Dynamic Interactions in Artificial Environments: Causal and Non-Causal Aspects for the Emergence of Meaning

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ABSTRACT

Initially, the analysis and development of adaptive artificial systems has been based in metaphors taken from philosophical schools as well as the disciplines of biology and cognitive science. So far, the dominant approaches exhibit many advantages in specific domains of application but there all have a certain drawback, which is their inability to produce an artificial system which will be able to internally ground its representations so as to use them to produce newer, more developed ones. The respective frameworks are studied in terms of this inability and it is concluded that the problem is traced in the purely causal treatment, function and creation of the notion of representation, wherever it is used. In the case of purely dynamic systems, where the representations seem not to be very useful, it is proposed that the incorporation of a special non-causal kind of representations would give a framework which seems promising in realizing real adaptation. The relevant architecture is analyzed and discussed mainly in terms of its functionality and its contribution to the integration of pragmatic meaning aspects in an artificial system's interaction.

Keywords: Meaning, Representations, Self-organisation, Peircean Semiotics, Information, Causal Interaction.

1. INTRODUCTION

The first attempt in building an adaptive system has been based on the computationalist approach, which supports the view that adaptive behavior is the result of assigning the system's variety in abstract symbols, which should then, depending on the environmental perturbations, be manipulated based on rules that have been externally imposed into the system [1]. There is no need for self-organization of the system, and all its variety is externally selected. As there is nothing that is being determined by the system itself, it can be said that the system exhibits a disembodied and implementation-independent adaptation. These systems by their nature, separate syntax and semantics, and manipulate their externally given representations (meaning) as sequences of symbols being manipulated by also externally given rules. As a result, they will never be able to produce inherent meaning in order to intentionally classify their environment.

Additionally, these systems are characterized by a high degree of causality which, by means of computationalism, supports the view that all intentional content is a kind of information, in the technical sense of a physical structure transmitted by a causal flow [2]. This results in the view that the meaning structures of a system are solely defined by its external relations with what lies outside of it (the system), and moreover, outside the given intentional state.

The paradigm of classical AI has been followed by "knowledge-based AI", which has traditionally emphasized a top-down approach by building systems that possess a certain amount of knowledge about a certain problem domain and then tries to model high-level cognitive capacities, such as planning, game playing, etc.

There has been an attempt to confront the apparent lack of grounding in purely computational systems by introducing connectionist and dynamic architectures. Here, the dominant view is that mental elements are a vector distribution of properties in dynamic networks of neurons and the proposed solution for a proper modeling of the thinking process is the set-up of parallel distributed architectures. It has to be stated that connectionism overcomes the problems imposed by the linear and sequential processing of classical computationalism and finds application in areas like perception or learning, where the latter is, due to its nature, too slow to deal with the rapidity of environmental input [3].

The most important connectionist criticism against purely symbolic AI is the difference in the constitution of system's representations. In connectionist architectures, representations are massively distributed, being stored as weights between neurons. Consequently, representations are distributed across the weight vector, which serves to store more than one representation. Therefore, there is not one-to-one correspondence between individual neurons and individual concepts. Their activity is subconceptual or subsymbolic, in contrast to symbolic architectures, where representations are mapped to symbol tokens in order for rules to operate over them, thus, making them purely symbolic.

Although connectionist architectures have made an obvious departure from classical AI, their underlying nature has many disadvantages. First of all, a connectionist architecture does not resemble the dynamics of a biological neural network, as if it does, it should be able to alter its transfer functions, something which does not happen in any connectionist architecture. Defenders of connectionism argue that this is not a problem since brains store and retrieve representations in ways incompatible with symbolic AI systems, but quite compatible with connectionist systems [4] [5]. Their subsymbolic function and the distributed nature of their representations are those properties that make them an advantageous alternative to symbolic AI systems. Furthermore, many researchers [6], [7], have tried to argue that connectionist architectures are able to internally ground their representations, therefore, they can possess internal semantics. This is a well-known problem posed by Searle [8], which states that there is a clear distinction between rule-based operations on symbols, which proceed independently of the symbol's meaning and semantics. It is assumed that connectionist architectures overcome this problem as each pattern of activity over the nodes of a network causally determines the nature of the representation. This means that either a specific input cannot be supported by two different activation patterns, which is not the case in all connectionist architectures, or that the subsymbolic level is purely syntactical and that causality is always at hand in order to take care of the semantics, which are related to the intrinsic structure of each subsymbolic representation. Thus, due to the parallel of their nature, connectionist architectures may sometimes bear richer syntactic structures, but as [9] among many others argues, the form of the computation, whether logico-syntactic or connectionist, is merely a matter of implementation, and in addition, the implementation of computation, whether classical or connectionist, lies in causal processes.

