LUMIS - SCHRIFTEN
aus dem
Institut für Empirische
Literatur- und Medienforschung
der
Universität-Gesamthochschule
Siegen

Peter M. Hejl

SELF-REGULATION IN SOCIAL SYSTEMS: EXPLAINING THE PROCESS OF RESEARCH

LUMIS-Schriften 21 1989

LUMIS - PUBLICATIONS
from the
Institute for Empirical
Literature and Media Research
Siegen University

Herausgeber: LUMIS
Institut für Empirische Literatur- und Medienforschung

Zentrale wissenschaftliche Einrichtung der
Universität-Gesamthochschule-Siegen
Postfach 10 12 40
D-5900 Siegen

Tel.: 0271/740-4440

Redaktion: Raimund Klauser

Als Typoskript gedruckt

ISSN 0177 - 1388 (LUMIS-Schriften)

Peter M. Hejl

SELF-REGULATION IN SOCIAL SYSTEMS: EXPLAINING THE PROCESS OF RESEARCH

LUMIS-Schriften 21 1989

Siegen 1989

Self-regulation in Social Systems: the Example of Science

Autor: Peter M. Hejl, Winkelstraße 1, D-5220 Waldbröl

Zusammenfassung

Der Streit um die Erklärung der Wissenschaftsentwicklung durch wissenschafts*interne* oder *-externe* Faktoren (Internalismus/Externalismus), hat zwar alle Teilnehmer ermüdet, ein theoretisch konsistentes Steuerungsmodell wurde aber bisher nicht vorgelegt. Um ein derartiges Modell zu entwickeln, müssen die in den Argumentationen verwendeten Dichotomien aufgegeben und das Ineinandergreifen von Systemdynamik und externen Einflüssen verstanden werden. Dies ist schließlich in eine Theorie der Selbstregelung von Systemen zu integrieren. Die Arbeit stellt eine solche Theorie der Selbstregelung vor. Auf der Basis einer Theorie sozialer Systeme wird zwischen Selbstregelung durch organisatorischen Wandel und durch Veränderung der Systemkomponenten unterschieden. Während die erste Selbstregelungsart relativ konfliktarm ist, besteht ihr Defizit in ihrer Langsamkeit. Systemregelung durch Veränderungen des Komponentenverhaltens ist jedoch nicht unabhängig von der Systemorganisation. Eine permanente hierarchische Organisation ist aber nachweisbar mit Selbstregelung unvereinbar. Dementsprechend wird im Anschluß an W. S. McCulloch die Konzeption einer heterarchischen Organisation entwickelt und gezeigt, daß Selbstregelung im Rahmen einer solchen Organisation möglich ist, wenn die Bildung temporärer Hierarchien zugelassen ist. Das vorgestellte Modell wird anhand von Beispielen aus der Wissenschaftssoziologie diskutiert.

Summary

The controversies about the explanation of the development of science by *internal* or *external* factors (internalism vs. externalism) has wearied the participants but not yielded a theoretically consistent model of regulation. The successful construction of such a model requires that the dichotomies underlying the arguments are abandoned and that the interplay of system dynamics and external influences is properly understood and integrated into a theory of the self-regulation of systems. This paper presents such a theory of self-regulation. In the context of a theory of social systems a distinction is made between self-regulation through organizational change, and self-regulation through changes in the behavior of system components. The first kind of self-regulation rarely leads to conflicts but has the disadvantage of being very slow. Self-regulation through changes in the behavior of system components is, however, not independent of system organization. A permanent hierarchical organization has been shown to be incompatible with self-regulation. Therefore, following W. S. McCulloch, the conception of a heterarchical system organization is developed, which allows for self-regulation as long as the formation of temporary hierarchies is possible. This model is discussed in further detail with special reference to examples from the sociology of science.

SELF-REGULATION IN SOCIAL SYSTEMS: EXPLAINING THE PROCESS OF RESEARCH[1]

1. Introduction

We do not know whether dualistic thinking – and hence conceptualizing – results from some innate properties of our cognitive systems, or (to state the problem in a dualistic way) whether it is a cultural phenomenon which became influential long before it was first institutionalized in Manichaeism. Either way, it has been with us for a long time, and it is therefore not astonishing at all that sociology of science paid its tribute to this fundamental scheme by asking whether the development of science must be explained as a result of influences external to it, or if they are better viewed as resulting from the internal functioning of science (or disciplines, laboratories, or research groups).[2]
But this oscillation between internalism and externalism exists as well at the level at which scientific activities in a more narrow sense are considered. Must they be understood as activities of specialized – normally even professionalized – groups?[3] In that case, they might be explained with respect to their group-specific origin and to their contribution to the stability of the group itself. It is, as well, possible to examine characteristics of the formal or informal organization of groups of scientists and see whether any correlations can be observed with different levels of activities, with productivity, or with types of research. One might equally well ask whether it is more promising to see science as a predominantly cognitive activity, a position which leads of course to a host of different questions.[4]

More puzzling, if we review these dichotomies, is that it becomes evident that they appear at *any possible level of analysis* between the individual scientist and the totality of all scientific activities, grouped under the rather vague collec-

[1]The theoretical model presented here resulted from and owes much to continuous discussions I had over recent years with G. Roth, A. Barsch, S. J. Schmidt and many colleagues from different disciplines. Yet, without the patient help of R. Hunt, whom I have the pleasure to thank particularly, it would have been very difficult to produce this text.

[2]Cf. as examples and discussions of internalist and externalist explanations of the history of science P. W. G. Wright, 1981; B. Hessen, 1971; G. Clark, 1970, R. Krohn, 1977; W. van den Daele, 1977.

[3]Cf. J. Ben-David, 1971; M. Crosland, 1975; R. Darnell, 1971; R. Whitley, 1977.

[4]This position has been developed especially by G. Böhme, 1974; 1977.

tive name of "the science system." Obviously enough, we are confronted with an unsolved theoretical problem. Its core is the apparent contradiction between two groups of observations which seem to exclude each other, hence the oscillation between internalism and externalism. Whereas the first group covers all phenomena related to the autonomy of science as a cognitive *and* social activity, the second designates all influences on science from non-scientific sources. By using a dichotomous explanatory scheme, one of these two groups of factors *must* be neglected. The problem is, of course, well known and the pragmatic researcher simply ignores the theoretical problem and looks for a way to combine internal and external causes to explain the effects he has at hand.

Nevertheless the theoretical problem exists. To neglect it is tantamount to disregarding how the behavior of systems is produced, and hence *regulated* from within (self-regulation) and/or from their environment (hetero- [or machinelike] regulation). A solution to this theoretical problem is all the more important as it answers at the same time questions stemming from other famous dichotomies such as "reductionism versus holism" and "behavior of individual actors versus behavior of social systems." Finally, and equally important, one should not forget that questions of regulation of social systems are political questions. This holds for both sides of the regulatory process: regulatory efforts (inputs) are often undertaken for political reasons and the output of the science system (academic education, systematic knowledge and appropriate techniques) is of evident political importance.[5]

My claim here is that any understanding of self-regulation in social systems *must* solve the problems these dichotomies indicate. To substantiate this view, first, I will try to demonstrate that the claimed connection between the dichotomies mentioned exists, and that for conceptual reasons neither reductionism nor holism is in fact interested in self-regulation. Then I will present a model of self-regulation which results from social self-organization (seen as an interaction between the micro and the macro-level of systems). This type of self-regulation

[5]The relation between science and politics is a topic which has been treated in hundreds of publications since the formation of modern science. The scientific and public debate on the autonomy of science vs. regulating influences from the political domain became particularly heated in Germany after the publication of an article on the "Finalization of Science" by G. Böhme / W. van den Daele and W. Krohn (1973). In this debate the problem of regulating science appeared as a distinct topic, cf. W. van den Daele / W. Krohn / P. Weingart, 1977. Cf. as just one example of a systematic treatment of the relation between science and politics in a sociology of science context S. S. Blume, 1974a and as studies of a domain in which the relation between science and politics became particularly important during the last years G. Küppers / P. Lundgren / P. Weingart, 1978 and J. Cramer / R. Eyerman / A. Jamison, 1987.

is based on structural changes of systems, which can be seen as a kind of long-term decision-making. Finally I will show that as a result of the social change brought about by self-organization, a social situation might appear that allows for a second type of self-regulation. This type of self-regulation requires a specific organizational set-up, characterized by a "heterarchical" (W. S. McCulloch, 1965; cf. 3.3.3 below) type of organization. It allows for quick adaptations and high social creativity, but it is highly unstable and might need supplementary support.

2. Dichotomies and self-regulation

The problem of self-regulation (be it social self-regulation or self-regulation as a general problem) has a long history, which can be traced back to Greek political philosophy more convincingly than probably a host of other ideas which "have already been discussed" by Plato and Aristotle.[6] In modern political philosophy, the most influential effort towards political and hence social self-regulation was probably Montesqieu's idea of the division of powers in government. But we have to be careful: not every instance of theorizing about how to govern societies or about what a desirable institutional set-up would be for societies or for social groups aims at self-regulation. To avoid confusion we might, as a starting point, define as "self-regulating" in a broad sense only those systems which determine their behavior from within.

Due to the long historical concern, it is not surprising to find striking parallels to modern social scientific work on the topic of self-regulation if we look back into the history of political philosophy. Interestingly enough, the main similarity seems to be an interest in two groups of questions:

1. How is it possible to *influence purposefully* the behavior of social systems?
2. What are the *characteristic features* of the dynamics of a given social system or of social systems in general?

Models of processes are normally constructed to explain those processes. But besides curiosity (scientific or not), explanation is linked either to interest or to

[6]In fact, it seems as if political thinking about democracy was the forerunner of any interest in self-regulation. This is backed by the fact that early attempts to explain the becoming of what we take as "nature" are more based on the idea of some mythological being who created our world than on the secular idea of interacting processes which finally led to life and hence to every being acting as a creator. Cf. on early natural philosophy as a forerunner of science J. Ben-David, 1971: 33ff.

available knowledge. Both seem to lead, moreover, to an adoption and hence continuation of historically produced convictions and philosophical traditions. Consequently, both types or groups of questions can be thought to represent two different kinds of interests and traditions of thought. If we ask how systems might be influenced, we inquire of course into possible actions which might enable us to impose a will, be it our own or that of a third actor, on the dynamics of the system. The corresponding tradition is that of atomism and rationalism. If, on the contrary, we are more occupied with overall dynamics, our interest is focused on predicting and reflecting long-term changes in the system's behavior. Here the corresponding tradition is more that of looking at broader contexts together with a certain skepticism towards the possibility of influencing the course of events purposefully.

Both interests are of course legitimate and both correspond with well established beliefs or basic convictions in the social sciences. The interest in "What can be done?" is as an interest situated at the level of political actors. As a stimulant to scientific inquiry it aims at explaining the contribution of the system's components to the behavior of the system. This type of interest is a microscopic one, an orientation which has often been linked to reductionism because its protagonists frequently denied the emergence of specific properties at the level of the system.[7]

The opposite, "holistic," tradition has several origins, both philosophical and political. Without going into details we can say, that in a philosophical context, the interest in the dynamics of a system, e.g. that of a society, results from considering social phenomena as "natural," in exactly the sense in which natural sciences speak of "spontaneous" or "natural" processes.[8] More for contingent historical than for systematic reasons, the concept of society as a self-

[7]The reductionist tradition can be traced back in sociology to E. Durkheim's adversary G. Tarde. It is particularly true of empirical studies in most of the social and economic sciences, that they are largely dominated by the individualistic-reductionist approach. Although often read as an unremitting fighter for an early version of holism, E. Durkheim, who of course never accepted reductionism, thought it evident, that members of social systems had to be taken into account if one were to explain social phenomena, cf. E. Durkheim, 1973 (1893): 68f, 74, 146, 262ff, 267ff, 284ff; 1987 (1888): 86; 1983 (1894): XVIf as well as A. Giddens, 1971b.

