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Abstract:	<p>This paper draws on biosemiotics to provide new insights in the role that scientific inquiry plays in generating (useful) inputs to the process of decision making. In particular, the social theory of Luhmann is used to postulate that the formation of society's identity requires the effective integration of two processes: (i) on the biophysical side: self-organization, which requires effective norms, and (ii) on the notional side: self-referential autopoiesis, which requires shared values. Norms are based on explanation narratives useful for guiding action. Values are based on societal myths and socio-technical imaginaries needed to select the concerns to be addressed by collective action. It is argued that in the process of decision-making, norms (generated by communication) and values (generated by the psychic structure) affect each other in an impredicative way. Thus, the reproduction and updating of a given identity of society require a systemic quality check on the whole process of production and use of scientific information for decision-making through a negotiation based on a mix of technical, moral, political, and ethical issues. These insights provide a theoretical basis for one of the main concerns addressed by Post-Normal Science.</p>
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Bellaterra, 30 August 2023

Dear Editor,

I hereby submit a paper to the special issue of Futures on post-normal science and ethics (VSI PNS Ethics). The paper draws on biosemiotics to provide new insights in the role that scientific inquiry plays in generating (useful) inputs to the process of decision making. Given the rapidly exacerbating sustainability and political crises, I believe the subject is timely, and I am confident that the manuscript will be of interest to the readership of Futures.

The material presented is original and has not been submitted for publication elsewhere.

Looking forward to receiving your feedback,

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Combining Biosemiotics and Post-Normal Science to Study the Formation and Adaptation of the Identity of Modern Society

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HIGHLIGHTS

A biosemiotics narrative is used to provide new insights in post-normal science

It draws on the social theory of Luhmann about the formation of society's identity

It contrasts self-organization (norms) versus self-referential autopoiesis (values)

The role of the psychic structure in quality control of information is emphasized

The paper identifies novel quality checks for science of governance

Combining Biosemiotics and Post-Normal Science to Study the Formation and Adaptation of the Identity of Modern Society

Abstract

This paper draws on biosemiotics to provide new insights in the role that scientific inquiry plays in generating (useful) inputs to the process of decision making. In particular, the social theory of Luhmann is used to postulate that the formation of society's identity requires the effective integration of two processes: (i) on the biophysical side: self-organization, which requires effective norms, and (ii) on the notional side: self-referential autopoiesis, which requires shared values. Norms are based on explanation narratives useful for guiding action. Values are based on societal myths and socio-technical imaginaries needed to select the concerns to be addressed by collective action. It is argued that in the process of decision-making, norms (generated by communication) and values (generated by the psychic structure) affect each other in an impredicative way. Thus, the reproduction and updating of a given identity of society require a systemic quality check on the whole process of production and use of scientific information for decision-making through a negotiation based on a mix of technical, moral, political, and ethical issues. These insights provide a theoretical basis for one of the main concerns addressed by Post-Normal Science.

1. Introduction: The epistemological predicament

In their paper “The ethos of post-normal science”, (Kønig et al., 2017) reflect on the practical responsibilities associated with the process needed to guarantee the quality of science advice and the advisory process. According to the authors: “In Post-Normal Science quality is the goal, not knowledge. Quality is not only about the product but also includes process, people, and purposes when information is to be fit for sustainable decision-making” (ibid, p.13). This statement entails that post-normal science calls for a careful analysis of the factors that determine the quality of the process used to inform policy decisions under high levels of uncertainty, rather than the quality of the advice itself. This change of focus (compared to the traditional evidence-based policymaking approach) introduces a notable complexification of the issue. Indeed, when considering the entire process leading to a given decision-making, the factors to be considered and integrated include not only the quality of knowledge claims used to inform the process, but also the endorsement of values, the choices of purposes, and the ability of handling uncertainty by taking chances when deciding action. As argued by (Kønig et al., 2017): “it should still be clear that the norms and values of the different problem-solving strategies depend on and are developed under different conditions of problem solving” (p. 13). Thus, if we agree that decision-making requires the ability of properly integrating norms and values depending on the circumstances, then it becomes necessary to guarantee a process that allows to reach an agreement on the *identity* of the entity capable of endorsing both norms and values in relation to a given decision. This carries us into the realm of complexity. Note that all living systems face the problem of quality control in their process of decision making. In this sense, human society is no exception.

The etymology of the term “identity” derives from the Latin *identidem* - a contraction of *idem* and *idem* - which literally means “same and same”. Hence, the very concept of identity is related to establishing a recursive mapping between something that is observed or experienced on the tangible side and a definition of an expected reference type on the notional side (Giampietro et al., 2006). This is where semiotics or better biosemiotics joins the game. Biosemiotics is the scientific discipline that deals with the ability of living systems to interpret signs coming from their context to guide their action. More in general, a biosemiotic process is used by all complex adaptive systems (including living systems and human societies) to generate, reproduce, and adapt their identity. For this reason, in this paper, I adopt the narrative of biosemiotics to provide new insights in one of the major concerns of the field of post-normal science, i.e., science for governance.

The rest of the paper is structured as follows. Section 2 illustrates the key distinction between the formation of shared norms (recorded information about the situated process of self-organization) and the formation of shared values (identified in the self-referential process of autopoiesis) in society. Section 3 sets out the conceptualization of the process adopted by society to define, preserve, and adapt its identity using a biosemiotic narrative. It builds on the basic ideas of (Luhmann, 1995) about the functioning of social systems and on the concepts of exosomatic and endosomatic metabolism (Georgescu-Roegen, 1971; Giampietro et al., 2012; Lotka, 1956). Moving to science for governance, Section 4 analyzes the factors that make it impossible to separate passion and reason in dealing with the “tragedy of change” (the need for updating the old identity). Section 5 proposes a re-interpretation of the iconic post-normal science graph identifying the various aspects relevant for studying the quality of the process

determining the production and use of scientific inputs for governance. Section 6 concludes with a reflection about the nature of the problem of justification of the chosen identity: Is this choice a political, ethical, scientific or a moral issue?