In contrast, behaviour-based AI follows a bottom-up approach in the development of adaptive artificial systems, in which adaptation is taken to be a biological system's capacity to interact with its environment, rather to represent it internally [10]. Additionally, it also studies the intelligent behavior as a result of adaptation at the cognitive and social level [11], [12]. Here, the main idea is to start with the design of simple modules with multiple interaction capabilities, while expecting their interaction to give rise to complex adaptive behavior. Brook's subsumption architecture is such an example [13]. This kind of architectures are based in the concept of intelligence not as formal and abstract input-output mapping, but as a property rising from the system's physical interaction with their environment. Although system's adaptivity emerges from the interaction of the individual behavioral modules in a self-organized manner, its variety is externally imposed, as each module's behavior is pre-programmed in an algorithmic manner. Radical supporters of such approaches have carry on their research agendas trying to build evolutionary connectionist architectures. These evolutionary techniques are inspired by the mechanisms of natural selection and give the possibility to evolve a large number of individuals, each representing a possible adaptive behavior. It can be described as the mutation and crossover of genes to move the organism around a state space landscape, trying to find the most fit point. Evolutionary algorithms can exhibit high adaptation where no reinforcement learning is available, and also, they can be used in combination with neural networks as the evolving mechanism of their connection weights [14].

In this way, connectionism has borrowed the idea of emergence, from the theories of self-organization, which has as a central point the system's nonlinear dynamical processing. In this context the brain is seen as a dynamical system whose behavior is determined by its attractor landscape. The dynamics of the cognitive substrate (matter) are taken to be the only thing responsible for its self-organization, and consequently for the system's behavior [15]. It should be stressed that there is an on-going debate between dynamic systems theory and connectionist networks. The latter exhibit many of the properties of self-organizing dynamical systems, while not discarding the notions of computation and representation.

On the contrary, advocates of the pure dynamic approach [16], argue that although the emergent-enactive view shares with connectionism a belief in the importance of dynamical mechanisms and emergence, disputes the relevance of representations as the instrument of cognition [3]. Instead, emergent cognitive systems are self-organized by a global co-operation of their elements, reaching an attractor state which can be used as a classifier for their environment. In that case, the distinctions thus produced are not purely symbolic, therefore meaning is not a function of any particular symbols, nor can it be localized in particular parts of the network. Indeed, symbolic representation disappears completely – the productive power is embodied within the network structure, as a result of its particular history [17], [18]. The diversity of their ability for classification is dependent on the richness of their attractors, which are used to represent events in their environments. Therefore, their meaning evolving threshold cannot transcend their attractor's landscape complexity, hence, it cannot provide us with architectures supporting open-ended meaning-based evolution.

2. THE NEED FOR REPRESENTATIONS

As it has been argued above, the computationalist and the connectionist paradigms make use of representations in order to map the external world into the states of the system. On the other side, one finds the enactive and dynamical approaches to adaptive behavior. In this case, an adaptive artificial system consists of a number of processes running in parallel and being represented by means of differential equations establishing a continuous relationship between a set of quantities. This paradigm is closer to the descriptions used in biology, cognitive science and cybernetics. The self-organization component is emphasized, but the role of the environment is disguised, thus, there is no well-based support for system – environment interaction. These kinds of architectures do not seem to bother with representations. However, objections are mostly made on the base of fixed, single and completely general purpose representations, a vocabulary of which is assumed to be used in order that the cognitive process to take place. Such types of representations are not found in emergent and dynamically self-organised architectures, where complex and non-linear processes are at the core of the system. There, one cannot find discrete representation structures obeying algorithmic rules.

The immediate rising question is if representations are indeed needed in order for a system to exhibit intelligence and consequently adaptive interaction. Although the answer from the self-organizing camp will be negative [19], there are a lot of anti-representationalists that find representations necessary in order for the system to exhibit high-level intelligence [20] and others [21], who agree that every intentional behaviour should be mediated by representations, which can only be defined in a dynamical interactive context [22].

