Interactivist naturalization of biosemiotics and Peircean semeiotic

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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 (the level phenomenal objects) 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 (the level of symbolic signs) 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). Thus, the basic assumption of biosemiotics is that such (originally) *mental* concepts as sign or representation, meaning, interpretation, etc. can and *should* somehow be either applied or extended into the phenomena of life. Living systems have to be considered as *real mental systems* in some general sense and not as merely physical systems.

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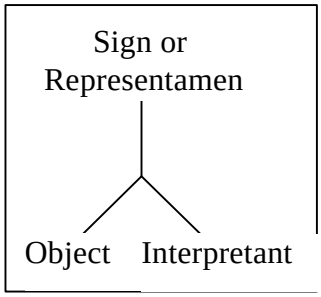
However, because living systems are natural, externally observable, and *real* systems, some kind of *naturalization* or 'operationalization' of mental, semiotic concepts is needed.[1]

For the dominant wing of biosemiotics[2], the basic semiotic concepts (sign or representation, etc.) that are predicated to living systems and processes has been adopted from Charles S. Peirce's semeiotic.[3] Peirce's semeiotic was his theory of *logic* (in broad sense) and he considered logic as a theoretical, positive, philosophical, and normative science.[4] The basic definition of logic is "the science of self-controlled or deliberate thought" (Peirce, CP 1.191, 1903). One of Peirce's most central doctrines is that *all thought is mediated by signs* ("in intuition, i.e., in the immediate present, there is no thought", Peirce, CP 5.253, 1868). Therefore, logic extends into *the science of self-controlled signs*, i.e. of signs that control their behavior or transitions (to other signs), of signs that carry within a kind of *norm* or *criterion of their value* or 'goodness'. Because biosemiotics should find out where, how, and when the concepts of this kind of logic (or semeiotic) appear in biological phenomena, its object of study is not merely the signs and their meanings in nature but also the 'natural' *norms* or *ends* that living systems are striving to satisfy. Without them neither signs nor meanings could be *real*. Because Peirce defined the concept of *mind* (in its most abstract sense) in terms of final causation, i.e. of 'internally normative action',[5] biosemiotics can be understood as a *theory of mind or thought operative in living nature* (cf. Vehkavaara 2002: 302):

Peirce defined his concept of sign as a non-reducibly triadic and dynamic relation. All three relates of the sign —*representamen* (or *sign* itself), its *object*, and its *interpretant*— may be cognized as existent things separately,[6] but it is their mutual triadic relation that allows them to be called these names. There is no representamen without an object



[1] For both biosemiotics and Peirce's semeiotic, a quest for *semiotic realism* is essential — 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.

[2] This might be called the 'Copenhagen interpretation' of biosemiotics. Its basics are presented in Hoffmeyer 1996b, Hoffmeyer 1997a, Hoffmeyer & Emmeche 1991, and Stjernfelt 2002.

[3] Another basic classic of biosemiotics is Jacob von Uexküll whose concepts of *Umwelt* and *functional circle* (among others) are central in biosemiotics (see e.g. Uexküll 1928).

[4] As a theoretical positive philosophical normative science, Peirce's concept of logic includes most of what is today labeled as the epistemology and general methodology of science but excludes most of the 20th century formal (or mathematical) logic. Although philosophical logic uses and rests on mathematical logic, mathematical logic still belongs more properly into the theoretical science of pure mathematics: "Logic, […] is a normative science. […] Mathematical logic is formal logic. Formal logic, however developed, is mathematics. Formal logic, however, is by no means the whole of logic, or even its principal part. It is hardly to be reckoned as a part of logic proper." (Peirce, CP 4.240, 1902.)

[5] "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.)

