

Why the statement: 'Plasma-membrane transport is rate-limiting for its metabolism in rat-liver parenchymal cells'¹ cannot meet the public

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The sciences evolve in terms of paradigms. Paradigms can be considered as temporary forms of the self-organization of social communication in a specific language. The question of how communication is possible among otherwise 'incommensurable' paradigms has been crucial to the sociology of science for the last two decades. The theory of self-organization provides us with a new perspective on these issues. Various models for understanding communication among communication systems can be compared; 'integration' into public discourse can then be considered as a negative feedback loop that cannot be localized, but acts as a regime. By reconstructing 'nature' in terms of representations, the modern sciences provide this regime with increasing complexity. The sciences replace ignorance with uncertainty, and therewith generate a continuous pressure of 'modernization' of social and normative frameworks. The historical roots of this regime are discussed, and some of its practical consequences are elaborated.

Introduction

Is the *theory* of communication able to contribute to our understanding of an issue as pragmatic as 'science meets the public'? In contrast to some other contributions to this theme, this paper is not based mainly on results of empirical investigations, but it discusses the issue from a perspective in communication theory that has become available only recently. Notably, I shall elaborate on Luhmann's proposal for a sociological theory of communication.² This theory is best known for the thesis that society can be considered as a self-organizing communication system.

Of course, I am not able to explain self-organization theory fully in a single paper, but I shall introduce some of the major ideas discursively by focusing on the contribution of this new theory to the topic at issue. However, one should never expect theorizing to be useful for answering empirical questions on a case-by-case basis, but one may require from *empirical* theorizing that it enables us to improve our understanding of patterns of interaction. Relevant questions about such patterns of interaction between the sciences and the public include, for example:

1. Why doesn't 'science' more regularly and directly meet 'the public'? Why do we need other institutions (e.g., science journalism) as mediators? Is this mediation historically and culturally specific? How does this pattern of mediation change?

2. Are meetings between science and the public necessary for the sciences? What is the structural position of the public in the development of the sciences? Is the so-called 'structural transformation of the public sphere' (e.g., Habermas³) relevant to this issue? On the other side: what does it mean that the specialized sciences communicate 'truth' in a jargon that cannot be communicated to a larger audience without previous translations?
3. What then is the structural position of the mediating 'public relations system' of the sciences? Can one provide the various empirical findings about processes at this interface with a theoretical interpretation in terms of the changing relations between science and society? Is one able to specify a theoretical expectation about the further development of 'the public understanding of science'?

Before I address these questions, let me first introduce self-organization theory briefly with the help of some familiar metaphors.

Self-organization of the social communication system

Luhmann argued that the social system is composed not of human beings, but of communications among human beings.⁴ Why should such a communication system be considered as a self-organizing system? How does the communication systems metaphor relate to the idea that translations are brought about by intermediating networks of communication?

The prevailing metaphor for self-organization has been biological, while the prevailing metaphor for communications has been one of networks. Kuhn's notion of a paradigm⁵ has enabled the sociology of science to integrate the two concepts: a paradigm is a self-organizing communication network that exhibits an evolutionary pattern at a supra-individual level. On the one hand, the paradigm is self-organizing in the sense that it determines the relevance of each contribution to the communication: it sets the stage for the members of a scientific community. On the other hand, paradigms are defined as subsystems of the larger communication system, since they tend to be 'incommensurable' in their communications with one another.

Empirical studies in the sociology of science have subsequently taught us, among other things, that:

- There is no one-to-one relation between paradigmatic discourses and groups of scientists: all systems are in flux and uncertain in their delineation, both historically and socially (e.g., Mulkay *et al.*⁶).
- Communications contain translations: input (e.g., a contribution or a text) is provided with a reflexive meaning (output) according to the rules of the translation system (cf. Latour⁷). Discourses are reflexive translation systems.
- While a discourse is reflexive at each moment in time, a receiving system has an additional degree of freedom in selecting among the various (reflexive) meanings of the communication, i.e., the receiving system can be hyper-reflexive (Woolgar⁸). The hyper-reflexive system operates in a hyper-space (of space and time), and can therefore understand the various meanings in its instantiations (cf. Giddens⁹) with reference to its self-organization.

