbitrary entities; at the same time, I was aware of the fact that we use the same colour term for extremely diverse spectral compositions; our colour terms, therefore, refer to our own experiences, they are indicators of experiences. What had to be demonstrated was that the activities of the retina and the retinal ganglion cells are correlated with the specific experiences represented by colour names. That is precisely what I managed to show.

POERKSEN: What, then, is a colour?

MATURANA: It is nothing external but something happening in an organism – merely released by an external source of light. A colour is what we see, what we experience. The colour designation refers to the particular experience of an individual in certain situations, which is independent from the given spectral composition of light. My approach was to compare the activity of the nervous system with the activity of the nervous system, to relate the activity of the nervous system to itself, and to view it as a closed system. My focus was on internal correlations.

POERKSEN: Even this version sounds strange and obscure, at first. The classical view, after all, defines the nervous system of an organism as an open system: receptors react to excitation by external stimuli, and these are then processed further. The result is a more or less faithful representation of the real world.

MATURANA: Those who share my conception and accept it as a basis for their own reflections first have to get rid of an erroneous interpretation of the concept of information processing which was once quite popular in biology but did not really contribute very much to our understanding of the nervous system. For a long time, the dominant belief was that the nervous system of an organism processes

information coming from outside in order to generate adequate behaviour of this organism. The source of information located in the environment would – so the assumption – modify the structure of the organism in such a way as to generate behaviour that would be adequate with regard to given external circumstances. Such a view, however, is not helpful at all; the nervous system does not function in this way.

POERKSEN: How would you describe what is going on? What happens, in your view?

MATURANA: When light reflected by an object that the observer describes as external reaches the retina, an activity is initiated that is enclosed in the structure of the retina itself (and not in the structure of the source of light, nor in the structure of the world). The external world can only trigger such changes in the nervous system of an organism as are determined by the structure of the nervous system itself. The consequence is that there is no possible way, in principle, for the external world to communicate itself in its primordial, true form to the nervous system.

POERKSEN: What does this mean? How does this abandonment of the idea of information processing inspire or even compel us to think and speak differently about the external world, the organism, and the nervous system?

MATURANA: Our approach changes completely. We can no longer accept descriptions of the nervous system as a system that computes representations of an external world and processes information coming in from outside, which then results in adequate behaviour and appropriate reactions of the organism. The nervous system now appears as a structure-determined system with its own specific mode of operation. Any change in it is only triggered but neither determined nor specified exclusively by the features and properties of the external world. It computes nothing but its own transformations from state to state. People who accept this insight must draw a strict conceptual distinction between the operations taking place inside the nervous system and all the processes occurring outside it. They must also be quite clear about the fact that there is no inside and

no outside for the nervous system but only a perpetual dance of internal correlations in a closed network of interacting elements; inside and outside exist for the observer but not for the system itself.

DOUBLE LOOK

POERKSEN: It seems to me that such an interpretation of neuronal processes must inevitably lead to the biologically grounded denial of the external world. What you are saying raises once more the suspicion of solipsism. The nervous system exists, if I understand you correctly, in complete cognitive isolation. It is floating along as if in a void.

MATURANA: Once again I have to reject this classification of my views as solipsistic. Again: as the observer that I am, I do not at all deny the experience of an external world, nor the experience of common discourse and the experience of other people's existence. I vehemently deny, however, that the operations of the nervous system can be related to this external world and its features in any meaningful way or that they can be derived from them. The nervous system operates as a closed system of changing relations between neuronal states of activity that continually lead to other changing relations between neuronal states of activity. For its operation as a system, nothing else exists but its own internal states. Only observers can distinguish between inside and outside or input and output and can, consequently, diagnose the impact of an external stimulus on internal processes and the organism or, conversely, an impact of the organism on the external world. What is described as adequate behaviour is the result of a relation established by observers. They have related the features of an external world to the organism and its nervous system although these external features are not part of the operations of the organism nor of its nervous system.

POERKSEN: Surely people who speak of the closure of a system can neglect the existence of an external world, can challenge and deny it.

MATURANA: The assumption of closure has to do with the internal dynamics of the nervous system and refers to its mode of operation; it has nothing to do with the question whether there is – indepen-

dently from the closure of the system – an external world or whether we must consider reality an illusion. That is no longer the problem. Once we have accepted that there is no possibility of making testable claims about an observer-independent reality, the fundamental change in our epistemology has been completed. All forms of observation and explanation are now expressions of the system's operations with whose production we may now deal. A re-orientation has come about, a change from Being to Doing, a transformation of the classic philosophical questions.

POERKSEN: The assumptions of the closure of the nervous system and the external viewpoint of the observer imply, if I understand correctly, the distinction of two perspectives of observation. On the one hand, observers describe external impingements upon a system and construct correlations between stimulus and response, input and output, cause and effect. On the other hand, the system operates – independently of external influences – in its own specific manner.

MATURANA: That is it. The phenomenal domain of physiology and internal system dynamics does not intersect with the domain of behaviour and observable movements in an environment. These domains cannot be reduced to each other, nor can the phenomena of one of the domains be derived from the other.

POERKSEN: Could you provide an example?

MATURANA: On certain occasions I use the example of an instrument flight when I want to explain the difference between the internal operational dynamics of a system and what happens in the domain of interactions of the system as a whole. Imagine pilots sitting in the cockpit and flying a plane in complete darkness. They have no immediate access to the external world nor do they need it, they act on the basis of measurement values and indicators, employing their instruments when the values change or particular combinations of values emerge. They establish sensorimotor correlations in order to keep the relevant values within specified limits. When the plane has landed, friends and colleagues may appear who have observed the plane arrive, and congratulate the pilots on their successful and admirable landing in thick fog and dangerous storms. The pilots are confused

and ask: "What storm? What fog? What are you talking about? We just handled our instruments!" You see: What happened outside the plane was irrelevant and without meaning to the operational dynamics inside the plane.