[8]Seen from a logical point of view, any idea not only of a social science but of a scientific treatment of social or cognitive phenomena in general, presupposes basic processes which follow some unattainable regularities. The reason is simple, but apparently not evident. Once the investigation which follows the phenomenon back into its origins is pushed to the point where further analysis seems impossible or useless, it turns out that the remaining activities have to be taken as "spontaneous," hence "natural." Cf. I. Kant, 1983 (1790): 483ff who defines: "products of Nature" (Naturprodukte) through their capacity to be their own cause and effect.

regulating or at least self-equilibrating process became associated with ideas of political and economic liberalism.[9]

From either background it is equally obvious that intervention in "natural processes" will only disturb them. "Nature" and "the invisible hand" of the early liberal economists are closely related concepts in that respect. Non-intervention becomes a rational behavior, even when the "natural course" of events leads to all kinds of undesired consequences (which might be "explained" or justified as only "temporary"). From such a point, it is of course not far to a position where philosophical and theoretical considerations are no more than expressions or justifications of political and social attitudes which stem from quite other sources.[10]

If we look at the positions just outlined, it becomes obvious that neither is very much attracted by the topic of self-regulation:

- The reductionists are uninterested because from their perspective, there are no macro-phenomena endowed with specific (or sui generis, as Durkheim would say) properties. Accordingly, nothing has to be considered except individuals, who can be isolated in examining their knowledge, beliefs and action potentials. From this perspective, there is no problem of self-regulation at the level of social systems. Any regulation results from the "autonomous" decisions taken by the members of a social group or society. The corresponding paradigm is the *homo oeconomicus*, or its theoretical counterpart, the rational decision maker of game theory. The interest here is not an interest in social self-regulation but an interest reduced to the knowledge and the techniques needed to allow individuals to attain "their" (meaning: "not socially influenced") goals.
- Holists (taken here primarily as those amateurs of the second approach who define their convictions in opposition to atomism/reductionism, see below) are equally indifferent to social self-regulation, but for the opposite reasons. If one starts, coming from a mere counterposition to atomism and reductionism, with the

[9]One might of course argue that there is a systematic connection between the growth of science and (relative) political and economic liberalism. Cf. as a recent example G. Steinmann, 1988. Factually, although there where important concomitant factors, scientific thinking developed best in countries where this liberalism, together with the necessary internal differentiation and resulting individualization, was developed up to a certain point. Cf. P. P. Wiener / A. Noland (Eds.) 1957; R. Mandrou, 1978; J. Ben-David, 1971; E. Zilsel, 1976.

[10]I am of course to some extent oversimplifying these positions. Politically they have been amalgamated with rather different political and other interests. Marxism, to take this example, considers itself the theoretical explanation of social processes which follow a path prescribed by some natural-law-like regularities. As has often been noticed, Marxists did not conclude from this that their actions were irrelevant with respect to the course history would follow.

assumption that the components of a system are of mere technical interest,[11] there is no reason to be interested in the "mechanics" of a process like social self-regulation, seen as one of the defining properties of autonomous systems and hence unproblematic. From a systematic point of view, for the holist, systems are self-regulating anyway. With the work of H. R. Maturana / F. J. Varela (1979), moreover, there is a seemingly satisfactory explanation for self-regulation at hand: the operational closure of systems as the source of their autonomy.[12]

At this point two clarifications are required, one systematic and one historical.

(1) Of course it is not possible here to outline the history of atomism/holism and of the related concepts. Nevertheless, for the sake of clarity it should be mentioned that the pair of terms "atomism/holism" provides the systematic basis for the methodological pair "reductionism/collectivism." Systems theory, and hence the very notion of system, is conceptually an attempt to escape the limitations stemming from the dualism of these concepts. Their conceptual foundation is the Greek distinction between wholes and parts (seen with respect to the conception of a sum and its parts). Systems theory enlarged this much too narrow and untenable position by contributing the modern idea of interactions or relations between the parts, which in this contribution are discussed under the topics of "components" and "organization." Therefore, holism and systems theory can be clearly distinguished. Any approach which uses mainly wholes and parts and which treats their mutual relation as one of its central topics is a holistic approach.[13] In contradistinction, the systems theoretical concept is characterized by its use of components (elements, parts etc) and organization (relation, structure, etc.) as

[11] In the sense that social systems "presuppose" the existence of humans, but without having them as components. Cf., as only one example, N. Luhmann 1984: 245f and 346.

[12] The interest which encountered the theory of autopoiesis in German sociology and the way it was "generalized" and integrated in existing theoretical traditions has, of course, been influenced by these traditions and their development. Part of the context for this is a theoretical change which in fact took place in what is often presented as a certain continuity of ideas. Durkheim started with the conviction that sociology as a science must (besides being empirical) be rationalistic and even mechanistic at the level of explanations – understanding both as the opposite to what he took as the "ideological" approach of the Geisteswissenschaften, (cf. J. Larrain, 1980). With Parsons and Luhmann, however, the pendulum swung factually back to the traditions Durkheim wished to leave. It seems that from Durkheimian beginnings not much more than a merely metaphorical use of terms drawn from "hard sciences" has survived these transformations – at least in the holistic context.

[13] The widespread habit of calling every composite unity a "system" and taking every utterance about composite unities as "systems theory" leads to confusion and discredits "systems theory" used in a more precise sense.

those conceptual elements used to *replace* the notion of system in any endeavor to explain the behavior of the composite unity called "system."[14]

(2) The second comments concern the functionalist basis[15] of the theoretical tradition in sociology whose proponents are attracted by the theory of autopoiesis. First, it should be remembered that Maturana argues convincingly that functionalism was in fact the theoretical position he considered to be so problematic that he developed his theory of autopoietic systems (cf. H. R. Maturana, 1982: 14f). Second, there seems to be an important and mostly over-looked "function of functionalism" which prevents it from being abandoned as a theoretical approach: it helps to stabilize holism! If holists looked closer at the system's mechanics, they would be forced to take the risk of getting more involved with the individuals who constitute the social system under consideration. This could lead them to recognize that rejecting reductionism is not equivalent to the (political) claim that social systems cannot be influenced purposefully.[16]

From these considerations we may conclude that, although their reasons, both scientific and political, are different, neither reductionists nor holists are interested in understanding self-regulation. As can be grasped from this brief exposition of the two historically dominant positions, any attempt to clarify the notion of self-regulation has to cope with the micro- and the macro-level of

---

[14]As N. Luhmann seems to ignore this fundamental difference between holism and systems theory, he proposes to modernize the latter by abandoning the dualism "whole/parts." As a consequence, his proposal to use instead the dualism "system/environment" overlooks the fact that systems theory defines systems not via the difference "whole/parts" but via "components plus organization." As a result, the border of a system is necessarily at the same time a border to the system's organization. This makes it unacceptable to define the differentiation of a system as an internal repetition of the difference between the system and its environment. Cf. N. Luhmann, 1984: 20ff.

[15]Conceptually, functionalism can be traced back to the biological distinction between morphology and physiology – the first leading to an interest in what is called "social structures" and the latter to its (original) dynamic co-concept "social functions." With the declining biological knowledge of social scientists, the two ways to look at organisms were transformed into more or less separate theoretical approaches. They developed rather independently from each other and far from the position of a Durkheim, deciding for pragmatic reasons in favor of the pursuit of a more functionalist line of inquiry. Cf. E. Durkheim 1987 (1888): 103f.

[16]Although ignored by most scientists involved with holistic ideas, there is a historical connection between holism and the romantic critique of science and industry which can be followed back into the last century, cf. R. P. Sieferle, 1984. Nevertheless, there is as well an anti-authoritarian tradition, which is connected with the use of the related metaphor of society as a body or an organism. This metaphor often served to rationalize calls for the submission of the organs (and hence lower parts [citizens, medieval towns, guilds etc.]) to the central subsystem (mostly but not always the head – politically, the king or, more generally, government). But of course, it could just as well be used to claim that the head fulfilled its function only under the condition that it considered the needs and rights of the other parts of the body. Cf. on the general use of these metaphors G. Dohrn-van Rossum, 1978 and E.-W. Böckenförde, 1978. On the use of these metaphors in jurisprudence cf. H. Rottleuthner, 1988.

systems, with components and systems, or with the relation of "individuals and society."

3. Self-regulation of social systems

3.1 Social systems: the conceptual frame

Speaking of social systems presupposes, of course, a clear understanding of which kinds of phenomena may be called "social system" and what is implied by the use of that expression. For our purpose[17] it may suffice to define a social system as a group of individuals who

1. have, through social interactions, generated a common set of reality constructs[18] together with a set of actions and behaviors deemed adequate to handle the so defined realities and who
2. interact with respect to these realities by means of socially defined actions and behaviors.

According to this definition, individuals are members (or *components*) of a given social system only to the extent to which they fulfill both conditions. The advantage of system formation and the reason of their being lies[19] in that they allow for meaningful interaction and communication between the members of the same social system. Due to the shared reality-constructs and action-programs, every utterance or action which belongs to the shared domain triggers socially produced individual experiences of the members which hear or see them; hence they are understandable as part of that socially created reality and the attached actions around which the system is constituted. To highlight the constitutive importance of the shared reality construct, and the corresponding action-programs, as the cognitive and often even bodily domain to which members of a system refer in their interactions, social systems might usefully be called *synreferential*. This designation has the advantage, as well, of allowing for a clear distinction of social systems from any other type of system. Examples of social systems are sportclubs, political parties, and of course research teams.

Following the definition, individuals are normally members of several social

[17]Cf. for more details P. M. Hejl, 1984; 1987a.

[18]Cf. on the used understanding of Constructivism E. v. Glasersfeld, 1977; 1980; 1982.

[19]For the anthropological reasons for system formation, cf. P. M. Hejl, 1987a: 313ff.

systems at the same time (i.e. a research team, a family, a political party, etc.). This allows us to conceive of social systems as being connected via individuals who belong to several systems at the same time, and to state that every system is influenced from other systems as a result of their influence on members who belong to them.

From the definition of members of social systems, another important consequence can be drawn. If we ask "What makes an individual member of a social system?" it is evident from the definition, that it is exclusively the display of those capacities of interaction which define a given individual as member of a particular social system.[20] In generalized form, components are therefore defined exclusively by those interactive capacities (taken as the sum of all observable interactions) they exhibit in the system.

Any treatment of components immediately raises, of course, the question of how their activities are coordinated or regulated in such a way that the composite unity they constitute forms in fact a unity or a whole. This is the question of what *causes* the assumed specificity of the system as something distinguishable and worth to be distinguished from the components. The answer has in fact been given by systems theory: organization.

The use of the term "organization,"[21] however, is not unproblematic:

1. "Organization" is used to designate two different classes of phenomena.
2. The second class, which is the important one for systems theory, is only poorly understood so that we are rather unaware of some of its implications – even though we use it in scientific and everyday discourse.

The problem of the ambivalent use of the term is directly connected with its history. "Organisation" meant, in the famous article of the Abbé de Sieyès "Qu'est-ce que le tiers Etat?," the establishment of specialized parts of the nation within itself, such as legislative (Parliament) and executive (Government) institutions. The activities which lead to the formation of such functionally specialized parts of a whole were called "organizing." This would have been unproblematic, if not any result of an organizing activity had been termed "organization" as well,

---

[20] This definition of the properties of members or components of a system is in no way trivial, as a comparison with the influential definition of A. D. Hall and R. E. FAGEN (1956) demonstrates. They defined components through properties and interactions, establishing a distinction which unavoidably leads to confusion, cf. for more details P. M. Hejl, 1990.

[21] Cf., on the history of the notion, which in its actual form is to an important degree a product of the French Revolution, E.-W. Böckenförde, 1978.

though confusing the difference between the *activities* going on in the "organization" and the "material–biological substratum of these activities." In this sense one can call a firm or a hospital or a public administration an "organization." "Organization" then is a synonym for a particular class of social systems including men, houses, the paper in the offices, the car park, machinery etc. At the same time it is clear that, if speaking of its functional parts and their interactions, one would as readily use the term "organization." This leads to the "organization" of an "organization," a clearly unsatisfactory situation.

Although we may distinguish the two different meanings of "organization," it is still not very clear what we mean when we speak of "organization" with respect to the activities which might be observed within a system. Instead of searching for an essentialist definition it is perhaps more helpful to look at the activities themselves from the perspective of a somewhat distant observer in order to get a clearer understanding of this type of "organization." Our observer should be able to see all the members of a given social system and their interactions, and he should be able as well to distinguish between interactions which contribute to the global activity of the system (that is, those which are to be explained) and those activities which are of lesser importance. Under these conditions he will quickly become aware that not everyone interacts with everyone else and that not all interactions are important for the global or systems activity he is interested in. Looking from his perspective at the system, he might even decide to make a statistical description of his observations with respect both to the frequency and the importance of the interactions he observes. The interactions which are the subject of a description of this type are what I propose to call the "organization" of a social system (becoming aware of this is, of course, not merely a matter of having the appropriate observational standpoint).