As it has been extendedly discussed in [23], causality does not undermine internal representations. The authors argue that causality and specifically the situation in which “an outcome is generated by a network of multiple, co-contributing causal factors that extends readily across identifiable systemic boundaries”, which is termed as “*causal spread”*, is the dominant view among other ideas explaining intelligent behavior. But, they also pose the very important question of whether the situation of causal spread alone is able to threaten explanatory strategies that appeal to internal representations. Using the correlation between genes and neural states, and between phenotypic traits and behavioral outcomes, they conclude that although causal spread is acknowledged in biological systems (dynamical complexity, self-organization, environmental interaction) the whole situation needs the incorporation of the basic idea that genes represent phenotypic forms. They conclude that the same can be assumed for the internal representations of a cognitive system. Thus, neural states encode certain parameters and stabilize the complex neural and bodily dynamics of the system, that in turn, in interaction with the environment yields appropriate behavioral outcomes. At this point, it should be noted that in order for internal representations to be seen as inner states or processes whose functional role is to bear certain specifiable contents, *arbitrariness*, *interpretation* and *contextuallity* should be three essential conditions, in the context of which the internal representation will be functionally organised.

In other words, not any kind of representations are needed, but only representations that emerge in the interaction between the system and its environment. One might better understand this kind of representations by conceptualizing the inseparability between intentionality, meaning and representation in a dynamic information-processing system [24], [25]. In this context, a representation represents its reference and does not represent its meaning, as the meaning belongs to the structure of the representation, not to the reference that is represented by its means. Meanings are abstract “contents” of intentional thoughts and experiences. They are the abstract properties which determine the representational structure that needs to be activated in order to access an object in a way implied by this very meaning. Intentionality and meaning have a dynamic information-processing structure, which is based on the use of forms of representations. In this perspective, representations are only defined with respect to, and in the context of, the behaviour of a system within an environment. Consequently, any representational functional organisation of the system is an emergent product of the intentional and meaning-based interaction between this very system and its environment.

It is obvious that such kind of representations admit no relation to merely linear causal processes dominating classical computationalism, and on the other hand, they constitute a basic prerequisite in the open-ended development of a dynamic self-organised system. Additionally, such meaning-based and internally constituted intentional representations complement the circular reciprocal causality or the more dynamic causal spread of complex self-organised systems.

3. CONCEPTS FOR INCORPORATING INFORMATION IN SELF-ORGANISED SYSTEMS

Purely symbolic approaches cannot give answer to issues related to the emergence of new meaning structures and levels of organization, which justifies the existence and the role of anticipation in adaptive systems [25],[26]. Alternatively, the self-organized dynamical systems seem like a good candidate for meaning-based adaptation and evolution, but their capabilities are limited due to the limitations of their attractors. The complexity of an emergent self-organized system can only be enriched through its interaction with other systems in its environment. In the context of 2nd order cybernetics, which is the umbrella of the self-organization, the proposed solution in order for the ability of the system’s classification to be increased is to be structurally coupled with its environment [27], [28]. This way, the environment will act on certain structural changes of the system and it will force it to choose specific dynamics (particular states) for a certain task. Therefore, meaning-based adaptation can come to such a system in an open-ended way.

The immediate problem to overcome is to find the means by which this structural coupling will take place. Second-order cybernetic systems admit no functional usefulness to representations and they regard information only as socially ascribed to a process from other observers [27]. It seems that if one accepts the dominant view that all of the necessary information for an adaptive self-organized system must be embedded in neuronal patterns, which are cross-correlated with incoming ones, in order to be built up (in case of similar patterns) or to dynamically form new ones in dependence with the system’s anticipation, then, the incorporation of a process to support the vehicle of the representation which carries internal information about an external state seems imperative [29]

This process should give the interactive dimension to the self-organizing system. It should comprise of the appropriate mechanisms to support and guide system’s interaction with the environment, formed by other systems. As much at the level of cognition, as for the level of communication, representations and their emergent meaning structures must correspond to that described above. Additionally, the mechanism which will embed these systems in an information-based representational architecture should also correspond and satisfy this structure. This way, the cognitive system will preserve its self-organizing status and the respective properties (self-reference, operational and organizational closures), but it will also acquire a fruitful mechanism for interaction. Specifically, the mechanism under consideration should underpin the combination of the situation of the causal spread, stemming from the self-organized nature of the interactive system, while simultaneously, permits the creation of representations originated by totally non-causal roots. Most interestingly, although this representations should function within the boundaries of a dynamic system, the essence of their function should not be causal at all. Instead, interpretation and not mere substitution should be at the core of their functionality.