[6] However, there will never be any existent interpretant if the representamen is not cognized as a sign of its object.

and an interpretant. The act of the recognition of a representamen as a sign of its object creates the interpretant (see e.g. Peirce, W3: 82-83, 1873). The triadic sign-relation is *internal* one.[7]

> 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 [other] interpretant. (Peirce, CP 1.541, 1903)

Because the interpretant of a sign is another sign referring to the same object, it must also have another interpretant, and so on. Thus, every sign tends to produce a chain of interpretant-signs that constitute a process of interpretation. 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 provides the criterion for the *successfulness* of the interpretive process so that the interpretation may *fail* during its actualization.

The recognition of a representamen as a sign of its object has its immediate result the *emotional* or *immediate interpretant*. It appears as some kind of 'feeling', 'irritation', or 'excitement' in the system where the interpreting habit is embodied. The process of interpretation does not necessarily arise above this state of 'feeling', in which case the feeling just fades away and the system returns to its earlier state without any significant effects. If the process proceeds beyond that temporary state, it produces some real action, i.e. some directed internal restructuration or external action of the system. These are called *energetic* or *dynamic interpretants* of the sign that act as signs themselves. The chain of interpretants is potentially endless (as in seemingly endless discussion of the existence of God), but it may as well achieve a kind of end, the *final interpretant* (or *final logical interpretant*).[8] It is no more a sign in itself, but the *form* that the resultant action takes — it is a form of a *habit* that either strengthens, modifies, or entirely replaces the habit according to which the interpretation was originally executed.[9] The process of interpretation, *semiosis*, is a process of *self-control*, a process of *self-controlled habit-formation*.

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[7] Compare the discussion and distinction between internal and external relations in Bickhard (in press).

[8] See Peirce, EP 2:418, 1907. It may be that in his last thoughts, Peirce assumed that final interpretant belongs to every genuine sign-process, if not as actually achieved, then at least as some kind of limit in distant future. The mode of being of final interpretants is 'would-be' (Peirce, EP 2:410, 1907).

[9] This description of semiosis is based mainly on chapter 28 in EP 2. In it semiosis is a kind of 'off-line process', some kind of thought process that starts from perception and ends up to totally internalized and embodied belief (i.e. habit of action) about the (real or dynamic) object of the perceived sign.

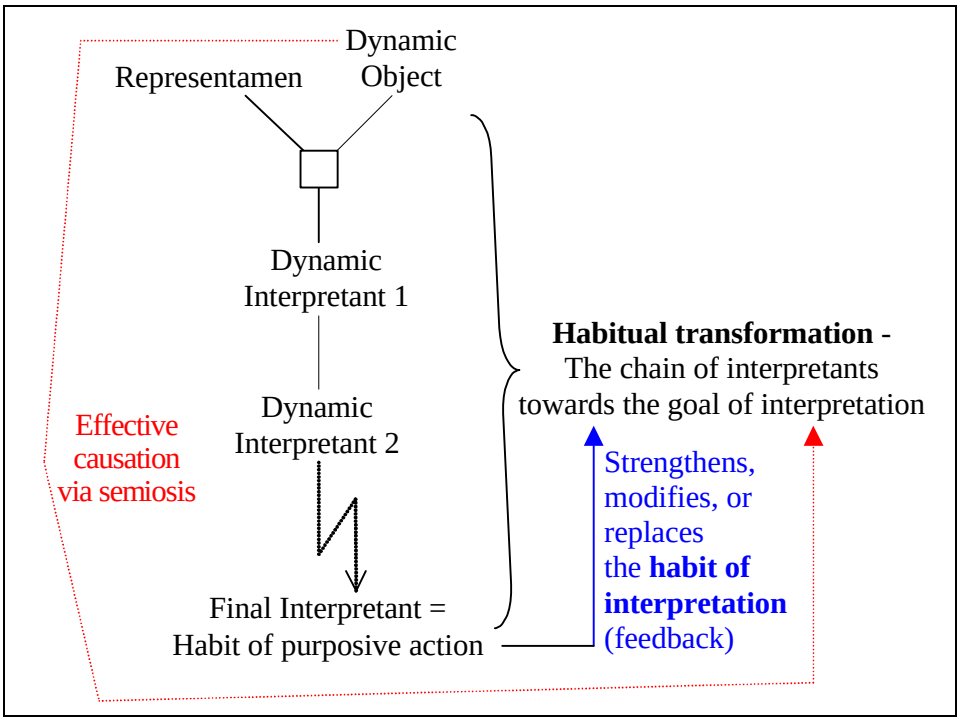

Figure 2. Peircean scheme of habituation.

