return

Some Epistemological Implications of Semiosis in the Social Domain

Loet Leydesdorff
Science & Technology Dynamics
Amsterdam School of Communications Research (ASCoR)
Kloveniersburgwal 48, 1012 CX Amsterdam, The Netherlands
loet@leydesdorff.net; http://www.leydesdorff.net/

This draft is under submission with the SEED Journal
(Semiotics, Evolution, Energy, and Development)

ABSTRACT

The semiosis of the social domain is shaped by the specificities of language and symbolic communication among human beings. Language can be considered as the evolutionary achievement of the capacity to communicate at two levels simultaneously: humans can communicate both uncertainty and meaning. The operation of giving meaning to the uncertainty is recursive since the interaction among meanings generates uncertainty. Scientific communication can be considered as a next-order mechanism of social coordination using meaning that is codified into (paradigmatic) jargons. Potentially incommensurable paradigms entertain different hypotheses about realities and thereby they provide the system with a variety of expectations. This system can operates in terms of exchanging expectations by translating them. The scientific communication guides the advancement of knowledge endogenously, that is, as an evolving subsystem of translations among ever more specific and differentiated expectations.

Introduction

How can the social medium of communication structure human behaviour so that one can act on the basis of science-based counter-factuals? For example, how can we be persuaded to travel by airplane despite our natural fear of falling?

I shall argue that social relations can be understood in terms of a recursion of interactions among human beings at different levels. Texts can be provided with meaning since they belong to a language in which they can be contextualized. Texts contain information that is provided with meaning by embedding the information in other texts. Languages can further be codified, for example, into scientific paradigms.

From the perspective of the social system of communication, the input by human agents sending information can be considered in terms of variation that disturbs the network. The network that mediates is initially shaped by the aggregation of the communication, but over time this medium can sometimes develop a structure, be stabilized, and exhibit systemness.

For example, sciences can be generated as specific systems of communications by researchers making knowledge claims. When these knowledge claims can further be organized into a body of knowledge, a peer review system can be developed that increasingly provides a context of justification that feeds back on the knowledge production system in terms of what will be considered as a relevant contribution to the emerging themes. Thus, the knowledge control system is differentiated from the knowledge production system, and a wealth of social and cognitive relations mediate between these two layers of communication.

Given this differentiation between a context of discovery and a context of justification, knowledge claims may initially disturb the system since they have yet to be reflected at the emerging system's level of quality control. When the medium further develops, a next-order system emerges operationally, that is, as a differentiation within the social system. In other words, a channel of communication

is added as a degree of freedom to the communication. Communications systems, however, operate in a selective mode.

The next-order system is specific (since different) in terms of how it organizes the relations between signal and noise within its own domain. Although the formalisms of non-linear dynamics apply to both levels, the understanding of what is being organized and reorganized requires substantive theorizing at the level of the appropriate system's level. The (sub)systems are substantively different in terms of what they communicate.

The Incursion of the Social System

Systems incorporate systems like Chinese boxes (Simon, 1973). However, the further emergence of systemness reaches a ceiling at the level of the social system. The social system can differentiate internally. However, next-order (e.g., virtual) systems of communication can be considered as specifically coded social systems of communication. Epistemologically, they remain subsystems of the social system, although one can investigate them using other methods (e.g., artificial intelligence). ICT technologies are engineered by human beings in order to enhance inter-human communication (if only for play and pleasure), but they would loose their historical meaning if this contingency can no longer be reflected.

When the social system gains a new dimension by internal differentiation, it undergoes a phase transition. Each new dimension multiplies the number of possibilities for the realization (the maximum entropy) of the system. The additional subdynamics can be considered as a globalization of the social system. However, the globalization remains a subdynamics of the system. Since the social system can develop further by internal differentiation, this system can be both local and global at the same time.

Globalization originates as a further differentiation. From an evolutionary perspective, it increases the complexity that can be processed by the system internally. The internal differentiation first differentiates the communication of

information into the communication of uncertainty and meaning. Meaning, however, is always provided with hindsight. It can be modelled as an incursion: incursion uses the time axis as a degree of freedom, whereas recursion assumes the arrow of time as a given.

The feedback from the global level incurs on the lower-level communication by providing it with another meaning, but from the hindsight perspective. Dubois (1997) has proposed to call this second-order operation of meaning within a system also "hyper-incursion" (Rosen, 1985). Recursion shapes the system historically, but incursion is specific for systems that evolutionarily shape themselves in the present by giving meaning to what happened with hindsight.

Both the recursion of the incursion and the hyper-incursion codify previous meanings, but with reference to different subdynamics. In the case of recursion of the incursion the process is historical and the meaning of the uncertainty is fixed and organized, for example, by engineering it as in computer code. Alternatively, the meaning can be further communicated and provided with additional meaning in the case of hyper-incursion. The results of this interaction can again be codified. The higher-order meaning can thus develop continuously at the level of a social system building on historical manifestations as its retention mechanism. The two operations can be expected to disturb one another.

For example, a scientific specialism can sometimes develop with reference to an emerging set of technological problems (Rosenberg, 1976). The provision of meaning to previous layers of meaning can be considered as the development of knowledge within the system. The social and the psychological systems can be expected to differ in terms of how this operation is achieved (Luhmann, 1986). The knowledge produced at the level of the psychological system is already reflected individually, although it may still have to be brought to bear on a system of communication. The knowledge at the level of the social system develops on the basis of the interaction among individual knowledge claims, that is, as a distribution. If these differences can be exploited evolutionarily, discursive knowledge can further be developed into scientific knowledge.