Semiosis can be seen as the process which drives the system into meaningful interaction. In [25] and [29] the process of semiosis and especially Peircean triadic semiosis are extensively presented as a proper mechanism in order to complement the interaction of 2nd order cybernetic systems in a dynamic information environment, as well as, the ability of such processes to model intentional interactions. A more philosophical discussion on the complementary roles of

Peircean semiotics in human communications can be found in [30] and [31].
In the proposed framework, intelligence is not consider as an extra module, but as an asset emerging from the agent's functionality for interaction. Specifically, the use of the proposed framework aims at the unification of the modality of interaction, perception and action with the smallest possible number of representational primitives. The present attempt is in correspondence with contemporary works in AI, such as [32], where only the concept of semiotic symbol is used to ground lexicons in robots, [33] where semiotics and schema theory is used to ground language in action and perception of a robot and [34] where the simulation of specific predator-warning communication in a virtual prey-predator environment is attempted. In the present paper, there is an attempt to introduce a more generic framework which will integrate aspects of self-organisation and embodiment with Peircean semiotics. There is in no way a demonstration of a totally autonomous system, but the introduced framework overcomes the symbol-grounding problem [6], which is the fundamental obstacle for the frame problem [26], and by doing so, it introduces a type of representational structures that are not trivially causal but integrated into the functional structure of the artificial agent. This types of representations are more consistent with the demand for representational autonomy coming from dynamic anticipatory systems research [26]. Finally, the whole endeavour is in parallel with ideas relating research in cognitive science to AI systems, as these are outlined in [35].
In the next sections the structure and the components of the Peircean sign processes are analysed in terms of their ability to provide a mechanism which will guide a dynamic self-organized system into an intentional interaction with its environment.

4. EMERGENT REPRESENTATIONS VIA SELF-ORGANISED SEMIOTIC PROCESSES

As it has been defined by [36], "in a semiotic process a sign, or representamen, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. The more developed sign is called the interpretant of the first sign. Each sign stands for its object, not in all respects, but in reference to a sort of idea, which is called the ground of the representamen."
The first thing that should be clarified is that sign is not a sort of static proxy standing in for an equal static thing, as, if it was, it could not evolve in other signs along the flow of semiosis. After all, with each new instantiation a sign becomes a difference, becomes a new sign. Secondly, as it will be shown below, the sign partakes in mediation processes, which is the essence of its function. Especially, mediation is the way information is acquired from the system via the sign. Therefore, a mere proxy could never engage in such processes.
Initially, before the sign merges with an object through an interpretant there is, in contrast to the sign-relation, the *sign-vehicle*. The sign-vehicle is the representative element, the foundation over and above which, a relation arises. In case of an absence of such a relation, the foundation is just a self-representation or *object*. The sign-vehicle can be implemented in any kind of structure. Independently of its implementation, it is the element responsible for the conveyance of the object signified to the cognitive system. The sign-vehicle is often called as a *representamen*.
A cognitive system may link the sign-vehicle to its signified object. In this case there is an actualized triadic relation, which forms the sign itself. The sign itself does not stand for its object in all respects, but in reference to a sort of idea, which is called the *ground* of the representamen. The ground is that which is directly and immediately presented by a sign in its signified object, by reason of which whatever else is presented in the object as well is presented. It can be said that the ground is the *object signified* as such and such and consequently, a complete sign is the one in which a representamen refers to a ground, to a correlate (sign-vehicle) and an interpretant, which is itself a more developed sign. It should also be noted that as a sign-vehicle, the idea or 'mental image' exists only insofar as it guides an apprehension to the awareness of this rather than some other object (or state of affairs). It is the constitution in the cognitive system's representation that *forms* the idea as an idea *of* its object, as the rationale and form whereby an object is pre-cognized formally in a cognitive system [37].