While the interpretant can be considered in three different senses, the object can in two ones: 1) as an *immediate object*, which is the object as it is presented in the sign (for the interpreting habit), or 2) as a *real* or *dynamic object* that, in turn, can be considered as the hidden totality of *past* causes of the sign as an *event* to be the sign it happens to be. The dynamic object is always more or less absent or hidden in the sign.[10] In the prototypic case of the sign-process, the scientific *investigation* aiming for *truth*, it is exactly this dynamic object that is supposed to be revealed during the investigation. The end of the investigation, its final interpretant, is expected to be the true *conception* about the dynamic object — moreover, it is expected to be a true *belief*, i.e. a reliable habit of action embraced in the community of investigators.

The relation of a representamen to its dynamic object constitutes the best known division of signs made by Peirce:

[10] In order to recognize a representamen to represent its object, a habit has to have been in some earlier contact with this object. This 'earlier contact' can be only with dynamic object. Peirce calls it "collateral observation" (when talking about human interpretations): "The person who interprets that sentence (or any other Sign whatsoever) must be determined by the Object of it through collateral observation quite independently of the action of the Sign. Otherwise he will not be determined to thought of that object. […] I do not mean by "collateral observation" acquaintance with the system of signs. What is so gathered is not COLLATERAL. It is on the contrary the prerequisite for getting any idea signified by the sign. But by collateral observation, I mean previous acquaintance with what the sign denotes." (Peirce, CP 8.178-179, from a letter to William James, 1909.)

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

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

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.[11]

2. Non-interactivist features in semeiotic

If compared with interactivism, the most striking objection should concern the concept of the object in the above sketched scheme. The role of object makes Peirce's concept of sign clearly an *encodingist* notion of representation. Otherwise, I would say Peirce's scheme is quite compatible with interactivism — as far as I can see, all the unfit features are consequences of this one. My intention in this paper 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. I argue that Peircean sign (from the perspective of objective logic) can be defined as a special case of interactive representation, the structure of which has certain minimum complexity.

The reasons why there is the concept of object in semeiotic may reciprocally clarify some basic issues in interactivist naturalism. It is not merely an anthropomorphic relic resulting from an introspective method of research. Besides that, the concept of object is needed to establish the concept of *truth*. If truth is considered as a *truth for the system*, this holds for interactive representation too — truth must be *about* something (though *error* need not).

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

[11] It is noticeable that in all these three types of signs, the object has to be somehow familiar or 'known' beforehand. In iconic signs, it is thus the similarity between the representamen and *remembered* object that is recognized. In indexical signs, it is not only the object that has to be remembered, but it also has to be remembered that there is a 'real' *relation* between two different *types* of entities (the types to which the representamen and the remembered object fit). Symbolic signs provide the most complex class of signs (or the class of most developed signs), of signs that in order to function as signs, involve and contain some iconic and indexical signs (cf. Peirce, EP 2:17, 1895). It can be noted that the relation between the symbolic representamen and its object is arbitrary in Saussurean sense: "The symbol is connected with its object by virtue of the idea of the symbol-using mind, without which no such connection would exist." (Peirce, EP 2:9, 1894).

view of 'transcendental logic' by introspective self-reflection, 'by thought that is thinking about itself'. It was a concept of *thought sign*, in which both representamen and its interpretant are *mental* entities, although it has commonly been applied (also by Peirce) to refer to such external signs as traffic signs, written or spoken words, etc.[12] Later the same concept was considered from the point of view of 'objective logic' in a sense that the whole chain of signs was considered as object, 'by thought that is thinking about other thought'.[13] This second perspective, 'logic of the other one'[14] can be naturalized (without being necessarily naturalistic) and if it is naturalized, as I have suggested, the original triadic structure of the concept of sign has to be revised.