But in what sense does the organization have an integrating effect? How is it possible to understand the organization as that (observable) part of the overall activities which exerts those macro–influences on the system's behavior which we have in mind when we speak of "the activity of the system" ("The system remembers, decides, resists, perceives, transforms etc.")? The idea of an influence of "the system" on its behavior or, to put it differently, the idea of a behavior which is not amenable to an explanation through its decomposition into the behavior of its components seems all the more bizarre if we remember that the system has been defined by the interactions of its components, which have, in their turn, been defined through their interactive capacities. Where could there be something "more" in a system than its interacting components? The answer lies in the characteristics of components, and organizations, and their interplay.

Trivially enough, our behavior in a specific social system might be influenced from three sources, which can be distinguished analytically. First, there is of course *the system itself*: Due to frequent discussions during meetings, common work on research problems, etc. members of a research group might modify their view of the problem and how to solve it. If such processes take place, the behavior of the members will change accordingly, even if they are not aware of the resulting shift. The second source is provided by interactions with members of *other social systems which are part of the system's construct of its environment*: Members of research groups interact with members of neighbor institution, of agencies and institutions which serve as links to politics or industrial interests etc., and of course with members of funding bureaucracies or private sponsors. There exists normally a system-specific way to "see" these interactions, how they should be handled and how to evaluate them. As a result of these interactions, those members of the research group who are engaged in such contacts on a more or less regular basis will develop a view which differs of that of their colleagues. Putting it in a more theoretical way, we may say that these interactions trigger a sequence of behavioral changes which, although still compatible with the requirements of the original system, select a path of modifications which is different from those of components with other interactions. Finally, there are modifications of the interactive behavior of members of a social system which are due to *influences independent of the system under consideration*. Such influences might include social systems which do not appear in the reality construct of the social system under consideration.[22] Change might also result simply from processes which are almost never taken into account in scientific explanations: processes of autonomous thinking[23] such as reflections on one's involvement in different social contexts, on mutual exclusive consequences of the resulting engagements, and whether there should be some change.

---

[22]Examples of the growing importance .of reality constructs which are normally not taken into account by employers include such issues as "quality of life" or the possibility for the partner in private life to get an acceptable position. The growing aspirations of more and more women to equal career opportunities, and a nearly unchanged career pattern of men, quite often makes geographical mobility possible only at the price of family disruption. One can ask whether, in a not too far distant future, mobility will depend on employers able to tackle the resulting problems. This entails immediately, of course, an enlarged view of the relevant social environment of the system.

[23]For an explanation of the concept of cognition to which the notion of "autonomous thinking" refers, cf. P. M. Hejl, 1987b.

As should be clear from this brief discussion and from its definition, "components" are taken (in the Parsonian tradition) as analytical but observable entities. They consist of a specific subset (cf. the definition) of all the interactive capacities of an entity (in the case of the social sciences, an individual or other social system) which might be observed. As indicated by the third source of modifications of behavior listed above, individuals are understood as systems in their own right. They display actions and behaviors which can be analytically linked together as expressions of socially generated, and hence shared, reality constructs. Nevertheless, the fact that a particular reality construct and the corresponding actions and interactions are used in a specific social system does not mean that they are influenced only by the interactions which take place in the context of that system. Individuals must be understood as systems in their own right, who act in part as components in a varying number of social systems. Thus it is clear that the cognitive processes (and their behavioral correlates) which allow them to be described partially as components of social systems are always influenced by the overall dynamics of the individuals. There is an important consequence to be drawn: If we accept this conceptualization of the relation between "individuals as systems" and "components of social systems," it follows that the individual and all its actions and behaviors have to be understood as the integrated result of a) the proper dynamics of the individual-system and b) the multiple triggering effects of past interactions. Both are combined or amalgamated in the actual (historically brought about) state of an individual taken as a system, and the cognitive and behavioral possibilities available to the system at that point in time. This allows us to assume that any interaction of a component triggers the cognitive processes and the behavior which are "allowed" by the actual state of the component as such, and as part of an individual understood as a system in its own right. As such it must be granted spontaneity[24] and be understood as "autonomized"[25]: it has an eigenbehavior.[26] This clarifications allows us to return to the organization of a system.

---

[24]Which is the basis of any self-maintenance, cf. U. an der Heiden / G. Roth / H. Schwegler, 1985.

[25]In contradistinction to F. J. Varela's (1979) notion of autonomy, it follows from the concept of components and hence of the system, that both are to be understood as having only a "relative autonomy." This holds in different respects. This "relative autonomy" or "autonomization" characterizes not only the relation between system and components but also that of the system with respect to its environment.

[26]I use the term "eigenbehavior" - cf. H. von Foerster, 1979 and F. J. Varela, 1979: 170f, - to designate an unexplained, spontaneous, self-determined behavior, the German prefix "eigen" meaning at the same time "proper" and "self." Cf. as well the mathematical terms "eigenvalue" and "eigenvector."

Fundamentally, every organization can be characterized by its selectivity. As has been explained earlier, this means only that not every component interacts with every other (it may be that they do not interact at all, or interact only indirectly [through other components], or that they do not interact at any given time). This selectivity is apparently the necessary condition for a coordination (whether it be the result of purposeful action or the result of spontaneous interactions in the system) of the interactions of the components. If we stipulate some spontaneous activities of the components, it is clear that these activities (defined as interactive) take place between components or members of a system who might have already interacted (thus creating a routine) or who interact because they have to, either because they are told to interact, or because they are interested in what the other might contribute to such a relation. In every social system there exist such patterns of interactions between its members, which are stable for a certain period of time. This allows to define the *organization* of a social system as *the pattern of interaction which is observed in a system during a certain period of time*. This definition is apparently not contrary either to that of social systems nor to that of components.

If we look now at the process by which a system produces its behavior (leaving aside the interactions with other social systems), the specific role of the organization becomes visible. Interactions in social systems depend on the ideas its members hold on behalf of the group: its boundaries (who belongs to the group and who not, and according to what criteria?),[27] its internal differentiation (what are the formal or informal cooperations on a specific research problem and what are the formal or informal controls of resources), the interactive capacities of co-members in a more narrow and personal sense ("difficult character" or "nice person"), "scientific importance" (be it on the level of knowledge or creativity or/and that of "political" importance in academia). All these factors contribute to the generation of an organization as a relatively lasting pattern of interactions in a research group. As N. Luhmann[28] has shown in a series of analysis, such an organization works and gains an importance "of its own" due to the very fact that its existence allows the individual member to act without deciding every minute, from scratch, what to do with whom. At the same time, every individual member

[27] This problem has been discussed as early as 1962 by D. Claessens with respect to the personality structure needed to fit into a research team. With respect to the work of BAVELAS et al Claessens mentions (p. 496) the high performance of "circular-egalitarian structured groups" in contrast to hierarchically organized ones.

[28] Cf. for instance N. Luhmann 1968; 1970; 1972.

relies on the fellow member's knowledge of the organization. This permits him to expect his colleagues to behave in a way which reduces unexpected claims for actions and interactions to a minimum, and gives unexpected claims for help or discussion, etc. the specific importance they need to be successful.

Now, if an individual member or a small number of the participants in the research group modify their ideas and their behavior (e.g., convictions of what constitutes a legitimate research problem and adequate methods for the group) the interactive capacities (with all the concomitant and interrelated reality constructs) of *other* group members will not change both simultaneously *and* in an adjusted manner (such change is brought about as result of a rather long series of interactions). More probably they will go on just as before, perhaps with some more or less clearly felt additional problems in some project: *due to its organization the system is in principle independent of or autonomized with respect to particular actors, although it consists only of individual actors*. As there is in most cases a well established net of interactions, a member which changes its behavior for whatever reason continues to be treated in the "normal way," i.e. the way defined by the reality construct and the action programs of the system. Put in a more formal manner: if a component changes its behavior, it still receives to a large extent the same inputs as before, at least for a certain period of time.[29]

These inputs are defined by the "location" of the individual member in the network of interactions between all the members, – that is, the organization, which constitutes, together with the members, the complete system. Due to the selectivity of the organization, its triggering effects are specific, but, as they depend on a great number of other components, their experiences and their cognitive processes, they are not very sensitive to modifications in the behavior of small numbers of components. From a general point of view, the organization provides inputs to the components. These inputs trigger the spontaneous activities which in turn are determined by the dynamics of the components provided a certain input. Seen from this perspective, it is clear that, although the output produced by a component depends entirely on its eigenbehavior, the organization provides inputs which stimulate the component to produce the output it is able to produce at the given point in time. Before turning to the two types of self-regulation we may conclude therefore that "organization" and "components" are distinguishable

---

[29]There is the possibility that minor causes might produce effects which seem to be out of proportion. Effects of this kind are normally observed when the system reaches, for whatever reason, an unstable state, allowing some modification in the behavior of a member or some unexpected result, etc. to trigger a whole series of modifications.

analytically and empirically – even though the organization consists of nothing else than the interactive pattern which holds between components.

3.2 Self – regulation as organizational change[30]

If we take "regulation of a system" as the process by which its generation of behavior is modified, "self – regulation" than designates that set of regulating influ – ences on a system which is generated by the system itself. What has been said so far about components and organizations allows to look afresh at a process which traditionally is labeled "internal differentiation."[31] The concept uses the biological phenomenon which consists in the observation that at different levels components of biological systems develop in such a way that the effect might be described as a functional specialization. As this differentiation between components does not lead to a disaggregation, it is "internal," in contrast to a "segregational" one. Looking at this concept, we may realize that internal differentiation has an effect on the regulation of the behavior of a system. Any change – and this holds of course for specializations as well – leads necessarily to changes in the interactive capacities of the components, since they are exclusively characterized by a specific set of interactive capacities. Now, if this holds for components, it follows from the definition of the organization of a system, that, from a certain level on, the modifications of the components must result in a modification of the organization. For example, if a not too small number of the members of a research group or of an invisible college[32] modify the definition of what constitutes their subject matter and how to investigate it, the general pattern of their interactions will

---

[30]Cf. for a more detailed explanation of the concept of self – organization to be developed in this part P. M. Hejl, 1988.

[31]The concepts goes back at least to 19th century biologistic thinking in the social sciences, which was deeply influenced by Darwin. This influence can be easily seen e.g. in Durkheim, Spencer and other authors. Interestingly enough, the sociological concept of "internal differentiation" covers in fact only a specific part of the biological phenomena which served as model. The sociological concept stands for the idea of a process of differentiation and functional specialization which is thought to go on more or less forever. This concept is understood either as positive, because it is thought to lead to an increased adaptation (without being very specific about *to what* societies should adapt), or negative, because the process is under suspicion of bringing about atomization of societies, and hence isolation of its members – with all the imaginable outcomes. Now, the core of this model is not evolution as such but what is called "anagenesis," i.e. a natural process of evolution towards "higher" developmental levels. The idea seems to be connected with anthro – pocentric Judaic – Christian notions of the special role of mankind in nature, and hence in evolu – tion. As a recent example of the persistence of this understanding of evolution cf. R. Mayntz / B. Nedelmann, 1987: 650.

[32]Cf. D. Crane, 1972.

change as well.[33] These changes might concern the relations with the remaining members and/or the interactions of those who came to see their field from a new perspective.

Granting the proposed analysis of the traditional concept of internal differentiation and functional specialization, the analysis can be pushed a step further. Cognitive – and hence interactive – developments of the members of a social system do not engender only organizational alterations. Due to the selective triggering of component behavior through the organization, organizational variations in turn precede modifications of components. As specialization is the basic result of organ-formation and as from the very creation of the notion on, "organization" meant the coordination of different active parts or components of a whole, I propose to call the complete cycle "self-organizing." "Self-organization" then means an interaction between the components of a system and its organization that leads to modifications on both sides. Consequently, a system is self-organized to the extent that its behavior results from these interactions.[34]

If we look at self-organization from the point of view of regulation, it is evident that every variation of behavior which springs from self-organization is at the same time a self-regulation. The path of self-organizational changes of a system can be seen from this perspective as a series of self-regulations. But these self-regulations have an important trait: they are linked to organizational evolution. This makes them rather stable, but slow to bring about and slow to alter. The situation is different with the second type of self-regulation. It is not linked to organizational change but to a certain type of organization.