2. The distinction between producing norms and producing values

2.1 Situated self-organization versus self-referential autopoiesis

In his theory of social systems, (Luhmann, 1995) claims that human society distinguishes itself from its environment by simultaneously carrying out two distinct activities: (i) situated self-organization, which is related to the ability of reproducing and adapting its structural and functional elements, i.e., HOW to self-organize; and (ii) self-referential autopoiesis, which concerns the ability of reproducing and adapting the justifications of the functions it expresses, i.e., WHY to self-organize. The former activity has to do with the elaboration and adaptation of norms, while the latter concerns the definition of the final causes of the whole and its parts, that is, the elaboration and adaptation of values. This means that human societies, as “reflexive” complex adaptive systems, preserve and adapt their identity through the simultaneous expression of these two distinct processes. Expressing this concept within a biosemiotic narrative, we can say that social systems must express the ability of integrating the norms and values of the individual members of the society into a group identity perceived as desirable by its members. Adopting this narrative, I postulate that:

1. In relation to the reproduction of the part of the identity instantiated on the tangible side, the society must be capable of reproducing and adapting the tangible part of institutions, records of knowledge claims, anticipatory models, norms used to guide the actions of society in the external world. That is, the process of self-organization in human society (like that in any other complex adaptive system) must be capable of maintaining a correspondence between: (i) the instantiation *established* in biophysical terms in an admissible environment in the form of a metabolic pattern (this realized state is associated with the activity of a set of entangled structural and functional types stabilizing each-other); and (ii) the state of the social system as *expected* and described by the validated system of controls on the notional side.

In this process of self-organization, the “criterion of truth” for the inputs of information used in the system of control is represented by the ability of reproducing and adapting the tangible structural and functional components of the society. Hence, the process of self-organization is about being able to reproduce and adapt a given set of expected interactions taking place in the external world. The information used to stabilize these biophysical activities of self-organization only refers to the technical and tangible interactions needed to generate the metabolic pattern of the society. This process does not address the feelings and the perceptions of the members of the society in relation to their affective interactions. It only has to do with the ability of the system to stay away from thermodynamic equilibrium, i.e., “staying alive” in plain language. Nonetheless, these structural and functional elements are needed to guarantee the expression of the social practices associated with the affective interactions experienced by the members of the society.

2. In relation to the reproduction of the part of the *identity*, internally defined on the notional side, the society must be capable of establishing a self-referential process of autopoiesis determined by the sharing of feelings among its members. This process is associated with the ability of preserving a coherent mapping between: (i) the feelings that individual instances of human beings have about the roles they should play in the society when expressing their affective interactions; and (ii) the social roles defined by a given representation of types of agents in the society agreed upon by society. These social roles are used to organize and guide the integrated expression of social practices. The preservation of the coherence over *established* and *expected* social roles, translates into the preservation of a “group identity” that is essential to carry out effective communications based on a shared language (Habermas, 1979). Using this group identity, the individual members of a human society can establish a self-referential process bundling together their shared feelings allowing the endorsement of a common purpose (e.g., the concept of socio-technical imaginaries of (Jasanoff & Kim, 2015)). This perception of shared feelings about a common purpose, allows the formation of a social fabric holding the members of society together by integrating social practices across different levels of organization (Schatzki, 1996). The definition of a common purpose for the group justifies collaborative action and legitimizes the institutions determining social decisions. Without a robust social fabric, the individual members of a society will lose their feelings of belonging to the group, and this would make it impossible to decide how to preserve and adapt the integrated set of social practices aimed at achieving a common purpose.

Thus, the “self-referential” process of autopoiesis has the goal of defining the identity of the society, in notional terms, independently from the boundary conditions provided by the environment. This process must be capable of answering questions - as perceived and decided from the inside - like: Who are we? Why are we doing what we are doing? How do we know that we are “we”? Therefore, this second process has to do with the ability of the system to define the final causes of its functional compartments (i.e., defining why the various functional elements are expressing their specific tasks) within the overall process of self-organization. The emotional endorsement of this side of the identity is needed to justify the commitment of the members of the society to collective action.

2.2 Analog versus digital use of language

The distinction between the two processes of situated self-organization and self-referential autopoiesis is crucial because it provides new insights that help to understand the message of post-normal science about the inadequacy of the current use of reductionism in sustainability science. In fact, the process of biophysical self-organization focusing on the external world has the goal of learning how to reproduce and adapt the biophysical metabolic pattern of the society associated with the expression of social practices. It does not consider the effect of this pattern on affective interactions. Whereas the self-referential process of autopoiesis explores the internal world in terms of feelings perceived inside the psychic structure (of both individuals and society), with the purpose to define what is desirable and “what we want to become” when adapting both the identity of the society and that of its individual members. Both processes rely on a symbolic language, used in the society to communicate. However, the method of interpretation of the symbols used in the language is different in the two cases.

To explore this difference, I draw on the distinction between the use of codes in communication proposed by (Sebeok, 1976).

In the case of self-referential autopoiesis, the language is used by the members of a given society to reach an agreement on shared feelings. Here the purpose is to agree on “who they are”; and “why they do what they do” as a group. In line with Sebeok’s work (Sebeok, 1976), the interpretation of the symbols of the language in this case is *analog*, i.e., it depends on the context (surroundings) of the communication. The external referents of the communications based on the language are the *feelings* associated with the existence of shared affective interactions in the group. Therefore, the ability of sharing the meaning associated to specific statements about feelings depends on the resonance of the collective feelings experienced by those participating in the discussion. Put it in another way, in the internal self-referential autopoietic process a shared interpretation of statements about “the self” is the product of the impredicative effect of emotional feedbacks across the members of the group. Statements and questions can only be interpreted and answered in relation to the perceptions they evoke. For example, “is it acceptable to perform this specific social practice?” is a question that forces us to consider both the social dimension of the issue and the unavoidable implications of the existence of a heterogeneity of individual perceptions in society (i.e., the answer to the question will be different for a single mother of two, a wealthy yuppie, a Muslim immigrant, or an atheist).

On the contrary, in the case of the process of biophysical self-organization (i.e., how to reproduce existing institutions, validate knowledge claims and anticipatory models, define the characteristics of social roles) the use of the language is based on *typologies* of external referents, and not on special *instances* of external referents. These typologies are recorded and stored in a shared library of ontologies, narratives, and models, supposedly valid for representing relevant events in the external world. This communication is *digital* in nature, i.e., it refers to expected valid relations of a given representation of the external world based on types interacting with other types. The representations of events based on types may evoke emotions, but they are not perceived because of emotions. A digital communication based on symbols in a language does not require a quality check based on the compatibility across local shared feelings (i.e., a book can do it). That is, the knowledge used in the communications relative to the process of self-organization is a “generically validated knowledge”. For this reason, and as discussed below, we should be skeptic about the claim that the quality of decision making can be based on generically validated knowledge (i.e., the claim that decision making should be considered as a process of rational choices informed by scientific evidence) (Giampietro & Funtowicz, 2020; Saltelli & Giampietro, 2017).

3. The functioning of society through a biosemiotic looking glass

3.1 The biosemiotic process in relation to complex adaptative systems

Biosemiotics is a vast and diversified scientific field. In this section, I exclusively focus on those aspects of the biosemiotics process that are relevant for my argument.

