Interactivist naturalization of biosemiotics and Peircean semeiotic

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A draft of a proposed presentation in Interactivist Summer Institute, ISI-2003,

Copenhagen, Denmark, July 22-26, 2003

Abstract. Intention is to show how the concepts of Peircean semeiotic can be transformed to interactivist ones, and what restrictions this transformation brings along to the application of Peircean concepts especially to biosemiotics. The basic interactive re-interpretation of Peircean semeiotic for biosemiotics can be done with three levels of representation. At the first level the concept of minimal (interactive) representation is constituted. The second level is crucial, because at it the basic concepts of Peircean semeiotic emerge, like the object of sign, truth and both iconic and indexical types of signs. Finally, it is suggested that a more complex level is needed to establish symbolic signs.

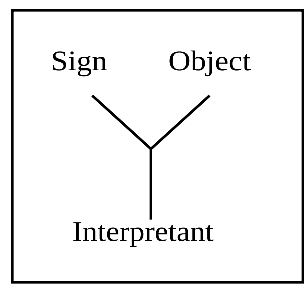
1. Biosemiotics and Peirce's semeiotic

Biosemiotics has been characterized as ”biology that interprets living systems as sign systems” (Emmeche & Kull & Stjernfelt 2002: 26) or “as the science of signs in living systems” (Kull 1999a: 386), which contains the conviction that ”the sign rather than the molecule is the basic unit for studying life” (Hoffmeyer 1995: 369). Basic assumption of biosemiotics is thus that such (originally) *mental* concepts as sign or representation, meaning, interpretation, etc. can and *must* somehow be applied or extended into the phenomena of life, i.e. that living systems are essentially in some general sense *real mental systems* (and not just physical systems). In the dominant (perhaps?) wing of biosemiotics, the ’Copenhagen interpretation’ (Hoffmeyer and Emmeche), the basic mental concepts (sign or representation, etc.) were adopted from Charles S. Peirce’s semeiotic and predicated to living systems and processes.[1]

Peirce’s semeiotic was his theory of *logic* (in broad sense), i.e. *normative* philosophical science of logic that he defined as ”the science of self-controlled or deliberate thought” (i.e not in the modern sense of formal logic that is sheer mathematics). Biosemiotics, in turn, should be *objective logic,* a *theory of mind or thought operative in nature,* but that does not make it non-normative science, instead, its object of study are not just signs and their meanings in nature but also the *norms* or ends that living systems are striving to satisfy. In fact, Peirce himself defines the concept of mind in terms of final causation, of ‘internally normative action’:

> Mind has its universal mode of action, namely, by final causation. The microscopist looks to see whether the motions of a little creature show any purpose. If so, there is mind there. (Peirce, CP 1.269, 1902.)

What is essential to both biosemiotics and Peirce’s semeiotic is thus a quest for *semiotic realism* — that the properties and effects of signs, norms, and mind, wherever they were found, would be the same even if they were not found or recognized.



Peircean concept of sign is non-reducibly triadic and dynamic relation of *sign* itself or *representamen,* its *object,* and its *interpretant.* All three parts may be cognized as existent things separately, but it is their mutual triadic relation that gives them these labels. E.g., there is no representamen without object and interpretant — their triadic relation is internal.[2] It is also a dynamic concept, interpretant or its becoming into existence is temporally following the representamen and its object. The conception was originally (and essentially) a concept of *thought sign*, in which both representamen and its interpretant are *mental* entities, but it is commonly used (also by Peirce) to refer to external signs like traffic-signs, written words, etc.[3] Peirce gave numbers of definitions of sign, from (at least) two different points of view (internalist and externalist) and with varying levels of abstraction and context:

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[1] Another classic of biosemiotics is Jacob von Uexküll whose concepts of *Umwelt* and *functional circle* are essential in biosemiotics (Uexküll 1928).

[2] “A sign is something which stands for another thing to a mind. To its existence as such three things are requisite.
In the first place, it must have characters which shall enable us to distinguish it from other objects.
In the second place, it must be affected in some way by the object which it signified or at least something about it must vary as a consequence of a real causation with some variation of its object. (…)
The third condition of the existence of a sign is that it shall address itself to the mind. It is not enough that it should be in relation to its object but it is necessary that it shall have such a relation to its object as will bring the mind into a certain relation with that object namely, that of knowing it. In other words, it must not only be in relation with its object, but must be regarded by mind as having that relation.” (Peirce, W3: 82-83, “Of Logic as a Study of Signs” 1873.)