Semiosis and Mediation

For information carriers to be properly integrated and inform the representations of an adaptive system, the whole process of interaction must not be a mere sequential transmission, it must be a transformation. In [38], Liszka by describing the transcription and translation processes of the DNA mechanism, explains that meaning can be generated from non-meaningful processes only if there are two basic type of algorithms realized in one process; one which produces *text* and one which can *read* it, while the reader-text relation must be a transitive one. A transitive relation is a mediation in which, the form of the input of the text is included and simultaneously expanded into the form of the output of the reader by means of the form of the output of the text. It should be noted that this is not the case in the classical computationalist/connectionist paradigm, where there is only substitution and not inclusion. There, the interaction process exhibits only identity and equality functions, hence there is no expansion of the meaning of the system above the one already given by its designer. In this perspective, mediation is necessary to transitivity as it permits an indirect connection between two parts in a process and brings a certain degree of compression to it. Only by such a kind of mediation is an adaptive system capable of increasing its complexity and its meaning. Several such examples can be drawn from neuroscience [39], [40], as well as from developmental biology.
In the context of a semiotic process, the *dynamoid object* would be the source of transitivity, so, it would determine the interpretant. Due to the nature of the process and the existence of mediation, the determination cannot be direct. The determination is realized in a form and is the *ground* of the representamen. The ground should only be understood as form, as only as such can preserve the characteristics of the source, while allows it to be realized by a different process. Accordingly, the mediator (representamen) will exhibit this form or ground by means of some qualities, the properties and relations it has independently of whether it serves as a mediator. This means that it is the qualities, properties and relations of the sign-vehicle that determine the form of the ground, which, consequently is constrained by the sign-vehicle. The form of these qualities, properties or relations is what has been mediated from the source of transitivity to the mediator, it is that which will determine the ground of the representation for the cognitive system. There are three cases: In the case of a Q*ualisign* the mediator shares certain qualities with what it mediates (the sign-vehicle), when it realizes (at this very time)

the form of what it mediates it is a *Sinsign*, and finally, when the mediator's pattern realizes the form of what it mediates, it is a *Legisign* [38].

A very important aspect of the whole process of mediation is that initially the mediator acts as a representative of what it includes, and this can be highly arbitrary as the three abovementioned cases declare. As [23] suggests, it is not the form of the individual representation which matters, but their role as content-bearers. Also, the mediator's ability for content (by form) inclusion gives the ability to expand the included form, which is to be interpreted by a cognitive system. In other words, as it will be analyzed below, since the cognitive system, by its definition, cannot read directly the source of transitivity, it is necessitated to translate the given informational content using its own representations.

Therefore, the mediator has the ability to be schematized in order to include these aspects of the sign which concern its relation to the interpretant. Here, one can also find three cases depending on the type of schematization: *Rhemes*, which are considered to be at the threshold of meaning, since they represent the point in the process at which the mediator can address an interpretant (i.e. percepts of colour and shape, or words, etc.), *Dicents*, where the mediator has been formed in such a way that it can become information-giving for interpretants (i.e. a proposition), or *Arguments*, where the mediator has been formed in such a way as to become provocative inference for the interpretant [38].

Semiosis and Intentionality

The object given (by the inclusion of its form) is not apart from the whole relation, but its effect is to put the receiver and the giver into an intentional relation. As soon as the system represents the object based on information gathered by the representamen, the intentional action is completed and the system has successfully interacted with its environment. In order for the system to be able to be intentionally related to its object then there must be a kind of interpretation for the mediator to be read as a representamen of its source, and not as the source itself. Otherwise, representation cannot take place, or if it takes, it may be a mere causal process, a mere substitution as the one which appears in the systems of classic AI. Afterwards, the system will be able to build a representation of the object. The result of the representation gives the system the kind of the representation –icon, index and symbol-that the mediator supports for its source. An *icon* is the case when whatever the type of sign-relations of the mediator, they are taken to be similar to its dynamoid object. In case of an *index*, they are read as being temporally connected with the source, while in case of a *symbol*, there is a conventional and habitual connection with its object.