Giambattista Vico, a pioneer of the concept of the semiotic process, provided in 1710 a simple criterion to check the truth of information: *Verum esse ipsum factum* or “what is true is precisely what is made” (Viana, 2017; Vico, 1988). This basic idea resonates with similar concepts found in the literature on self-organization of complex adaptive systems. Several authors have described the generation of these systems as an iteration between a notional representation (recorded in an informational side) and a tangible realization of the system (established in the biophysical side). For instance, (Simon, 1962), the father of complexity theory, describes this process using the narratives of “recipes (notional representations) determining processes (tangible interactions) reproducing recipes”. (Prigogine, 1980), on the other hand, describes the same concept with a different set of terms: “genomes (notional representations) determining metabolism (tangible interaction) reproducing genomes” in an iterative process. In theoretical ecology, H.T. Odum refers to this resonance between notional representations and tangible activities as “informed autocatalytic loops” making ecosystems (H. T. Odum, 1971). In the same line, (Margalef, 1968) describes ecosystems as networks of biophysical transformations that evolve and adapt by sending messages to themselves into the future. A similar concept has been proposed by Holling when describing the evolution in ecosystems under the name of “adaptive cycle” (Gunderson & Holling, 2002).

Biosemiotics provides the same basic framework about the mechanism used to generate the identity of complex adaptive systems: these systems produce meaningful codes inside functional cycles (Campbell, 2019; Emmeche & Kull, 2011; Hoffmeyer, 2008; Kull, 2020a; Kull et al., 2008; Pattee, 2001; Rattasepp & Bennett, 2012; Von Uexküll, 1957, 1982). This conceptualization entails that the quality of recorded information (on the notional side) used for guiding action can only be validated by checking its usefulness (on the tangible side). Hence, the criterion of truth for semiotic controls is their ability to achieve a given purpose (Pattee, 1995). In relation to the two processes taking place in human society to preserve and adapt their identity (that of internal autopoiesis and external self-organization), this check requires to define and establish: (i) an effective *system of communications* capable to preserving and expanding the meanings of information carriers used to define and update the expected states of the society (on the notional side); (ii) an effective system of controls determining the realization of a network of *biophysical interactions* among functional and structural elements stabilizing each other in an impredicative set of relations operating in an admissible environment. The stabilization of this tangible system of interactions is required to generate and preserve the meaning of codes (information carriers) and the core of shared feelings required for guaranteeing communications on the notional side.

The narrative of the biosemiotic process allows a re-interpretation of the theory of social systems proposed by (Luhmann, 1995) in relation to the process used for the reproduction and adaptation of the identity of social systems. The reinterpretation I am proposing is illustrated in Fig. 1 where the basic elements of Luhmann’s theory are represented as the factors needed to generate a biosemiotic process. According to Luhmann, a societal system can be interpreted as a system of recursive communications capable of defining and maintaining a self-referential distinction between itself and its environment. It can do so by establishing a recursive set of communications as illustrated in Fig. 1: COMMUNICATIONS (inside the social systems) and INTERACTIONS (between the functional and structural elements of the social systems and the external context). What is peculiar about the analysis of Luhmann is that the “context” of a

social system is divided into two typologies of contexts: (i) a biophysical context associated with the existence of an external admissible environment (needed to get a stable structural coupling); and (ii) an emotional context associated with the feeling of the people making up the society (what Luhmann calls the *psychic structure* of the society).

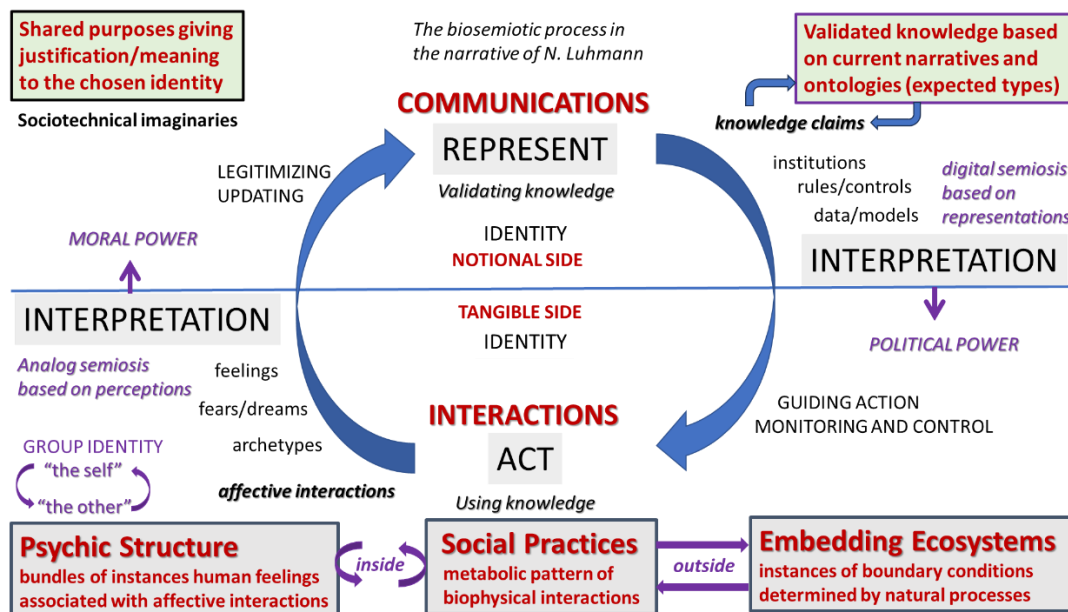


Figure 1: A novel interpretation of the social theory of Luhmann using narratives grounded in the biosemiotic process.

The recursive interactions between *communications* and *interactions* are taking place across the notional (on the top level of the figure) and tangible (on the lower level of the figure) side of the identity. These two activities can be associated with the semiotic concepts in the semiotic triad proposed by (Peirce, 1994) of REPRESENT and ACT. The recursive communications allowing to reproduce and adapt the identity require two steps of INTERPRETATIONS (originally “transduce” in the jargon proposed by Peirce) in between REPRESENT and ACT:

... → represent → interpretation → act → interpretation → represent →...

(1) When moving from the tangible to the notional side, instances are used to define types needed for communications on the notional side. Here, we have an *analog semiosis* based on *perceptions*. However, this requires the existence of a group identity allowing: (i) the formation of a shared feeling of belonging to the society (a group identity needed to operate the language); and (ii) the operation and the updating of a shared language used for the implementation of the activities of self-organization.

(2) When moving from the notional to the tangible side, types defined on the notional side are used to identify and describe the instances relevant for dealing with tangible interactions.

Here, we have a digital semiosis based on *representations*. The existing language is used to select relevant perceptions (the external referents of the language) and anticipatory models used to guide action.