The one example of a hyper-reflexive communication system with which we all are familiar is psychological identity.⁸ Each of us is able to tell different stories about our

personal lives, and human beings self-organize their identities by making selections among these reconstructions. A social discourse in which participants can tell stories to one another is different mainly because the identity of such a system cannot be physically located. Each reflexive participant can read a text (input), then come up with an interpretation (output) according to his or her own rules; but additionally one can revise this interpretation as a result of interaction. The interactive (social) system is by definition distributed. Therefore, it has to remain uncertain, for example, in its delineation.

On the one hand, the discursive network contains more than its constitutive texts. This surplus has sometimes been called 'intertextuality'.¹⁰ On the other hand, the network is responsive to a local text or spoken contribution, while it remains able to accommodate change and to restore order; it tends to constitute a global regime. In addition to the metaphor of a paradigm, one needs the metaphor of a parallel and distributed processor to understand this additional function of the network: each processor runs its own program (as an actor or a 'text'), but the output of each (reflexive) processor is input for a communication network that runs according to a different program (like an 'intertext' or an 'interaction'). Each reflection provides us with a snapshot of the complex interaction. Observable stability of parts of the social system can occur in the special case when action and counter-action are expected to find balance in a local optimum.

In self-organization theory observable stability (e.g., 'facts') consequently requires explanation in terms of a specific interaction among developing systems. For example, the processes in our brains can be considered as the locally observable results of interactions between our minds and our bodies. Analogously, scientific institutions are the observable results of interactions between the scientific communication sub-system and the larger social system. All systems are contingent in space *and* historically contingent over time. However, the four-dimensional systems are not localizable, since they change by exhibiting their nature in interactive instances.

Various models for integration in the hyper-system

A reflexive system translates input into output; a next-higher-order self-organizing system is additionally able to select among various reflexive meanings with hindsight, and with reference to its identity or its *regime*. A regime can be considered as the identity of a distributed system. Note that the regime of a system can be globalized in relation to a stabilized representation of its past in three dimensions (e.g., a trajectory). The self-referentiality closes the system: the input is an external disturbance and not an instruction, while the output is a consequence of only the operation of the system.¹¹ A cognitive system is able to intentionally feed back on this exhibition. However, the selected output informs a self-organizing observer both about the message and about the state of the reflecting system. A cognitive system has information about its own state available reflexively as a cognition, and therefore this system is able to learn by theorizing, and not only through practices.

How can self-organizing or hyper-reflexive systems communicate with one another? In order to understand how such systems 'interpenetrate', one has to combine what reflexivity means for a subjective mind *and* for a sociological discourse. The major author on the issue of interpenetration in social systems has been Weber, on the basis of whose works various lines of reasoning have been developed. Before Weber, the

dominant metaphor for reflexivity had been based on Kant's idea of the transcendental subject. Kant's model essentially deals with the human *cogito* as a specification of the transcendental subject that is an assumed common denominator of reflexivity (see Figure 1). This subjective model of 'interpenetration' of the various communications considers 'the' reflexive (human) mind as the single integrating mechanisms of society.

Following Weber, communication between different social systems must be considered as an objective process in society. In his model, the different (value) systems exhibit an overlap in a single intersection that he has called the *Kampfsplatz* or 'battlefield' of culture (Figure 2). Nowadays, one might wish to label this arena 'the public'. The crucial point is the assumption of an objective integrating mechanism *in society* (e.g., through historical development). The meta-historical analyst (i.e., the

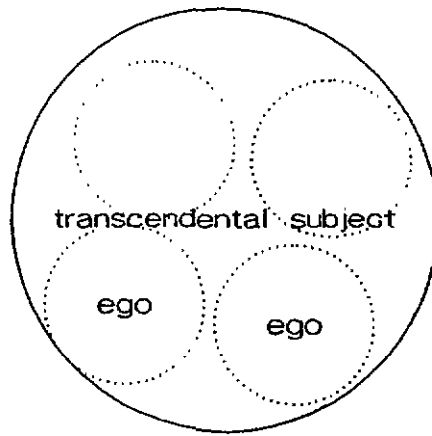


Figure 1. Kant's transcendental subject model of reflexivity.

