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# The wholeness of the unity: Conversations with Heinz von Foerster

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Heinz von Foerster is a remarkable man. In this most of his friends agree and my statement offers no novelty. What nobody knows, however, is why I consider him a remarkable man, and it is of this that I am writing in this essay to honor him.

I consider Heinz von Foerster a remarkable man because he is both in thought and in action essentially a magician, and, hence, a man that can consciously exist simultaneously in many realities. I do not claim that he is in this unique, I only claim that in this he is remarkable, and that this I admire in him.

We worked together for about ten months while I visited him in the Biological Computer Laboratory at the University of Illinois during the years 1968 and 1969. Maybe that we did not work in the usual sense, but we talked a lot and embraced each other frequently, spending many full hours conceiving a Tractatus Biologico-Philosophicus that we never had the time to write. Yet, we learned with each other, and I was enriched with a most fundamental insight: the understanding of the unity of the unity through the understanding of its wholeness.

As a biologist I had been interested for many years in the organization of both the living and the nervous systems. This for two basic reasons: i) I wanted to understand living systems as autonomous entities; and ii) I wanted to understand the participation of the nervous system in the phenomenon of cognition. I was well versed in the ways of speaking in purposeful terms about the organism and its organization, describing it functionally as a goal oriented system. I was also well versed in the ways of considering the nervous system also in purposeful terms, and talked about it as an organ of perception and as a processor of the information received from the environment. I felt, however, that the notions of purpose, function and goal were fundamentally fallacious when applied to living systems in order to explain their operation, even though they were heuristically useful in view of the adaptive character of both phylogeny and ontogeny in living systems. The notions of purpose, function and goal, are referential notions, and their use always implies a relation with a domain different from the domain in which the system to which they are applied exists. The value of these notions is clear in human design because through their use man defines domains of selection for his actions. Yet, when one wishes to understand living systems as autonomous entities, this reference to another system or domain to which the observer must have an independent access, and with respect to which he makes the description in purposeful terms asserting that the system is realized through goal oriented processes, is misleading. The same happens when one tries to understand the participation of the nervous system in the phenomenon of cognition. In fact, if a purposeful description is used, and a goal is claimed in the processes of the organism, then the observer either believes that the purposeful description reveals the way in which the system described operates, or he (or she) uses the purposeful description as a metaphore. However, in the first case the observer would commit a mistake because the components of a system operate (through their properties) only on neighbourhood relations, and any reference to a goal in their operation only asserts a cognitive relation that the observer establishes when he beholds simultaneously the components and the system that they integrate; in the second case the purposeful description that the observer makes is misleading because a metaphore requires that the listener should already know that to which it refers, so that it only orients him or her to his or hers pre-existing knowledge, and, hence, it carries no novelty in relation to how the system operates. Thus, for example, if I were to say, ‘The function of the messenger ribonucleic acid (mRNA) is to convey to the ribosomes the information needed for the synthesis of proteins’, then I would say nothing about how the mRNA operates in the synthesis of proteins, or how is the protein synthesis realized, to a listener that does not know how it does take place. The notions of function and information (which is also referential), only address the observer to his state of knowledge and to his certainties and uncertainties about the system, but do not address him to any feature in it. Similarly, if I were to say, ‘In mammals one function of the level of oxygen in the blood is the control of the breathing rate of the organism’, then I would be again making a referential statement that reveals my view of the relations that I establish between oxygen concentration in the blood, activity of the nervous system, and contraction of the diaphragm, in the perspective of the organism as a whole. This is obvious for almost everybody, and it is not necessary to be a cybernetitian in order to realize that such an expression only has communicative value, in a metadomain with respect to the operation of the components of the organism, between the persons that know how the system works. Yet, unless this is fully realized in fact, in cases less obvious an

observer may be misled by the use of expressions like control, feedback or information, and act as if these expressions were telling something intrinsic to the components and their operation as components, and not only something about their relations viewed from the perspective of the whole that they integrate. I imagine that cybernetitians never commit this mistake, but we biologists frequently do. Therefore, at least from the perspective of a biologist, it is legitimate to ask the questions: 'If to use the notions of purpose, goal or information, is fallacious, how should one then refer to the relationship of the components and the whole that they integrate?, and, 'How should one speak in order to grasp the wholeness or unity of a system in a description that reveals the system and not only our cognitive relations to it? At present the answer to these questions is for me obvious. However, it was not obvious for me when I came to work with Heinz Von Foerster at the University of Illinois, and although he did not give me this answer (which I am sure he had), I found it inspired through my conversations with him, and through my attempt to answer other questions that he posed to me. In fact, I think that he gave me the answer through its use. Let me tell of this:

His actions

Heinz is indeed an accomplished magician. Yet, as far as I know he did not earn his living as a magician in a professional manner, but he may well have retained his intellectual and ethical health through it in Berlin, during the second World War. The following is a revealing instance of his abilities that proved very enlightening for me. He had at his house occasional evening parties in which he performed informally as a magician. Of course, he had to prepare many tricks in advance, and he had to have them in his mind continuously, in a perfect tuning with the circumstance of his performance, in order to realize them at the proper moment during the evening. One of these tricks consisted in placing a playing-card (say the queen of hearts) between a particular pair of pages (say between pages 184 and 185), in a par ticular volume (say vol. 7) of an encyclopedia (say the Britanica) in the living room. Since a Magician's performance frequently leads to conversations about the supernatural, or about unique powers (that many people seem to desire) such as telepathy or telekinesis, in a few occasions the following would occur. One of Heinz's friends (the most skeptical, of course) would passionately claim that magicians could not perform really outstanding feats that would require more than usual powers. Heinz would play his role in the expected unexpected game and ask, 'such as what?'. 'Well...' his friend would say, 'such as to make appear a playing card in a particular place'. Heinz: 'What card?' Friend: 'The queen of hearts'. Heinz: 'Where?' Friend: 'In a volume of Encyclopedia Britanica'. Heinz: 'In which volume?' Friend: 'In volume seven'. Heinz: 'Between what pages?' Friend: 'Between pages 184 and 185'. Heinz then would act a little and then say: 'Go and see'. Of course the card would be found since Heinz had placed it there before, earlier in the evening.

How can one explain the success of this particular event? I asked Heinz, and his answer was like this: 'Since I had several tricks prepared I had to be careful of not forgetting any of them, and of not letting my arrangements to be disturbed, and, therefore, I had to check in my mind frequently where everything was. This must have characterized my whole conduct during the evening, and I must have been giving clues continuously that could very specifically orient any one in the audience sufficiently atuned to my behaviour. He who was most critical, obviously, had to be the most perceptive of these clues that did not tell him anything in the semantic domain, but which oriented his attention towards that to which I was continuously attending. Therefore, when he had to act, he acted according to a state of attention specified through his interactions with me.' This was revealing. Heinz's actions showed his implicit understanding that he and his friend operated as components of a single system (apparent only to a metaobserver) that were coupled only through neighborhood relations determined at any moment by their properties (psychological and otherwise), and not through relations of purpose specified by their intentions.

His understanding

While Heinz was President of the Wenner-Gren Foundation for Anthropological Research he attended an international conference in anthropology at Moscow. One of the participants in this conference was Margaret Mead. Heinz likes museums; in fact, when he and I met for the first time and became friends at Leiden during the symposium on Information Processing in the Nervous System, in the XXII International Congress of Physiology, he and I skipped the ceremony of condecoration of Professor Ralph Gerard by the Queen of Holland in order to go to visit the museums of Amsterdam. There we followed the rules that visitors must accept. In Moscow the situation was different. As Heinz told me, he went with Margaret Mead to visit a certain museum where, at the entrance, she was told that she could not enter carrying her walking stick. At this Margaret Mead decided not to visit the museum because she would not walk without her stick; yet, a moment later, Heinz convinced her to do otherwise. He said something like this: let me carry your walking stick within my trousers, along one of my legs, inside I shall take it out and nobody will say a word. In this country, whether by perfection or by design, people do not commit mistakes, therefore, any guard that sees us inside with the walking stick will be forced to admit that we were granted a special permit because otherwise we would not be inside with it.' They did as Heinz proposed, and as he predicted nobody interfered with them.