[3] However, all external signs are after all essentially internal because of Peirce’s strikingly interactivist conception of perception (e.g. Peirce, CP 5.181, 1903).

> A REPRESENTAMEN is a subject of a triadic relation TO a second, called its OBJECT, FOR a third, called its INTERPRETANT, this triadic relation being such that the REPRESENTAMEN determines its interpretant to stand in the same triadic relation to the same object for some interpretant. (Peirce, CP 1.541, 1903)

Because the interpretant of a sign is thus another sign referring to the same object, it also must have another interpretant, and so on — thus every sign tends to produce a chain of interpretant-signs that constitute a process of interpretation (or more properly, of *investigation*). This process of interpretation is not just a simple succession of signs, but it is a (quasi)-purposive or goal-directed process — a representamen is recognized to represent its object by some *normative habit* of interpretation. The norm in this habit is the criterion for the *successfulness* of the interpretive process — the interpretation may fail during its actualization. If the process of interpretation does not arise above the state of 'feeling' or 'excitement', the feeling or excitement just fades away and the system returns to its earlier state without any significant effects (i.e. without any directed internal restructuration or external action). Still, the process of interpretation may proceed into real action so that the end of the chain of interpretants is achieved. This *final interpretant* is the form that the resultant action takes, it is a form of a habit that either confirms, reforms, or entirely replaces the habit according to which the interpretation was executed — the process of interpretation, *semiosis*, is a process of self-control.

2. Non-interactivist features in semeiotic

For supporters of interactivist notion of representation, the most striking objection might be against the concept of the object of sign. Peirce's concept of sign is most certainly an *encodingist* notion of representation. But I claim that this is the only unfit feature with interactivism, or that all the other problems are consequences of this. In this paper, my intention is to show how the concepts of Peircean semeiotic can be transformed to interactivist ones, and what restrictions to the application of Peircean concepts (e.g. to biosemiotics) this transformation brings along. In interactivism, the role of an object in semiosis has to be replaced by the interaction between the differentiator of a system and the environment of this differentiator.

However, the reasons why there is the concept of object in semeiotic, may reciprocally make clear some basic issues in interactivist naturalism. The basic idea is that there is an asymmetry between truth and error (for far from equilibrium systems). Even if the concept of object of representation is unnecessary for the concept (and emergence) of objective *error,* it is necessary for the concept (*and* emergence) of the active and objective concept of *truth.* Truth is always *about* something and it is never the 'whole truth'. Still, there is always the absolute or ultimate error, *death* or even better, *extinction* — the final failure in self-maintenance. Error does not need to be *about* anything, although it is the error *of* something or some*body.*

I have elsewhere (Vehkavaara 2002 and forthcoming) criticized the Peircean concept of the object of representation (or sign), and especially its biosemiotic application, for falling into anthropomorphic (or better zoomorphic) and logocentric error. The basic idea is that firstly, the concept of sign as a triadic relation was originally discovered and constructed from the point of view of 'transcendental logic' by introspective selfreflection, 'by thought that is thinking itself'. Later the same concept was considered from the point of view of 'objective logic' in a sense that the whole chain of signs were considered as object, 'by thought that is thinking other thought'. This second perspective, 'logic of the other one'[4] is not necessarily naturalistic but it can be naturalized. Secondly, the main context or 'the prototype' of semiosis was for Peirce *science*, a *research process of an honestly truth-seeking experimental scientist* although he intended to generalize the concept of sign far beyond this application. The object of sign was needed for the *norm*, the criterion of success of investigation, without the object there could not be any real progress in investigation.

Thus, Peirce's initial starting-point intuition of representation was *explanative representation*, representation about 'how things are' that is a central intuition of scientific inquiry. But in order to make biosemiotics (most animals, and even many people, do not explain anything), the starting-point should rather be the intuition of *anticipative representation*, representation that is for the *guidance of appropriate behavior,* for the *model* of 'how things should be'.[5] Peirce did embed this intuition into his theory — it is not merely an explanatory concept, but even independently of its explanatory use, an *anticipatory* concept too. A sign or representation is not just looking at its past causes — it has no meaning or signification, i.e. it is not a sign at all, if it *could* not have *future effects*, if it is not *able* to direct *future actions*. Still, the concept of object can not be settled as one of the basic semiotic concepts, presumably there are no objects *for* the *least* complex representative systems.