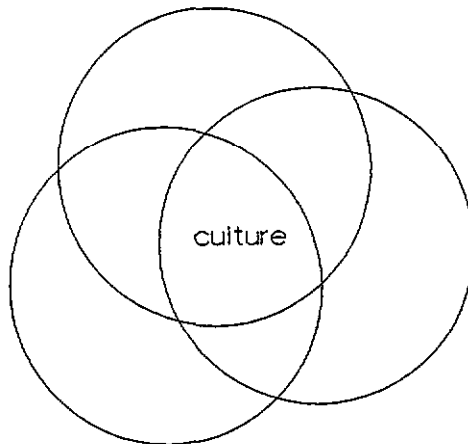


Figure 2. Weber's model of 'interpenetration'.

sociologist) is able to choose among analytical perspectives for the purpose of an ideal-typical reconstruction.

The translation model of social communication (see Latour⁷) combines the Kantian and the Weberian models. On the one hand, a reflexive subject has to perform the translation. (Whether this subject must be human involves a different discussion.) On the other hand, while zones of interpenetration among social discourses are carried by reflexive subjects, these zones do not necessarily coincide into a single intersecting area, since they may be carried by different subjects. Consequently, different social roles are expected, and this model of society formulates a basic notion of differentiation. While I depicted the previous (Weberian) model as a Venn diagram, the new model can be depicted as a series of Olympic rings (Figure 3). Note that this series contains a reference to the time dimension.

Each circle contains a sub-system that runs its own program as a discourse over time. If one subsequently concatenates the extremes of the Olympic rings into a circle, the circles can be moulded into a hyper-cycle, as indicated by the dotted line in Figure 4. At the level of the hyper-cycle, reflection on the relations between the reflexive subsystems requires a hyper-reflection. The hyper-cyclic development remains virtual in the observable instantiations at the level of the cycles, but it controls the frequency of these instantiations over time by providing them with feedback. In other words, the various cycles at the lower level are functionally geared into the further development of the higher-order system as a consequence. Therefore, the discourse of self-organization is a most adequate self-description of a functionally differentiated society.

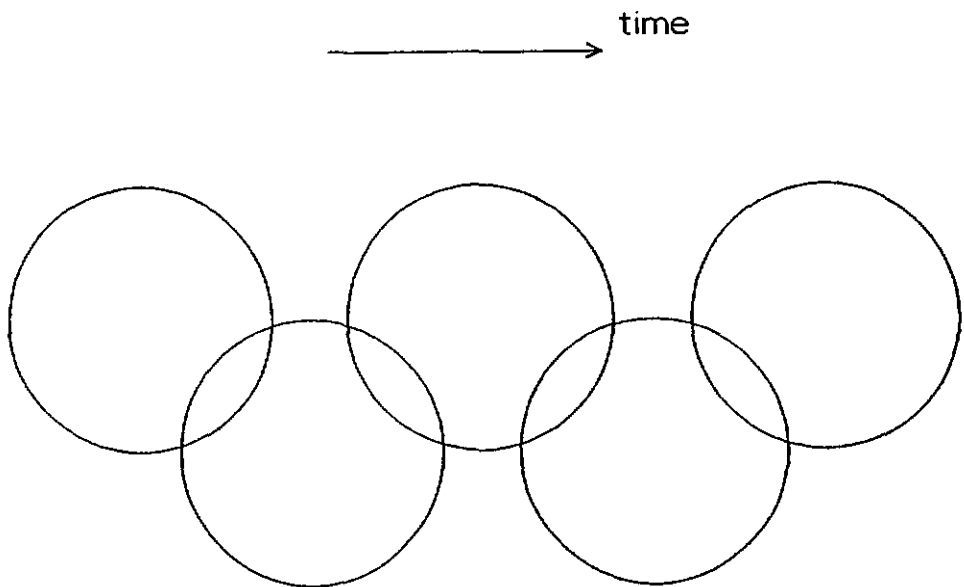


Figure 3. The translation model.