3.3 Flexible self-regulation

Whereas in the case of self-organization the regulation occurring is merely a necessary consequence of the self-organizing processes (which themselves might

[33] In fact we must distinguish two extreme cases. If there are only very few members who change their relevant cognitive constructs, the system will be affected only in a negligible way. If, on the contrary, an overwhelming majority undergoes changes, there might be cases where the existing organization remains invariant even though the defining reality constructs and action programs have evolved.

[34] This definition takes into account, the fact that no explanation can avoid the use of unexplained assumptions. For this reason and because the explanation would go beyond the aim of this contribution, the question of the source of events which lead to self-organizing processes is left open. For the present purpose it may suffice to point at the implication, that the definition does not exclude successful external influences on the system, even if it must be thought as operationally closed to the extent that it is self-organizing and self-regulating.

have been triggered by a great variety of possible events which do not need to be regulatory problems properly speaking) the same does not hold for the second type of self-regulation. We must therefore look briefly at the regulation problem itself, rather than to examine the traditional way to regulate systems. This enables us to underline exactly what the problem of regulation is and why the traditional hierarchical way to solve it is not compatible with the requirements of self-regulation.

3.3.1 The regulatory problem

One of the factors which distinguishes social systems from other types of systems is the fact that in social systems nothing resembles the situation of those components of, e.g., biological or technical systems, which do not belong to the boundary of the system: In social systems *every* component is part of the boundary (notwithstanding the fact that there might be specific components which fulfill specific functions – for example, in the interactions with other social systems). Moreover – and this is another important particularity of social systems – the components belong (as cognitive processes and the corresponding behavior) to individuals who participate at the same time in other social systems. Both aspects influence of course the dynamics of the components and have to be taken into account. They contribute, together with the proper dynamics of the components, to the problem of regulation in social systems.

According to the definition of social systems, the behavior of the system is the behavior of its components as it is determined by the proper dynamics of the components at any given point in time and triggered by the inputs they receive due to the pattern of selective connections which constitute the system's organization. If all or most input events are responded to by a behavior which is seen as "normal" in the context of the system, and hence accepted as "right" or "adequate" or "well understood," there is of course no need for regulation, simply because there are no conflicts which have to be solved and no decisions which have to be either agreed upon or imposed. In this case all members of the system will "spontaneously select" the same behavior, so there is no need to take special actions.[35]

[35] This situation corresponds to Durkheim's conception of "mechanical solidarity," which he thought typical for primitive (i.e. internally undifferentiated) societies. "Mechanical solidarity" is defined as a behavior whose uniformity and congruence stems from the socially produced cognitive uniformity of the actors. As this requires, of course, very specific social conditions, the resulting spontaneity is by no means "spontaneous" in the naive sense of "just occurring." Cf. E. Durkheim, 1973: 73f.

Now, if the dynamics of components differ – due, for example, to differential experiences of the members of a social system – the same event might constitute different inputs. It is, as well, possible that different events, seen from an external observer, are taken as identical by component individuals. Even more, the same might happen at the output side. With respect to an observer, the same inputs can therefore lead to different outputs or different inputs to the same outputs. If such divergences between components happen in a more or less regular way, they probably stimulate self-organizing processes and lead to internal differentiations which can be qualified as "functional."[36]

The situation is different, however, if divergences between components are produced in an unsteady or unpatterned way, so that the possibilities of self-regulation via self-organization do not suffice any longer or are inadequate, because too slow in occurring, or too coercive to be accepted by the members of the system[37] (although self-organization may take place as well). In fact, it can be argued (P. M. Hejl, 1988) from the proposed model of self-organization and its use to reconstruct Durkheim's theory of the division of social labor, that socially produced individualization plays a major part in the processes we are looking at. If individualization increases above a certain level, or, equally, if for reasons of internal differentiation, the system constructs an environment so complex[38] that there are events to cope with, which demand more flexibility than the functional differentiation from self-organization allows for, self-regulation through self-organization becomes insufficient. To put the problem in a more general form: a system confronted with a need to decide continuously between different and changing possibilities of action generated as a result of the dynamics of its components, is confronted with a regulation problem that cannot be solved through self-organization. Such a system must develop possibilities to cope with

[36]If, to give an example, the use of the word "information" in C. E. Shannon and W. Weaver's Mathematical Theory of Communication (1949) is not understood in the specific sense it has in this theory, but as corresponding to the normal use of the word, then this might lead to different questions and research strategies and finally contribute to the differentiation of a group or whole field. This is what apparently happened in the formation of the psychology of information treatment and cognitive psychology.

[37]In systems theoretical terms, "coercion" might be understood here as an unacceptable gap between the dynamics of components and the inputs they continue to receive from the social system to which they belong.

[38]This refers to the unavoidable "internalist" conclusion (typical of brain and cognitive sciences), that any perception depends crucially on the perceiving system and hence on its possibilities of perception. But to "be aware" of problems does not imply automatically the potential to solve them. Especially in functionally differentiated systems, perception production might be better developed than the possibility of generating what might be perceived to be a solution.

its regulation problem or it will disintegrate. Stated still differently, one can say: every system which does not completely control the behavior of its components must have regulating devices to cope with the resulting decision problems. The traditional answer was hierarchy formation in various forms. But hierarchies have specific problems which ensure that they are never realized completely in social systems. At this stage and as individualization grows, self-regulation becomes more important. To gain a clearer understanding of what it might mean, we have to understand hierarchies.

3.3.2 Hierarchical regulation

As I have noted, one of the most common (or shall we say, most visible?) ways to solve decision problems is the formation of hierarchies, both cognitive[39] and organizational. The structure of all hierarchies is fundamentally linear. The classical examples are most norm systems, military command chains or traditional bureaucracies. This linearity is by no way contradicted by the frequent existence of tree-like structures (e.g. several subordinates per superior) or of feedback loops (decisions are taken on top but on the basis of reports from the bottom of the organization). The core idea of hierarchy is that of the existence of a decision center endowed with ultimate power and knowledge. Components which are "higher," or which come "earlier" in the hierarchy, are thought to be nearer that decision center. Seen from a structural point of view, the idea of hierarchy is linked to that of a linear concatenation of processes. But it is not just ordinary linearity, because it is thought to have its origin in a fixed point or center of knowledge and power. Ultimately, this center is of course derived from the idea of an almighty god or, in its secularized version, an absolute monarch, or complete knowledge.

Of course we know that even in strongly hierarchical social systems there is never a completely hierarchical organization: nobody is endowed with absolute knowledge and information is chosen on lower levels to trigger decisions on top of the hierarchy that subordinates desire. This being widely accepted as the fundamental problem of hierarchical organizations in the social domain, we might think the problem of hierarchy to be less important. But seen from a logical (and hence theoretical) point of view, there is a general incompatibility between hier-

[39]The formation of hierarchical static systems such as classificatory or norm systems are good examples. From the point of view of systems theory, cognitive hierarchies are situated at the level of components.

archical organization and self-regulation. It stems from the fact that a hierarchical regulator is defined as the component of the system which regulates the behavior of other components without being itself regulated by other components of the same system. Everyone only superficially acquainted with the history of logic knows of course that this is the paradox of the barber who is defined as the one who shaves everyone who does not shave himself. The question is, of course, who shaves the barber? In the case of regulation, then, the question is "Who regulates the regulator?".

Although these logical and of course practical problems exist, hierarchies are important and their potential should not be dismissed too hastily. It seems to me that there are at least two strong pro-hierarchyarguments:

1. Hierarchies are needed for decision making. As N. Luhmann (1971: 69) has demonstrated so beautifully, hierarchies can be seen as a priori decisions on how decisions shall be taken. In this sense, they in fact reduce divergences and allow quicker decision making.
2. If all the factually existing priorities (i.e. the states of the components of a system and hence the behavior it would choose) are considered (what does not mean, that they are to be taken up) democratic requirements of participation are fulfilled and there is nothing problematic about hierarchical regulation.

As we can encounter these arguments in many forms, it is clear that hierarchies have to be analyzed more carefully. Interestingly enough, when analyzing the hierarchy problem, we encounter once more the system-theoretical pair component/organization.

3.3.2.1 Hierarchical behavior of components: requisite variety

From the early seventies on, many researchers engaged in the then-active debate on political planning and concerned about a reform of public services in Germany were interested in W.R. Ashby's "law of requisite variety." Although frequently not understood in this sense, the idea of requisite variety can be seen as an example of hierarchical regulation at the level of the behavior of components. Interest in Ashby's "law" could be justified, and was in fact nourished, by its specific combination of advances towards more democratic participation and increased political and administrative effectiveness. It thus fitted particularly well into the political setup of that time, at least in liberal academic circles in the

U.S.A. and in the then-dominating coalition of social democrats and liberals in the Federal Republic of Germany. As "requisite variety" appeared to offer a fulfillment of normative aspirations through the use of "modern" and "scientific" concepts, it appeared to be a "responsible" approach and also an alternative to the conservatism typical of the years before the students' movement. This explains why the concept was particularly attractive in a wide variety of disciplines, often without being overtly mentioned.[40]

Ashby's basic idea was derived from game theoretical considerations, namely from the fact that a player can only win, if he can counter any possible move of his adversary. This implies that he has to have at least as many different moves (or as many degrees of freedom, or the same complexity of thinking and behavior) as his adversary (plus the advantage - normally not mentioned - of the last move). In its popular version, the "law of requisite variety" states therefore: "only variety can destroy variety" (W. R. Ashby, 1965: 207). The idea of requisite variety then describes a relation between a system and its environment (or parts of it). It stipulates that the system's success in manipulating or controlling this environment depends on the degree to which the required correspondence is achieved. Consequently, the concept was used to advocate planning and advisory institutions which were, to a certain extent, to model the domain for which they were planning or advising. Although Ashby's law holds for the situation in games and game-like situations,[41] it is, to say the least, not applicable to the problem of self-regulation which is fundamentally different from the competitive situation in games. This demonstrates a logical analysis of one of its implications, the need

---

[40] Indirectly or directly the concept was present in numerous works when the authors were forced to deal with differences of what, not by mere accident, was and still is called "complexity." The German discussion was enormously influenced by the American debate, which was at that time stimulated by the ideas of cybernetics (which were not yet absorbed by disciplines in need of a theory of regulation) as is shown by citations in publications on planning and administrating. Cf., as a work of great interest for political as well as theoretical and historical reasons, 'Perspectives of Planning' (edited 1969 by E. Jantsch) with contributions by Madariga, Ozbekhan, Dubos, Jantsch, Rea, Forrester, Novick, Rubin, de Sola Pool, Gabor, Ansoff/Brandenburg, Beer, Levine, Peccei, and Ackoff. As examples of the discussion on political planning in Germany cf. G. Schmid / H. Treiber, 1975; Ch. Lau, 1975; F. W. Scharpf, 1973 and as a work which in its functionalism is not only deeply influenced by the idea of requisite variety, but which tries to understand what "requisite" might mean with respect to a system and its environment, N. Luhmann, 1984.

[41] In fact it is important to underline that it holds exclusively for games and game-like problems which are necessarily defined by an built in egalitarianism which is accepted together with the acceptance of the rules. Without this egalitarianism no game would be possible, the disadvantaged player being condemned to lose from the very beginning. As every producer of western films knows, this situation is completely changed if one of the, let's say card players, can use a weapon as a final trump card.

for complete (self)knowledge. Exploring it leads directly to one of the two core problems of self-regulation we are interested in here.

The idea of requisite variety leads logically to the requirement of modelling the whole system in itself. To be precise, it has to be modeled as properties of the regulating component[42] which is of course part of the system. This consequence was clearly seen by Ashby himself, as one of the last papers he published demonstrates. Coauthored by R. C. Conant and published in 1970 its title asserts: "Every good regulator of a system must be a model of that system" (R. C. Conant / W. R. Ashby, 1970). Now, this requirement leads in fact to an infinite regress of models in models in models etc. The interesting point, however is that this demand is tantamount to the claim that any self-regulation which uses the idea of requisite variety poses as its condition of success ("Every good regulator ...") that the regulating component should possess a complete knowledge of the system to which it belongs. This necessarily includes knowledge about itself and its role in the system as well as knowledge about the dynamics of the behavior of the other components and hence about the surrounding world. We encounter, then, disguised in the technical claim of requisite variety, the fundamental idea of hierarchy, which is the idea of a center of absolute knowledge (including absolute self-consciousness) and power as the superior regulator. As this claim cannot be satisfied,[43] it follows that the requirements of requisite variety - and hence of hierarchical concepts of regulation - are incompatible with systems characterized by operational closure of their internal interactions.

