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Evolution of the "window"

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Abstract. We propose a general model that integrates meta-system transition theory with biosemiotics on the basis of an "evolvable window" metaphor. The evolution of the "window" proceeds via meta-system transitions, during which new windows are created iteratively on the "inner" side of the pre-existing ones, generating a "telescope" growing inwards starting from the "outside". The tendency of "inwards growth" of the "telescope" can be explained in terms of the following circular causality: (1) the tendency leading from unity towards individualisation, (2) individual learning providing a basis for more complex semiotic interactions, (3) creation of additional, non-conflicting "values" leading to habit formation, (4) strong control bringing forth a unification at a higher (meta-system) level. Using the proposed metaphor we hope to provide clarity to the fluctuation between objectivity and subjectivity inherent to the circular causality loop described above.

Introduction

Different authors have argued that there is an evolutionary trend towards increasing complexity by meta-system transitions (Turchin 1977, 1995, Heylighen 1999, Karatay, Denizhan 1999). The general ideas underlying such arguments have previously been proposed as the "meta-system transition theory".[1] On a different but related track, there is a growing field called biosemiotics, which among other things

[1] For an extensive review and references, see the *Principia Cybernetica Web* (http://pespmc1.vub.ac.be/DEFAULT.html).

emphasises the evolutionary trend towards increasing semiotic interactions — or the "unfolding of the semiosphere" (Sharov 1992, Hoffmeyer 1996a, 1997a, 1998a). In spite of the fact that they are closely related in their focus of interest, proponents of the two fields seem to remain rather unaware of each other's works. In agreement with Alexei Sharov (1998), we believe that a merger of these two approaches can be promising with respect to the construction of a generalised model of biological evolution, particularly in dealing with issues like symbiosis and symbiogenesis (for a good review, see Margulis 1998), evolution of multicellular organisms, evolution of cellular differentiation and complex physiological systems, such as the immune system and the nervous system in higher organisms, etc.

According to Peirce the word "symbol", to which he attached the signification of a sign, has the meaning of a convention or a contract in its original use in Greek (Peirce 1998: 9). In our opinion, the closest link between biosemiotics and meta-system transition theory is related to the establishment of objectivity during meta-system transitions through conventions, which result from and further the mediatory role of the (growing) signs.

The route towards a meta-system transition

We propose an evolutionary model driven by meta-system transitions going through the following circular causality loop (Figure 1):

(1) a well-accepted tendency of nature leads from unity through proliferation/ reproduction towards individualisation,
(2) individual learning provides a basis for more complex semiotic interactions,
(3) creation of additional, non-conflicting "values" by those semiotic interactions leads to habit formation,
(4) in the long run, stabilised habits lead to strong control, which brings forth a unification at a higher (meta-system) level on which evolution proceeds according to (1).

The first step consists in the proliferation/reproduction of evolving agents followed by the achievement of some inter-agent difference (in the context of biological evolution, agents refer to organisms). This difference can either arise by intra-group variation — say genetic and blind — or by independent evolution of agents, which later on take

part in a symbiosis (actually, this possibility is not mentioned by Turchin). Such diversification from unity to individualisation has a fundamental role in evolution and it may ultimately be related to the symmetry-breaking tendency in the universe ever since the big bang (Hoffmeyer 1998a).

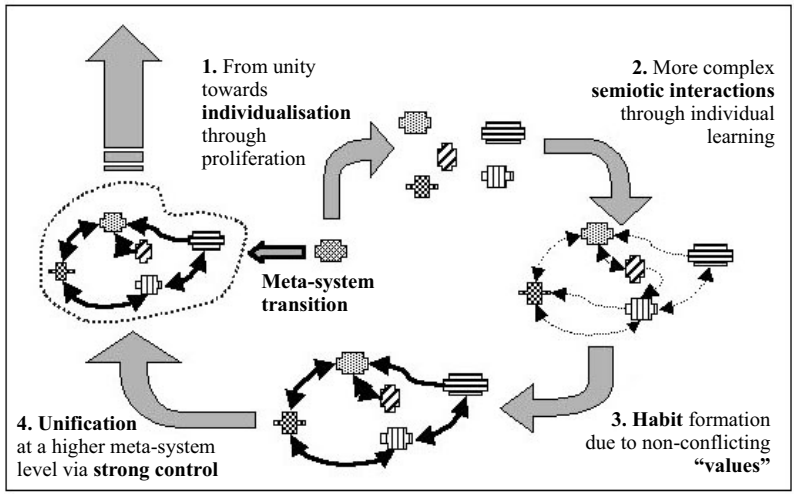

Figure 1. Meta-system transition by intra-group variation.