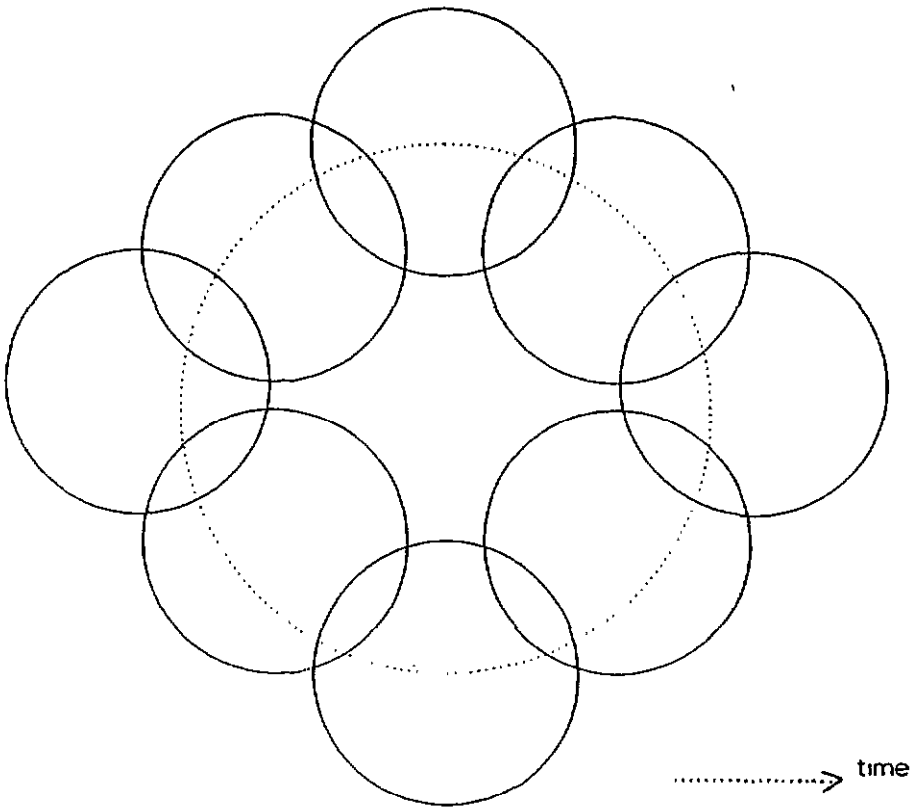


Figure 4. The hyper-cycle model.

Consequences for relations between observations and theorizing

Geometrical space has three dimensions; a hyper-space is a space with four dimensions. Usually we think of time as the fourth dimension in relation to the three spatial dimensions. In this case, something which exists in hyper-space has an extension also over the time dimension, and thus it has a beginning and an end *in time*. Using a biological metaphor one can think of a hyper-cycle as a life-cycle, i.e., a dynamic development of a complex system with a beginning and an end. Alternatively, one may think of the dotted line in Figure 4 as a spiral that at each moment represents a balance between increasing complexity and the organization of the fluxes of chaos by the communication systems.

A three-dimensional system translates input into output, or in other words, it creates representations like mirror images. A four-dimensional system is able to compare among mirror images by changing the aperture of the reflection. A system that performs a hyper-cycle is able to reflect on the relations between observable reflexive systems. Therefore, a second-order reflector is sometimes able to improve the quality of its reflection over time, i.e., to learn. Like a solar panel, the self-organizing

system can vary the quality of the reflection, but this system is not a clock that straightforwardly runs out of time or energy. By performing a hyper-cycle it synchronizes *ex post facto* a series of otherwise uncoordinated cycles.

Where does this leave us with respect to the theme of 'science meets the public'? What does it mean in practical terms? The introduction of hyper-cycles enormously complicates the issue: as noted, the fourth dimension remains virtual during the observation. Observable subsystems (e.g., paradigmatic discourses) may be reflexive in themselves, e.g., by translating signals. But how many there are, and how different they may be, can only be conjectured by the analyst, since one can only observe instantiations in three dimensions with reference to an expectation over time.