3. Minimal interactive representation — a representation without the object

As the object of biosemiotics is life or living systems in general, we are naturally dealing with self-maintaining far from equilibrium system and within these kind of systems the initial system-relative normativity emerges. The property of *self-maintenance* is an *existential precondition* of these kinds of systems so that we can define that *serving* a function of self-maintenance is a ***natural self-***

[4] Cf. D.T. Campbell's 'epistemology or phenomenology of the other one' (cf. Campbell 1969 and 1977: 445).

[5] Third possible and perhaps dominant intuition is the notion of *communicative representation*, which governs especially structural semiotics (as the semiology of Saussure) and major parts of linguistics and philosophy of language. This notion may, however, be just a subclass of the notion of *explanative representation*, because it is supposed to *explain* how (mutual) communication of *meanings* (usually between individual human minds) is possible and mediated.

interest of any self-maintenant far from equilibrium system. It is not about the plain survival of a system, but about the survival of a system *by means of its own activity*. The self-interest for self-maintenance is not necessarily the only ‘value’ for the system (like Darwinian ‘survival value’), but it may set up new goals, ‘values’, or purposes as the system develops in its continuous self-organization. Natural self-interest is only *initial* normativity. Moreover, different interacting systems have sometimes conflicting self-interests, and because of that, one may ‘try’ to manipulate other systems to maintain oneself, i.e. to ‘indoctrinate’ ‘alien’ goals to these other systems, goals that are not for their own interest (e.g. parasitic ecological relations).

Even if the concept of natural interest or normativity is essential for interactivist approach as a whole, that is not necessarily so merely for the theory and concept of interactive *representation*. For any representative system, some kind of goal, norm, or purpose is necessary, but this goal does not need to be its own. Thus, we can consider representative systems with non-natural purposes and goals that are set up by humans and that are serving human interests. If the nature of goal is not considered but it is taken as granted, we can say that any control system is representative system, even simple mechanical thermostat that is connected in radiator. This kind of ‘overgeneralization’ of the concept of representation has several benefits. First, it gives a clear sense in which respects robots and other self-regulating devices are human-like (or life-like) and in which respects they are not. Robots can be considered, modeled, and developed as representative systems. Second, mechanical man-made representative systems can be considered as extensions of their constructor (or user), i.e. as newly constructed subsystems of human agent. This is quite natural point of view especially when devices produced by medical technology are considered — e.g. when a malfunctioning organ is replaced by such an artificial device that secures the function of the organ.

However, the asymmetry between success and failure, between truth and error appears only in far from equilibrium systems and when the ultimate goal of action is self-maintenance. There are millions of ways of self-maintenance as the history of life and evolution witnesses but the way of extinction makes no difference, the meaning of total failure is absolute for the system, but one of success depends on the way of self-maintenance.

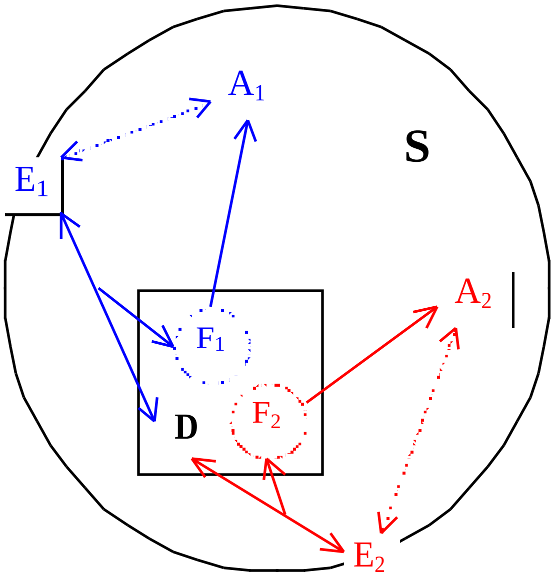
The interactive re-interpretation of Peircean semeiotic for biosemiotics can be done with three (or four?) levels of representation, presented in Bickhard’s “Levels of representationality” (1998b). Level 4 is the basic one, at which the concept of minimal (interactive) representation is constituted. Level 7 is crucial, because at it Peircean concepts of the object of sign emerge. And with it, the active concept of truth becomes accessible to the representative system. Moreover, at that same level, iconic and indexical types of signs emerge. Finally, it is suggested that symbolic signs can be based on the representation of level 8. These can, however, be kind of ‘private’ symbols for the system — whether the genuine intersubjective communication (language) can be based on this or some higher level is not settled.