By translating meaning into theoretically specified meaning, scientific knowledge can be stabilized as an incursive codification of the meaning that was first discursively stabilized. As long as this social system is only shaped historically by recursion, its knowledge base remains integrated as in a belief system. By opening the system both socially and along the time axis, counter-intuitive ideas can be used for making further distinctions. The knowledge base can thus function as the origin of new dimensions developing internally within the social system. Organized knowledge production and control as a subsystem of codified communication enables us to increase the complexity of the social system by generating new sciences as other systems of codified communication.

This differentiation through reconstruction can be studied in a sociology of the sciences. The more recently emerging sociology of science is different from the philosophy of science in its focus on the construction of differentiation in codes of communication. Specialties can be expected to develop their own paradigmatic assumptions which can be almost incommensurable (Kuhn, 1962). As against an idealistic integration (Kant, 1781), the sociology of scientific knowledge no longer assumes a harmonic integration of knowledge into a single epistemology on *a priori* grounds. If integration happens, this remains to be explained historically and sociologically (Bloor, 1982; Leydesdorff, 1995).

The introduction of the distinction between recursion and incursion enables us to add the evolutionary perspective of reconstruction in the present to the "social epistemology" of constructivism with its focus on historical reconstruction (Elzinga, 1985; Fuller, 1988). The focus can shift accordingly from historical stabilization, reconstruction, and retention to an incursive recombination into innovative perspectives.

Differentiation among the Sciences

As the scientists under study are able to specify their subjects of study, they develop a discourse containing specific codes. A new science is shaped by these

participant/observers on the fly as a cultural achievement. Sociological reflection on this semiosis at the level of the social system operationally closes the semiotic cycle by reconstructing the scientific reconstruction of nature as a cultural achievement, that is, as the reconstruction of nature in terms of communications (discourses and texts) among reflexive agencies (Taborsky, 1997).

This "social epistemology" remains distributed and uncertain: the scientific specialties can be expected to differentiate and integrate among themselves as systems of translation. Hypotheses are reformulated, and as these prove to be useful in other discourses, the expectations can be provided with new meaning (e.g., by using analogies and metaphors).

When the knowledge claims are first communicated, a network of communication is shaped. However, this network is not yet necessarily stable. It can be expected to contain both stability and change. The instability of the network generates uncertainty that has to be discarded as noise in order to reconstruct the original signal at the receiving end. This rewriting of the original signal codifies and stabilizes the expected information content of the message. Thus, a meaning can increasingly be shared among senders and receivers and a next-order network system can evolve and find stability among them.

One expects recursion and incursion to be phenotypically mixed in the observable results. The system alternates between the various options in a distributed mode. Note that it is distributed both in the social dimension and in the time dimension (Luhmann, 1984; Leydesdorff, 1994). Therefore, the global system can be expected to remain fragmented and especially fragile at the top of its structure. The subdynamics disturb one another at the margins where each interface turns the signal ninety degrees. At interfaces the systems can develop a coevolution if the coupling is structural.

The information is packaged in a message at the interface so that it can be processed at the network level. However, the message can be unpacked as containing information upon decomposition at the receiving end. A full reflection of 180 degrees requires two interfaces: one between the sender and the medium, and

one between the medium and the receiver. The reflection provides us with a rewrite of the information originally sent.

At the level of the network system, the agencies carrying the network as senders and receivers provide it with disturbances that the network can process by using its specific substantiveness for the selection. If this substance allows for inscription, a network of networks can sometimes be established on top of the provisional stabilization of the records. Let us call this next-order network a hyper-network. The hyper-network cannot be reached directly by the first-order systems carrying the original network—that is, by surpassing the first-order communication—but the information content of their messages can be provided with additional meaning while the messages can be processed in parallel, that is, at the first-order and at the next-order level.

Whereas the underlying network can sometimes be stabilized, the hyper-network can be considered as globalized with reference to the original signal. It operates as a dimension that remains virtual for the agents carrying the communication (Giddens, 1984). As these reflexive agents develop communicative competencies (Habermas, 1981), they may increasingly be able to change their perspectives, to perceive the various modulations, and to perform the necessary translations, that is, to provide the message with functionally different meanings.

Note that after differentiation the network and the hyper-network communicate in terms of specific substances, since each interface assumes a new packing of the message. For example, the social network may be shaped so that one can communicate in natural languages, whereas the hyper-network evaluates the communication in terms of specific (e.g., scientific) codes.

The hyper-network can also use other symbolic media of communication such as power, love, or economic value. For example, the economic value expressed in prices reduces the need for using language in a process of bargaining in exchange on the market. The codifications are functional for refining and accelerating the communication.

The codes can be further differentiated under selection pressure. One expects differentiation among the codes that structure natural communication to be mediated

symbolically. However, the differentiated codes have to be culturally constructed when they are no longer naturally given. “Truth” can be considered as one such symbolic medium of communication among others (Parsons, 1963a and b; Künzler, 1989; Luhmann, 1990).

For example, a scientific statement—in addition to being communicated—can be evaluated in terms of whether the information content of the statement is deemed true or not. This additional assessment requires a hyper-network of communication that includes and excludes communicators in terms of the communicative competences of some, but not all carriers of the communication. Scientific communities can thus be shaped as dependent upon a specific quality of a communication.

As noted, each interface requires the reconstruction of a message in terms of signal and noise along two orthogonal (90°) axes. Thus, each (sub)system requires a substance or an extension in two dimensions of the probability distribution in order to discard the noise generated at the interface. A two-dimensional structure can operate as a selector on the variation. Whereas variation can be random, selection is determined by the system’s substantive extension.

Selection operates at each moment in time. If selection operates repeatedly, a trace can be formed in the substance, but this trace can only be recognized from the perspective of a context, i.e., by taking another turn of ninety degrees. A trace or a record can be considered as a stabilization of the uncertainty by rewriting it using the time dimension and the substance of the receiving system.