Within the overview of the biosemiotic process illustrated in Fig. 1, the recursive set of communications that keep coherence over the two sides of the identity, must be able to generate, preserve and adapt five basic elements, of which three on the tangible side and two on the notional side.

On the tangible side, the biosemiotic process requires: (1) *an integrated set of social practices* (Schatzki, 1996) organized according to the principles of the metabolic repair network studied in relational biology (Louie, 2009; Rashevsky, 1954; Rosen, 1985, 1991); (2) *a psychic structure* determined by the affective interactions of the members of the society within an operational social fabric; (3) *a set of embedding ecosystems* guaranteeing an admissible environment in which the biophysical interactions controlled by notional communications must result feasible. This is a key and tricky constraint for society. In fact, the admissibility of the environment does not depend on the activities carried out inside the social systems: it is not under the control of the self-organizing process and, by definition, it is not directly involved in the self-referential autopoietic process (the society must be different from the environment). Indeed, as proven in the past and in the present sustainability predicament, social systems can damage the work of self-organization of embedding ecosystems (the admissibility of the environment) and in this way create a threat to their own stability. Given the laws of thermodynamics, the metabolic pattern of human society cannot avoid the constraints (biophysical limits) determined by the dependence on an external admissible environment.

On the notional side, the biosemiotic process requires/generates: (4) *a defined set of shared purposes* that are needed to justify the commitment of the members of the society to operate together toward a common purpose. The members of the society must hold a shared feeling that the given identity “it is worth” the burden it entails. This condition is essential to maintain the vitality of the biosemiotic process in human societies. It is this shared feeling (moral power) that legitimizes the institutions and check the validity (suggesting updates or major revolutions when needed) of the recorded and validate knowledge of the society; (5) *a corpus of validate knowledge claims* that is used to organize and use the experience done so far in the interaction with the external world. This knowledge is organized in taxonomies of narratives, ontologies and recorded data used in the representation of the external world and in the definition of institutions, rules, and controls.

In conclusion, the graph of relations illustrated in Fig. 1 shows that each one of these five elements is essential to guarantee the proper functioning of the whole biosemiotic process – i.e., the ability of generate, reproduce, and adapt the identity of a society. These elements, except for that of embedding ecosystems, depend on each other in the process needed to preserve the sustainability of the whole.

3.2 Exosomatic and endosomatic metabolism and knowledge formation

A human society is organized over several hierarchical levels (individuals, households, communities, countries, international organizations). When using the term “we”, a given

human may refer to a group of individuals, a household, a social group, a country, the whole humankind. When coming to the formation of knowledge this fact generates a problem. If several hierarchical levels must be considered simultaneously in the stabilization of the biosemiotic process, which mind is doing the thinking and which body is doing the action? When considering two hierarchical levels - individuals vs society - Whose mind and whose body should we consider in establishing the impredicative loop? Who is defining the expected behavior of individuals and how? To address this conundrum determined by the coexistence of two relevant non-equivalent levels of analysis that must be considered simultaneously, we must introduce the distinction between endosomatic and exosomatic metabolism (Georgescu-Roegen, 1971; Giampietro et al., 2012; Lotka, 1956).

Regarding the process of self-organization on the biophysical side, (Lotka, 1956) called the functioning of the network of material and energy transformations associated with the expression of the economic process (i.e., the production and consumption of goods and services in the society) the *exosomatic metabolism* of society. This term refers to the continuous flow of material and energy forms that are transformed to maintain, reproduce, and adapt the complex of machines and infrastructures under human control (Georgescu-Roegen, 1971). As explained by (Lotka, 1956): “*The most singular feature of the artificial extension of our natural body is that they are shared in common by a number of individuals . . . has in a most real way bound men together into one body: so very real and material is the bond that society might aptly be described as one huge multiple Siamese twin*” (p. 369). Therefore, human beings can carry out the process of self-organization (the reproduction of functional and structural elements on the tangible side) in two different ways: (i) an endosomatic mode, i.e. by converting energy and material inputs inside their body using their muscles to express agency, and (ii) an exosomatic mode, i.e. by converting energy and material inputs outside their body, but under their control, by using external technical devices to express agency. In the endosomatic metabolism, each individual corresponds to a given physical body, whereas in the exosomatic metabolism, agency is disembodied from the person, giving control to the exosomatic devices (Labanca, 2017).

Endosomatic and exosomatic metabolisms generate a challenge to the distinction between mind and body. In fact, together with the creation of an exosomatic biophysical metabolism (a shared biophysical technical body), human societies generate also an *exosomatic memory* that provides a semiotic scaffolding (Hoffmeyer, 2008, 2015) based on the use of a common language to share knowledge claims, anticipatory models, norms, organizational patterns (a shared set of habits). Indeed, even in primitive society, based only on endosomatic metabolism (when human activity was totally based on human muscles), the use of language entailed a breakthrough in their capability of learning and communicating. To learn how to express adaptive behavior while preserving their subjective conscious experience, individual human beings needed to learn and agree about a given set of useful categories and grammars for encoding the perception of relevant signals, generate useful meanings and identify pertinent causal relations. Therefore, it is important to note that language was not developed within individual minds but emerged in relation to the societal culture of the society of reference. Hence, the knowledge of human society is an emergent property of the group, it is exosomatic in its nature (Deacon, 1998). Accordingly, we can argue that in modern societies many bodies, when using the same language, share the same *exosomatic memory*, and that many minds

using technology to express their agency are using the same *exosomatic body*. In this regard, (Saltelli & Boulanger, 2020) observe: “This differentiation is what distinguishes our modernity from the previous stratified social structure, whereby every single individual had a role assigned at birth. In a functionally differentiated society, individuals inhabit and function in a plurality of systems: “Nobody can live in only one of these [functionally differentiated] systems”. The exosomatic memory shapes the different functional identities that a given individual (expressing her own endosomatic metabolism) can take during its life (e.g., mother, professor of philosophy, member of the community choir, videogame addict, etc.).

The existence of different scales associated with different levels of organization generates an obvious epistemological predicament. Indeed, with this narrative, we have to conclude that Individuals operating inside the metabolic pattern of society – inside the exosomatic metabolism – cannot see it or know it directly because the exosomatic metabolism is operating at too large a scale and too complex to be observed, let alone understood by individuals who can only grasp some of its relevant aspects (e.g., economic, technical, legal). Therefore, individuals are living in a *shared virtual world* (Ricketts, 2016) or a sort of *simulation* (De Winter, 2020) generated by their belief in the validity of the representations given to them by the existing set of semiotic controls. Returning to the representation in Fig. 1, individuals are living in the notional representation determined by communications taking place on the notional side, in what Luhmann called “the social system” represented by the box *communications*.