A minimal ontological representative system (S) have to include a subsystem, a *diffenretiator* (D), engaging in interaction with its environment (E).

> [T]he internal course of that interaction will depend both on the organization of the subsystem and on the interactive properties of the environment being interacted with. […] [T]he internal state that the subsystem [D] ends up in when its current interaction ceases will depend on the environment that it has interacted with. Some environments [E_1] will yield the same final state [F_1], while other environments [E_2] will (or would) yield a quite different final state [F_2]. The possible final states of such a subsystem, then, serve as classifications of the possible environments: each final state classifies all of the environments together that would yield that particular final state if interacted with. Each possible final state [F_i] will serve as a differentiation of its class of environments [E_i]. (Bickhard 1998b, 186)

However, this is not yet enough to define the possible final state of a differentiating subsystem to be a representation of the corresponding class of environments. What are needed more are indications to some goal-directed activity (A_i) of the whole system (i.e. to some effector-subsystem) that may provide a feedback to the environment. This corresponds to representation at level 4 in Bickhard's hierarchy of representations (Bickhard 1998b, 189-191).

This basic model can be applied to any goal-directed control system, even to such a simple system as a mechanical thermostat that is connected in a radiator (see Fig. 4). The interaction of the differentiating subsystem (temperature measuring device) of a thermostat with its environment indicates different activities (switch on or off heating) depending on the quality of the environment (the temperature). A thermostat makes the environmental representation and uses it when it is functioning to fulfill its goal (to keep up minimum temperature etc.).



S = Representative system,
D = Differentiator (differentiating subsystem),
E_1 = Possible local environment 1 of D (alternative to E_2),
E_2 = Possible local environment 2 of D (alternative to E_1),
F_1 = Final state 1 of D (alternative to F_2),
F_2 = Final state 2 of D (alternative to F_1),
A_1 = Activity 1 of S (alternative to A_2),
A_2 = Activity 2 of S (alternative to A_1),
$\longrightarrow$ = Indication, $\longleftrightarrow$ = Interaction.

Figure 4. Basic model of minimal interactive representation.

The case of **S = thermostat** (connected in radiator):

D = Thermometer or temperature sensor
E_1 = Environmental temperature below the goal-temperature
E_2 = Environmental temperature above the goal-temperature
A_1 = F_1 = Switch on heating
A_2 = F_2 = Switch off heating

The case of **S = *Escherichia coli***:

D = System of transmembrane chemoreceptors
E_1 = Increasing concentration of nutrient molecules
E_2 = Decreasing concentration of nutrient molecules
F_1 = Relative saturation of receptors in D
F_2 = Relative non-saturation of receptors in D
A_1 = Counter clockwise flagellar movement (leads to linear movement of S)
A_2 = Clockwise flagellar movement (makes S tumble around itself)

The basic model of minimal interactive representation suits well also for the 'hidden prototype' of horizontal biosemiosis (Emmeche 2000), the chemotaxis of *Escherichia coli.* (See the more detailed description of *E. coli* e.g. in Hoffmeyer 1997a.) Coli bacteria move in the direction which offers more nutrient molecules rather than less. They do this by measuring the saturation of their transmembrane chemoreceptor-sites while they move and by transmitting the weighted result of this measurement to the flagellar motors that are co-ordinately moving the cell. The system of transmembrane chemoreceptors that is sensitive to nutrient-molecules (wherever its internal limits will be defined) is a natural candidate for the differentiator for *E. coli*. Relative saturation and non-saturation of these receptors (or in the 'internal ends' of the receptors, the corresponding binding of ligands) form the two possible final states of this differentiator. When an external nutrient concentration is increasing relative to the motion of a bacterium, receptors will keep on saturated, otherwise the degree of saturation of the receptors will diminish. Each of the final states indicates counter clockwise or clockwise flagellar movements respectively and these will make a bacterium either to move linearly or to tumble around itself.

Although both thermostats and coli bacteria are representative systems, thermostats (like the most of the man-made self-regulating machines) are not alive in any sense unlike *E. coli.* The difference between these is not based on the nature of the representation they are using but on the nature of the goals they are pursuing. Unlike thermostats, coli bacteria are real far from equilibrium systems and have to maintain themselves continuously thus having the natural self-interests of their own. The open question arises: is it sufficient to characterize living systems —or (bio)semiotic agents— as minimal representative systems with at least one 'own' natural self-interest? Or are these merely necessary conditions?