(Although the concept of requisite variety turns out to imply a knowledge as well as a behavioral hierarchy, it has to be underlined that authors who felt attracted to it for political reasons were not mistaken altogether. On a general level, the concept stresses the importance of a differentiated view of the surrounding world and of internal differentiation as a condition of differentiated action. In this it was and is right, and certainly served as an important stimulus in

[42]To do this, the component has to be seen as a system which produces (due to the interactive properties of its components and the. organization which holds between them) a specific behavior. If we than disregard how this behavior is produced, we see the system as a component whose specificity of behavior is that it regulates the other components. The required knowledge and the required interactive capacities have to be modelled in the mechanism which generates the regulating behavior.

[43]In technical contexts it is less problematic because regulators are constructed to meet the requirements of predefined events. If the engineer speaks of "self-regulation," using the term not merely as a "façon de parler," he refers to environments and hence possible events of either limited variety or it is understood that there are limits to regulation beyond which breakdowns might happen.

the political and scientific debates in which it was used. Moreover – and despite its technocratic aspects – its use certainly demonstrates a high cultural level of social legitimization which many think a necessary condition for socio-political action. This becomes obvious if we ask about the consequence of maintaining hierarchical structures without claiming that decisions should be taken in the light of nearly complete (or at least, compared to the common mortal, "better" – but of course still problematic –) knowledge. The result would be simple and undisguised dictatorship, defined as the power conferred on a component to decide, on the basis of the knowledge it has "at hand," and without any obligation to integrate the knowledge present in the system.)

If we take requisite variety at the more modest level of theory construction as the claim that good regulation requires the more complex to regulate the less complex, there is an important conclusion to be drawn from the argument I have presented: *Self-regulation must be characterized in contradistinction to the law of requisite variety by processes through which less complex components or subsystems can regulate more complex components or subsystems.*

For the technically interested, this claim seems to be by no means revolutionary, because it is the way most technical regulation is apparently organized. But – and I think this constitutes the major difference in this respect – in technical systems the regulation of complex components of a system through less complex ones relies on human intervention, which is external with respect to the system considered. If, to take a simple and time-honored example of a regulator, we look at the old thermostat which regulates a central heating system, it is obvious that the thermostat is far less complex than the system it successfully regulates, however we define complexity. The reason is equally obvious but is usually not taken into account. Because of the work of the engineers who designed the whole system and the supervision by the user and the mechanic who maintains it, the thermostat functions as it does because all it has to do is to switch electricity off when it is modified through the temperature of its environment, and to switch it on again if it is modified in the opposite direction. The more complex tasks are therefore fulfilled by those who construct and use the technical equipment. This is underlined by the fact that in every case in which we try to push back the "human factor" in controlling a technical system, regulators become extremely complicated – and of course expensive – without becoming independent of the users. They still belong to hetero-regulated systems in which the more complex regulates the less complex.

3.3.2.2 Organizational hierarchy

Requisite variety is located merely at the level of the generation of regulating behavior by the component which serves as regulator and which acts as a hierarchical superior due to its *behavioral* variety. But what about *hierarchical organization* as a type of hierarchy which *does not necessarily imply the behavioral variety requested by Ashby's law?* In everyday experience the organizational variant of hierarchy appears at least to be the most visible type.

Like any organization, a hierarchical organization is characterized by a pattern of selective interactions between the components of the system. In the case of organizational hierarchy, this pattern of interactions is such that some component-specific behaviors or preferences dominate the behavior of the system in a *permanent* and *transitive*[44] manner.[45] In this sense, hierarchical organization can be seen as a functional equivalent to an hierarchical regulator. By its selectivity it establishes the transitivity of the order in which the components join in the decision making process resulting in the overall behavior of the system. This participation is such that those taking part earlier define the remaining range of possibilities for those which enter at a later point in time. If we disregard what has been said so far about regulation resulting from behavioral differences of components, it is clear that in this case it is the selectivity of hierarchical organization as such that makes components regulators. If regulators defined in such an organizational way are themselves connected hierarchically, they form an hierarchical system.[46]

This ordering or ranking is in principle independent of any considerations as to the content of the decisions it might produce.[47] However, also hierarchical organization, like any organization, is also nothing but a pattern of interactions of

[44]The logical theorem of transitivity establishes a linear order of preferences. Applied to a set of e.g. three choices (A, B, and C) it stipulates that if A is preferred to B and B to C, A is as well preferred to C.

[45]Of course one might think of hierarchically organized social systems in which modifications of the system's behavior are brought about through decisions from top of the hierarchy, which allow intransitivity as well. This case, which is not taken into account at the level of the general discussion of this contribution, can be understood as a historically produced combination of both types of hierarchical regulation discussed here.

[46]Cf. the discussion of the relation of hierarchical and heterarchical subsystems.

[47]Of course social hierarchical organizations are often, if not mostly, designed to assure a specific output as result of a preselected sequence of activities of the components of the particular system. Nevertheless, as a type of organization, hierarchies and their functioning are independent of the activities they structure as well as of considerations of which particular component should participate in which way.

components,[48] this pattern of interactions connects components through their outputs and inputs. As follows from the discussion of the different sources of modification of the behavior of components, *inputs do not produce but trigger* (and in this sense of course "select") *outputs*. As the dynamics of the components keep them mostly within a certain known and expected range of behavior, the result of the selectivity of the organization is *in actual effect*[49] a selection of outputs. This is of course well known – and one reason why it is possible, at least to a certain extent, to influence the course of action of hierarchically organized systems, as for example public administrations, by changing the personnel occupying its top positions.

In his famous and widely influential "Social Choice and Individual Values," Kenneth J. Arrow (1976), implicitly introduces at what he takes as the social level, an hierarchical structure by using transitivity as the criterion for rationality, to which individual as well as social preferences have to conform. Arrow's misapprehension of transitivity springs from a reductionism[50] which does not allow him to ask whether the rationality principle has to be a different one at the social and at the individual level. To reformulate the same criticism, one may say that Arrow ignores the specific conditions of decision making in operationally closed systems in which there is no possibility of reaching the knowledge required by hierarchical regulation. As far as transitivity, and hence hierarchical organization, is concerned, Arrow's work might be seen as the last word in traditional thinking on self-regulation. However, when he republished it in the midsixties, the concept of heterarchy was already available.

3.3.3 Heterarchical regulation

Whereas an hierarchical organization is rather well defined, the same seems not to be the case for its opposite, the "heterarchical" organization, to use the expression and the model W. S. McCulloch proposed in his 1965 paper "A

---

[48] And to avoid any mystification, it should be underlined that the organization "does nothing." The only active agents in a system are in fact the components, the role of the organization being precisely that of a social pattern of interactions which for this very reason is not at the disposal of singular individuals who participate as components in the system's activities.

[49] I.e. as a result of the interplay between the components and their input/output linkages, the organization of the system, and not as the result of some "purpose of the system," seen as some superindividual actor.

[50] Predictably enough he sees the social level as an "aggregate," a position which is typical of a reductionist position.

Heterarchy of Values Determined by the Topology of Nervous Nets." Of course, that paper does not treat heterarchical systems as such. Rather it discusses the minimal organizational requirements a net of idealized formal neurons would have to meet in order to generate heterarchical i.e. intransitive, choices between different values. But the ideas McCulloch advances in this discussion might serve as a starting point for further developments.

The important contribution McCulloch makes in that paper consists of a demonstration that two different value systems (hierarchical and heterarchical), understood as leading to observable choices between alternative inputs coming from other components of the same system, could be produced, as a result of modifications to the organization of the system. In doing this, McCulloch in fact gives a beautiful example of the (neo)mechanistic understanding of science which lies at the bottom of cybernetics and systems theory, and which consists in designing a mechanism to generate the phenomenon one wishes to explain. Although this was not his main interest, he showed that phenomena like transitivity and intransitivity were not restricted to logical analysis, and that the idea of values and value systems did not lend itself only to a verbal type of explanation. Instead he demonstrated that a transitive value system may result exclusively from a hierarchical organization of the system and hence be completely independent of any evaluation of the outcomes.[51]

This allows us to define *heterarchical systems* as *systems whose components interact in such a way, and hence give rise to such an organization, that no component is excluded from the decision process on an organizational basis*. This means that in heterarchical systems every component has organizationally the same opportunity to participate in the interactions of the system, and hence in the shaping of its actions. Examples can be seen in all kinds of egalitarian groups or communities. The more or less heterarchical character of their organization[52] might be factually or formally established, the main examples being declarations (like the UN declaration of Human Rights) or constitutions which at least stipulate that all citizens should have equal opportunities to participate – via elections, etc. – in the decision processes of their countries.

---

[51] Cf. the analysis of the characteristics of hierarchical organizations in the preceding part.

[52] It has to be stressed that we are concerned with ideal types. Clearly enough, observable systems normally present characters which make them for good reasons partly hierarchical and partly heterarchical. Cf. below. Part 3.4.

At a first glance it might seem that the organization of a heterarchical system comes close to the case in which all components are connected, thus emptying the concept of organization of its central aspect, its selectivity, which is needed to understand important traits of the behavior of certain systems. Such a position overlooks that the organization is merely one part to be taken into account (the others being the components) if we want to explain the behavior of a system. It is the interaction of both which leads to what we take as the system's activities.

The best way to explore the characteristics of heterarchical systems, may be to compare them with hierarchical systems. In a hierarchically organized system, the impact of components on the system's course of action is limited as a result of the selectivity of the organization. Hierarchically organized systems can produce decisions which are consistent with respect to the principle of transitivity. This can be achieved by a sequential participation of the system's members such that at each step, all alternatives left over from previous choices fulfill this criterion. Therefore the members of the system are factually restrained in their liberty with the effect that although *they* choose (according to their own dynamics at the given point in time), the outcome of their selections might be unsatisfactory to more or less everyone except to those, who, from in- or outside the system, established its specific hierarchical organization to regulate its behavior. In heterarchical systems, this type of sequentiality does not exist. As a consequence, *the organization does not hinder components to contribute to the interactions within the system according to the whole range of possibilities their proper dynamics allow for.* Whereas hierarchical systems depend for creativity and innovations on modifications of their organization or on changes in the regulating components, *heterarchical systems are as systems indifferent to change because they do not prevent it on an organizational level.*

But there is another aspect which differentiates hierarchical from heterarchical systems. Hierarchical organization not only assures a specific way to handle events from inside or outside the system; by establishing a certain sequentiality of participation and by limiting the range of choices offered to particular members, it assures a certain efficiency in reaching decisions (if we take "efficiency" to mean merely "rapidity"). Although this aspect is often overestimated, there can be no doubt that systems sometimes encounter situations, in which quick decisions are needed. Therefore it seems clear that the lack of the organizational support offered by hierarchical organization disadvantages heterarchical systems: they face the problem of being organizationally unable to decide. This situation, which most of us know from experiences in committee work, results at least partly from the organizational opportunity for all components to participate in decision making. The typical manifestations of this problem are never ending debates, even when decisions are urgently needed.

The argument from ineffectiveness is of course well known. Although it is commonly found in defenses of hierarchies, it overlooks the importance of the components of a system and of their interplay with the organization (and hence the possibilities the organization offers to their activities). Hierarchical systems are systems in which the freedom or the (relative) autonomy of the components is rather modest, *heterarchical systems are systems in which complex autonomized components or subsystems interact through an selective utilization of the existing connections between the components.*[53] What does this mean?