While one is able to study complex systems at a given moment in time or to study how subsystems interact over time, one is not able to grasp the whole of a four-dimensional system (e.g., the 'intertextuality') without an additional hypothesis. The additional hypothesis accounts for the time dimension: what one observes has to be specified in relation to what one expects. But by specifying hypotheses, one creates or develops another scientific discourse, and not one that is likely to integrate the other discourses into ordinary language. Thus, one gets caught in a regime of self-organizing discourses that one seems unable to escape.

The modes of adequate self-description change with the historical change of society. With hindsight, the transition from a high culture to a regime of functional differentiation and self-organization has dissolved and continues to dissolve the integrating community (*Gemeinschaft*) by replacing it with the differentiating society (*Gesellschaft*). Common languages tend to become special languages, while universal languages become increasingly jargonistic in their nature through functional differentiation. No longer does a community exist that uses either Latin or the vernacular as a common and universal language. All communication is increasingly complex. Each integrative effort with respect to other discourses induces the establishment of new specific discourses. (The complex system tends towards functionally differentiated languages (e.g., computer languages); the current tendency to attribute the function of a universal language to English which is a common language, should be understood as a provisional stabilization.) What remains are only discourses in which terms have different meanings, and which interact asymmetrically. Each system translates the incoming signal into its own substance, and outputs it as a sender without control of the signal's reach other than as an expectation.

All three-dimensional representations remain in need of a specification in the fourth dimension for their more complete understanding. Observations remain incomplete *without the formation of expectations*. While the various representations convey the impression of discernable stability, the fourth dimension introduces another layer of change. Disturbances of the four-dimensional regime in an observable dimension will cause it to develop in the dimension that has remained virtual in the observable communications under study. The regime is more flexible than its composing cybernetics, since it is expected to have 'unintended consequences'.⁹

'The public' tends to disappear

As noted, a regime includes contingency in the time dimension, and therefore, it is by definition in transition. One is not able to observe it, but one can formulate a hypothesis about it on the basis of a study of its transitions in the past. Transitions at

the level of the regime, however, are of the utmost importance, since they force redefinitions at the level of all the lower-level systems, and thus, for example, of the role of 'the public' and of the social functions of science.

What is the prevailing regime for the larger communication system? In my opinion, we are nowadays witnessing the decay of the last (normatively integrated) cosmology into a secularized chaology. The no-longer synchronized communication systems contain, as noted, reflexive discourses within their own dynamics. How can one study these systems in empirical terms? How can one, for example, delimit them in terms of domains? As noted, this requires a hypothesis, but where can one find grounds for formulating an expectation?

As a heuristic for finding the specificities of these lower-level systems for the purpose of empirical studies, I suggest that we first consider *what* a specific communication system communicates when it operates. For example, *the public* may function as a public insofar as something can be revealed to it. Christianity has been a religion of revelation. While in antique religions the Mystery was hidden during the service, the Gospel had to be communicated. Monotheistic Christianity completed the identification of the top of the hierarchy with the Divine that had already been framed during the Roman Empire. The centre of this hierarchically organized system provided the lower levels with unambiguous meaning that could be communicated. During the period of the Holy Roman Empire, God's Word was communicated in Latin. This communication was sacrosanct; those who did not share in it were ex-communicated. A high culture is self-contained; the interaction with competing high cultures does not affect its internal organization.

During the Middle Ages, it gradually became clear that the centre of secular power (the Emperor) and the centre of Christian meaning (the Pope) could conflict *within* the system. Eventually, the Reformation broke the power of the Pope as the instantiation of the cosmology, i.e., the Vicar of Christ. The Bible could then be translated into the vernacular. Thus, the reflexive interpretation was made uncertain, and then it could be reattributed among different nodes in the network.

What happened to the public dimension during this transformation? When the centre of a stratified system is in crisis, the system has a tendency to return to its previous state, which was the segmented social system based on kinship relations and ethnicity. But in the mean time the communication system had become more complex, and thus the segments were no longer comparable: the segmentation turned out to be a differentiation among national cultures. A variety of courts emerged as centres for public debate, and eventually this led to the formation of nation states.