Some characteristics of the model [SKIP THESE?]**:**

1. *Formality of the model.* The interactivism offers only a *formal* model for the most primitive *real* representation. The counterparts in *real systems* have to be identified separately in each case. For instance, a differentiator need not be spatially differentiable 'organ' in the whole system, but it can be integrated in a distributed manner into the system.

2. *Constructivism.* The representations, the possible final states of the differentiator, are not continuously existent things. In this most primitive type of real representation, representations are not like already written letters or stable DNA-segments that are just waiting to be read and interpreted. Instead, their *construction* is repeated in every interaction/interpretation again by the differentiator (or by the interaction between the differentiator and its environment). They are permanent only as *possibilities*, not as existing states.

3. *Internality of representations.* Consequently, minimal representations are *internal states* of the system — they are not stable external things or objects that are just waiting to be perceived. Still, these final state representations are not purely internal or 'solipsistic' constructions of the system, but they are constructed in interaction with the environment so that they are produced *in contact* with the environment.

4. *No objects of representations.* Therefore, *for the system* there are no objects any more than the qualities of objects in its environment. All that a simple thermostat 'perceives' is the type of the environment it is interacting with. They are *we, humans* (who use thermostats) who can say that a thermostat measures the temperature and compares the measured value with its goal- or limit-temperature. Concepts as temperature and object are human concepts — thermostats have no access to them.

5. *Objective error and internal error-detection.* It is important to notice that goals or interests do not have to be represented in the system. A mechanical thermostat has no self-interest, there is no goal for the thermostat itself (although there is for the man), and in the case of a bacterium whose ultimate self-interest is just self-maintenance, the interest is not represented either, life or death is the criterion for the success. Thus, it is not circular to define the concepts of function, self-interest, and goal first, and the concept of representation afterwards.

In the recursively self-maintenant far from equilibrium systems, minimal interactive representations guide the goal-directed activity, and that guidance can be appropriate or erroneous — to be in error does not undress the representationality of the representation. Moreover, the system might even have means to find out that its representation is in error at this same level of minimal interactive representation. There is not only the possibility of error *per se*, but the possibility that the system might discover that it is wrong. "Specifically, if the system fails to reach its goal, then something was in error in the indications of further interactions for that goal, and, since that failure to reach its goal is itself an internal condition of the system, information of such failure is functionally available to the system for further processing". (Bickhard, 1998b, 190)

Consider, as an example, the case of so called *alarmones*, the bacterial signal molecules that signal stress (like glucose starvation), discussed by Gordon Tomkins (1975) and Jesper Hoffmeyer (2002: 111-112). When, say, saccharin molecules block the chemoreceptors of a bacterium, the bacterial system erroneously interprets the situation as if the glucose concentration is still increasing. The bacterium keeps on swimming linearly although it does not catch its primary nutrient, glucose, enough by doing so. If the bacterium had no other means to ensure its energy production, it would starve to death. However, in glucose starvation, when there is no glucose in the cell, the same enzyme (*glucose kinase*) that starts the process of glucose degradation starts its minor side reaction (because of the privation of the substrate of its main reaction), to degrade ATP to cyclic AMP (cAMP).[6] Because cAMP and ATP are closely related compounds and ATP is the major energy-carrier molecule of the cell, the increasing concentration of cAMP leads up to the displacement of ATP from its normal binding sites by cAMP which blocks thus effectively the energy consumption of the cell.

In the situation like this, the high concentration of cAMP is an 'alarm-sign' of an error in the interpretive process that guides the chemotaxis (i.e. movements) of the system. If this error is detected, the earlier dysfunctional indication (straightforward moving) of chemoreceptor-subsystem is blocked off by the indication (lowering the energy consumption) of the 'error-sign' produced by energy-consumption-subsystem. Moreover, the lowering of energy consumption is not the only functional indication of cAMP-alarmones. In the course of evolution, the bacterial systems have learned to use cAMP as a release-sign for specific transcription processes of the production of a series of enzymes needed for the degradation of non-glucose sugars. I.e. when glucose starvation is detected, the production of the means for an alternative energy production system is launched and after that, the original interpretation-error in chemotaxis may no more appear dysfunctional, i.e. erroneous, for the system. It is noticeable that minimal interactive representation is all that is needed for these kinds of switches in behavior. Error of reaching a goal can be detected and compensated by other differentiators.