Following this first step, some of those different — or individualised — agents may form semiotic interactions. Under suitable conditions, especially when there is complementarity between participants, it is likely that some of those semiotic interactions prove to be synergetic due to mutual benefits of the participants, thus conferring selective advantage upon them (Campbell, Heylighen 1995). In other words, cooperative interactions may evolve when the participating agents receive additional, non-conflicting "values" from those interactions (Sharov 1997[2]).

At this point, maintenance of the stability of the synergetic interactions gains importance. There is a continuing threat from the

[2] Sharov, Alexei 1997. Signs and values. http://www.gypsymoth.ento.vt.edu/~sharov/biosem/txt/isas98.html.

"others" who do not participate in the alliance, such as parasitic neighbours (in case of symbiosis) or parasitic variants (in case of intra-group variation). Thus, the synergetic interaction can only be stable if a boundary or a surface (either physical or semiotic and usually selectively-permeable) is drawn separating the inside (the self) and the environment (non-self). Here, the environment is meant to denote in a very broad sense every external thing that the system is in semiotic interaction with. It must be noted that this point of view stresses the subjective side of the system. Maybe a more suitable term instead of the environment is *umwelt* (Uexküll 1982), which refers to the subjective universe of an organism. A more detailed discussion of these issues will be given in the next section.

So long as its stability is maintained by an encapsulating surface, the semiotic (and synergetic) interaction can go on to become an even strengthening habit (Hoffmeyer 1998). In the long run, the habit shapes the participants more and more strongly due to the phenomenon of downward causation (Emmeche 1997). This eventually drives the participants even more complementary to each other.

The final step in the route to a meta-system transitions is the emergence and growing stronger of shared control, eventually making the participants lose their autonomy and integrate into a unified, coherent agent, a new self. Loss of autonomy as outlined will make it very unlikely that inter-dependent participants can quit the alliance and revert to their earlier, relatively autonomous states. This comes close to the model suggested for the easier acceptance of additional components (in mutants, during development) than component deletions (Saunders, Ho 1976, 1981). An integration of this scale must surely include the precise control over the reproduction of the emergent whole. The means of such control can be genetic, as in the case of social insects (Campbell 1983, Campbell, Heylighen 1995) or *memetic* (Dawkins 1976) at biological and post-biological levels, respectively. But in any case it can be safely accommodated under the term semiotic.

Now, the new agents can proliferate/reproduce as in the first step, thus closing the circular causality loop.

Stability and nested, selectively permeable surfaces

In a certain sense, biology has always been a science of complexity (Emmeche 1997). Attempts to comprehend living things with reductionist, mechanistic models have been, for the most part, unsuccessful. 20th century science has gradually come to recognise that self-reference and (operational) closure are essential in understanding life (Schwarz 1997).

Yet, for a more complete picture, one should consider the imperfectness of that closure, too. In the words of Claus Emmeche (2000: 195), when "used and defined in the biological realm, [… closure] is not merely informational, or organisational, but also material and energetic, and thus biologic closure is never perfect".

Also, the issue of "other reference" is of crucial importance in addition to self-reference (Merleau-Ponty 1945, Hoffmeyer 1996b).

An encapsulating surface, selectively permeable as it usually is, not only contributes to the maintenance of the stability but also provides a means of interaction between the "inside and the outside". Organisms can hardly be thought of in isolation from their "extended phenotypes" (Dawkins 1999, Karatay, Denizhan 1999). Furthermore, this consideration is likely to be valid for each level of their nested, hierarchical organisation.

The existence of other-reference opens a door for the emergence of "objectivity" through inter- (or meta-) subjectivity. The meta-system transition offers a mechanism for the establishment of "objectivity" by confining the semiotic relations of agents to a set of conventions valid within the meta-system. The hence established objectivity is solidified via the further development of shared control. Although this process limits the semiotic freedom of the participating agents, it also creates a totally new meta-system level where the emergent, new agents can exercise their semiotic freedom. The scene is ripe for the repetition of the above sequence of events, but this time among the emergent new agents.