The differentiated system, however, contains a potential for functional differentiation. In the long run, a functionally differentiated system is better equipped to handle a complex environment than an otherwise differentiated one. But one can think of a function only in relation to a super-system. Historically, the super-system has re-emerged as a universal system, i.e., a system that can be understood in terms of universal laws. Since the modern sciences study these universal laws, they have played a key role in the gradual transition of the social system from one of national differentiation into one of functional differentiation.

The scientific hyper-culture

Scientists have a particular need for functional differentiation, since they need room for provisional interpretations that they may wish to change with hindsight. The

sciences can allow for normative control only over the conditions of the communication (e.g., resource allocations), but not over the substantive or the reflexive contents of these communications. Thus, the differentiation from normative integration has been a functional requirement for the further development of natural philosophy, i.e., the new sciences. This crucial conflict was fought in Western Europe between the appearance of Galileo's *Dialogo* in 1632 and the publication of Newton's *Principia* in 1687. From that time onwards, functional differentiation has been further institutionalized in the social system.

What is the precise cultural role of the new philosophy? Why was it able to drive this development? By reconstructing 'nature' in an experimental setting, the observation is transformed into an instantiation with reference to an expectation. Insofar as this reconstruction proves successful, i.e., historically stabilized, nature can be *replaced* with the representation of nature in the reconstruction. Consequently, the one paradigm can gradually be replaced with the other. The new paradigm, however, overwrites the old one. For example, it is difficult for us to understand *why* Huygens rejected Newton's concept of 'gravity' as completely 'absurd'.¹² Equally, we no longer understand *why* it seemed important to Medieval physicians to let sick people bleed. Nowadays, we understand 'gravity' and 'blood pressure' as intuitively meaningful concepts.

This translation mechanism in the reconstruction drives cultural evolution or, if one wishes, modernization. Scientific discourses provide the other subsystems of society with a reflexive window on the uncertainty contained in whatever is represented in the representations. The post-modern achievement is that one is able to understand this process of representation recursively in terms of representations, and then to reconstruct the reconstruction by using the computer. In the latter reconstruction, however, one reconstructs not a natural object, but a discursive process of translations.¹³ Cultural evolution can then be considered as the development of a social system which happened to be the case, but which could be modelled as only one possibility among a range of options. The reconstruction of these reconstructions is hyper-reflexive in principle, and therefore should lead to the self-organization of a general theory of communication. The discussion of this theory, however, would lead us beyond the scope of this article.¹⁴

In summary, a self-organizing communication system rewards communications that are functional for the reproduction of the hyper-system, and thereby functional differentiation is self-enhancing. Functionally differentiated communication systems tend to be 'incommensurable', since they process different types of communication. Their interaction modifies the functional differentiation only during the reproduction of the complex system.¹⁵ The spread of functionality in a self-organizing system is only a question of time, since each system develops towards its attractor. However, this virtual development can never be observed by a participating agent; the emerging order can only be conjectured by reflexive participants.

Some normative implications

In redefining the function of 'the public' in a functionally differentiated communication system, the sociologist does not have to start from scratch. The disappearance of the public as an observable entity from the political system has been noted, particularly in German sociological literature under the heading of *Strukturwandel der*

Öffentlichkeit, or 'the structural transformation of the public sphere'.³ This question has been particularly urgent in the German context because of the need to explain the potential for a modern democracy to degenerate into a fascist system. During fascism, the virtual public function of the self-organizing system degenerates into an observable mob.

How can this be explained? When the illusion of 'steering the social system' can no longer be maintained in political discourse (for example, as a consequence of hyperinflation), the system contains a tendency to fall back on a 'natural', i.e. seemingly not constructed, basis for understanding power; the more primitive biological metaphor of a people can then emerge. Thus, the social system does not return to its previous state, i.e., to Medieval high culture—which acknowledges an important role for the public, to which the sacred Truth *had to be revealed*—but it may degenerate into a model based on the metaphor of a biological culture. The more complex system, however, is a next-higher-order hyper-culture: it allows for a wealth of cultures. These cultures can be considered as translation systems, between which one is also able to translate.