Secondly, for Peirce, 'the prototype' of semiosis was *science*, a *research process of an honestly truth-seeking experimental scientist* and this constituted also his basic purpose in developing his theory of signs — it was meant to provide a general methodology (*methodeutic*) of scientific investigations, a normative logic of science. Still, the concept of sign after being recognized seemed to have 'purposes of its own', of which Peirce became more and more aware, so that the concept of sign tended to be generalized far beyond Peirce's preliminary purpose. Nevertheless, the original structure of a concept with the concept of the object remained untouched — the object of sign was needed to establish the *norm*, the criterion of the positive success of investigation, to make the concept of *truth* as a goal of investigation comprehensible.

The initial reason why the concept of object is central in Peirce's semeiotic is the centrality of the concept of truth in science. Peirce's starting-point preconception about representation was *explanative representation*, representation about 'how things are', because it corresponds the intuitive purpose of theoretical scientific inquiry. However, most animals (and even people) do not tend to ask any *explanations* for unexpected occasions that are in conflict with their purposes or interests of action. Instead, what they are asking in such situations are just indications for appropriate action. Therefore, especially *biosemiotics* should start from another intuitive preconception about representation, from the notion of *anticipative representation* that is for the *guidance of appropriate behavior*, i.e. for the *model* of 'how things should be'.[15]

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[12] However, the distinction between external and internal signs is not fundamental. If considered thoroughly, all external signs are after all essentially internal because of Peirce's strikingly interactivist conception of perception (e.g. Peirce, CP 5.181, 1903).

[13] These two points of views ('transcendental' and 'objective') appear in Peirce's texts as different kinds of description of sign. E.g. in his "On a New List of Categories" (1867), which is dominated by the point of view of 'transcendental logic', it is the *interpretant* that mediates the relation between representamen and its object. However, in most of his more mature texts, it is rather the *representamen* that is described as mediating between the object and its interpretant. In this latter point of view, the one of 'objective logic', 'mediation' refers to some kind of 'contentful information transfer', while in the former one, it rather refers to mere 'contentless cognitive access'. Note that both points of view can be and were used in introspective method of research, but only the one of 'objective logic' can be externalized and naturalized.

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

[15] Third possible and perhaps even 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

Peirce did not dismiss this intuition of anticipative representation, quite contrary, he consistently stated that any conception or explanation has no meaning at all, if it does not have any testable anticipatory consequences. According to his 'maxim of pragmaticism', the whole (intellectual) meaning of a conception is the sum of its possible (or *conceivable*) practical bearings (Peirce, CP 5.402, 1878). So, 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*. This future looking part of Peirce's concept of sign fits well with the interactivist scheme, but the role of the concept of object has to be revised. It should not be settled as one of the basic semiotic concepts.

3. Minimal interactive representation — a representation without the object

Natural and artificial norms and goals

As the object of biosemiotics is life or living systems in general, we are naturally concerned with the certain kind of self-maintaining far from equilibrium systems. The initial system-relative normativity emerges within these kinds of systems. Because the property of *self-maintenance* is an *existential precondition* of these kinds of systems, we can define a *serving* the function of self-maintenance as a ***natural self-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 during the development of the system in its continuous self-organization. Natural self-interest provides only the *initial* (or *minimal*) normativity. Moreover, different interacting systems may have conflicting self-interests, and because of that, one system may 'try' to manipulate other systems to maintain itself, i.e. to 'indoctrinate' 'alien' goals into these other systems, goals that are not of their own interest (e.g. parasitic ecological relations). I would like to suggest that when the evolution of these 'natural *norms'* is considered, some etiological concept of function is inevitable although it would not be necessary for the theory of interactive *representation*.

