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# On Information and Autonomy

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# ON INFORMATION AND AUTONOMY [1]

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Abstract
Autonomy literally means self-law, i.e. the absence of control, an idea elaborated in the theory of autopoiesis. It can be demonstrated, however, that biological and social systems (which are autonomous systems *per se*) do exhibit (internal) controls in a rigorous sense. It is argued here that this control, and therefore the autonomy of these systems is necessarily described in terms of information, a concept expelled from autopoiesis. A sharp distinction drawn between *referential* and *nonreferential* aspects of information might enable a characterization of autonomy with the aid of referential information.

Résumé
Autonomie signifie absence de contrôle et de commande. Cette conception a été élaborée en détail dans la théorie de l'autopoïese. Mais, en réalité, on peut démontrer qu'un contrôle interne au sens strict se manifeste dans les systèmes biologiques et sociaux (systèmes autonomes par se). Dans cet article, l'auteur montre que cet état contrôlé et par conséquent l'autonomie des systèmes considérés peuvent être décrits à l'aide de la notion d'information, évacuée par la théorie de l'autopoïèse. Une nette distinction entre les aspects référentiel et non référentiel de l'information est rendue possible par une caractérisation de l'autonomie à l'aide de l'information référentielle.

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## 1. Autonomy as a scientific theory

The aim of this paper is to proceed some steps further towards an operative definition and characterization of autonomy.

The widespread and more or less plausible intuition is that a system is autonomous if it decides upon its own fate. More scientifically, this means an internal determination of system laws. Examples are found in biological and social systems.

Human dignity certainly falls into this category. Also animals are capable of making decisions on an internal basis. In recent years the «internal activity» paradigm of human and animal brain functioning became popularized. According to this view, sensory percepts only serve as subsidiary inputs to a basic nervous activity which actively forms the ways in which the environment is perceived and acted upon. Furthermore, even plants and bacteria contain, in an integrated form, the information necessary to their functioning. This is expressed in intricate behaviours such as developmental programs and other manifestations of gene expression. That key factors of these activities are internal to the organisms is proved by the known fact that they can be permanently altered by genetic manipulation.

However, it is easy to see that there are some arbitrary elements in the above statements. The problem is that other factors such as abiogenous parameters (energetic conditions etc.) and properties of the biological environment (i.e. of the ecosystem which provides suitable food, shleter and mating partners) are also necessary for the functioning and long-term permanence of this organization. In this light, the meaning of the word «autonomy» becomes rather questionable.

This problem can be solved, however, if we dig deeper. I would like to illuminate this on another biological example. An important recent topic of evolutionary biology is the role of *evolutionary constraints* [1]. This term denotes any «bias» in biological variations which is not due to «evolutionary forces» (selection, populational drift, etc.). Now one may rise the question wheter *gravitation* is an evolutionary constraint or not [2]. Trees never grow up to the sky – because their constituting material cannot sufficiently support their mass against gravitation. In this intuitive sense, this is a constraint. But the actual explanation of biological processes does not need any reference to gravitation, although it acts everywhere. That is, these processes effectively *decouple* from gravitational ones (in biologists' terms, it is enough to examine the role of gravitation on the *existing* phenotype and the effect of constraints is just to bias the *generation* of phenotypes – therefore, gravitation is not a constraint). In other words, processes within organisms as biological *units* are describable independently from such factors. In fact, the biological units can be delimited by considering exactly these decouplings.



It is in this sense that we may start to distinguish between «internal» and «external» factors in a meaningful theory of autonomy. An attempt to formulate such a theory is known as *autopoiesis*. Whereas admitting its great heuristic value, we expressed (with V. Csanyi as the first author) a criticism on details of this theroy elsewhere [3]. Here an alternative, but closely related approach to autonomy will be suggested.

The difference stems from the notion of *control*. In autopoiesis, it is understood in the following way [4]. The unity (or, alternatively, the purpose) of a system is defined by the specification of its organization. This is usually done by an observer who uses indications [5] which distinguish the system from its environment. Now basic claim in the theory is that an organization can be defined in two fundamentally different ways [6] : either from *inside* or from *outside* the system involved. The latter case is said to involve the possibility of prescription, design, and *control* : whereas the former means *autonomy*, or organizational closure : the systems enters its own indicational space (which leads to self-reference). (Autopoiesis is defined in this framework as a particular autonomous organization (see the original texts).

## 2. Control and the dialectics of «in» and «out»

In order to put the notion of control into a different light. I should like to return to the intuition on autonomy. The observation I emphasize is the following : the *same* network of interactions that constitutes and defines biological and social systems, manifests *internal controls* in these systems. That is, we may conclude : if these systems have autonomy, they have it because of their ability for self-control. I shall develop this point in the rest of the paper.