The modern sciences tend no longer to address 'the public', but specific audiences. In general, the sciences do not communicate in terms of a common language, but in terms of specialist jargons. If a science journalist addresses a 'public', they need to use a metaphor and to simplify the message. Only a hyper-culture can sustain this complex arrangement with an appeal to universal values.¹⁶ As noted, the differentiation has to be reproduced because of the need to organize the increasing complexity. In each communication the scientific and the political systems interact, but what these interactions mean is again clarified during the reproduction of the differentiation. While scientists in the science system may assess these interactions as conditional for obtaining resources, politicians have to use the interaction for legitimacy purposes in a completely different discourse, notably one that allows for comparisons in terms of priorities. The representations in the political discourse may be carried by representatives, but the integration operates only at the level of the representations, and not at the level of what is represented. In a modern society political discourse creates an illusion of integration by integrating representations. For example, one is able to compare completely different activities in terms of budget requirements. The political 'integration' has the *functional* role of disturbing the movement toward functional differentiation with a negative feedback.

The sciences, however, feed forward by processing hypothetical expectations reflexively. Their development can be understood only in terms of developing expectations. Correspondingly, the sciences replace traditional ignorance with rationalized uncertainty at an increasing speed. This historical situation grows nowadays more complex than a political or a public discourse is able to handle. The need for an integrated representation, however, seems to differ between the US and Europe. The US has an elected President, a Congress, a Constitution and a Supreme Court that more vigorously process the *illusion* of integration than the European system does. While well integrated at the level of national states, Europeans have become accustomed to a bureaucratic Commission in Brussels and a powerless Parliament in Strasbourg: European integration is highly visible as a construction. This system mainly processes its own discourse by translating regulations of representations into nine European languages.

During the previous transition, 'Brussels' was the capital of a Catholic Empire on which the Sun never set. Nowadays, it is the physical location of a system of translations. Is this image cynical? I don't think so. As reflexive human beings, we are

caught in the regime of a co-evolution with a scientific hyper-culture that needs the stimulus of normative disturbances. We need a system of public relations of science in order to secure the further development of the represented system. Big science requires the function of management. Analogously, we need 'Brussels' as a higher-order bureaucracy in order to secure our lower-order democracies.

Are we left with the option of stabilizing the results of the co-evolution with the science system proliferating uncertainty, notably as a subsystem that produces cultural representations of science? Indeed, audiences have to be provided with representations of science which are of such a nature that they can be perceived by these audiences as meaningful signals. The feedback is a political imperative for a democracy: if the relevant audiences are not well served, they may turn into illiterate mobs and deny the universal values that underlie this civilization. Hyper-reflection and the uncontrolled explosion of uncertainty are potentially as dangerous as hyper-inflation and the uncontrolled printing of banknotes.

However, one should always be aware that it is not science that meets the public, but only its culturally constructed representations. Consequently, the accounts of journalists should not be evaluated primarily in terms of whether or not they are true—a criterion that can be provided with a meaning only with reference to the operation of a scientific paradigm—but of whether or not they reach their intended audiences. The publicist or the science journalist enjoys a measure of freedom in telling stories that has to be denied to the scientist.

On the one hand, the represented science systems are a degree more complex than their exhibitions in cultural representations of science. In a moment, both the content and the interpretation may have changed. Thus, the information can become obsolete both in content and in meaning, and the informed observer may feel lost in a chaos of fragmented discourses. From the perspective of the science system, however, these open ends suggest a wealth of researchable questions.

On the other hand, the receiving communication system selects according to its own criteria. The audiences are not a determinant, but remain a relevant context for legitimating the further development of the sciences that are represented. This relation is in important respects asymmetrical: cultural representations of the sciences should never be confused with the sciences represented by these representations. While the sciences communicate in terms of uncertainties and further research questions, the cultural representation systems have to communicate these uncertainties as scientific discoveries and competing claims for truth in order to legitimate the allocation of resources for the further development of the scientific hyper-culture.

Summary and conclusions

Before drawing practical conclusions with reference to the topic at issue, let me first summarize my conclusions.

1. The social system of communications runs in cycles and hyper-cycles. All observable communications are necessarily localized in specific parts of this system. The specific parts run lower-level cycles which tend towards functional differentiation with reference to the higher-level reproduction of the evolutionarily more complex system.