Stabilization can be considered as a recursion of selective operation using time as another degree of freedom: some selections can be made for the sake of stabilization over time. Selection along the time dimension, that is stabilization, stands analytically in orthogonal relation to selection at each moment in time.

Whereas selection requires a substance in two dimensions (an extension), a stabilized system can be considered as a three-dimensional probability distribution. The first dimension of this probabilistic entropy can be considered as the variation, the second as the selection, and the third as the stabilization. As noted, variation disturbs the system to the extent that the system selects from this disturbance a part

of the uncertainty using its structure. A stabilization, however, requires a context. This context is provided by the development of the network over time.

Recursion of the selections refines the signal. Some stabilizations can also be selected for globalization at the hyper-network level (if this additional degree of freedom is available). The hyper-network adds another layer of selectivity to the network level. The next-order system can be expected to "rest" on the underlying systems because it operates by selecting. If it fails to rest, the underlying systems may become hyper-active because their variation is no longer selected appropriately. An overload of communication (e.g., hyper-inflation) may lead to a crisis. If order cannot be restored, the crisis may feed back on the carriers and develop into a catastrophe that affects different systems levels at the same time.

As noted, the feedback from the higher-level system upon the lower-level system can increasingly invert the time axis. The higher-level system is more at rest and therefore it can assume control. However, this can only be achieved when the higher-level system is first sufficiently constructed using the time axis historically. Thus, incursion depends on recursion, but control is gradually shifted as the system further emerges.

Brooks & Wiley (1986) proposed to use the ratio between the probabilistic entropy of a system to its maximum entropy (H/H_{max}) as an indicator of the balance of this process over time. The redundancy generated by adding new dimensions to the system also adds to the capacity of the system to communicate complex information in more detail. Incursivity feeds back top-down and purifies the system of unclarities because it allows for the further decomposition of the information, but at the same time it generates other uncertainties.

An Information-Theoretical Appreciation

Four dimensions of probabilistic entropy suffice for a parsimonious description of the expected information content of a global system (Leydesdorff, 2001). The first dimension can be characterized as uncertainty or variation. In a

second dimension this uncertainty can either be provided with meaning (incursively along the time axis) or it can have an impact as an event at that moment in time, that is, without yet further being reflected. If the event is both positioned and provided with meaning, the information can be stabilized as meaningful information.

When two selections reinforce each other as in a resonance, the incoming uncertainty may also reduce the uncertainty that prevails within the reconstructing system by allowing it to operate on the basis of a representation or a record of the uncertainty. Note that this incoming information can also be considered as observed by an updating system, whereas Shannon-type information can only be defined as expected information contained in a message. Brillouin (1962) proposed using the word "negentropy" for the reduction of the uncertainty in the receiving system when uncertainty can be provided with meaning. The information is provided with meaning by the incursive and/or recursive operation of the system that operates along a time axis.

Selection is an operation with a negative sign: it subtracts from the variation by discarding some (Shannon-type) information as noise. If the original variation is A, the variation is only $A * (1 - b)$ after selection. The b parameter is specific for the transmitting system. After two selective operations the remaining variation is $A * (1 - b) * (1 - c)$, where c is the characteristic in the third dimension of the system under study. Note that the resulting uncertainty can be written as $A * (1 - b - c + b * c)$. Since both b and c are by definition fractions of one (that is, percentages of the variation are being selected), the representation contains less uncertainty than the represented uncertainty A. Thus, the system may rapidly become more rigid than its environment and thus may defy Ashby's (1958) "law of requisite variety."

The further addition of a next operator $(1 - d)$ turns the tables. As noted, the addition of another dimension in the expectation expands the phase space of possible realizations, and therefore requires a phase transition. A next-order system may be formed, but it was also noted that the social system can only achieve this expansion by internal differentiation.

The social system had first to be developed from a high culture that is stratified and stable into a functionally differentiated system that tends to be global

and volatile. The observable system (e.g., visible in terms of organizations and social institutions) entertains a variation in the "virtual" dimension, for example, in terms of hypotheses that assign meaning to the observable variation. The observables then become instantiations (e.g., records) that can be evaluated in terms of their theoretical value. In this way, a knowledge-based society can increasingly be generated.

Two negative operations selecting upon each other add a positive value ($b * c$) to the prevailing uncertainty, but this observable variation is relatively small. However, stabilization can be observed, whereas selection (for example, on the market) remains latent. The stabilization can recursively be shaped historically along a trajectory. The next-order system remains pending in the form of selection pressure on the observable trajectories. It can also be considered as a regime (Dosi, 1982).

This next-order system can only be hypothesized as an expectation on the basis of theorizing that is methodologically able to entertain hypotheses, that is, to abstract from the given "realities." A knowledge-based system entails its own possible variations endogenously, but it needs a variety of codifications for making selections among the possible expectations. Therefore, this complex dynamics remains part of the social system.

The hypothesis of languaging

The above reasoning was based on the assumption that the initial disturbances can be considered in terms of a single probability distribution. Let us entertain the hypothesis that natural language provides us with a channel of communication that allows for two dimensions of the communication at the same time. When we communicate using language, we communicate both uncertainty and meaning. A statement can be expected to contain an information i, and this uncertainty can also be provided with a meaning j. These two dimensions of

language can also co-vary and thus entertain mutual information. This mutual information can be considered as "meaningful information."