When Heinz told me this anecdote I did not ask for an explanation. Indeed I was impressed. I admired his self confidence, but I admired most his clear grasping of the definitory relations of the guard system of the museum that permitted him either to interact or not to interact with it at will. In fact, this particular event was revealing for me in two respects:

i) Heinz behaved as if he knew that the guards did not consider the totality of the museum as a reference for their behaviour as guards, and that they acted only on local relations. Thus, although a walking stick should not be allowed to enter the museum, a walking stick carried by some one that needs it inside the museum is seen as something that belongs in the museum, and not as something that

should not have been allowed to enter into it. Yet, one can imagine that in some previous occasion the guards received instructions from a leader that had a general view of what should be done, and who acted accordingly. One can also imagine, however, that his instructions would have only specified the properties of the guards for their operation on local relations, without giving them his general view of their responsibilities. If it had been otherwise Heinz and Margaret Mead would have been expelled from the museum.

ii) Heinz, by not asking beyond the entrance whether they could or not carry a walking stick, behaved as if he considered that through his interactions with the guards he could either interact with the protection system of the museum as a whole, or with its components as independent entities, and as if he had chosen the latter. He, thus, revealed that he understood that the guards realized through their properties two non-intersecting phenomenal domains, and that they could do this without contradiction because they operated only on neighborhood relations. This allowed Heinz and Margaret Mead to move through the museum carrying what a meta- observer would have called an invisible forbidden walking stick.

His questions

While Heinz and I were talking about the nervous system during our long conversations in our attempt to generate a Tractatus Biologico-Philosophicus, Heinz made me the following question: 'What is a stimulus for the operation of the nervous system?'

For me this was a very interesting and revealing question, even though it seemed formulated in very standard terms. As every scientist knows, the formulation of a question defines the domain in which the answer must be given in order to be acceptable. Accordingly, I felt that I should examine Heinz's question in the domain in which it demanded an answer, under the assumption that the way he formulated it was not accidental. This I did by evaluating the question in the following manner: i) In this question Heinz does not distinguish between internal and external stimuli for the operation of the nervous system. Therefore, this question implies a view that considers the nervous system as a closed system for the operation of which the observer's distinction between internal and external perturbations of the nervous system is not valid, and for the operation of which internally and externally triggered changes of state (relations of activity between neurons) are states of the same class. ii) In this quettion Heinz leaves out the observer as a generator of the stimulus. Therefore, this question implies the view that what constitutes a stimulus for the nervous system is determined by the nervous system itself. In other words, the question implies the view that although the observer may choose a stimulus from a set of them, he does not determine what structural configuration operates as a stimulus because this is determined by the structure of the nervous system. iii) In this question Heinz does not specify the domain or domains in which the stimuli may exist. Therefore, this question implies the view that a stimulus to the nervous system is any structural configuration of the medium (as the domain in which the nervous system operates as a unity) that triggers in it a change of state, but it does not prejudge about what constitutes the medium of a nervous system, and does not exclude the possibility that the activity of the nervous system itself may recursively constitute part of its medium. iv) Finally, in this question Heinz makes no use of notions of goal, finality or function, in relation to the stimulus. Therefore, there is nothing in this question that may suggest that the answer must include any notion through which the nervous system as a totality may be seen to participate in the operation of its components.

Of the many interactions and conversations that I had with Heinz Von Foerster I have chosen these three because I find them representative in revealing his insights in the operation of systems, as well as in revealing the way he moved simultaneously in many domains of reality. Let me explain this. It is apparent to me that Heinz shows, in every aspect of his conduct, either consciously or unconsciously, that he, as a magician: i) understands a system as a composite whole that he can manipulate (if he so wishes) either by coupling himself to the operation of its components as components, interacting thus with the system at a surface of interactions of his choice, or by abstracting the components from the domain in which they constitute the system, and through interacting with them in the domain in which they are independent entities, change the properties of the system by changing the properties of its components; ii) does not expect from the components any "understanding" of the system that they constitute, nor that one should find in the operation of the components through the interplay of their properties through neighborhood relations, a reresentation of the whole that they integrate; and iii) understands that the wholes does not participate in the operation of its components, and that any interaction of the whole with its components takes place in a different dimension than that in which its components are its components.