This entails that individuals belonging to a given society cannot directly check the existence of their external reality as perceived and represented using the exosomatic memory. The reality they know has been described to them (in their infancy) using the exosomatic memory transmitted through their given language. Therefore, when deciding about their own individual identity, their option space is strongly determined by the received representation of their external world (including the set of admissible behaviors associated with the social roles defined in the society). Put in another way, their behavior, expectations, and concerns as individuals should be consistent (as much as possible) with those provided by the semiotic controls operating in the society. The members of the society have to adopt an individual identity compatible with what is expected by society, even though they *know* that this identity does not completely reflect their feelings, hopes and fears.

This awareness generates a constant tension, or *irritation* in the jargon of Luhmann (Halsall, 2012), requiring a continuous process of patching on the two sides of the identity, i.e., the perceptions and the rules implemented by individuals and those indicated by society. For this reason, individuals operating at their local scale, must be capable of influencing the process of changing the identity of society, which operates at a much larger scale. This requires a mechanism capable of scaling the heterogeneity of societal meanings that are associated with different definitions of purposes and different forms of situated knowledge of individuals (Haraway, 1988, 1991). Regarding the mechanism of scaling the coordination of agency inside ecological systems from local to larger scale, (Kull, 2020b) flags the existence of a convergence among different authors on the concept of *semiotic fitting*, quoting a variety of terms found in literature that refer to the same phenomenon (see section 4.1 for a definition of this term). In theoretical ecology we find an analogous concept referring to the functioning of ecosystems as a combination of constituent components – functional compartments – associated with the

interaction across ecological niches (Lomas & Giampietro, 2017; E. P. Odum, 1969; H. T. Odum, 1994; H. T. Odum & Odum, 1976).

3.3 The common purpose of a complex society

The complexity of the identity of social systems is associated with the ability of preserving a multilevel organization inside the social systems. This entails that the perception of “who” are “we” cannot be falsified objectively from the inside and cannot be observed in all their relevant aspects from the outside. Causal relations identified by narratives used to guide action can only be perceived and represented, from the outside, considering “a level of organization and a scale at the time” (Giampietro et al., 2006). Therefore, within the semiotic process illustrated in Fig. 1, if the individuals do not like what they experience, they can only react by refusing the identity forced on them by the semiotic controls. As a result, they will lose their feelings of belonging, leaving the group (emigrate) or stop respecting group rules (becoming an outcast). As described by (Tainter, 1988), the collapse of complex societies is unavoidable when the process of iteration between semiotic control and exosomatic metabolism no longer satisfies the hopes and the fears of its members (as perceived at the lower level). In this situation, the exosomatic memory of the system of control loses the original meaning at the lower level, because the psychic structure of individuals no longer recognizes the associated knowledge as useful. This loss of meaning of the system of control that is regulating the metabolic network (on the tangible side) will progressively translate into a loss of its ability to process the negative signals of feed-back received by the society - a situation that has been described as “ancient régime syndrome” (S. O. Funtowicz & Ravetz, 1994).

As shown by the collapse of the Soviet Union, the sudden implosion of the system is not necessarily triggered by debates about the truth of the statements associated with the exosomatic memory (e.g., the truth of the economic plans decided by the central soviet committee). Rather, the collapse can result from a sudden flip in the emotional perceptions of the psychic structure about the purpose of the society (e.g., people felt that the regime was not worth it). As a result, in the case of the Soviet Union, the given social role of “guard” stopped to make sense for those working at the gates of the Berlin wall. As shown in Fig. 1, the two sides of the definition of identity: (i) at the individual level mediated by the psychic structure; and (ii) at the societal level represented by the semiotic controls, affect each other in an impredicative way. For this reason, the survival of ideologies associated with the identity of large socio-economic systems (e.g., communism and capitalism) does not depend on the quality of the knowledge claims related to the stabilization of the process of self-organization. Rather it depends on their capability of reducing the emotional stress and ensuring a decent quality of life to the individuals, i.e., how to preserve the meaning that the psychic structure gives to the communications received when using the exosomatic memory. Can it preserve the social bonding defined in the process of self-referential autopoiesis?

4. The role of science in the biosemiotic process

4.1 The impossibility of separating reason from passion

A different view of the steps taking place in the social system (using again Luhmann's jargon) in the two activities of self-organization and autopoiesis in the notional side is proposed in Fig. 2. In the upper right corner of this figure, we have the set of relations determining the formation of the exosomatic memory. After having defined the concerns to be addressed – i.e. the set of final causes that have to be addressed by the different functional elements of the society - the society has to decide how to organize itself internally (institutional setting) and chose a set of validated representations (ontologies and narratives) useful to describe and anticipate the effects of its biophysical interactions in the tangible side.

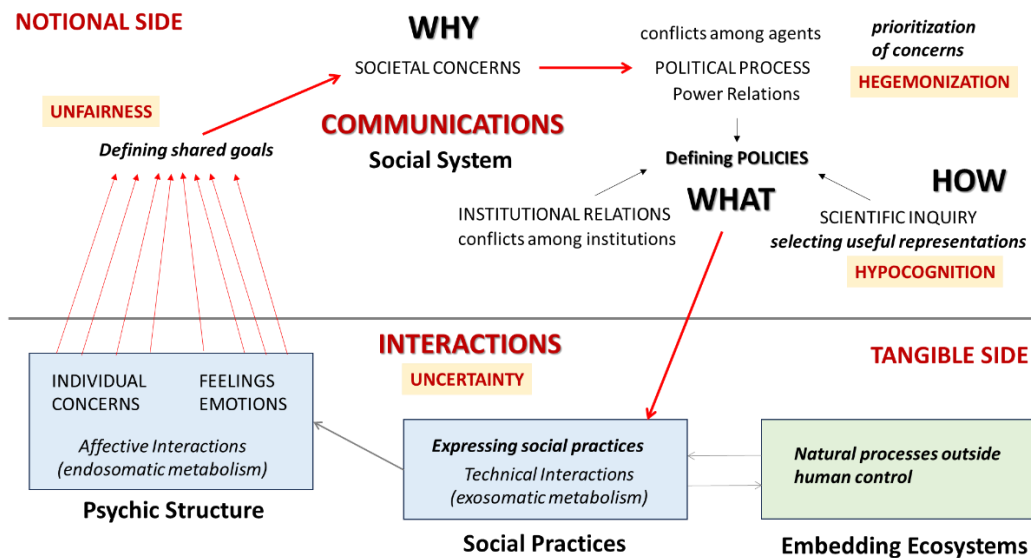


Figure 2: A representation of the semiotic process in relation to the functioning of the social system.