Clearly enough, active systems – and this holds especially for heterarchical systems – have to "decide" what the actual situation is and hence what to do. This is the regulation problem. In hierarchical systems the organization functions as a rather stable regulator, with respect to the dynamics of individual components. A deeper analysis therefore reveals that the negative aspects of hierarchical regulation are linked not only to assumptions which cannot be met (absolute knowledge), but, as well, to different time intervals serving as references. In this line of reasoning, problematic effects of hierarchical organization must be derived from the fact that the organization of the system changes much more slowly than individual components. At the same time, and as its raison d'être, the existing organization of a system serves as the precondition for problem solving. This simply means that the organization remains more or less stable, while a possibly great number of different problems is solved according to the sequence of choices the organization "selects." Besides the positive effect of efficiency, the requirement of complete knowledge must produce at some point poor results and discontent. Nevertheless, every decision taken in the presence of competing preferences requires a hierarchical ranking of available possibilities.[54]

[53]"Selective usage" does of course not necessarily refer to "conscious selections," although they are not excluded, neither at the cognitive nor at the social level.

[54]The minimal case being the hierarchical ranking of "decision" and "non – decision"!

The problems, then, are

a) the stability over time of the hierarchical organization on the organizational level and
b) the required absolute knowledge at the level of the components.

Both problems are solved through the already mentioned "selective utilization of the existing connections between the components." The lack of organizational support for decision making in heterarchical systems is compensated for by an increased importance of the components that might lead to the formation of *temporary hierarchies*. This allows me to propose what I think to be the basic theorem of self-regulation. It states: Self-regulation is only possible in systems with an heterarchical organization and which allow the formation of temporary hierarchies.

The theorem sets forth two conditions for self-regulation: a heterarchical organization *and* the formation of temporary hierarchies. Requiring temporary hierarchies for decision making may seem to overstate the case. But it is not only this issue (which is in fact the subject of this contribution), but more systematic reasons which render this requirement necessary.

Of course one could claim that a sharper distinction is needed between temporary hierarchies of members of a system at one hand and temporary hierarchies of choices on the other. This would in fact distinguish between choices and their proponents and allow us to put more stress on consensus formation. In fact, heterarchical systems should allow for consensus formation, but they should not be mistaken for communities in the Durkheimian sense. Communities in this tradition are defined as social systems characterized by the absence of internal differentiation and hence by the presence of a shared construct of reality. It is for this very reason that the more an internally differentiated system approaches the community type, the more problems which need regulation, and hence call for self-regulation, tend to disappear.[55]

If we take the case of community, and hence consensus formation, without temporary hierarchies as one extreme of heterarchical systems, we find at its opposite another group of systems, where the formation of temporary hierarchies does not succeed, although regulation problems exist and although a heterarchical type of organization - or at least relationships between the individuals concerned

[55]Not surprisingly, heterogeneous membership in a research group is associated with its superior performance. Cf. C. G. Smith 1971.

which look like a heterarchical organization – has been brought about. These situations seem typical for social systems on the brink of breaking down as composite unities, or for sets of individuals who mistake being together for being a social system with respect to the problems they have to solve. In this sense, not only members of the same university but as well members of the same faculty might be considered a social system, if the university or the faculty comes under attack from outside. But if one looks at certain aspects of collective decision making which call for self-regulation, one can find that much effort is dedicated to preventing temporary hierarchies from forming. The reason is that the individuals concerned often do not constitute a social system in the sense described in the definition above or that, in the name of abstract egalitarian principles, they oppose the formation of *any* hierarchy.[56]

From these considerations we can conclude:

1. The formation of temporary hierarchies is not only a useful but a necessary requirement for self-regulation.
2. Temporary hierarchies presuppose a heterarchical organization of the interactions of the members of the system concerned.

Finally both propositions can be connected by the (already drawn) conclusion:

3. Self-regulation depends on heterarchical relations between the components of the system.

How are temporary hierarchies produced and what is their significance beyond being a solution to the decision-making problem of heterarchical systems? Not surprisingly, temporary hierarchies result from the processes briefly discussed under the question of the groups or sources of processes which influence the dynamic of the components (cf. Part 3.1). Now we must have a closer look at these processes.

If there are, as it is the case in heterarchical systems, no organizational reasons which constitute an *a priory* hindrance to participation in the group's decision making, the only effective factor of differentiation may be what can be called "attention." Assuming for the sake of convenience that the participation of the members depends only on their level of attention (including cognitive and physical ability and readiness to act), it follows from what has been said about

[56] An attitude which may easily turn out to be in practice one way to establish a hierarchy: cf. below the discussion of factors leading to the formation of temporary hierarchies.

systems, components and entities (or individuals in case of social systems), that this level of attention can be differentiated according to three general groups of causes. They all can trigger changes in those sets of properties through which components of systems are defined. The groups of causes (which sometimes intersect) are:

1. the internal functioning of the system and its dynamics,
2. influences from the environment of the system,
3. individual factors.

Internal functioning of the systems

The internal dynamics of a social system may well contribute to a differentiation of the level of attention of its members, and hence to a difference in their participation in the decision-making process of the system. Here are a few aspects:

– Not everybody is interested in everything: There always exist differentiating effects at the level of attention which stem from an internal differentiation of the system into subsystems, or which result simply from specific variations of interests between members of the system (theoretical or practical, more interested in one kind of subproblem instead of another, etc.).

– Temporarily varying levels of occupation modulate "free attention": Different levels of activities are often of a differentiating effect. As an example, a high level of activity during the work on a specific problem might be so time- and strength-consuming that other processes are neglected.

– Routine and habitude differentiate attention: The formation of routines and habitudes, both theoretical and empirical, focuses attention and contributes at the same time to a differentiated level of participation. In a research group there might exist routines which specify how a given problem has to be analyzed or to which type of problems it belongs.[57]

– Specialization differentiates attention as well: Another example is the case of a research group in which specific methods of gathering data have been mastered, whereas others are less familiar. This might have the consequence that specific experiments or observations cannot be made or that reported results are not received with the same interest as results obtained with techniques whose implications are well known.

[57] Here the use of static systems (= explanatory systems – in contradistinction to active individual or social systems) by active systems becomes important.

Influences from the environment of the system

The cognitive constructs and action-programs which exist at the base of any social system necessarily contain definitions of what constitutes the system's environment as seen from the system. These environments are therefore socially defined.[58]

Hence there exist, as well, evaluation schemes and "action-programs"[59] which allow them to be handled in a way agreed upon by the system (however the process of reaching such an agreement might be explained). Everything which happens in the so defined environment then triggers the corresponding behavior of the system, or, to be more precise, of its members. Although the environment is defined as a class of possible events and actions specified by the system, the system can only partially control the sequence of events which actually occurs. Therefore, and this can be seen as a certain analogy to the influence from the organization of the system, the environment acts upon the system. These actions might accidentally or purposefully lead to differentiations in the system (self-organization) and hence influence its self-regulation.

In contradistinction to biological and many other systems, all components of social systems have access to the system's environment, although they are normally not all in charge of the relations between the system and those other systems which exist in this environment. This is particularly important for systems such as not highly specialized research groups. In this case the members belong to different larger social systems (at minimum, to different disciplines or specialties within them) of recognized importance for the system. As each participant is often, in the context of the particular system, the expert in this particular domain, and as every domain is important for the group, every member is often in practice responsible for an important part of the interactions of the social system with the environment.[60]

---

[58]As a result, events which do not belong to the so defined environment of the system, are normally not taken into account, or, if they are, are considered to be merely "individual problems" of the members of the system.

[59]This term overstates their formal character. The idea is that in parallel to socially defined environments, there exist normally corresponding, equally socially produced and agreed upon sets of ways to handle these environment.

[60]In larger research institutions the same might happen at the level of subgroups or the personnel responsible for them.

It is clear that the integration of these necessarily different knowledges and competences is one of the main problems in every research group. But it plays as well an important part in the self-regulating process of such groups. The reason is that events in the environment which fall under the competence of a particular member normally activate him. Now, every member of the group has to take a somewhat authoritarian position as to his specific competence, but if his position – and hence his specific interests – become permanent (if the temporary hierarchy he can create becomes permanent), the orientation of the whole group is altered to a more hierarchic type of organization, with consequently diminished self-regulatory capacities.

Besides these more diffuse influences from outside the system (cf. below, "Individual reasons") there are of course intentional efforts from other social systems, and even from individuals in the environment, to influence the self-regulatory processes of a social system. To give just a few examples: Levels of attention for specific inputs can be heightened through concomitant inputs or through inputs which announce an event. If a member, or a group of members, knows earlier than others that a particular experiment was successful or failed, that a certain line of research will be strongly funded, or abandoned, his attention, or that of the group, is altered. This might lead to diminishing the apparent importance of events inside the system or reported from other sources, an effect which is sometimes produced unintentionally – and, of course, sometimes on purpose. In any case, it can function as a regulating input by creating a temporary hierarchy through differentiating between events – and hence participation. Finally, there are all those well known influences exerted by other social systems which have the power to control inputs, considered to be vital, or at least important, by the system one is interested in. In the case of research groups, one has to think of course of those institutions which control funding, or which decide on other monetary issues on which not only the expansion but even the existence of the group quite often depend. These demands, requests, or only "suggestions," produce in fact a continuous pressure on the group. As they are seen as "critical" with respect to the future of the system, there is great readiness to respond positively. This leads to a multifaceted process of presenting the group's research work as the logical result of a more or less coherent view of the problem one is working on, a view which is described as a solid basis such that it allows for its continual transformation, with the brio of perfect management, into research activities in a highly goal–oriented (but, of course, time–, manpower–, and hence money–saving) way.[61]

As part of the same process, or connected with it, some tacit theoretical positions and convictions of the group (which, as part of the insider knowledge, remained somewhat informal, unspoken and thus at the same time unclarified – although functioning perfectly well in the frame of reference for the group's internal communication) must be made explicit and consistent. This effect, known since the rediscovery of the work of L. Fleck and ethnomethodological studies of the functioning of laboratories[62] should not be seen solely as a social pressure leading to communicable presentations. What also happens are processes of redefinition of the subject according to the perceived needs and wishes of those seen as the potential "important readers": hierarchies of activities and their distribution among the members of the group are formed.

These redefinitions are not merely verbal, or without practical and cognitive consequences. B. Latour's (1980) example of the conduct of the research on somatostatin in a large, apparently state–owned, French research institution is quite illuminating on this point. Latour reports the development of research on a growth blocking hormone (named, for this very property, "somatostatin"). The research on substances like somatostatin is done via the testing of slightly modified reproductions of the original substance ("analogs") in different biological contexts. Now, the point is that the number of possible analogs is too high,[63] and their production too expensive, to allow the testing of all possibilities, hence there is no "rational strategy" to test them all or to decide which tests are the most promising ones. Moreover, it turned out, that there is nothing like a definite interactive property of the substance called somatostatin. Varying with the biological system or subsystem on which it was tried out, its properties changed, even radically.[64] Consequently, decisions about which analogs to produce and what to test had to be taken on another basis. The result was a process which seems to

---

[61] That the request of funding institutions to present requests for money in the form of research projects might influence the whole process of research, and perhaps inhibit more creative procedures, has recently been suggested by J. Matthes, 1988.

[62] For an overview and numerous examples cf. K. D. Knorr / R. Krohn / R. Whitley (Eds.) 1980.

[63] Because the number of possible combinations of the sequence of aminoacids is, according to Latour (p. 55) 2.6×10^{22}, it is of course not possible to calculate the number of possible utilizations.

[64] If an appropriate notion of "component" is used, such as the one proposed in this contribution, this should not be surprising. Such a finding is amazing only if properties are defined as attributes of an isolated entity.

be merely chaotic, but which Latour convincingly describes as "opportunistic." Here are a few features of that process.

Because the laboratory had a quasi monopoly on the production of the substance and its analogs, and as enormous economic interests were at stake, they had to produce samples of analogs according to the wishes of other institutions. This of course took time, diminished free capacities which otherwise could be used in a more systematic way, and encouraged research on finding production methods and analogs which would be easier to produce in great quantities. But these proliferating research activities, inside and outside the research laboratory which originally "discovered" somatostatin, resulted in a variety of results, many of which were published. Some of these publications proposed specific modifications of the analogs. These propositions (from outside) were often taken up inside the laboratory: "JR [the chief scientist – P.M.H.] immediately manufactures these analogs ... and combines them with his pet analog." (p. 60). He would, of course, be able to justify the use of his "pet analog" – the main reason probably being that it is the one he knows best. This taking up of suggestions being made outside the system is only one example of how external events trigger internal activities and contribute to the creation of a temporary hierarchy (i.e. the decision to follow the external suggestion – and hence to postpone other possible experiments or to combine the externally proposed variant of an analog with a substance especially well known inside the system). Another example results from the economic relevance of the research. Latour reports that "Lawyers are also asking for more specific analogs in order to protect further important analogs through patents." (p. 58) In this case, economic necessities served as triggering inputs for activities which had to conform to these necessities, but it is the members of the system who decided which activities should be actually conducted to meet them.