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 may be 'alien' as well as its own. Thus, we can consider representative systems with non-natural purposes

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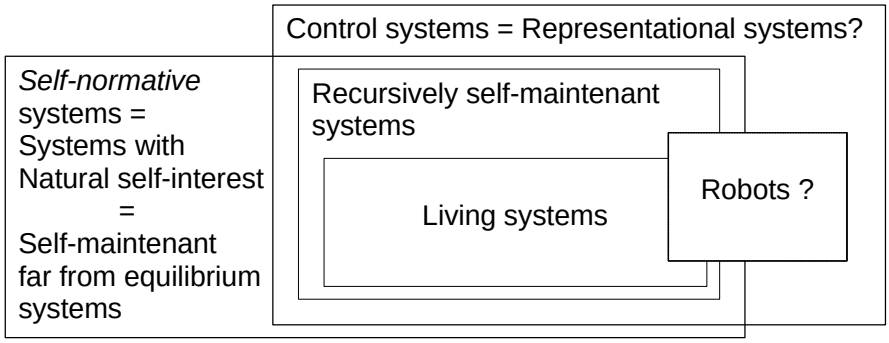
supposed to *explain* how (mutual) communication of *meanings* (usually between individual human minds) is possible and mediated.

and goals that are set up by humans (or other systems) and that are serving human interests. If the nature of the goal is taken for granted, we can say that any control system is a representative system, even a simple mechanical thermostat that is connected in a 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 the extensions of their constructor (or user), i.e. as the newly constructed subsystems of human agents (as 'extended phenotype'). This is quite a natural point of view especially when devices produced by medical technology are considered — e.g. when a malfunctioning organ is replaced by 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 simplest model of minimal interactive representation.

The interactive re-interpretation of Peircean semeiotic for biosemiotics can be done with three (or four?) levels of representation (levels 4, 7, and 8), presented in Bickhard's "Levels of representationality" (1998b). A minimal ontological representative system (S) have to include at least one subsystem, a *diffenretiator* (D), engaging in interaction with its environment (E).

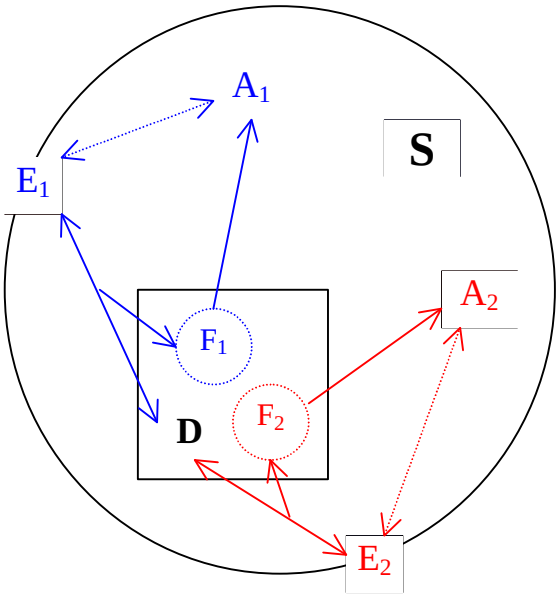
> [T]he internal course of that interaction will depend both on the organization of the subsystem and on the interactive properties of the environment being interacted with. […] [T]he internal state that the subsystem [D] ends up in when its current interaction ceases will depend on the environment that 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 feedback to the environment[16]. 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.).

[16] Note that interacting environment is the environment of a *differentiator* (D), not of a whole system (S). The environment of a differentiator may be either completely internal for the system (e.g. the environments of some internal thermosensors in homeothermic animals) or partly external for the system (as in external senses).



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),
⟶ = Indication, ⟷ = Interaction.

Figure 3. The simplest model of minimal interactive representation.