The structure of relations illustrated in Fig. 2 identifies three distinct families of narratives required to operate the semiotic process: (1) justification narratives referring to the identification of societal concerns – WHY action is needed; (2) normative narratives referring to the target and results to be achieved – WHAT has to be done (about the action to be implemented); and (3) explanation narratives – HOW do we know it and HOW can we do it (e.g., the scientific evidence used to support the validity of the first two narratives).

In the lower left corner of the figure, we can see the operation of the psychic structure “experiencing” the result of the biosemiotic process. It shows the key role that it plays in judging the quality of the whole process: considering what was expected and what has been established, it answers the question whether what has been “experienced” was worth it.

Kull defined *semiotic fitting* as the capacity for making and preserving the local semiotic bonds, defined as the agent's functional or communicational match with its environment (Kull, 2020b). This semiotic fitting is essential to deal with *intersectionality*, i.e., the ways in which various social categories such as gender, class, race, sexuality, disability, religion is interwoven on multiple and simultaneous levels (Center for Intersectional Justice, 2019). These perceptions of local groups of interacting agents, in the daily establishment of social practices coalesce in a shared understanding of concerns leading to the adoption of common narratives (the sharing of a set of beliefs about the causality over relevant events). When these shared narratives about the relevance of perceptions of threats or opportunities reach a critical size in the society they can be used as inputs on the notional side, where the selection of representations (expected to be relevant and reliable) are finally used by the system of control.

This analysis suggests that the three narratives about WHY, WHAT and HOW affect each other in an impredicative way, and therefore their quality cannot be discussed in an isolation. The entanglement between passions (aspirations and concerns) and reason (the logic application of knowledge claims coming from scientific inquiry), key for the proper functioning of the semiotic process, must be unavoidably mediated by the political process. Consequently, the quality of the scientific inputs to policy decision-making is affected by four factors that should be considered simultaneously:

1. *Unfairness* – referring to the scaling up of the mass of concerns of individuals into a limited set of societal concerns to be addressed. Indeed, it is important to decide how to filter the different concerns found in society.
2. *Hegemonization* – referring to the step of deciding a priority over the different concerns to be addressed. This translates into deciding about the urgency of the implementation of policies.
3. *Hypocognition* – referring to the step of selecting useful representations to be used to inform policy. When relying on selected knowledge claims it is essential to be aware of possible “unknown unknowns” or “unknown knowns” ignored by the validated knowledge selected as input (Giampietro & Bukkens, 2022).
4. *Uncertainty* – referring to the aggregated effects of the four factors on the entire biosemiotic process. When considering the whole process, it is wise to be aware that a given level of uncertainty is unavoidable. This level of uncertainty, depending on the type of decision to be made, can become extremely relevant.

4.2 The tragedy of change

Based on the preceding, we can identify a moral power associated with the operation of the psychic structure in society (upward causation). The psychic structure interprets the practical results of the biosemiotic process determining whether the matching of the expected and the established state in the identity is also experienced as a *desirable emotional state*. If the state is not desirable, then there is no justification for the identity. At the same time, we have a political power (downward causation) determined by the exosomatic memory - the institutions, knowledge claims and the results of political processes - that defines the modalities of the biophysical interactions on the tangible side. In this arrangement, the moral power does not define rules and policies, but legitimizes the institutions and the process of

decision making. The moral power can change the identity of the whole society (and force changes in the political power) by applying a systemic censorship on the communications on the notional side – i.e., by limiting the option space of what can be represented and communicated (e.g., cancel culture). Certain types of societal practices deemed unacceptable by the psychic structure must be blocked. Moral power can make certain social practices intolerable by imposing taboos that sooner or later will have to be acknowledged by the political power in terms of changes of norms. In this way, outdated societal representations in the exosomatic memory are progressively replaced by new societal representations: the existing politically correct regime is replaced by a new politically correct regime. The process of “coarse-graining” – i.e., integrating downward (political power) and upward (moral power) – is illustrated in Fig. 3.

In this graph, the narrative of the biosemiotic process reintroduces psychoanalysis in the analysis of the functioning of societies. In this way, Luhmann’s analysis can be interpreted as suggesting a common pattern for the operation of the psychic structure at the individuals and societal level. Where institutions and the recorded assemblage of traditions, norms, data, and anticipatory models (the exosomatic memory) play the role of the *super ego* indicating the social roles to which the individuals must adhere. The feelings associated with the perceptions of affective interactions of individuals – fears, stress, aspirations, dreams - when scaled up to the level of the whole society play the role of a sort of aggregated *societal id* (*emotion and volition*). Finally, the continuous processes of updating and adjusting the purposes of individuals and the society (the coarse graining) can be imagined to be the generators of the *societal ego* generated by the incorporation into the definition of the identity of the feedbacks received from the interaction with the external world (the expression of the endosomatic and exosomatic metabolism).

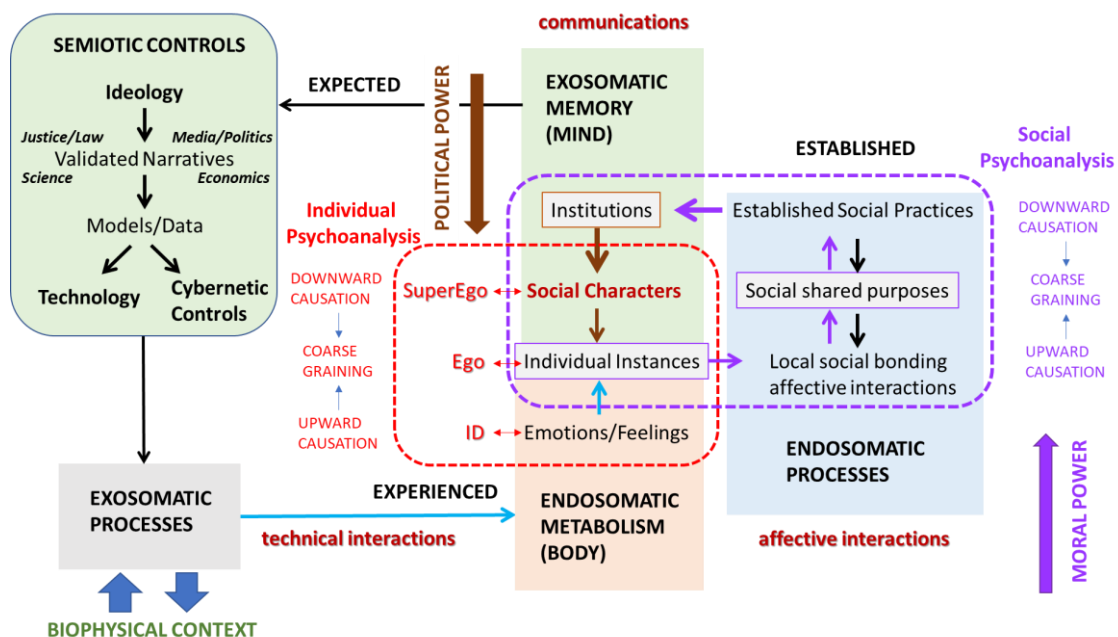


Figure 3: The formation of the identity across two psychoanalytical frameworks: individual psychoanalysis (in red) and social psychoanalysis (in purple).