The decomposition of the message into the meaning (*j*) and the uncertainty (*i*) can be performed by reflexive receivers at different locations in the network, potentially using other angles. Thus, the message is also positioned (*k*) and time-stamped (*l*) in a complex dynamics at the network level. Interhuman communication can be considered as a complex system of coordination in its own right (Parsons, 1968: 432). Meaning can be generated endogenously to the linguistic communication, and this process is recursive: previous meaning can be provided with new meaning, that is, one can reconstruct the system of inter-human communication if there is—historically—sufficient freedom within this system to do so.

As noted, the differentiation of information and meaning in human communication is a consequence of the inability of the social system to develop a supersystem other than as an internal differentiation. This differentiation can only be sustained if the communication using the different channels can also be differentiated. By differentiating among the differences contained in the probability distribution, different meanings can be attached to them. Thus, the codifications can also be differentiated, for example, in terms of symbolic dimensions. Meaning can again be communicated and then generate noise and/or be further codified into knowledge.

The complexity of the communication drives the carriers of the communication to develop their communicative competencies because they would otherwise (at least partially) be excluded from the communication. This process can again be expected to be socially distributed, for example, by a division of labour that can become more efficient to the extent that it corresponds with the differentiations that are functional to the further development of the communication itself. The retention mechanisms (e.g., institutions and nation states) compete in terms of how they have solved this puzzle of integrating the differentiations among the communications.

Note that the match between retention (recursion) and further development (incursion) does not imply a harmonic consonance, since the mediation among communications in different directions, for example, in terms of translations among codes of communication, is continuously required for the integration and the maintenance of the system's operation. These translations require a perspective slightly different from perfect resonance with the systems dynamics. The need for these disturbances structurally couples the social system to the human carriers who can develop these communicative competencies reflexively.

Further codification of the communication

Under the condition of differentiation symbolic media of communication can be shaped as a means of communication in addition to natural languages. The symbolic media provide higher-order codifications to the communication in "natural" languages. For example, a statement within a scientific communication contains not only an information and a textual meaning, but it can also have a theoretical meaning (for example, in terms of being true or false).

The theoretical meaning of a text can only be reconstructed in relation to the practice of the relevant scientific community. The scientific community includes and excludes human resources in terms of their scientific competencies. Whereas, in a premodern system, the truth of a statement was perhaps a matter of belief at the level of the individual mind, the modern system of communication is able to attribute truth as a value to a statement (or not). Scientific knowledge is therefore discursive knowledge.

In biology, one can observe a system and may use a semiotic model for the study of this system. However, the division between the biological development under study (e.g., a population of insects), and the biological discourse that studies the biology, remains analytically clear. Maturana (1978) discussed this distinction in terms of an observer that can be generated within a neural network endogenously

and a super-observer, that is, the biologist who contributes to a biological discourse. These two roles cannot be collapsed or confused in biology.

In the social domain, however, human beings are both observers embedded in the network and super-observers at the same time. We are able to participate in the discourse, but "God has given us language to hide our thoughts" (attributed to Talleyrand).[1] We are able to develop ourselves into meta-observers who study networks of communication, and under this condition we "objectivize" the intersubjective systems under study. But the insights from this exercise can be brought back into the communication as a participant. Giddens (1976) called this "the double hermeneutics." This double hermeneutics is methodologically inherent to the social sciences.

Perhaps more than other sciences, sociology requires analytical clarification about the methodological status of a statement before it can move forward as part of the cultural evolution. The reflexive communication has to be analytically distinguished from the substantive one. Phenotypically, however, the reflexive results feed back on the substantive communications as well as on one another.

First, this can happen through translation, for example, using languages. The scientific text can be explained in normal language, albeit perhaps in a longer text. Second, however, the various subsystems may begin to interact among themselves at a level beyond the control of the individual observer because the interaction terms among the individual contributions are increasingly codified at the network level.

For example, a statement which first had value only in a scientific domain may at a later stage become important as an economic resource through patenting. Although a recursion to natural languaging remains always possible in principle, the language exchanges at the interfaces carrying the translation can be highly codified. This short-circuiting at a latent interface, for example, enables (some of) us to appropriate the results of the translation in the private sphere by optimizing the communication.

[1] "Ils ne servent de la pensée que pour autoriser leurs injustices, et n'emploient les paroles que pour déguiser leurs pensées." Voltaire, *Dialogues* (1763), "Le Chapon et la poularde."

The relation between the modern techno-sciences and a knowledge-based economy of the capitalistic type is not incidental. The speed of the communication is enhanced by functional differentiation which is based on selection and therefore exclusion. Sociological reflection makes us aware of the interaction of these different dynamics, whereas philosophical reflection tends to obscure the complex dynamics because it focuses on identifiable concepts without sufficient attention for the substantive differences caused by the respective (sub)systems of reference.

In summary, the theoretical meaning of a text is not identical with its textual meaning. Different meanings can be attributed to the same instance. Consequently, the observable data can lose their unambiguous status as identifiers of what is the case and what is not. The science system operates in terms of expectations that can be informed and updated as a result of the observations.

Accordingly, the original signal can lose its status as a cause. With the inversion of the time axis, the relation between cause and effect may gradually become inverted. From this perspective, "nature" tends to be dissolved into a scientific "culture" that is able to entertain an external referent from potentially different angles. What is observed depends not only for its interpretation on the text, but also on an answer to the question of which text (discourse, paradigm) should be considered as the system of reference.

The next question then becomes: which communications select among the texts? The organization of discursive knowledge, however, remains concurrent and endogenous to the social system when it takes place at a next-order level. Since this next-order system of communications remains partially latent for the carriers, they may feel "alienated." The results of the science-based processes of reconstruction can therefore be increasingly unintended and counter-intuitive.

Structural coupling

Both psychological and sociological systems differ from biological systems in that they no longer operate in terms of observables, but also in terms of what the

observables mean to these operating systems. Meaning-processing systems can be expected to contain a double hermeneutics. In addition to operating socially in relation to each other, psychological systems operate also in a "structural coupling" with the biological body that generates uncertainty in what Habermas (1981) has called "the life world."