It was, in one way or other, through my grasping of these understandings of Heinz the Magician that I reached my own insight into the wholeness of the unity that I summarize below:

■ A unity is always defined by an observer who distinguishes it by a set of operations of distinction that specify its properties.

■ An observer can distinguish a unity, either as a simple unity that he or she cannot or chooses not to analyze into components, and which is characterized only by the properties with which he or she endows it at the moment of distinction, or as a composite unity that he or she anlyzes into components that hold between each other a configuration of relations, static or dynamic, that remain invariant while they integrate it as a composite unity of a particular kind.

■ The invariant relations that hold between the components of a composite unity, and constitutes it as a composite unity of a particular kind, constitute its organization. The actual components (all their properties included) and the actual relations between them that realize a composite unity as a particular composite unity, constitute its structure. Therefore, the relations that constitute the organization of a unity of a particular class are a subset of the relations included in the structure

of a particular unity of that class.

■ The identity of a particular composite unity as a composite unity of a particular kind remains invariant as long as its organization remains invariant. In other words, if the organization of a composite unity changes, the unity disintegrates. However, since the structure of a particular composite unity includes more relations than its organization, the structure of a particular composite unity may change without it losing its class identity as long as the relations that constitute its organization do not change.

■ A simple unity does not have organization or structure. A simple unity, therefore, only exists in the space established by the properties with which an observer, or its operational equivalent, endows it in the operation of distinction.

■ From the perspective of the observer a composite unity has a double existence. In fact, an observer sees a composite unity only to the extent that he or she can define a domain from the perspective of which he or she distinguishes a simple unity as composite by distinguishing the components that integrate it. By doing this the observer makes two non intersecting operations of distinction that he relates, in a metadomain, by mapping them in his descriptive domain through the recursive closed operation of his or her nervous system in a single domain of relations of neuronal activities. In other words, for an observer a composite unity exists: i) as a simple unity (that is, as a whole) in the space specified by its properties as a simple unity, if he or she distinguishes it as such by not distinguishing components in it; and ii) as a composite unity in the space specified by the properties of the components that he or she distinguishes as integrating it as a simple unity, and which realize it as a whole by the way they are organized and determine the boundaries of separation through which the observer distinguishes it as a simple unity. Therefore, the description of the properties of a composite unity as a simple unity necessarily does not include any reference to its components. (For example, a person as a person can be fully described without reference to its component organs and their relations or interactions). But, the description of a composite unity as a composite unity cannot be made without reference to it as a simple unity, because it is with respect to its operation as a simple unity that a composite unity is composite and its components are components that realize its organization. Accordingly, a composite unity and a simple unity exist in operationally different phenomenal domains.

■ A simple unity interacts with other unities through the operation of some of its properties, but a composite unity interacts with other unities through the operation of some of the properties of its components.

In conclusion, an observer can always treat a collection of simple unities as a composite unity by specifying an organization that defines a domain in which the collection of simple unities operates as a whole, and makes the simple unities that integrate its components. Yet, operationally, whenever an observer interacts with a unity, regardless of whether this is, from the perspective of a meta-domain, a simple or a composite one, he always interacts in a space specified by the properties of the unity as a simple one. Accordingly, an observer cannot interact in the same phenomenal domain with a composite unity as a simple unity and with its components as components. The wholeness of a composite unity as a relation of totality in a composition, therefore, is a cognitive relation established as a function of the manner of composition (organization) of a collection of simple unities by an observer who beholds simultaneously, from a meta- domain, the composite unity as a simple unity and its components as components.

I do not pretend that what I have said about unities and wholes is necessarily a novelty for cyberneticians; most likely it is definitively not. Nor do I think that Heinz was not fully aware of all the conceptual implications of his actions and questions. What I am saying is that the fact that Heinz distinguished through his conduct the several non-intersecting phenomenal domains in which a composite unity and its components exist, and that he did this in a manner that revealed that for him the wholeness of a composite unity is never a factor in the operation of its components, was for me inspiring. It permitted me to fully understand notions such as control, regulation, goal or information, that are used to describe the participation of the components of a system in its constitution as a whole, as notions that refer only to cognitive relations generated by the observer in a metadomain of descriptions with respect to the system and its components, and not to any aspect of the actual operation of the properties of the components through neighborhood interactions. Also, it made for me more obvious that the way that the components acquire their properties is irrelevant for their operation as components, because it is only their actual properties at any moment what determines at any moment their actual neighborhood interactions. This I considered then, in 1968, of great relevance for the clearing of misconceptions in the understanding of the relations between a whole and its parts, particularly in the study of organisms as autonomous entities and in the study of the participation of the nervous system in the phenomenon of cognition.