In fact, in the activity of the self-referential autopoiesis, the concept of intersectionality (determining the heterogeneity found at the level of individuals) plays a key role in determining the semiotic fitting that must take place in the psychic structure. The evolution of relations over different social categories (gender, class, race, sexuality, disability, religion) defined across different levels of organization may require a re-adjustment of the rules used for the semiotic fitting and result into adjustments to the societal identity.

The diversity of concerns and aspirations generated by the intersectionality does affect the agency across different levels (individuals, households, communities, countries, humankind). Therefore, the quality assessment of the effectiveness of the semiotic fitting can only be the result of a process of learning by doing in relation to the capacity of making and preserving local semiotic bonds. Through the expression of social practices, individuals in society learn how to ensure an effective communicational match with the other agents in the surrounding. An incongruity among what is expected, what is established and what is experienced is translated into an activation of moral power, i.e., the experience of a failure in the biosemiotic process. Then the goal of the moral power will be to generate an adjustment of the definition of political correctness capable of revising history not only in the records in the exosomatic memory (from which banned representations have to be deleted), in the universe of communications (where the banned representations must be filtered away), but also in the cultural and emotional history associated with the experiences and feelings of individuals forced to re-adjust their own identity (Rauch, 2020). Thus, when a new wave of feelings and passions coalesce inside the psychic structure to reach the status of moral power, it can even legitimate the use of violence to change the existing order in the ongoing exchange of messages inside the society by imposing a systemic bias (censorship) on the communications.

When a new political correctness imposes new societal representations, some individuals may lose their sense of belonging to the updated identity. For instance, clusters of instances of specific social groups may resent the resulting loss of aspects of their identity. The situation might become potentially violent, because the recorded identity in the semiotic control (i.e., the given representation of the social system in the notional side reflecting the old political correctness) is associated with an established political power. This power can be used to legitimate the use of violence to control the interactions of individuals according to the old rules and regulations. In this case, violence might be the result of the adjustments of identity both at the individual or the social level, because of uncertainty, operating on perceptions, representations, anticipatory models, and even on the ability of institutions to implement plans according to the selected strategies. In general, we should expect a resistance to change the old system of semiotic control, because social memory is essential to keep together the social fabric and maintain coherence in the psychic structure. In a situation of crisis, a generalized challenge to group loyalty, to family, religion, political party, or national identity – the heterogeneity in the characteristics of individuals operating in the psychic structure – can generate additional stress/irritation and a resistance to change. A rapid replacement of the old set of semiotic controls can also result in the loss of valuable knowledge, and an increased risk of inadequate incumbents (in the institutions) or the establishment of ineffective new institutions incapable of expressing quality assurance when expressing agency.

5. The quality of scientific inquiry in the biosemiotic process

In the analysis of the biosemiotic process provided so far, science occupies a peculiar place. According to Luhmann, science has an operational code – true/false – but within a biosemiotic process science does not have a generalized criterion of truth. Within a biosemiotic process the quality of a given scientific explanation depends on the desirability of the results obtained when using it. That is, if we acknowledge that science can only provide *explanation narratives* that, depending on the purpose of the analysis, can be, for instance, useful or irrelevant, then I postulate that we should adopt a different quality code, moving from the code “true/false” to the code “useful/irrelevant”.

A conceptual illustration of how post-normal science can be seen as an integration of the scientific and political spheres in the biosemiotic process (used as a problem-solving procedure) is given in Fig. 4.

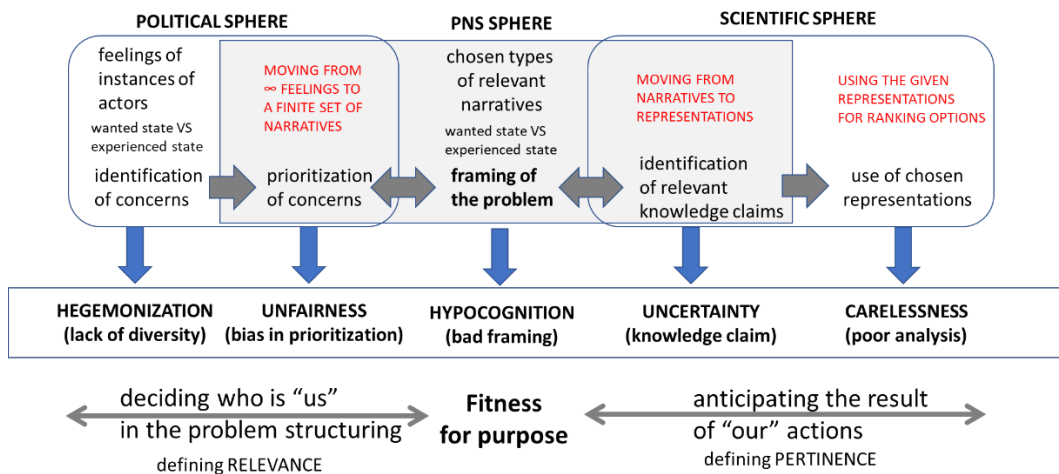


Figure 4: Five sources of trouble for the quality of knowledge inputs used for governance.

The set of impredicative relations illustrated there shows that before deciding on a specific scientific problem-framing, it is necessary: (i) to explore relevant concerns in the society, (ii) to establish priorities over these concerns to articulate the justification narratives that will guide the choice of explanation narratives. At the same time, an analogous process of selection has to be carried out in relation to the pertinence of the scientific information – i.e. choice of narratives and ontologies – and the individuation of knowledge claims providing relevant insights about *how to frame properly* the problems to be addressed. The inputs coming from the left have to be validated by processes taking place in the psychic structure. The inputs coming from the right reflects the existing set of validated communications in the exosomatic memory. The two sets of inputs have to be integrated within a process of reciprocal entailment – i.e. concerns can be defined wrong by new scientific explanations and explanations can be defined as irrelevant by new concerns. This dynamic reciprocal entanglement implies that *optimal solutions* based on the results of scientific inquiry only, are a mirage. One of the major insights of post-normal science is that the quality of scientific information used for governance depends on its fitting for function or purpose (S. O. Funtowicz & Ravetz, 1993, 1994, 1997). This entails that the quality check on the information generated

and used to guide action has to be performed over the different steps of the biosemiotic processes. When adopting a biosemiotic narrative we can generate an alternative version of the iconic graph of post-normal science, as illustrated in Fig. 5.