2. The 'common' public that was available for communication in a high culture presupposed a community. In a modern hyper-culture, observed order is a provisional and local instance of interaction among communication systems. In general, order is emergent; its dynamics cannot be understood in terms of its instantiations, but the instantiations can be analysed in terms of the dynamics.
3. Consequently, 'integration' in a complex interaction among different systems is a result. One should not think of the public or a social process as an entity that is reflexive like an individual mind. The reflexive selection is always carried by a distribution of minds, i.e., not by a localizable identity but by a global regime that manifests itself as a difference.
4. Public discourse makes a difference by providing a negative feedback to the further development of the self-organizing system, but is not an instance of its integration. Public discourse integrates only representations of the systems under discussion.
5. The sciences continuously reconstruct 'nature' or whatever raw material (e.g., natives, natural languages) they may have under study. The sciences actively translate the represented into representations, and thereby drive the increase in complexity of the social communication system. This increase in complexity has led to differentiation, and therewith to the further development of culture into a hyper-culture.
6. The more complex system contains the constituting systems as its sub-cybernetics.¹⁵ Thus, there may still be scientists who behave like priests, and who want to convince others about the 'truth' or wish to announce happy or bad tidings. But ever since the Lisbon earthquake, the sciences could no longer contain or produce such tidings: they have become rationalized systems of expectations that proliferate uncertainties by distinguishing themselves from systems of beliefs and persuasions.

Scientific results, however, can sometimes be codified, and thus provisionally stabilized. These codified results have (almost by definition) no or hardly any news value. New and important results, however, remain only expectations. This situation generates a dilemma for what we have called 'the public relations system' of the sciences. The public cannot be expected to understand scientific results as the setting of further research questions, since then this audience would no longer be a public but would itself constitute a scientific discourse. However, the sub-cybernetics of informing the public have to be maintained, since otherwise the public might degenerate into a mob. As noted, public understanding is a function of the further development of the hyper-culture; the higher-order system is a cultural achievement that has to be maintained and reproduced by operating.

Implications for the public understanding of science

Can one specify an expectation about the options for enhancing the 'public understanding of science' from this theoretical perspective? Which types of communication would nowadays improve the public understanding of the sciences? In my opinion, one obvious implication of this line of reasoning is that presentations of the sciences

should show both the complexity at each moment in time, *and* the uncertainty in the developments over time. Since the sciences are four-dimensional communication systems in which conclusions come and go, the representations should preferentially be four-dimensional, i.e., they should include the time dimension. Video clips and movies provide us with an opportunity to make visual representations that include the time dimension, while 'natural language' exhibitions allow us only to depict situations or trends by selecting a perspective. Since both the data and the categories in terms of which we organize the data are in flux, and the two fluxes are related additionally through feedback mechanisms, one should not reify a presentation, except perhaps for didactic purposes.

In more formal terms, the aim of the 'public understanding' enterprise can be considered as the construction of a dynamic attractor for a specified audience. Thus, audiences should be understood in terms of recurrent fluxes. What attracts an audience over time? To answer this question, communication theory suggests that we focus on the receiving communication system and not on the sending one. When can the public understanding of science be expected to achieve the desired momentum, and which patterns may lead to a more intensive involvement? Let me suggest that such communications should combine the dynamic effects of video clips, police thrillers, fast-breaking news, and football matches.

The problem is to find the precise equivalents that would provide the public with an insightful representation, while at the same time reducing the complexity in the subject matter to such an extent that the message can be received. First, as noted, one might prefer to demonstrate the substantive dynamics of the system by using video clips rather than exhibitions of narratives. Second, the moves should probably focus on stories of discoveries, and visualize these stories in terms of moments of tension. Third, one could try to organize matches between teams of scientists for prizes. Remember that the reward offered for the accurate measurement of time on a ship at sea stimulated almost a century of scientific discoveries.

Over the last century, the Nobel Prize has obviously been too internalistic as a reward mechanism for attracting public attention to substantive themes. But the race between the US and the Soviet Union to conquer space and set a man on the moon fascinated a large audience in the 1960s and 1970s. Why could we not construct similar competitions for socially important objectives? Note that in addition to a trophy for the best solution, one could award a prize for the best communication of a solution!

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