Whenever communication systems communicate, they are coupled to systems with which they communicate in terms of the mutual exchange of information. Communication systems can only communicate with other communication systems by updating both themselves and the related systems. But each interface introduces an angle of ninety degrees.

If the coupling is direct and necessary, then this coupling can be called "structural". For example, our bodies couple our psychologies and biologies structurally. For our minds to think, biological processes have to take place (and vice versa). Each system is embedded by the systems to which it is structurally coupled (Varela *et al*., 1991). The co-variation between such systems can be expected to co-evolve.

These structurally coupled systems can also be expected to share structural couplings with yet other systems with which they also communicate in terms of mutual information. The system in the middle that is structurally coupled on both sides can then be considered as a channel of communication between the sender and the receiver. These latter two systems can also be coupled only operationally through the mediating system to which they are both structurally coupled. Whether and how the communication is performed, will then depend on the operation of the system between them. Maturana (1978) called this a consensual domain. The two agencies are then coupled through the network they share between them.

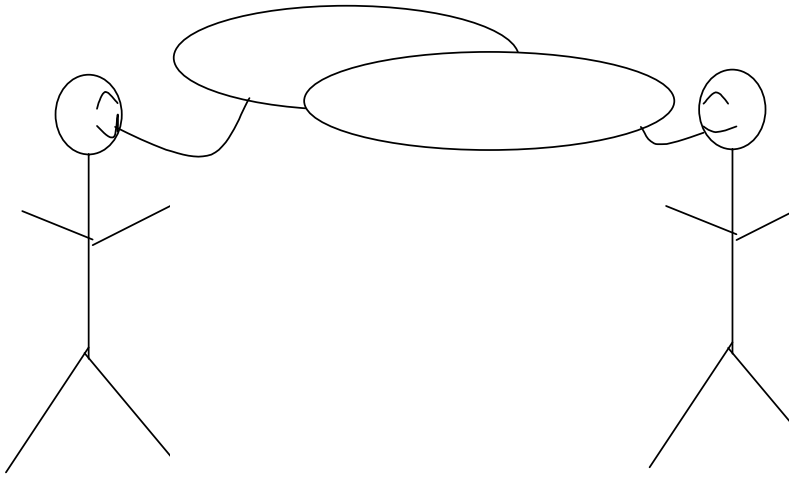

Figure 1

Human mindes (psychological systems) are structurally coupled to the communication at the network level, but only via this level to each other.

The two systems thus operationally coupled, can be coupled in yet another dimension. The system then gains a degree of freedom. The additional interfaces loosen the coupling further because the systems are then able to vary among the operational couplings. At the social level, these loose couplings add and dissolve "meanings" given the complexity of the system's operation. If this additional layer can be appreciated as a degree of freedom from within the system itself, a dual-layered network structure can become self-organizing or—as Maturana formulated—the system develops a semantic domain. A semantic domain can be considered as a consensual domain about a consensual domain.

Note that in using this model, the social system entertains no structural relation with the biology underlying the psychological mediation. Of course, our bodies are also engaged in what Luhmann (1984) called "symbiotic mechanisms" in a physical and biological world. But these are only made relevant to the social system through psychological mediation. Thus, the social and the biological systems are operationally coupled.

First, the physical and biological environments constrain us as psychological systems in terms of scarce resources. Second, we are able to deconstruct and

reconstruct our relationships with these environments using discursive knowledge in the biological and environmental sciences, that is, knowledge generated from and entertained by social communication. As the knowledge-based communications are further developed and differentiated, control can be expected to be increasingly top-down, while the resources to be reorganized flow into the social system bottom-up. The knowledge-based society can be expected to self-organize its acceleration by further organizing itself.

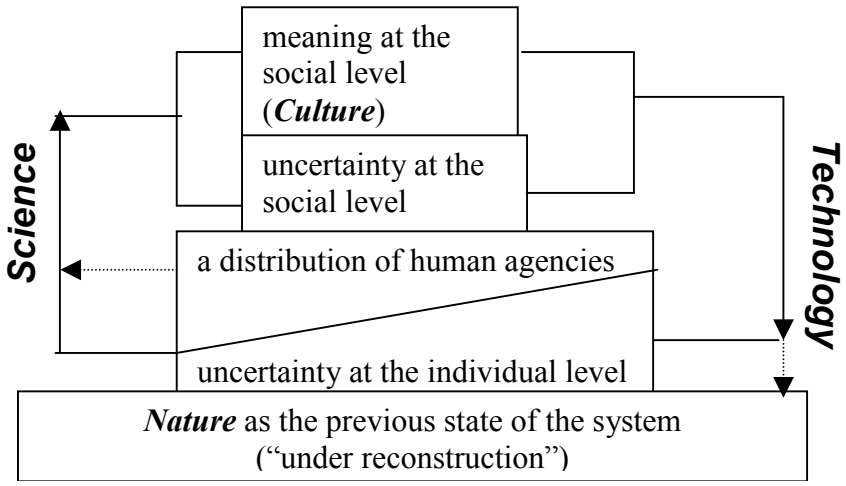

Figure 2

A schematic depiction of semiosis in the social domain

In a biological system, the relation between the two network layers—the one observable and needed for retention, and the other operational as incursion at the global level—is assumed to be "fitted" to the competition with reference to selection by a "given" nature. Thus, the variation in the selection mechanisms is resolved. The function of a communication in a given population, for example, is expected to have a meaning ("survival value") with reference to a cycle. In a social system this relation between function and meaning can also be reconstructed, albeit not by an individual carrier.