POERKSEN: Do you want to suggest with this pilot example that we are all enclosed in our own cockpits and our worlds? More drastically: Are we in the same situation as these pilots when we are trying to understand the world? If this should be so, then I would maintain that we would be incapable of diagnosing our situation the way the pilots do because we could not possibly know the limits of our knowledge. If we were able to do that, the limits would cease to be limits.

MATURANA: Correct. Only one condition permits us to perceive our own blindness: We must be able to see and to know, and we must, therefore, no longer be blind when we gain insight into our own blindness. However, this is not the point of the example. For the pilots just working their instruments in the situation described, the so-called limits of knowledge do not exist at all. The crucial thing is that only observers can speak of limits because they have access to their own domains and to the domain of the internal operational dynamics of the cockpit. They have to use their double look and compare what happens inside the cockpit with the circumstances in the external world and then relate what they have seen in the two different domains in another domain generated by themselves. All that observers can say is the result of this double look.

POERKSEN: These observers describing the perceptual limits of the isolated pilots must essentially be realists. They are able to grasp the reality that remains unknown to the pilots in their cockpits, and therefore they know what really happens.

MATURANA: How can these observers know that they themselves are not sitting in some cockpit containing a world in which pilots sit in cockpits that may be observed through double look? They could only diagnose limits of knowledge if they had absolute knowledge about precisely that situation. Under this condition only they would be able to establish the limits of knowing, with the necessary conse-

quence that they would have to declare themselves realists believing in some objective realities. I would claim, however, that these observers are comparing two different domains of distinction, not a real world with a merely fabricated world. They see the pilots at work inside, as if through a peephole in the wall of the plane, whereas from outside they see the plane as a whole in relation to its domain of operation.

POERKSEN: You say that the thesis that the nervous system is an open system results from a particular perspective chosen by observers. But is your claim that the nervous system is closed and cannot meaningfully be described in terms of input and output not the result of an observer's chosen point of view? Surely, both these assumptions cannot be right at the same time. They are essentially contradictory.

MATURANA: There are, in fact, two different perspectives of observation that naturally generate different descriptions. Still, the two conceptions are not equally valid. If one wants to find out how the nervous system operates on the assumption that it is an open system, one has chosen a misguided approach. Observers will believe, accordingly, that its mode of operation is dependent on its input. What they define as external stimuli in the environment will gain enormous importance and make them overlook the internal dynamics of the system and to confuse the domain of their descriptions with the domain of the internal dynamics of the system. Such a confusion of domains cannot offer an adequate explanation of the mode of operation of the nervous system. - If we, however, view the nervous system as a closed network we can understand its mode of operation and recognise how structural changes in an organism that is in correspondence with its medium will lead to structural changes in its nervous system and ultimately to changes in its behaviour. We need, therefore, no longer speak of the flow of information but instead, when observing an organism in its environment, ask ourselves how the strange structural coupling between the activities of the nervous system, the body of the organism, and the external circumstances functions in detail.

POERKSEN: What does it mean, then, to conceive of the nervous system as a closed system? It cannot be totally shut off against the envi-

ronment because it is dependent on the exchange of matter and energy. If this exchange fails for some reason, the organism will collapse and perish. So the input from outside cannot simply be neglected; every living being is vitally dependent on it.

MATURANA: Now you are arguing like a physicist in the context of thermodynamics. Naturally, the nervous system of an organism must be open for the flow of energy and matter – that is more than obvious. The cells will die otherwise. Closure is not a physical concept but characterises the self-referential working of an internal dynamics. The processes recurring in a particular domain remain in this domain; we are dealing with the operations of a system that determine its boundaries and make it a determinate entity. Therefore, by closure of the nervous system I mean that its states of activity always lead to other states of activity and are triggered by states of activity, and that all these diverse states of activity remain within the network of neuronal elements.

To LIVE IS TO KNOW

POERKSEN: You have already reported how certain intellectual experiences completely changed your epistemological views. The question now is how we can understand and describe the processes of cognition if the nervous system is considered as a closed network operating exclusively according to its own internal laws. What is cognition?

MATURANA: Cognition is the observation of adequate behaviour in a particular domain, not the representation of an independently existing reality, nor a process of computing according to the conditions of the environment. When an animal or a human being behave adequately and are in coherence with their circumstances, and when observers come to the conclusion that there is adequate behaviour in the situation they observe, then these observers will say that the animal and the human being in question possess knowledge, that they manifest cognition. Knowledge is, in other words, behaviour in a particular domain, which is judged adequate by observers.

POERKSEN: Your description of the circularity of the cognitive processes leads to a circular definition of cognition and knowledge, which mirrors the whole architecture of your theory. Cognition is understood and established by observers; knowledge appears as an observer-dependent product, not as something objective.

MATURANA: This is the idea, quite. Observers interpret the interaction of organisms with their environments in such a way as to diagnose adequate behaviour, and observers attribute knowledge to the observed systems and evaluate their actions as indicating cognitive operations because they consider them adequate and appropriate. The maintenance of life is an expression of knowledge, in this sense, a manifestation of adequate behaviour in the domain of existence. In the form of an aphorism: *In the living of living beings living entails knowing, and knowing entails living.*