As to the characterization of internal control, let us take the example of a living tree. In autumn leaves fall down because the tree withdraws liquids from the twigs and branches. This is a process initiated by genetic material, under some external conditions. Even more spectacular is the behaviour of some unicellular organisms which are able to stop entire metabolic networks and start others. They are like factories [7] which can be dramatically reorganized under internal initiatives. Entire production lines can be disassembled and completely different machines can replace previous ones. Cells themselves produce these machines.

Control is, by all means, an *intervention* to a process, depending on what is going on. Its best known description is via feedback equations and cybernetical theory. I shall not use these formulations here, because, as it can be easily verified, they presuppose the existence of some *model* of the controlled system. These models are, however, human products and are, therefore, observer-dependent. This immediately leads to the same type of definition of control as used in autopoiesis.

Instead, I shall focus on a relation between *systems* that control each other. Obviously, if a system is controlled, this presupposes the existence of an *external* agent (an «outside»). That is, there must be a separation between the controller and the controlled. Seemingly, we are back to the starting point again. Nevertheless, we shall see that this property also enbles the appearance of control *within* one object, one unity (such as an organism).

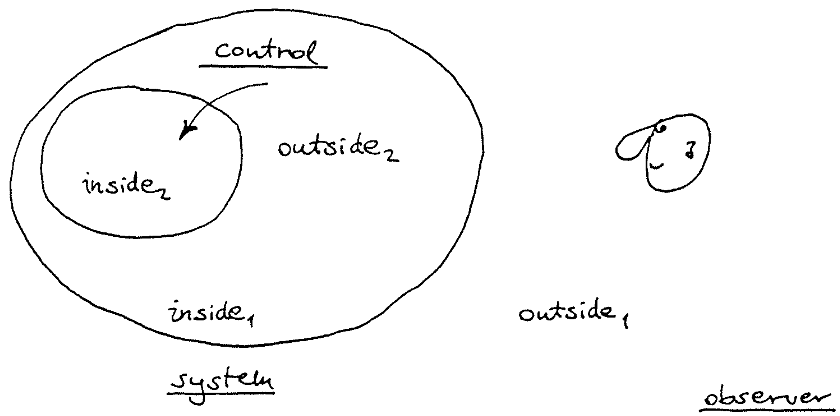
In a mechanistic, static view, an object in itself (an «inside») cannot be said controlled. This is a consequence of the generally accepted epistemological paradigm, stating that a suitably defined system has a definite internal structure which can be described and which uniquely determines the system behaviour, given the boundary conditions. Those are precisely the boundary conditions manipulation of which enables control over the system – and this control comes from outside [8], consequently.

At a closer examination, however, *inside* and *outside* prove to be more relative categories. To some extent, this was acknowledged also by F.J. Varela who proposed a dialectics of autonomy and control for the full understanding of living organization. His dialectics is based on the *epistemology* of the position of the observer ; I shall have a different concern here. The dialectic view envisioned here is based on som technicalities related to the very concepts of a *system* and its behaviour [9]. More concretely, it seems possible to define the categories of «inside» and «outside» not relative to an observer but relative to a system.

Briefly, this goes as follows. If we have a process in a system and we want to impose control on it, what we have to do is to *step out* of the system. That is, the system can be visualized as a domain (delimited as an «inside» by an observer standing «outside») – and now a *further* distinction is introduced that separates this domain into two new domains : to a new «inside» and «outside». Now, if it is possible to



*reduce* this description of the system (with separated domains), to a description with no internal separation, then there is no «outside» within the original «inside». If the internal separation is nccessary there *is* an «outside» within the system (for another part of the system). This is, in my view, the point where internal control can emerge (Fig. 1).




Let me put this idea into different words. *Dialectics,* as a philosophical notion comes along with a reference to an *activity*. Recall that its opposite, *mechanicism* suggests a world view in which the observer has no role. Now, when turning to dialectics, the sort of activity one has in mind is usually that of the observer. In this paper. I try to replace it, in the context of autonomy, with the activity of the system which gives rise to new domains by and from itself.

Do such systems really exist, however ? In other words : Is the introduced notion of control irreducible and necessary ?

## 3. Information

To answer this question, the notion of information, another difficult subject of system theory will be discussed. Seemingly, this is a byway. But very soon we shall arrive right to our question, and this will finally enable a sketchy characterization of autonomy in the last section.

Incidentally, the concept of information enters our discussion in a very natural way. Starting again from the intuition, control is intimately tied to information, in the sense that the controller should contain some information which is related to the controlled behaviour. This information is not present in the controlled system. If it were contained also in the latter, there would be no need for control. Let us observe that all traditional developments of the theory of control use this intuition in some or another way. One conrete utilization of this idea is a quantification of variety [10] and the conception of control based on choice, as a reduction of variety. This is, of course, a subfield of Shannonian information theroy which yields well-known results, such as Ashby's *law of required variety* [10].