The social system operates in terms of interactions among human beings. This system is no longer "alive" in the biological sense; it therefore no longer has to

develop in terms of generations. It is not sustained by a biology as an objective given, but an assumed given ("nature") is transformed by, among other things, the biological and environmental sciences as discourses. The knowledge-based reconstruction of "nature" can become focal to its further development.

The possibility of this reconstruction of our relations to nature is a cultural achievement that is associated with the Scientific Revolution of the 17th century. As long as the social order was "given" as in a cosmology, the order of meaning was contained with reference to the life and death of the carrying systems, for example, through religious communication at the top of the hierarchy. When this order broke down, during the Reformation, the various dimensions of the communication could be differentiated. For example, religious "Truth" could then increasingly be distinguished from scientific "truth" (that holds only provisionally).

Scientific insights can be constructed and reconstructed interactively and recursively. This can be considered as a cultural achievement. What is the function of this differentiation? First, it enables the social system to handle much more complexity. The processing of complexity within this system goes through a phase transition because an additional degree of freedom of communication becomes available. The construction of meaning no longer has to be controlled by religion.

Second, this additional dimension of meaning can be recognized as a constructed one. The constructed order remains emergent in relation to the "natural" order. "Nature" can then be considered as a previous state of the system. The definition of "nature" may also begin to vary among discourses and over time. The constructed order can always be further improved and adapted, since the order is no longer "given." The prevailing metaphor of this social construction of modernity has been that of the Engineer.

The post-modern turn reflects on this achievement one more time. Different social and cognitive orders can now be expected. In a secularized society, universal yardsticks can be recognized as Kantian constructions that remain embedded in a cosmology as a kind of transcendental anchor. Secularization, however, enables us to move from a cosmology into a chaology without feeling threatened that one can no longer distinguish between truth and belief (Bernstein, 1995; cf. Popper, 1963).

The linguistic turn (Quine, 1953; Rorty, 1967) has enabled us to attribute "truth" to statements, whereas "belief" can now be considered a private affair. Beyond the linguistic turn, one can consider a communicative turn (Leydesdorff, 2002). "Truth" then becomes a symbolic medium of communication that can also operate on the text in addition to being visible within it. "Belief" can be considered as another medium of communication. Shared beliefs are historically important in the formation of communities.

Let us inscribe these two categories as codes for communication at different systems levels, as shown in Table One. At the social level, the science system operates by changing the belief system, for example, by further rationalizing expectations. This system is continuously being updated; an individual can either join this process by enrollment or risk exclusion by holding on to the "truths" that were given in a previous round of codification.

	belief	*truth*
persons (psychological level)	normative prejudices; values	ideas can be true with hindsight (reflexively)
social communication	communities that share values or assumptions by aggregation	scientific communication that builds on interaction among individual ideas

Table One

Cross-tabling of codes of communication at different systems levels

The knowledge-based systems transform themselves as "the ship while a storm is raging on the open sea" (Neurath *et al.*, 1929). As long as ideas can be freely communicated and selected, stabilized and codified, globalized and reintroduced into belief structures, this system has to self-organize its complexity because otherwise it would lose its meaning for its human carriers. None of them can individually grasp more than part of the complexity, but interactively the bodies of discursive knowledge produce a distribution that is not flat.

"Truth" itself can then increasingly be considered as a dynamic operator of this system. "Truth finding" or heuristics (Simon, 1969) within this knowledge has become as important for scientific research as the validation of accepted knowledge, since the latter is recognized as a temporary stabilization of possible new horizons.

Integration

In addition to being differentiated, a system must also be integrated in order to sustain its reproduction. How can a system that is no longer "natural" but "cultural" by nature still be integrated? The evolutionary system contains an incursive mechanism of integration with hindsight, in addition to being integrated *ex ante*.

Historical reconstruction "follows" actors with the order of time (Latour, 1987). This historical metaphor tends to consider a system as emanating from an origin. The system is then reproduced and reorganized into new stabilizations, but its order was essentially contained already in a previous generation.

The evolutionary metaphor adds a concept of integration in which order emerges *ex post*. The system drifts towards integration. Let me try to explain these different mechanisms with two illustrations:

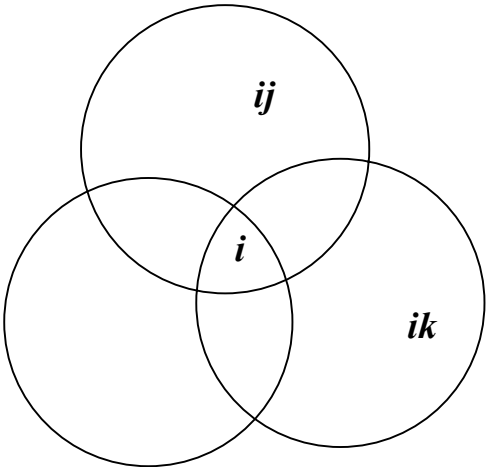

Figure 3

Three differentiated subsystems with an ex ante communality

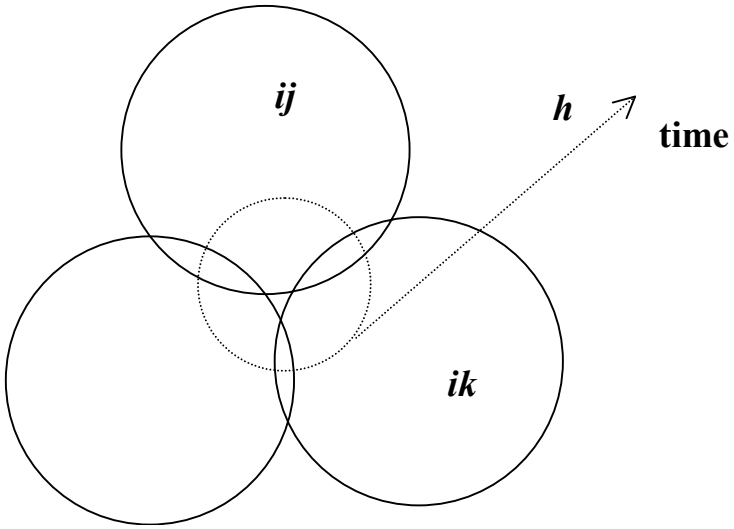

Figure 4

Emerging integration at the hyper-cyclic level (h)