In summary, successive meta-system transitions lead to the origination of more complex, swarm-like agents (or agents like *swarms of swarms* — Hoffmeyer 1997b) in the universe. This in turn leads to the unfolding of both the semiosphere and the biosphere. A visual metaphor of this process may be a "widening spiral" of evolutionary

expansion, which can be causally linked to the "law of maximum entropy production" (Swenson 1989).

The scenario described above gives a general account of how initially autonomous agents can spontaneously form a cooperative interaction that eventually results in a meta-system transition, which produces a new, presumably more complex agent at a higher meta-system level. This actually seems to be a recurring motif in evolution that has given rise to most novelty and complexification. The successive repetitions of the meta-system transition produces nested, encapsulated structures — or *surfaces inside surfaces* (Hoffmeyer 1998b) — that retain the unity of a single agent or organism.

The "window"

The existence of an organism depends on its producing the "correct" actions as a response to external perturbations which *make a difference* for the organism (Bateson 1979). In that sense, such perturbations can be said to be "interpreted" by the organism. Such an interpretation is at the core of biosemiotics. A way of describing such an interpretation is to say that the organism "sees" its environment through a "window", which stands for the totality of its semiotic interactions.

Keeping in mind that the organism consists of a nested hierarchy of sub-systems formed by consecutive meta-system transitions, it should be asked which hierarchical level is first affected by an external perturbation. We claim that the external perturbation first affects entities at the lowest level (in the biological context this can be the molecular or sub-cellular level) and "makes a difference", i.e. is "interpreted". This, in return, constitutes a perturbation for the next hierarchic level and so on.

This consideration leads us to the conclusion that the semiotic interpretation goes "upwards" through successive meta-system levels. In other words, the living system "sees" its environment "through" the sequence of its lower meta-system levels.

Depending on whether one is interested in the morphological, systemic or semiotic aspects of this process, different representations can be employed (Figure 2). It should be noted that although (unavoidably) similar graphical tools are used in the different represen-

tations, these designate different levels of abstraction. For instance, while the outer boundary in the morphological representation stands for the cell membrane, the outer boundary (dashed line) in the systemic representation symbolises the "wholeness" of the cell as an organisation and includes relational constraints in addition to physical ones.

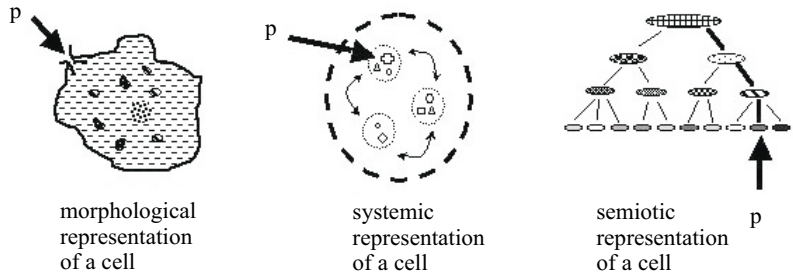

Figure 2. Different representations of a cell.

The semiotic representation in Figure 2 gives a more detailed look at what we have referred to as a "window". The window consists of different layers of "lenses". If for the sake of convenience we should continue with the cell example, the small "lenses" at the bottom row represent the semiotic functions of the ion channel or membrane receptor molecules. Each of these lenses can be considered as different selective filters for the incoming perturbation (*p*). For example, an extra-cellular signalling molecule (such as a lipid-insoluble hormone), upon binding to a membrane receptor, changes the conformation of the intra-cellular side of the receptor, which in turn triggers a cascade of intra-cellular reactions resulting in a perturbation on the organelle level. In that sense, a "lens" at a given level has the task of transforming a received perturbation *p* into a higher level one, *p'*. In view of this cascade structure, the "window" might better be described as a "telescope".

Although it is not shown in the simplified representations in Figure 2, it should also be noted that the virtually infinite diversity of small perturbations entering the telescope is reduced through this cascade of

lenses to result in a unified cognition at the innermost end, the perception of the organism. As a matter of fact, such reduction of diversity is strongly reminiscent of, if not principally identical to, the phenomenon of "complexity reduction" in the theory of Niklas Luhmann regarding social systems (Luhmann 1987).

The evolution of the "window"

Now that the basics of what is meant by a "window" are given, an attempt can be made to explain the emergence of its telescopic structure during the course of evolution on basis of meta-system transitions.

The telescopic structure appears as new lenses (representing the unified cognition of the agent/organism at the innermost end) emerge and are added to the inner side of the sequence of pre-existing layers of lenses through consecutive meta-system transitions. Obviously, the telescope has a tendency of growing inwards (Figure 3).