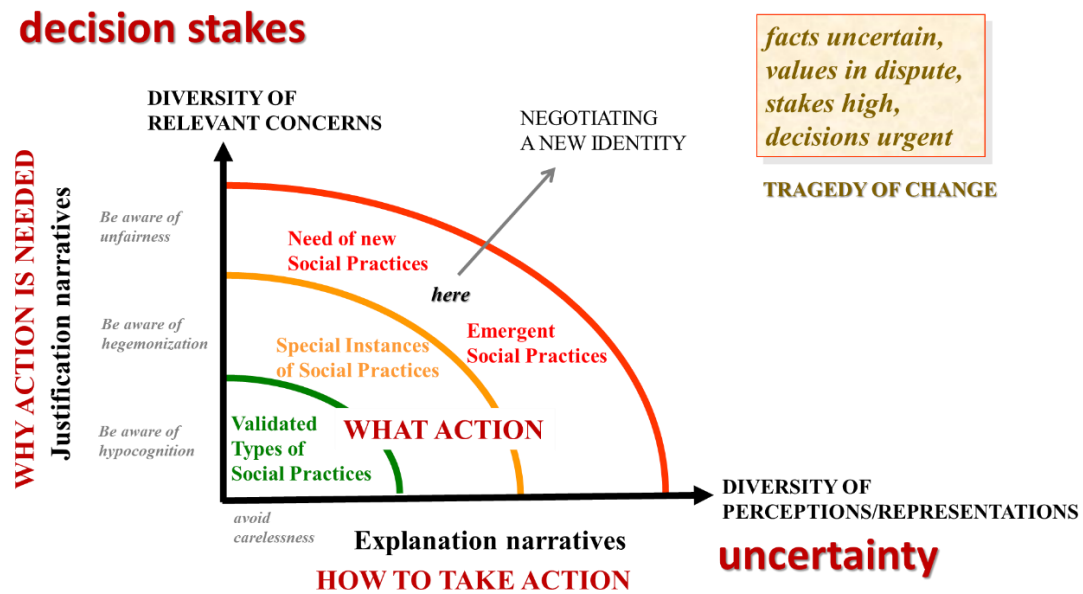


Figure 5: The iconic graph of Post-Normal Science described from within the biosemiotic narrative.

On the vertical axis, *decision stakes* can be related to the need of properly handling the concerns found in the society. Here we are dealing with the pre-analytical choice of a justification narratives: “why” action is needed. On the horizontal axis, *system uncertainty* can be related to the co-existence of a variety of perceptions and representations associated with the knowledge claims endorsed by society: “how” to take action to deal with specific concerns. Because of the complexity of social systems, this mix of perceptions and representations cannot be used to properly model and predict the future results of the interactions taking place in the tangible side, across all the possible dimensions and levels of analysis. A certain level of uncertainty is unavoidable.

Within the PNS plane we can define “typologies” of problem-solving strategies faced with the decision of “what” action should be taken. The three problem-solving strategies are: (i) *applied science* (when we deal with validated types of social practices – e.g. the making of an elevator). In this case, we have a clear consensus on the definition of the concerns to be addressed in the vertical axis and a clear consensus on the relevant perception and representations to be used to discuss the “what to do” questions – i.e. an uncontested definition of the problem structuring. In this situation two quality checks are needed: on the rigor of the analysis (application of validated knowledge claims) and on the possibility that the given problem structuring is missing some unknown unknowns or unknown knowns (Giampietro & Bukkens, 2022). That is, even when relying on validated knowledge, one must always be aware of the possible presence of hypocognition (Lakoff, 2010). In this situation the moral responsibility of the scientists enters into play in relation to the quality of the disciplinary work they do requiring a reflexive appraisal on the limits of applicability of their

own domain of expertise in relation to the given problem; (ii) *professional consultancy* (when we deal with a special instance of social practice – e.g. performing a delicate surgery). In this case, we have the coexistence of relevant concerns that need prioritization before taking a decision of what to do and also the co-existence of different perceptions and representations of the consequences of action. In this situation the moral responsibility of the choice of action must be shared between the scientists and those affected by the decision. The quality checks in this problem-solving strategy have to include the ones carried out at the lower level (checks against carelessness and hypocognition) and also consider the danger of hegemonization in the definition of priorities over the selected concerns. This explains why the choice of the instance of consultant matters and why several consultants are required when adopting this strategy; (iii) *post-normal science* (when we deal with the need of updating or introducing new sets of social practices – e.g. the move to a low carbon economy). As indicated in Fig. 5 in this situation we should expect legitimate contrasting concerns and aspirations, contrasting opinions about prioritization associated with a mix of perceptions and representations that cannot be integrated in a robust “grand narrative” about best course of action. This situation requires going through the “tragedy of change” at the large scale by negotiating a new group identity. As discussed earlier this is a quite complicated task to perform within an ongoing biosemiotic process in a complex society. In fact, it requires to change the functional elements of the plane on which you are flying. In the case of urgent decisions, the task of carrying out the process by respecting all the quality checks can become a mission impossible. For this reason, in addition to including all the quality checks defined for the other strategies of problem-solving, at this level a special attention has to be given to the issue of fairness. In fact, it is very difficult, if not impossible, to reach a “fair” agreement on who should be legitimated to impose his/her feelings about: (i) shared purposes; (ii) priorities over concerns; and (iii) socio-technical imaginaries, over the others.

6. Conclusions

In this paper I proposed the narrative of the biosemiotic process to gain new insights in the role that scientific inquiry plays in generating useful inputs to the process of decision making. These insights are especially important when the process of decision-making deals with issues relevant for sustainability. In this situation we are dealing with two distinct activities needed to preserve and adapt the identity of a society: (i) self-organization (on the biophysical side of the identity) requiring effective norms, and (ii) self-referential autopoiesis (on the notional side inside) requiring shared values. This fact entails that, in the process of decision-making norms and values do affect each other in an impredicative way. The knowledge claims generated by the social system (communications) are needed to produce explanation narratives useful for guiding action. Societal myths and socio-technical imaginaries, generated by the psychic structure, are needed to select the concerns to be addressed by the collective action of society. Looking at the impredicative set of relationships established in the biosemiotic process it becomes evident that a quality check on the whole process of production and use of scientific information for decision-making is at the same time a technical, a moral, a political and an ethical issue. This innate complexity explains why it is such an elusive topic to be addressed from a purely academic perspective.

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