Accordingly, it was only after I understood the manner in which Heinz the Magician treated systems that I understood that the meaning of his question ‘What is a stimulus for the operation of the nervous system?’ was ‘What interactions of the components of the nervous system tread into the operation of the nervous system as a simple unity?’ If the meaning of the question that Heinz had asked had not been this, then the answer to his question would have been obvious and trivial; namely: ‘Any perturbation of the nervous system at the sensory surface of the organism constitutes a stimulus’. But if the question asked by Heinz implied his understanding of systems, then it required a different answer. In fact, it required an answer that answered the reformulation of the question as given above. That is, an answer that simultaneously revealed the nervous system both, as a composite unity whose components operate only on local interactions, and as a composite unity whose components can, in principle, interact through their local interactions with the system that they integrate as a simple unity. It was only after I understood this that I realized that I had the answer from my

studies on color vision with Gabriela Uribe and Samy Frenk, and that Heinz, even without knowing it, also had it, implicit in his question. Thus, my answer was: If i), the nervous system is organized as a closed network of interacting neurons that operates in a manner such that in it every change in relations of neuronal activities generates further (recursive) changes in relations of neuronal activities in it, and if ii), the closed network operates homeostatically maintaining or generating certain relations or paths of change of relations of neuronal activities in a manner determined by its structure, then iii), any change in the relations of neuronal activities in the network that constitutes a compensable perturbation (that does not disintegrate it) in the network, is a stimulus for the operation of the nervous system. In an actual nervous system the relations of neuronal activity or the paths of change of neuronal activities generated by the closed neuronal network, must be subordinated to the maintenance of the organization of the organism which it. integrates.

This answer proved for me fundamental for my understanding of the phenomenon of cognition that I summarize in the statement: to live is to cognize. Yet, I shall not dwell now on this subject, which I have treated in an article called “Biology of Cognition” that appeared as a BCL Report (Report 9.0, 1970), nor shall I consider now the question of autonomy in living systems that is also central for the understanding of the phenomenon of cognition, and that Francisco Varela and I treat in an article called “Autopoietic Systems,” also a BCL Report (Report 9.4, 1975). I shall only make a few remarks about the nature of the problem of cognition as I saw it after my interactions with Heinz Von Foerster in the years 1968 and 1969.

The fundamental difficulty that a biologist faces when trying to cope with the question ‘What relations exist between the operation of the nervous system in the organism that it integrates and the phenomenon of cognition?’ is that the answer to this question necessarily involves his notion of reality, which obviously determines the perspective from which he selects the facts that he considers relevant in his observations of the organism and its nervous system. Accordingly, any independent view that permits the biologist to have a more sure holding in one or other of these domains, is for him of great help. This happened to me. When I visited Heinz at the University of Illinois, in Urbana in 1968, I had already concluded that the nervous system had to operate as a closed network of interacting neurons. Thus, when I came to the Biological Computer Laboratory I found this view of closure of the nervous system confirmed through my interactions with Heinz the Magician. I had reached this view while studying color vision when I discovered that one could, in principle, generate the color space of an animal by correlating his retinal activity with his color naming, in a process that entailed the operational closing of the neuronal network by correlating the neuronal activity of one part of the nervous system with the neuronal activity of the rest. My approach had been directly analytical. In Heinz the Magician, however, I found a Zen Master in the art of dealing with systems that revealed the same answer in his perfect tuning with systems, without requiring (at least apparently) to go through the analysis of the nervous system itself. In these circumstances I had to follow the notion of closure in the nervous system to its ultimate consequences, yet, in order to do so I had to accept at least two fundamental ones, namely: i) that whatever happened to the nervous system was necessarily determined by its structure through its operation as a closed neuronal network; and ii) that if the perceptual spaces (as I found studying color vision) are generated by internal correlations in the operation of the nervous system as a closed network, then I had to abandon the notion of reality as the independently given to be grasped by the cognitive operation of the nervous system. Cognition itself became a problem with a legitimate unexpected answer.