Semiosis and Meaning

As it has been shown in the last section, interpretation is a vital factor in order for the sign and source to be coordinated. When the mediator has been schematized so as to become a Rheme, the system will apprehend it as the *Immediate Interpretant*. For the mediator to mean something for the system, the latter must be able to correlate the mediator's schematization with the source (dynamoid object). Consequently, the system must maintain processes to reveal the meaning of the mediators [38]. This is the third essential condition for an internal representation to act functionally as an encoding, which is referred to as contextuallity. In case the system does not co-evolve with mediators, it will be almost impossible to have intentional and meaning-based adaptation. If this happens, then the sign will always function as a cause. The sense that the system earns from the rise of immediate interpretant, would be temporally tested, so that it can go from Firstness to Secondness and become real meaning. At this point, the immediate interpretant become a *Dynamical Interpretant* and it is this moment that information about the source begins to have a semantic effect on the system. In case the system reveals the intentionality of the object at stake, then the *Final Interpretant* has been reached. One should note that after the formation of the Dynamical Interpretant the self-organizing system has undergone a structural coupling with its environment.

5. AN ARCHITECTURE SUPPORTING ADAPTIVE INTERACTION BASED ON PRAGMATIC MEANING

The consequent architecture rising from the combination of the described semiotic framework with a self-organized cognitive system in an information dynamic interactive framework is shown in (Fig 1).

Throughout this paper, it has been argued that meaning-based adaptation requires intentionality, forms of representations and informational openness. The systems with operational and informational closure, (emergent/dynamic systems) although they have a good degree of adaptive classification, they cannot exhibit open-ended evolution, as they cannot extend their attractor landscape. Meaning-based adaptation implies extension of structural representations, thus emergent classification of the system's environment. This is the case for anticipatory systems where they have the capacity to anticipate on its own. As it has been suggested in [25] and [41], so far, any prudent kind of anticipation an artificial system has is derived from its design, thus, it is design limited.

One may assume, as it is shown in (Fig. 1), that the interaction initiates from the dynamic object (DO), the environmental element of interaction, which needs mediation in order to be determined in a representation of the cognitive system. As it is argued, it is impossible to gain knowledge of a DO directly. This implies that a direct relation between a DO and its interpretant is impossible, but, using a means of measurement, the nature of the DO can be indicated by a primitive internal representation, the immediate object (IO). At this moment of the interaction, the sign, specifically the sign-vehicle, indicates the direction of the reality to which it refers. A sign-vehicle contains several IOs which in turn refer to several DOs.

Which IO will eventually be actualized depends on the cognitive system's anticipations. This is where semantics play their role. They make use of the given information in order to infer its meaning, but only in the sense of the ground of the representation. As the form of the ground is a function of the qualities, properties and relations of the sign-vehicle, the latter constraints the former, which sets the borders for the structure of the impending representation, obviously, for the specific system.

Further to IO's formation, the result is tested against the system's anticipations, where an interpretation of the parameters of the sign-vehicle in a way narrow the IO's selection and give a certain directionality to the system. At this point the immediate interpretant (II) has been formed. It should be noted that for II's formation system's semantics must be tested against the pragmatics for the ground to be enriched with -not all possible- but only system's relevant and useful (at the specific moment) predicates.

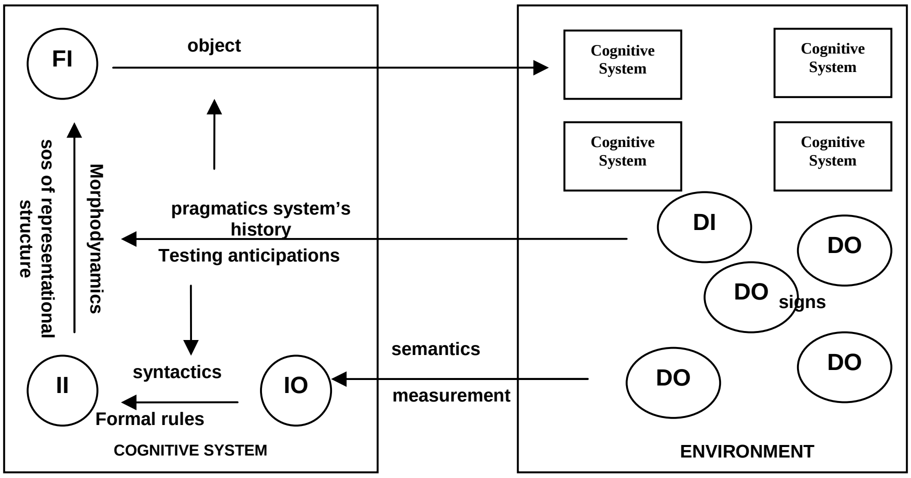

Fig. 1. Semiotic processes complement the self-organized nature of the cognitive system in order the latter to be able to achieve an adaptive interaction based on pragmatic meaning.