The case of **S = thermostat** (connected in a 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 on the cell membrane
E_2 = Decreasing concentration of nutrient molecules on the cell membrane
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 1997b.) Coli bacteria move in the direction which offers more nutrient molecules rather than less. They do this by measuring the saturation of their transmembrane nutrient-sensitive chemoreceptors 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[17], 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.

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.

Objective error and internal error-detection.

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 a 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 the 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

[17] Note that only a *formal* model for the most primitive *real* representation is defined. 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.

privation of the substrate of its main reaction), to degrade ATP to cyclic AMP (cAMP).[18] 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 error of interpretation in chemotaxis may no more be 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.

Correspondences between minimal interactive representation and triadic sign

The elements of the minimal interactive representative system have apparent functional counterparts in Peirce's semeiotic.

1. A differentiator-effector -subsystem (D + the set of potential A_i's in Fig. 4) constitutes a systemic *habit* (or its structural embodiment).
2. Each final state (F_i) of a differentiator (D) constitutes the representamen of a sign. Note that they are not continuously existent or stable things (in this most primitive type of real representation). Such external 'things', as already written letters, or internal 'things', as DNA-segments that are stable and just waiting to be read and interpreted, can function as representamens only for much more complex representative systems. In their simplest forms, final state representations are temporary *internal states* of the system that will be *constructed* repeatedly in every interaction/interpretation by the differentiator (or by the interaction between the differentiator and its current environment). They are permanent only as *possibilities*, not as existing states. This matches perfectly with Peirce's conception of sign

[18] 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)

(or its representamen) when it is considered in its most primitive or simple form (as a thought-sign).

3. The indicated action (A_i) of the system constitutes the (dynamic) interpretant of that sign which has the correspondent final state (F_i) as its representamen.
4. The interacting environment (E_i) plays the role of the (dynamic) object in a minimal interactive representative system. The interaction between the differentiator and its current environment provides the (possible) *contact* with the exterior of the system similarly as the dynamic object does in Peircean semeiotic.[19] The final state representations are not purely internal or 'solipsistic' constructions of the system — the system with minimal interactive representation is not a Leibnizian monad without windows. Still, the interacting environment (E_i) can not be considered as the object of representation *for the system* (S), except in very cursory or vitiated sense. There is no correspondent for *immediate object* (i.e. 'mental' or intra-systemic 'image' of the object) in minimal interactive systems. Therefore, a system is not capable to 'recognize' the object, but the final state representamen is constructed over and over again — the minimal interactive system has no internal remembrances of past. The interaction between the differentiator and its environment is completely undifferentiated *for* the minimal interactive system.[20]

4. Emergence of the objects (of representation)

More complex forms of representation may emerge in systems that 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 simplified description about the

[19] The interacting environment as well as the dynamic object can naturally be also internal to system as in a case of internal perception.

[20] For instance, 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.

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 simplified description about the level 7 in Bickhard 1998: 197).

Within this level of complexity, the emergence of certain biosemiotically central concepts and systemic activities appears. As far as I can see, also Peirce's concept of sign (but not his categories!) 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 repeatedly. Within memory and possibility to recognition, genuine *perception* emerges (or becomes possible) — perception which presupposes at least some kind of recognition and therefore also memory.[21]

This conception about perception is in coherence with Peirce's conception (see his Harvard lectures, 1903 on Pragmatism, EP 2:133-241). Individual things or objects (including external signs), like individual persons, are not perceived directly as individuals. They are directly perceived, but if the different reacting perceptual singulars are to be identified as one individual object or other invariance, some kind of general character have to be associated with them. Thus,

[21] 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.

our common sense individual objects etc. are not 'singular existent things' but semi-instinctively derived general notions, relations of identity between singular perceptual reactions. (Cf. Peirce, EP 2:222, 1903.)

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 and differentiated from each other.