If cognition as the grasping of an external reality could not be accepted when attempting to understand the operation of the nervous system, then reality and its cognition had to be accepted as a mode of operation of the nervous system as a closed neuronal network. Also, if to operate with the notion of an external cognizable reality was inadequate, then the question ‘how does the nervous system obtain from the medium the information needed for computing the adequate operation of the organism in it?’ should be changed into ‘how is it that the organism and its nervous system obtain the structures that permit them to operate adequately in the medium in which they exist?’ A semantic question had to be changed into a structural one. It was then apparent to me that this change could only be fruitful if the wholeness of a composite unity was recognized to be in a metadomain with respect to the operation of its components because then, and only then, the distinction between organization and structure permits the full understanding of the phenomena of spontaneous generation, stability and change, in biological systems. Biologists have intuitively known this distinction for a long time, and they have used it in the study of evolution and ontogeny without its full formulation. Yet, they have found it difficult to apply to the nervous system and to the study of cognition because they did not have a clear operational understanding of the wholeness of the unity, and of how a living system operated as a totality. This is very apparent in the frequent confusion between a system as a system and its description. The seduction of Von Neumann to propose outside of biology but under the influence of biological descriptions, a self-reproducing automaton in his article “The General and Logical Theory of Automata,” was a very interesting case of this kind. Von Neumann proposes an effective system of production by a system of another of the same kind as a separate entity. Why did he call his automaton self-reproducing and used an expression used by biologists to refer to cells in reproduction? If he pretended his proposition to be a model of cellular self-reproduction, then it was fully inadequate because what his model modeled was one description of what a cell does, and not what in fact takes place (not even closely) when a cell undergoes reproduction. If that was not his aim, then the name was inadequate because what the automaton does is to produce another automaton of the same kind at its side through a process of genetic determination only metaphorically similar to what takes place in a cell. Cells do not construct other cells, they just divide into two of the same kind like in the fragmentation of a crystal.

The transformation of the semantic question about the cognitive operation of the nervous system into a structural one, brings the problem of cognition within a domain accessible to biology, which has the conceptual and methodological instruments to deal with structural change in living systems. Thus,

learning becomes ontogenic adaptation, and the phenomenon of learning a phenomenon of selection of an ontogenic path of structural change through a history of interactions with invariance of organization in the learning system. In order to understand what takes place in the nervous system as a system while undergoing structural change, it is essential to understand the nervous system as a whole, and to visualize clearly the domain in which its wholeness takes place. Finally, the view of the nervous system as a closed network of interacting neurons has another interesting consequence also basic for the understanding of the phenomenon of cognition. This can be expressed as follows: i) if the nervous system operates as a closed network of interacting neurons, it is apparent to an observer that the nervous system operates only on internal relations, and only through internal relations; ii) an observer external to the organism can consider the internal states of the neuronal network as representations of the environmental circumstances under which they take place as a result of the interactions of the organism; and iii), if i) and ii), then the necessary recursion in the operation of the nervous system as a closed network of interacting neurons appears for an external observer as a recursive operation of the organism on representations of the environment. From all this two additional consequences become apparent to an external observer, namely: i), that everything takes place in the nervous system within the same phenomenal domain, that is, in the domain of relations of neuronal activities; and ii), that although the nervous system does not operate upon representations, the conduct of the organism appears as if it did take place in many disjoint phenomenal domains. These consequences, however, can only be fully appreciated if one sees clearly that the wholeness of a composite unity takes place in a metadomain with respect to the operation of its components, which, for me, has been the fundamental insight that I obtained through my interactions with Heinz Von Foerster.

I cannot say much more in this article without going beyond the generosity of the readers, therefore I shall conclude inviting them to contemplate thre relevant drawings made by my sons to honor Heinz. They are: Autopoiesis, The Tree of Knowledge, and Heinz the Magician.

Lastly, I wish to say that I once told Heinz the Magician that I found his understanding of systems so remarkable that I felt that if he had not been a scientist he would have been a Felix Krull. But I also told him that I was more happy that he was a scientist because this permitted me both, to meet him and to admire him freely.