Other important influences are linked with publications. There is of course within a research group a certain preeminence of those who are in contact with editors, or who edit books or a journal themselves – all the more, of course, if it is a main organ in the field. To have, or claim to have, privileged contact with members of these systems gives one, of course, greater weight within the group. At the same time it assures a greater importance to the inputs from this source. This influence results not only in a gate-keeping effect,[65] but influences the con-

[65] Cf., as the classical text D. Crane, 1967. Since the formation of science as a specialized professional activity, control of, or at least access to, scientific journals has been a major method of

tent of publications as well, through the perpetuation of "styles," for example. Whereas in some sciences the use of central concepts without an effort to define them properly is simply impossible, there are other disciplines where editors are afraid that their readers will be bored by such "unnecessary" definitions. Evidently enough, the results are different levels of precision in the respective disciplinary discourses, which must be respected by submitting authors. Important, too (though not often taken into account), are references to other disciplines and sometimes to different countries. In most disciplines it is regarded as proof of a high standard to refer to disciplines seen as "harder" than the one to which the publication belongs. Similarly, until not too long ago, there were countries who were perceived – and certainly sometimes with good reason – to be ahead of others. Scientists then could play a leading function in their own country, if they had studied some time in the "leading" countries. Up to the second world war, American scientists often came to Europe for this purpose, whereas the direction of such pilgrimage tended to be reversed after the war.[66]

Individual reasons

The last group, individual reasons, is comprised of causes which can be neither attributed to the internal functioning of a social system, nor to its environment in a strict sense. This group includes all those experiences of individuals that participate in the modification of the properties which define them as components of social systems. These causes influence a given system through the ways in which the flesh-and-blood-individuals cope with them, eventually changing in this way those characteristics which make them (partly) components of a specific system. They do not belong to the environment of the system because they are not defined as such within the constructs of reality and the action-programs which are partly constitutive for social systems.

---

scientific self-regulation. Cf. for an example from the last century E. Mendelsohn, 1974. Examples from the history of French sociology are to be found in R. L. Geiger, 1975 and Ph. Besnard, 1983 and for American sociology in P. M. Lengermann, 1979.

[66] The readiness to grant scientists back from abroad special freedom is demonstrated by the case of T. Parsons. The "dreadful style" of his "insufficiently structured, often only half thought out" 'The Structure of Social Action' is in the U.S.A. still (and wrongly) attributed to his studies in Germany, as R. Dahrendorf remarked as early as 1963 (1968: 142). Now, Parsons presented himself as an author who, having studied in Europe, came back to the U.S.A claiming that his own work was a continuation and a completion of the work of Durkheim, Pareto and Weber (the subtitle of 'The Structure of Social Action' is not by accident, 'A Study in Social Theory with Special Reference to a Group of Recent European Writers'). The fact that he studied in Germany suggested that the peculiarities of his style might result from this influence. Unfortunately, and this demonstrates the misunderstanding, his texts do not gain in clarity if they are translated into German. Cf., as another example, on the use E. Durkheim made of the reputation of other disciplines and the importance of his stay in Germany V. Karady, 1979.

There are of course such generally ignored "personal factors" as love, illness, age etc. which play a role in the participation of members in the activities of any social system.[67] K. D. Knorr (1980: 30ff) provides the striking example of a biologist who, during her pregnancy, performed experiments with her urine, which contains steroids. This contributed to the isolation of a hormone in a slime mold, with a sequence of interesting consequences.

Other factors, which might have an effect on the dynamics of the generation of cognitive states, are individual – but in the social sense of the word. If someone is more interested in theoretical or empirical questions, if a displacement of the center of interest of a member occurs, or if the position of a member of the system changes from a more central to a more peripheral position, or if he withdraws completely, etc., all this might result from an interplay between systemic and extrasystemic (but still social) interactions. To give just two further examples: There seems to be a not unimportant interplay between norm-guided or political activities and convictions and scientific and semi-scientific activities of quite a number of scientists, a process or a class of processes which has to be distinguished from the "normal" interactions between the political domain and science. B. Latour reports, in the paper mentioned above, one scientist saying that there was a decision at some stage, to use analogs "most helpful for diabetes – and so justify our one million dollar grant." (Latour, 1980: 61). Finally, of course, there may be increased "personal" needs for money, perhaps because the family has become numerous, or the equally "personal" wish to move from one town to another, etc., which may have important effects on the composition of a research group and hence on its work.

3.4 The relation between hierarchical and heterarchical systems

From this discussion of hierarchical and heterarchical systems it may appear they are mutually exclusive types of systems; that is, that a hierarchical system could include no elements of heterarchical systems and vice versa. Nothing would be more wrong. Constructed as ideal types (see below on idealization), both are in fact found in various combinations in our phenomenal world. Even theoretically, there is no reason to disregard the combinations they form.

[67] Cf. the discussion on the relation between scientific performance and loss of a parent in W. Woodward, 1974.

Since components are defined through the interactive capacities they actually display in a system, the way their behavior is produced is of no importance to the definition. Hence it may as well result from a hierarchical as from a heterarchical type of regulation *in the components* (or subsystems). Here different levels of systems analysis must be distinguished. A system is considered to be heterarchical or hierarchical, depending on whether its organization is seen as such *at the level at which the system is actually defined.* Of course, at the empirical level, there appears a problem – sometimes difficult to solve – of deciding to which level a given phenomenon belongs. As stated above, systems are analytical tools. Therefore, there is no possibility to find something like "natural" systems in the social domain. It is the scientist who decides, and who must then justify, why he draws the border of what he takes as a system in the way he does.[68]

As a result, it may well happen that a system has to be classified at a certain level as heterarchical, although a study of its components, taken themselves as systems, shows that they must be viewed as hierarchical. The contrary can occur as well – e.g., a system might be of a hierarchical type but consist of heterarchically functioning components or subsystems. And there are other compositions which are possible as well. It even seems – at least theoretically – that no combinatory possibility is necessarily to be excluded. Empirically, the most frequent case is probably that of a combination of heterarchical processes with hierarchical ones, such that the system changes from one type to the other, according to the problems it is working on. The typical examples are of course those social systems – and they are not rare, especially in science – in which routine work is done in a more or less hierarchically organized way, but where the system changes to a heterarchical type of functioning if problems of innovative research or with relevance to the overall politics of the group or institution have to be dealt with.[69] Just as the emphasis on internalistic versus externalistic explanations overstates the case, the postulate of a mutual exclusion between hierarchy and heterarchy holds only with respect to a specific system and its treat–

---

[68]The goal, of course, is to define the system in such a way that it includes as much as possible the "mechanism" which produces the phenomenon one tries to explain. But there are, of course, nearly always specific circumstances of various kinds which lead to different inclusions and omissions whose possible effects must be taken into account.

[69]Cf. C. G. Smith (1970) who gives evidence of this "organizational mix" in relation to the type of problems to be dealt with on the basis of an analysis of Decision Processes in a R. and D. laboratory. Smith of course uses the traditional opposition, "hierarchical vs. decentralized organization, and hence decision, which could not answer the question of how decentralization was coupled to the overall unit. Cf. as well T. Shinn's (1982) demonstration of a specific relation between task specificity and type of organization.

ment of a particular problem at a specified point in time.[70] Moreover, the theory-dependent question, to what type a system belongs, is overwhelmingly empirical and can only be decided through an investigation of the way it works.

4. Some final interpretive remarks on the proposed model

In the preceding pages I have presented a theory of social self-regulation in a rather condensed, and hence abstract, way. The aim of this last part is to link the theoretical argument more closely to the phenomenal domain of sociology by means of a specific look at the sociological (and psychological) study of science as a possible application of the theory. Just as a mathematical formalism has to be interpreted when employed in different fields of experience, different aspects of a systems theoretical model have to be linked explicitly to social phenomena, even when the model has been constructed in order to fit them.

As stated at the beginning, studies of science as a social and cognitive activity have often been dominated by various dichotomies, the opposition between "internal" and "external" being the most important one. One major effect of this widespread use of dichotomies is that they simplify situations by dividing their constitutive parts in two neatly separated classes. Now, theories must of course simplify. But quite often we are aware (or, at any rate, we suspect) that we use *over*simplifications - this is one reason, I think, why we frequently prefer not to speak of "simplifications" but of "idealizations." In any case, though we certainly cannot do without them, we should not lose our bad conscience about simplifications. And, of course, dualistic schemes are the most powerful cognitive strategies to structure and to reduce the complexity of our phenomenal world to an easily manageable size. Yet, the problem of oversimplification remains. In opposition to simplifications like "internalistic versus externalistic" explanations of science (which I share), E. Mendelsohn (1977: 3f) gave a much richer description of science. He wrote:

> "Science is an activity of human beings acting and interacting, thus a social activity. Its knowledge, its statements, its techniques have been created by human beings and developed, nurtured and shared among groups of human beings. Scientific knowledge is therefore fundamentally

[70] From this point of view, the reflections of Montesquieu on the separation of powers are interesting, because they propose to establish at the supreme level of society's institutions a permanent heterarchy of functions. But even the modern discussion on a theory of political pluralism and on democratic institutions might find the proposed models of self-regulation useful to overcome the somewhat sterile opposition between the capacity to decide on one hand and claims for participation on the other.

social knowledge. As a social activity, science is clearly a product of a history and of processes which occurred in time and in place and involved human actors. These actors had lives not only in science, but in the wider societies of which they were members.

There is another dimension to the problem worth noting at once. The human approach to understanding, explaining and interacting with nature has certainly not been uniform through time, nor across cultures. It has not even been the same for all groups or classes within a single culture or society."

It is this seemingly chaotic network of interacting human beings, continuously changing and interacting with other networks, giving rise to temporally and locally emerging "peaks" of order, which we have to explain. Although social scientists sometimes feel discouraged by the complexity of their domain, there are good reasons to doubt that "everything is connected to everything," even if there are certainly too many connections to allow for simple explanatory models. The concept of social systems and of how they regulate themselves appears to be rich enough to take into account a fair proportion of these connections.

Social systems

1 The *concept* of social systems designates a set of individuals who interact (in the frame of a existing or self-produced *organization*) on the basis of shared constructs of a particular reality and its behavioral and action correlates. These reality constructs and their action correlates are socially brought about (inside or outside the system) by the individuals who (as *components*), joined the system at some particular point in time: Scientists interact on the basis of, and with respect to, shared knowledge of their subject matter (What belongs to and what characterizes a specific discipline or a specific field? What are the important theories and their strong or weak points. What is considered as missing?) and agreed adequate ways to handle it. The systems they form are to a varying degree autonomized (cf. below 12.3) with respect to the production of relevant knowledge, and hence with respect to the criteria applicable to its evaluation and to new members.

2 More specifically, *social systems consist of components*, that is, of individuals who partly become members of the system they constitute. Their interactions give rise to a pattern of interaction, the *organization of the system*. It is, as a social phenomenon, autonomized with respect to singular interactions between components, though it consists of nothing more than interactions and their cognitive counterparts. A sociological explanation is situated either at the

level of social systems (as is mainly the case in this paper) or at the socio-psychological level, of individuals taken as systems of a different kind. Social systems and individuals (as systems) are linked via those cognitive constructs and correlated actions and behaviors that are taken as components of the social system but which, at the same time, must be understood as a specific subset of those processes which interact in the global cognitive processes of the individual (cf. below 8).

3 The *limits or borders of social systems* are limits of the knowledge and their action correlates which constitute a particular system: Scientists can (in principle) interact successfully on their particular scientific matters without the need and often even without the ability or readiness to share their convictions on other subjects. Individuals, on the other hand, who have not developed the required knowledge, cannot become members of the corresponding social system in science, although they might interact with scientists in other social systems (cf. below 8.3).

Component

4 The concept of component links cognitive constructs and their behavioral or action correlates: theories, methods, and the related research activities.

5 Components are understood as defined by those properties of individuals, and the processes to which they give rise, that contribute to what is taken as a social system and its behavior: a scientist belongs to a specific discipline, or to a particular research institution or group, only if, and as far, as his activities are related to the cognitive constructs and their behavioral correlates characteristic for the particular scientific system under consideration (in politics, for example, he acts as a politician, and a physicist who speaks about the social sciences, does this as a physicist and not as a social scientist).