2. Triadic sign. The triadic sign relations are brought along by the emergence of objects together with a possibility to remember (or recognize) and perceive the objects. The objects are, however, constituted as *internal states* of the system, moreover, they are *constructed* by the system itself (though in interaction with its environment). Therefore, they can not function as the *dynamic* objects of signs. But there is no need for any correspondent for dynamic objects, because they are always somehow external to and independent on mind. Instead, these interactive objects may function as the *immediate objects* of signs — they are *phenomenal objects* for the system, objects as they appear *in* the system.[22]

> One reason why I have criticized the application of Peircean sign into the chemotaxis of *E. coli* bacteria (cf. Vehkavaara 2002: 306-307, Hoffmeyer 1997b) is that they do not *seem* to have any immediate objects of representation at all. At least they do not *need* to have any immediate objects (and therefore objects at all) in order to behave appropriately. But whether they *really* have immediate objects, is a matter of empirical description. If we can find the correspondent structure of situation image etc. in *E. coli*, it is a system complex enough to be considered as an exemplar of Peircean sign-process, but if this can not be done, it is describable as a representative system only at the level of minimal interactive representation.

3. Iconic and indexical signs. Within the ability to 'experience objects', i.e. to discover invariances in the situation image, the system becomes able to discover also invariant relationships between these invariances, as causal, similarity, part whole, and nearness (i.e. spatial) relations between objects. Especially, a system can remember the objects it has perceived in the past and find them in some respects *similar* to a new perception. *Likenesses* can be recognized which makes it possible that this new perception is cognized as the *iconic sign* of the objects perceived in past. Similarly, because also causal and other real relations (like nearness) between objects become recognizable, a system becomes able to handle *indexical signs*.

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[22] The set of the possible phenomenal objects of the system can be said to constitute the *Umwelt* for the system. By this way, Jakob von Uexküll's concept of *Umwelt* becomes defined in interactivist terms. Uexküll's *Umweltlehre* (cf. Uexküll 1928 & 1982) constitutes a base for another main tradition of biosemiotics, besides Peirce's semeiotic.

4. Truth. So far, in minimal representative far from equilibrium systems, there is asymmetry between success and failure, between 'truth and error'. When the ultimate goal of action is self-maintenance, only failure, error is absolute, the *extinction* of a lineage — the final failure in self-maintenance. The way of extinction makes no difference, but *success*, instead, can be achieved in millions of ways as the history and diversity of life witness.[23] So, a minimal representative system has only a negative normativity (error), not the positive one (truth). At the level of phenomenal objects, however, a kind of progress toward truth becomes possible. A phenomenal object is a kind of 'approximation', a recognized invariance with respect to the *most* potential updates of the situation image. This means that a system may recognize also another invariances that are 'better approximations'. Then, the rivals can be compared and in some cases even *tested* in action (trial and error learning) so that the best available invariances are chosen to be active ones. And the rejected rivals can still be remembered as 'false representations'. Although truth is never the 'whole truth', it must still be about something — a phenomenal object is a prerequisite for truth.

Emergence of symbolic sign

Although the concepts of 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). In order to make complete the most widely used trichotomy in Peirce's semeiotic —division of signs into iconic, indexical, and symbolic— I will consider only symbolic signs here.

A system may have separate situation images for activities of a different kind that it uses in order to reach its goals. Each situation image has a direct 'on-line' effect into some activity. Still, the environmental information that is gathered for one activity, may not be available for another activity,[24] it may, for instance, be in an inappropriate form. The communication between different situation images can be achieved, if the system creates a kind of 'second order situation

[23] The meaning of total failure is absolute for the system, but the one of success depends on the way of self-maintenance.

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 a 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.[25] For this, at least a community of systems is needed, the systems of which may need to have more complex or specialized internal structure.

[24] 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.

[25] On the other hand, even at the lower levels, there certainly are a lot reciprocal interaction and interdependence between systems. This is communication of a sort, but here the term 'communication' is used in a more strict sense referring to interaction where some content is *intended* to transfer to other systems. In genuine communication between systems a message is sent that is supposed (by the sender) to be received and interpreted in some certain sense (by the receiver).

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