In Figure 3, the system is still integrated in a center. Although this system allows for differentiation in subsystems, these subsystems remain rooted in a communality (*i*). In Figure 4, the subsystems have lost this center. A social system can endure this transition, since it does not need such a center and is not alive. However, the option of discarding the biological metaphor has to be discovered historically.

Whereas a premodern system was integrated, for example, with a Pope, an Emperor or a King on top and in the center, the French and American Revolutions of the late 18th century made it possible to organize societies on the basis of a "balance of power" (Montesquieu, 1748). The decapitation of the King of France eventually freed this system from its biological roots, notably the life and death of the anointed body of the King. The integration of society was thereafter based on a text, notably the Constitution.

With time, such a social system can be further differentiated at the global level. Different constitutions can be proclaimed by different nations and these states can compete in terms of economic achievement, imperial power, technological advancements, etc. Between national languages, but increasingly also between higher-

order codes of functional communications, processes of translation may integrate the system at a next-order level. This is indicated in Figure 4 with the dashed hyper-cycle.

The emerging order of the "hyper-culture" is fragile because it is no longer biologically grounded, but socially constructed. The global system self-organizes at this level of expectations, but it remains in need of social institutions and organizations for its reproduction. This subdynamics of reproduction then sustains the development of the social system at the global level. The communication controls the upswings, but it sometimes breaks down in downswings, giving way to a reorganization of the social system on the basis of new insights.

This process of social change can be vehement since complex communications can disturb the prevailing order in a non-trivial way. A knowledge-based order cannot be brought to a harmonic and peaceful resolution, since it is part of the social system that remains distributed by its very nature. Different angles are possible for appreciation, and new codifications can be expected to emerge. From this perspective, the paradigms and worldviews function as the anchors that provisionally hold the systems together, but the hyper-cycles are expected to change the present order into newly emerging ones. The storm can no longer come to rest, given the production of variation in the virtual domains of inter-human communication and phantasies (Weinstein & Platt, 1969).

Conclusion

Social order emerges as an expectation that is communicated continuously. Information can be provided with meaning, and meaning may evolve into codified meaning. The social system can thus be considered as developing in layers of communication among reflexive actors. From this perspective, the observable institutions provide a retention mechanism for temporarily stabilized expectations. Along the interfaces among systems theory, communication theory, and evolution theory emerge puzzles which can be formulated as analytical questions for the social sciences.

The (mathematical) theory of communication enables us to clarify the relations among the different perspectives on expectations. A message is expected to contain a (Shannon-type) information; both the message and its information content can be provided with meaning. Although the uncertainty and the meaning cannot be observed directly—they remain expectations—the probabilistic entropy generated by a given communication can be measured if one is able to specify the operation.

In a sociological theory of communication, one first specifies—on the basis of relevant theorizing—the expectation of "what is communicated" when a system under study is assumed to operate. Second, one can raise the question of "how" this communication can be indicated, for example, in terms of its foot- or fingerprints (e.g., word usages, money exchanges). Third, the information content of the messages received can be evaluated in terms of updating one's theoretical expectation: "why" has the communication taken place? This explanation can be considered as a knowledge claim that the analyst can feed back into the scientific discourse.

Because the social system remains distributed (by definition), one can no longer expect ultimate integration into a single medium of communication. The differences can be expected to be stabilized into differentiations. The recursivity of providing meaning to information provides us (as reflexive agencies) with a mechanism to develop, first, natural languages in which messages can be expected to contain information and the uncertainty can then be provided with meaning. Thereupon, an interactive culture can be developed using symbolically mediated communication and higher-order codifications (e.g., in paradigms and computer coding). These higher-order codifications can be expected to feedback on the lower-order ones by dissolving their "communality" into near-decomposability because the social system of expectations is neither biologically nor physically constrained.

More particularly, scientific discipline formation and specialization can be considered as an example of these recursive processes of refinement of the communication. (Analogously, the stock market is developing further refinements of economic exchange processes.) These esoteric communication systems process representations which have already been selected. The coupling to an external reality

tends increasingly to be loose, and the knowledge-based systems therefore become aware of their development as reflexively updating discourses.

The epistemological status of "truth" changes with this reflexive turn in the sciences: statements themselves are no longer necessarily "true" or "false", but they are potentially useful in truth-finding and puzzle-solving (Simon, 1969). "All that is solid, melts into air" (Marx, 1848); still, some representations are more solid than others. The foregrounding and backgrounding depends on the research question, or in other words, the perspectives entertained in the respective discourse.

These nearly decomposed systems of knowledge-based communication can be expected to drive themselves towards the edge of fractional differentiation and global integration. Thus, one is able (or one will fail) to sustain a knowledge-based hyper-culture as a virtual integration. These successes and failures remain distributed and fragmented: the incompleteness propels the communication endogenously.

ACKNOWLEDGEMENT

A previous version of this paper was presented at the 2nd SEE Conference, Toronto, 6-8 October 2001.

REFERENCES

Ashby, R. 1958. Requisite Variety and Its Implications for the Control of Complex Systems, *Cybernetica* 1 (2), 1-17.