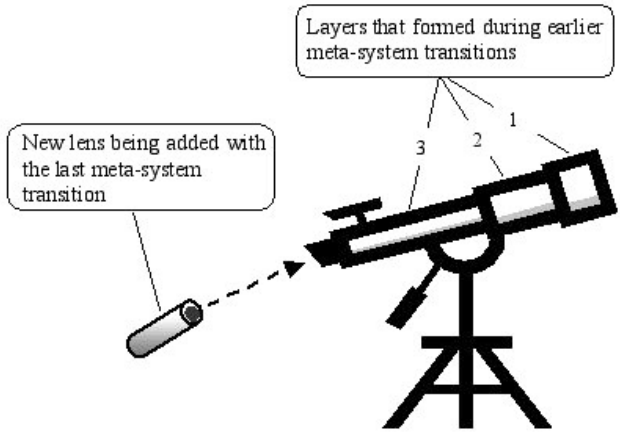

Figure 3. How the "telescope" grows.

This kind of mechanism for the evolution of the "window" is consistent and simultaneous with the previously described circular causality loop that leads to meta-system transitions (see step 4, above).

In fact, an essential element of that "unification" is the creation of a new lens at the inner side of the pre-existing telescope, representing the unified cognitive self of the emergent agent.

It should also be pointed out that the innermost layers of the telescope do not emerge in their full-fledged stable form. Rather than that they are "soft" at the time of their emergence, allowing the organism to learn about and adapt to different possible states of its environment. Only when (and if at all) this organism gets integrated into an even higher-level meta-system, its environment is stabilised rendering the maintenance of the learning capability unnecessary. Consequently, the "soft" innermost lenses of the once autonomous organism lose their adaptability, i.e. the organism is specialised and takes its place in the division of labour within the new meta-system it has been integrated into.

Although the metaphor of an evolving window or more precisely an inward-growing telescope can be applied to other evolutionary processes like individual, social or technological evolution, one should be aware of the specific conditions of those fields. For instance, in the case of social evolution it might not be appropriate to speak of a real meta-system transition (Campbell, Heylighen 1995). In our opinion social systems are more likely to be found at the 2nd or the 3rd stage of the 4-staged causality loop given above.

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Эволюция "окна"

Мы предлагем обобщенную модель, интегрирующую теорию превращения метасистем и биосемиотики, используя метафору "открывающего окна". Эволюция "окна" происходит посредством превращения метасистем, в ходе которого неоднократно создаются новые окна на "внутренней" стороне уже существующих, создавая таким образом "телескоп", который растет "снаружи" внутрь. Склонность "телескопа" "расти внутрь" можно в терминах циркулярной каузальности объяснить как: 1) тенденцию, которая ведет от общности к индивидуализации, 2) индивидуальное обучение, которое создает основу для возникновения более сложных семиотических связей, 3) оформление новых, неконфликтных "ценностей", которое приводит к возникновению привычек, 4) сильный контроль, что приводит к унификации на более высоком (метасистемном) уровне. С помощью предлагаемой метафоры мы надеемся внести ясность в флуктуацию между объективностью и субъективностью, что характерно для описаннного выше круга циркулярной каузальности.

"Akna" evolutsioon

Me pakume välja üldise mudeli, mis integreerib meta-süsteemide muundumise teooria biosemiootikaga, kasutades "areneva akna" metafoori. "Akna" evolutsioon toimub läbi metasüsteemide muundumise, mille käigus luuakse

uusi aknaid korduvalt juba eksisteerivate “sisemisele” küljele, luues nii “teleskoobi”, mis kasvab “väljastpoolt” sissepoole. “Teleskoobi” kalduvust “kasvada sissepoole” võib selgitada tsirkulaarse kausaalsuse terminites järgnevalt: (1) suundumus, mis viib ühtsusest individualisatsioonile, (2) individuaalne õppimine, mis loob aluse keerukamate semiootiliste seoste tekkeks, (3) uute, mittekonfliktsete “väärtuste” kujunemine, mis viib harjumuste tekkele, (4) tugev kontroll, mis toob kaasa ühtlustumise kõrgemal (meta-süsteemi) tasandil. Kasutades esitatud metafoori, loodame me tuua selgust objektiivsuse ja subjektiivsuse vahelisse fluktueerumisse, mis on sisemiselt omane ülalkirjeldatud tsirkulaarse põhjuslikkuse ringile.