The given information provided the tools for the object's discrimination, but, there will be many tests needed in order this core meaning to be temporarily stabilized into a dynamic interpretant (DI). This process is the most complicated one as it requires the properties of the self-organizing part of the system, which will try to incorporate the II in its structure. This requires self-reference and functional closure since the system must refer to itself in order for unsuccessful structure modifications to be obliterated. In systems exhibiting high-level cognition, the meaning of a representation is given by the system's expectations involving its object. Then the content of a representational structure could be said to be the intersection of the information sets of all these expectations and that this content provides the information needed to reason with the respective representation. As it has been stated, certain intentional representations may not be fulfilled by their objects, and this amounts to improper expectations. This is the reason for incorporating the pragmatic aspect of the representation. The, in a way, objective meaning, which results from the semantic processes, should be open to revision. This requires morphodynamical processes to dynamically manipulate meaning structures in terms and by means of forms, which are simultaneously tested against the system's anticipations (pragmatics) within the conditions of the functional closure offered by the dynamics of the system. A very important aspect in the whole process of interaction is that there is a constant causal relationship between the various interpretants and the constraining properties of the object, which attributes directedness to the interaction, thus, making it intentional. For an elaborated discussion on this see [42].

But this does not in any way undermine the interpretive dimension of the interactive process which demands the combination of the syntactic, semantic and pragmatic aspects of system's representations. It is only narrowing the domain up to the degree of offered directionality.

Meaning forms, such as the DI are not static, they always emerge and evolve in an interactive environment. As it is described in [24], in every intentional act, the new representation –together with its meaning- should be 'apprehended' by the matter of the act, which is nothing else than the whole dynamic and continuously self-organizing construct of the system's representations. The sign and especially its mediator aspect provides a certain form based on the ground, and this form has to be 'processed' in order to adapt to the system's self-organizing dynamics. It is only by this view that self-organization and information come together in the system's meaningful interaction. This is equivalent to the way an externally imposed form, which is given to the system by its semiotic interaction, manages to be incorporated in the system's dynamics by playing the very important role of stabilizing the system (with no matter what and how much complicated an attractor). When the system has been informed by its interaction, in such a way, that its new dynamic state is compatible with the system's representations, then a meaningful interaction has been achieved. The compatibility is immediately connected to the fitting of the new form with the system's functions, representations and structural constraints. It is only under this view that a self-organizing system uses information from the environment (or of its own). The new forms will self-organize reaching certain levels of discontinuity, while newer ones will come and carry on to new organizations. This is not just a mere self-organization which is based on the system's interaction in order to be selected or not. It is an interplay between signs and systems, where they are informing each other in the context of open-ended co-evolution in a dynamic environment.

6. SUMMARY AND CONCLUSIONS

This paper is attempting to suggest an architecture which will support intentional, meaning-based interaction. The drawbacks of other well-known architectures in terms of their ability to support adaptive interactions are discussed and it is indicated that such an interaction need not be based only on causal aspects, if it is for the artificial system to be able to evolve its own representations. It is stressed that in order for the artificial system to be able to act intentionally based on its own inherent semantics (meaning structures) the kind of representations needed should not based on mere causality but they should function like arbitrary encodings waiting for interpretation in a certain context. Then it is suggested that Peircean semiotic processes might be a good candidate for incorporating external information in a self-organizing dynamic system and moreover, their rich structure support the whole process of intentional interaction, providing also the kind of representations needed.

From a technical-oriented computational point of view, this architecture needs dynamic self-organized processes which can be driven by the rate-independent sign processes. In this perspective, cellular automaton or component-systems processes can harness their dynamics using computational semiotic processes, which use their rich structure properly initialized in the boundaries of the described architecture. On the theoretical side of the computational view, the structure of semiotic processes can support the abductive form of inference, which should be integrated to the self-organized dynamics of an artificial machine in order this to be able to manifest human cognition [40]. A recent work toward this direction can be found in [43].

Finally, this architecture offers the possibility to study an adaptive artificial system in all of its phenomenal aspects, as these emerge from its striving for primitive real-time adaptable interaction with its environment to high-level off-line intelligence.

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