However, this theroy of information is based on a separation of what are called *quantitative* and *qualitative* aspects. Today it is known that this idea is not sufficiently justified and its use may yield wrong results. This led to various redefinitions of the concept of information (for a partial review, see [11]. One of these, due to the present author, will be outlined below.

First consider the traditional scheme of information transfer through a channel, from a source to a receiver. Whether or not two physically different signs (such as «A» and «a») are identical is a matter of agreement between the participants of communication. If they do not talk to us, we have to look whether there are state transitions on the receiver side. If not, there is no information communicated. Also we have to look how subsequent messages are accepted. If there is no change in this, there was no information communicated. That is, when speaking about the scientific notion of information, we are no more considering probabilities and entropies but coordinations of proecesses in a system. This is the key observation.

That is, information is related to the modes of system functioning. This has a rather unexpected consequence. Information, appearing in a system is *different* from information appearing for an observer. The reason is that in a system information is related to some *actions* whereas information for an observer means an acquisition of *knowledge*. These notions are not compatible with each other. For instance, knowledge acquisition has a related energy cost, as known from thermodynamics. This energy is not expended by the system but by the observer, as long as the latter is not within the studied system itself. Therefore, information in a system is not equivalent to knowledge, at least from a logical point of view.

I proposed the terms *referential information* for the corresponding action and *non-referential information* for knowledge, repectively [11].



Of course, as long as we are interested in one system and its information, these forms of information constitute two sides of one thing. Further, and most importantly to our present subject, let us note that referential information always comes along with a causal separation of parts of the system we consider. This separation is essentially in the form «A informs B». In this expression emphasis is not on the relation which connects A and B, but on A as determining this relation.

Nonreferential information, by definition, corresponds to the amount of available knowledge about a system (or subsystem). That is, the concept of referential information is *necessary* only when nonreferential information, in a sense, does not (cannot) convey *all* information to us. For instance, referential information has to enter as a system description if available knowledgeit does not suffice for the derivation of the relation between the above A and B. As discussed elsewhere [12], exactly this is the case in a class of systems which can be called *complex systems*, characterized by the property that the temporal sequence of system relations is so intricate that it does not enable any description shorter than the enumeration of the sequence of relations. In this case, we never have enough (nonreferential) information so that we could replace referential information with relations derived from the former [13].

## 4. Conclusions : information and autonomy

With the concept of referential information, it becomes possible to describe internal controls in a more precise sense. As already discussed, the kind of control we considered here stands in no contradiction with any, no matter how restrictive definition of autonomy. Instead, I argue that a proper definition of the latter can be achieved through it, and eventually through the concept of information.

Note that *anything* shows a degree of autonomy if this control aspect is ommitted. An illuminative example is an electron moving in vacuum. One of its possible descriptions (exploited in some numerical approximation techniques) is that its own motion gives rise to an electromagnetic field which forces it to move in the way it does.

On the other hand, nothing has perfect autonomy – because the actual behaviour of any system is influenced by outside factors. Needless to say, outside factors can cause even interruption of identity (such as death in case of living organisms). That is, the kind of autonomy we are looking for must be identified as a specific *subclass* of internal determination. And since it is clear that the autonomy of biological and social systems is based on their way of functioning, we are in fact looking for a specific class of functioning – eventually of dynamics.

We argued that the characteristic way of functioning of biological and social systems is related to their internal control, characterized by an internal separation between parts of the system. Further, we formulated the claim that information (more precisely : referential information) should be understood as a class of dynamics, which is not describable in one uninterrupted description, rather, separation of the dynamical interaction into distinct parts in necessary.

This now enables us to conceive (intenal) control as an instance of referential information, and with this, as belonging to a definitie class of dynamics.

Based on these insights, I propose to define autonomy in terms of (referential) information. That is, autonomy can be understood in a meaningful way, and in accordance with intuition, as internal determination through internal control, whereas the latter is conceptually linked to information and to dynamics. To put it concisely : *Every autonomous system uses internal control based on referential information.*

Whether or not this gives a suitable *definition* of autonomy or only a *characterization* is a question which needs further discussion. One might say, for instance, that autonomy has to preserve system identity. According to this view, a system where referential information gives rise to the same referential information, that is, a system in which internal control directs processes in a way that they re-construct the system itself (in other words, a system which replicates itself [13] would ne autonomous.

In any case, constructions like the one outlined in this paper might give a more «down-to-earth», operative interpretation to the term «autonomy».

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