Bernstein, R.B. 1995. *The New Constellation: The ethical-political horizons of modernity/postmodernity*. MIT Press, Cambridge, MA.

Bloor, D. 1976. *Knowledge and Social Imagery*. London: Routledge & Kegan Paul.

Brillouin, L. 1962. *Science and Information Theory*. New York: Academic Press.

Brooks, D. R. and E. O. Wiley. 1986. *Evolution as Entropy*. Chicago/London: University of Chicago Press.

Dosi, G. 1982. Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change, *Research Policy* 11, 147-62.

Dubois, D. 1997. Computing Anticipatory Systems with Incursion and Hyperincursion, in D. Dubois, ed., *Computing Anticipatory Systems, CASYS—First International Conference*. AIP Conference Proceedings 437, pp. 3-29. Woodbury, NY: American Institute of Physics.

Elzinga, A. 1985. Research, Bureaucracy and the Drift of Epistemic Criteria, in: Björn Wittrock and Aant Elzinga, eds. *The University Research System*, pp. 191-217. Stockholm: Almqvist & Wiskell.

Fuller, S. 1988. *Social Epistemology*. Bloomington and Indianapolis: Indiana University Press.

Giddens, A. 1976. *New Rules of Sociological Method*; Hutchinson: London.

— 1984. *The Constitution of Society*. Cambridge: Polity Press.

Habermas, J. 1981. *Theorie des kommunikativen Handelns*. Frankfurt a.M.: Suhrkamp.

Kant, I. 1781. *Die Kritik der reinen Vernunft*. Hamburg: Felix Meiner, 1956.

Kuhn, T. S. 1962. *The Structure of Scientific Revolutions.*Chicago: Chicago University Press.

Künzler, J. 1989. *Medien und Gesellschaft: Die Medienkonzepte von Talcott Parsons, Jürgen Habermas und Niklas Luhmann,* Stuttgart: Fredinand Enke Verlag.

Latour, B. 1987. *Science in Action.* Milton Keynes: Open University Press.

Leydesdorff, L. 1994. Uncertainty and the Communication of Time, *Systems Research* 11(4), 31-51.

—. 1995. *The Challenge of Scientometrics: The Development, Measurement, and Self-Organization of Scientific Communications*. Leiden: DSWO Press; at http://www.upublish.com/books/leydesdorff-sci.htm

—. 2001. *A Sociological Theory of Communication: The Self-Organization of the Knowledge-Based Society*. Parkland, FL: Universal Publishers; at http://www.upublish.com/books/leydesdorff.htm

—. 2002. The Communication Turn in the Theory of Social Systems, *Systems Research and Behavioral Science* 19(2), (forthcoming); at http://www.leydesdorff.net/commturn/index.htm .

Luhmann, N. 1984. *Soziale Systeme: Grundriss einer allgemeinen Theorie*. Frankfurt a.M.: Suhrkamp [Stanford University Press, 1995].

—, 1986. The autopoiesis of social systems, in: Felix Geyer and Johannes van der Zouwen, eds., *Sociocybernetic Paradoxes*. London: Sage, pp. 172-192.

—. 1990. *Die Wissenschaft der Gesellschaft*. Frankfurt a.M.: Suhrkamp.

Marx, K. [1848], 1967. *The Communist Manifesto*, translated by Samuel Moore in 1888. Harmondsworth: Penguin.

Maturana, H. R. 1978. Biology of Language: The Epistemology of Reality, in G. A. Miller and E. Lenneberg, eds., *Psychology and Biology of Language and Thought Essays in Honor of Eric Lenneberg*, pp. 27-63. New York: Academic Press.

Montesquieu, Charles de Secondat, baron de, 1748. *De l'esprit des lois*. Paris.

Neurath, O., R. Carnap, and H. Hahn. 1929. *Wissenschaftliche Weltauffassung — Der Wiener Kreis.* Vienna: Veröffentlichungen des Vereins Ernst Mach.

Parsons, T. 1963a. On the Concept of Political Power, *Proceedings of the American Philosophical Society* 107 (No. 3) 232-62.

—. 1963b. On the Concept of Influence, *Public Opinion Quarterly* 27 (Spring), 37-62.

—. 1968. Interaction: I. Social Interaction, in: *The International Encyclopedia of the Social Sciences*, Vol. 7, pp. 429-41. New York: McGraw-Hill.

Popper, K. R. 1963. *Conjectures and Refutations: The Growth of Scientific Knowledge.* London: Routledge & Kegan Paul.

Quine, W. V. O. 1953. *From a Logical Point of View.* Cambridge, MA: Harvard University Press.

Rosen, R. 1985. *Anticipatory Systems: Philosophical, Mathematical and Methodological Foundations*. New York: Pergomon Press.

Rosenberg, N. 1976. *Perspectives on Technology*. Cambridge: Cambridge University Press.

Rorty, R. M., ed. 1967. *The Linguistic Turn: Essays in Philosophical Method.* Chicago: Chicago University Press.

Simon, H. A. 1969. *The Sciences of the Artificial*. Cambridge, MA/ London: MIT Press.

—. 1973. The Organization of Complex Systems, in H. H. Pattee, ed., *Hierarchy Theory: The Challenge of Complex Systems*, pp. 1-27. New York, George Braziller Inc.

Taborsky, E. 1997. *The Textual Society*. Toronto, etc.: University of Toronto Press.

Varela, F. J., E. Thompson, and E. Rosch. 1991. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge, MA: MIT Press.

Weinstein, F. and G. M. Platt. 1969. *The Wish to Be Free: Society, Psyche, and Value Change*. Berkeley, etc.: University of California Press.

return