4. Emergence of the objects (of representation)

If we consider the basic concepts of Peirce's semeiotic, some of them have equivalents in the above described minimal interactive representative system. Most notably, a differentiator-

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[6] The main reaction catalyzed by *glucose kinase* is

$$\text{ATP} + \text{glucose} \rightarrow \text{ADP} + \text{glucose-P}$$

and the minor side reaction is

$$\text{ATP} \rightarrow \text{P-P} + \text{cAMP}$$

where ATP = Adenosine-Tri-Phosphate, ADP = Adenosine-Di-Phosphate, AMP = Adenosine-Mono-Phosphate, and P-P = pyrophosphate. (Hoffmeyer 2002: 111) effector -subsystem (D + the set of potential A_i's in Fig. 4) constitutes a systemic *habit*, each final state (F_i) of a differentiator (D) constitutes the representamen of a sign, and indicated action (A_i) of the system constitutes the (dynamic) interpretant of a sign. But there is no object of representation, for that more complex representative system is required. It can be defined on the basis of minimal interactive representation

A representative system can contain several interlinked differentiators and several different goals. Indications based on one final state of one differentiator can be multiple — which one will be chosen can be dependent on other differentiators and the success in reaching other goals. In such a complex representative system, the internal processing time of a system may become too long for fast enough checkings of the environmental conditions. For such a system, it may be profitable to create and maintain a set of *standard* or *'default-settings' of activity indications* and to keep them *updated ongoingly*. These 'defaults' are then available if needed, without time-taking computation or processing of final states and indications to further actions at that time. (This is a representation of the level 6 in Bickhard 1998: 194.) An organization of the indications of interactive potentialities based on these defaults forms a kind of *situation image* that is used as a base for interaction while the continuous updating of its default-settings (*apperception*) is alienated to an independent process.

The updating process of the situation image leaves great parts of it untouched, so that there are certain temporal invariances in the situation image. If the system is able to discover such types of organizations of interactive potentialities in its situation image that tends to remain constant, unchanged or invariant as patterns with respect to the most potential updates of the situation image, then these invariances constitute something like *objects for the system itself*. Physical objects are then *epistemologically*, i.e. as they are accessible to the system, the "invariances of patterns of potential interactions under certain classes of physical interactions" (This is a representation of the level 7 in Bickhard 1998: 197). Moreover, within the ability to discover invariances in the situation image, the system becomes able to construct not only objects, but also invariant relationships between them, as causal, similarity, part whole, and nearness (i.e. spatial) relations.

Within this level of complexity, the emergence of certain biosemiotically central concepts appears. I suggest that both Peirce's and Uexküll's biosemiotic concepts presuppose this level:

1. Memory and perception. Discovering temporal invariances in the situation image constitutes a system *memory* and makes active *remembering* possible. Past 'experiences' can be reconstructed and the actual updates of the situation image (‘actual experiences’) can thus be identified with the past ones — objects and their invariant relations can be identified and recognized over and over again. Within memory and possibility to recognition, genuine *perception* emerges or becomes at least possible — perception which presupposes at least some kind of recognition and therefore also memory.[7]

The conception about perception is in coherence with Peirce’s conception (see his Harvard lectures, 1903 on Pragmatism, CP 5.14-212). Individual things are not perceived, because objects and other invariances are not individuals but generalities or types. At the most primitive level, there are just classes of environments — at the level of objects, invariant features of different classes of environments are constructed.

2. *Umwelt* and triadic sign. As phenomenal objects and percepts emerge the first time at this level of complexity, and especially because they are not external to the system but constituted as its *internal states* (although not without contact with its exterior) — they can be said to constitute the *Umwelt* for the system. Similarly, the concept of Peircean triadic sign or representation becomes applicable at this level.

If we take some closer look on that troublesome concept of the object of sign, Peirce defines two perspectives to the object. 1) The *immediate object* is the object as it is presented in the sign and 2) the *real* or *dynamic object* can be considered as the hidden totality of *past* efficient causes of the sign to be the sign it happens to be. The problem with e.g. *E. coli* bacteria is that they do not seem to have any immediate objects of representation at all (cf. Vehkavaara 2002: 306-307). But now we have objects constructed by the system itself (in interaction with its environment, however) and internal to the system — *immediate objects* of signs can emerge.

3. Truth. [HERE]

4. Iconic and indexical signs. If there is no object of a sign (for the system), signs can not be characterized either iconic, indexical, or symbolic, because they constitute the possible relations that a sign has with its real (or dynamic) object.

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[7] Two forms of memory (and perception) emerge: one of environmental continuities and the other of internal system flows of activity. (Bickhard 1998b, 197.) Although both of these forms of perception are internal states of the system, the difference between them constitutes the difference between *external* and *internal experience* (cf. Vehkavaara 2002: 295-296). The difference lies in the interacting environments: the perception about environmental continuities constitutes the external experience in which the interacting environment is at least partly exterior to the system boundaries. Consequently, the interacting environment in the perception of the activity history of the system is internal to the system and so it constitutes internal experience.

Iconic signs are representations that are based on the recognition of a similarity between the representamen and the object of representation.

Indexical signs are based on the knowledge or recognition of causal or other real relation (like nearness) between the representamen and the object of sign.

Symbolic signs are representations in which the relation of the representamen with its object is based merely on the *habit* that the representamen is *used* to represent its object, i.e. merely on the fact that the representamen is habitually interpreted as that particular sign.

At the level of phenomenal objects, as remembering, perception, and triadic signs emerge, a system can remember the objects it has perceived in the past and find them in some respects *similar* to some other perception. Thus, *likenesses* can be recognized which makes the emergence of *iconic signs* possible. Moreover, as causal and other real relations (like nearness) between objects have become recognizable, also *indexical signs* are ready to emerge.

I have suggested earlier (in this paper and in Vehkavaara 2002: 306-307) that no higher level than the one of minimal interactive representation is *necessary* for bacterial chemotaxis. However, whether the bacteria as *real* systems function at some higher level of complexity and after all construct internal objects remains still somewhat open question. If *E. coli* bacteria were as simple systems as thermostats are, the situation might be the same for them as for thermostats, i.e. there would be no represented objects for them — bacteria ‘recognize’ only the type of the environment, not the nutrient molecules, and respond with the appropriate strategy. However, depending on the details of the bacterial representation processing, they may be complex enough for us to be able to say that they perceive the object (nutrients) —i.e. that nutrients appears as objects to bacteria— and give an appropriate interpretation to the interactively constructed internal representation of this object.

Emergence of symbolic sign

Although the concepts of *Umwelt* and iconic and indexical signs have now found their place and proper interpretation in the theory of interactive representation, no symbols, no language, and no genuine social communication can yet be introduced. A more complex representative system is needed for all of these. A corresponding situation occurs in Peirce’s semeiotic, e.g. when symbolic signs are considered, they are defined as more developed than iconic and indexical ones, moreover, symbolic signs may have icons or indexes as its *constituents* (Peirce CP 2.261,293; 1903). I will consider only symbolic signs here in order to make complete the most widely used trichotomy in Peirce's semeiotic: division of signs into iconic, indexical, and symbolic.

A system may have separate situation images for activities of a different kind that it uses in order to reach it goals. Each situation image has a direct 'on-line' effect into some activity. However, the environmental information that is gathered for one activity, may not be available for another activity,[8] it may, for instance, be in an inappropriate form. The system can, however, create a 'second order situation image' that does not refer to environment directly but by the mediation of directly functional situation images. (This constitutes the level 8 in Bickhard 1998b.) The representations of this abstract situation image are alienated from 'direct' connect to their environmental referent, and this makes 'theoretical', vicariate, or 'off-line' processing of representations possible.

If we consider symbolic signs, the only property that makes a symbolic sign represent its object is that it is just used to represent it — that there happens to be such a *habit*. Now, the invariances in the relation of 'second order situation image' and directly functional situation images can be just such postulated habits (although they need not be). Thus, the symbolic representation and symbolic signs emerge. Still, these 'symbols' are purely internal to the system, they may be kind of 'private' symbols for the system — whether the genuine intersubjective communication of symbols (language) can be based on this or some higher level is not settled. For this, at least a community of systems is needed, the systems of which may need to have more complex or specialized internal structure.

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[8] For instance, according to Konrad Lorenz (1941), water shrew has separate spatial maps for hunger, thirst, escape from each predator, etc. The spatial information that is saved in 'hunger-map' may not be available when it is thirsty and seeking water etc.

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