6 Components are the only active parts of systems: Science is produced by scientists and not by any suprahuman actor(s) or force(s).

7 The concept of component underlines the mere analytical character of the dualism "individual/social": Theories, methods, and related actions are always located as knowledge "in" the acting individuals. But their "holders" developed them in social processes via learning, socialization, cooperation etc., which entails the fact that they are always shared. Theories, methods, etc. are therefore part of a *social domain* of cognitive constructs and interactive potentials *in the individual.*

8 The concept of component, moreover, links a specific subset of *socially*

brought about constructs and their action correlates (which hence "belong" to a social system) to the individual, conceived as a system of a different type than social systems.
This allows us to conceptualize several aspects:
8.1 Scientists have biological and emotional needs: The behavior of scientists is modulated by career aspirations, by jealousy and even hate, but as well by curiosity, friendship and emotional attachment to their work, either in general, or to particular parts as specific theoretical positions or methods. And there are still others who may "like" it simply because they have no professional alternative after a certain point in their career or after a certain age.[71]
8.2 Scientists are involved in several social systems at the same time and may try to avoid the resulting cognitive or normative dissonance: This leads to individualization and provokes them to think spontaneously about their role in society. Moreover, it renders the sharp distinction between an internalistic and an externalistic production of cognitive constructs obsolete. To maintain such a rigid distinction would require a given social system to be able to neutralize influences (via the individuals who are partly components) from other social systems, or to exclude such influences by interdicting multiple memberships of individuals. Interdictions are normally excluded in internally differentiated societies – they function only with respect to particular memberships[72] – but there are numerous examples of such neutralizing mechanisms and strategies: one can grant a lower prestige to other social systems (or disciplines, theoretical positions, etc.), require a certain level of discussion, or demand a particular type of evidence.
8.3 Cognitive constructs and the related action correlates of scientists may change as a result of extrasystemic influences from other social systems: Social systems like science, politics, or the economy – and, as well, the research groups, faculties and families of scientists interact, and are connected, via individuals who belong to them at the same time.

---

[71]Just as scientists, quite understandably, tend to describe their own behavior (cf. K. D. Knorr – Cetina, 1984; B. Latour / S. Woolgar, 1979; and the studies in K. D. Knorr – Cetina / M. Mulkay (Eds.) 1983; K. D. Knorr / R. Krohn / R. Whitley (Eds.) 1980) as theoretically and logically consistent, controversies are overwhelmingly presented – and analyzed – as "scientific controversies." Cf. at least on the importance of the study of scientific controversies H. Nowotny, 1975.

[72]It is possible to interdict a scientist from being at the same time member of a profit oriented R & D – institution and of a publicly funded laboratory in a similar domain. But, of course, it is difficult to block even those uncontrolled contacts between both domains which take place in public, e.g. during professional meetings, conferences etc., not to speak of other occasions which are normal in our societies.

Organization

9 The concept of organization makes it possible to explain particular behavioral traits of social systems which are not reducible to the actions of isolated individuals. Science as a whole is differentiated in disciplines and subdisciplines, fields, etc. with an enormous number of institutions of various kinds which are themselves all more or less internally differentiated. Now, differentiation always means "division and coordination of labor" – and hence entails a selective organization (cf. W. Storer, 1972). From this point of view, the existing disciplines with their traditional – or even institutionalized – linkages between some of them (but not between others) might be understood as an overall organization of science. The same holds true, of course, at the micro-level of internally differentiated research institutions or groups. In all these cases, the organization provides the individual scientists with information and possibilities of interactions according to the organization itself and its state at a given point in time.[73]

Self-regulation through self-organization

10 The concept of self-regulation through self-organization allows us to explain the interplay between the behavior of components and general, relatively stable, characteristics of social systems: As Durkheim has already asserted for the evolution from communities to societies, the mere fact of growth and "social condensation"[74] can lead, together with the resulting competition, to internal differentiation and specialization. Accordingly, we find in science a tendency to avoid parallel work by the creation of new domains of research: existing fields are differentiated into subfields which might become fields in their own right later on. But the same may take place within research groups with their typical mixture of formal and informal organizational elements. A given organizational setup might therefore become modified over time as a result of the continual interplay bet-

[73] As an example, the organization of science, and consequently that of sociology, changed when the close links between it and biology' where progressively loosened during the first half of this century. One important line of discussion of this connection (which included, at least partly, medical science) was that about eugenics, equally connected to the problem of internalist/externalist explanations in various disciplines. Cf. with respect to anthropology D. Freeman, 1984 and for its development in Germany P. Weingart / J. Kroll / K. Bayertz, 1988.

[74] This physicalist metaphor designates a development of social systems which is characterized by a growing number of interactions between members of the same social system. Such an increase, for example, of the number of scientists in a discipline, progressively exceeds the limited time or the limited capacity of attention of the individual scientist and forces him to better select his partners, and hence his interactions.

ween a state of the organization at a given point in time – with all its selective effects –, and the dynamics of the components. The components themselves, of course, may be interwoven in a great number of different systems, even different scientific systems. Such interactions in turn may engender new interactions, such that the organization undergoes changes. These modifications, typically enough, often correspond to changes in the scientific activities of the system.

Self–regulation in heterarchical systems

11 The type of self–regulation heterarchical systems allow for is characterized by less profound but quicker effects on the behavior of the system (in comparison to self–regulation through self–organization): It is much more difficult to modify the frontiers between scientific disciplines and even between subdisciplines, as well as those between formal or informal but established interaction routines in research institutes or small working groups, than it is to reorient activities temporarily (and, depending on the size of the system, partially) without touching the structure of the system – if the system's organization is neutral to such changes. Self–regulation in heterarchical systems thus has several crucial advantages:

11.1 In a heterarchical system, local events somewhere in the system (however they are produced) might lead to its reorientation and affect the whole system: In a hierarchically organized system innovations occur only if the innovators are in positions where their own decisions are accepted as data by those following them in the hierarchy, or if the innovators succeed in gaining the support of those who are (inside or outside the system) in such positions. As in a heterarchical system such positions exist only at a temporary level, there are better chances that wider notice will be taken of innovations, discoveries, or simply of the results of research activities of those institutions which are not judged any longer and once and for all as "minor."

11.2 A heterarchical type of self–regulation encourages the reestablishment of spontaneous dialogues and other interactions between subsystems that have become, as a result of processes of internal differentiation, organizationally separated and hence autonomized: Because, in a heterarchical situation no permanent hierarchical organization exists which contributes to the regulation of behavior, the components (or subsystems) must look themselves, on the one hand for support and alliances in the struggle for resources and on the other for possibilities to engage in scientifically fruitful cooperation. This allows (and, indeed, often re–

quires) the renewing of interactions between domains which have been separated in the course of the development of the sciences.[75]

11.3 As stated above, in systems with a heterarchical organization local events can more easily effect the whole system, and, as also mentioned, components or subsystems must take the initiative if they wish to affect the course of events. Now, as every system interacts with its environment through its components, all these conditions, taken together, have the consequence that the proportion of opportunistic reactions to events outside the system increases: Scientific social systems are always in need of resources, be they of a material or of a symbolic or legitimizing kind. This leads of course to a situation of competition between disciplines, research institutions and even the individual scientists who sign the "research proposals" (as the claims for money are called euphemistically). In such situations the links between social systems in science and other social systems that exist via the components, are used to establish numerous relations of exchange. These relations characteristically consist of importation and transformation of extrascientific problems into scientific research projects or even programs, together with the necessary material or other support to get public funding, and an exportation of solutions and academically trained personnel. The effect is of course a double one: These external influences function as a control from outside and diminish the autonomy of the systems concerned. At the same time they assure the acceptance (and the support) of the science system from outside and contribute to its necessary integration into the wider society.[76]

11.4 The temporary nature of regulating efforts in heterarchical systems allows for compensation for what later on may turn out to be a "mistake" or a cul-de-sac. It therefore diminishes risks and avoids requirements of complete knowledge: Examples of this effect can be seen in the widespread use of a combination of permanent and auxiliary staff in research institutions, permanent duties in teaching and research combined with a certain stress laid on self-produced projects, and of a corresponding mix of funding through a combination of (more or less) stable amounts of money of a budgeted type together with supplementary financing via research contracts.

---

[75] A good example is the interdisciplinary cooperation on the topic of self-organization, where scientists from various disciplines are attempting to establish a cooperation which had ceased for many years.

[76] It is clear that there must be an "equilibrium" between controlling influences from outside and the autonomy of the system. Although it is difficult to establish when this "equilibrium" is reached, it is important that the autonomization as crucial for the effectiveness of science does not descend too much.

Both concepts of self-regulation

12 Whereas the concept of components makes the distinction between internally or externally produced knowledge somewhat old-fashioned insofar as it reminds us too strongly of the difference between the externalistic convictions of early behaviorism and the exclusively internalistic positions of mentalistic approaches - both concepts of self-regulation allow for a *better understanding of how internally and/or externally produced new ideas are "selected" by a system.* Whether, and how, ideas from outside a particular scientific social system become relevant inside the system[77] depends on the system itself, primarily on its organization and/or its degree of autonomization.

12.1 In the case of a *hierarchically organized system*, it is the position of the individual component in the system which determines whether that individual's experiences from outside the system can be made relevant to it. This is why young or not yet established scientists often find it easier to provoke a segregational differentiation (establishment of a new field with its own paradigms, journals and, if possible, career opportunities) than to stay in the existing systems and struggle to modify their functioning.

12.2 The situation is of course different, if there are more or less strong elements of *heterarchical organization*. Due to its greater egalitarianism, it can be possible in such a situation to publish even "unconventional ideas" in established journals, to get a grant for more risky research, or even find a possibility of permanent employment working on a "promising line" of experiments, etc.

12.3 Although the social systems which constitute "the" (overall) scientific system decide about scientific standards and matters of scientific relevance mostly according to self-generated standards, they are normally much less free to decide on the socio-political or economic relevance of their output.[78]

This is expressed by the concept of *autonomization*. Due to their functioning, social systems in the scientific domain are, like all social systems, conservative. They tend to ignore and hinder innovations relevant to, or needed by, other social systems. Although there are positive aspects to this conservatism (cf. M. Polanyi, 1967), it, together with science's economic and politico-legal dependence, is seen outside science as partly a reason - and partly a pretext - to intervene

[77] In the sense that they trigger modifications of its characteristic theories, or even of its organization, in a way which (in principle) can be followed back to external influences.

[78] Seen from a historical perspective, the idea of the legally confirmed autonomy of science stems from the 18th century. It could not be realized because of religious and political censorship before our own time. That the claim for a "freedom of science" in a democratic society is not unproblematic is demonstrated by H. Asche, 1975.

more or less massively in the scientific system via a selective allocation of resources, or the establishment of fields of research. It may even entail the creation of scientific working opportunities for specific men and women for political or other reasons – and who are hence, of course, from outside the system. But not every question of the functioning of the system can be decided by such interventions, nor do interventions from outside normally last for a prolonged time.[79] Therefore, the resulting, or modified, social systems must always partially define for themselves what their subject matter is and how they are to work on it. At the same time, the surrounding scientific social systems have to adapt to the new situation. This process of intervention has from the point of view of regulation the peculiarity (mentioned in the discussion of Ashby's "law of requisite variety") that complex systems like scientific social systems (which, of course, can be constructed at various levels of generality) are in fact partly regulated through inputs from systems which are, with respect to the systems they regulate, *less complex*. But as they control *vital inputs*, they in fact force the system they regulate to produce through self-regulating processes a result of a specific type without being forced themselves to "model" or "understand" the internal functioning of the regulated system in detail.

To summarize the combined effects of both modes of self-regulation on science, one can say that they together allow us to explain the important and active role science and its institutions play in modern societies. Via self-organization, science creates the specializations and autonomizations which allow it to produce a highly valued output, and at the same time the organization which stabilizes its internal functioning and hence makes it possible to produce this output over prolonged stretches of time. But self-organization, if it were the only mechanism, would not explain why and how science became a social system (a network of social systems) that not only obtained a certain degree of autonomy from the surrounding social systems, but became progressively active and powerful as well. It is by preserving and introducing heterarchical elements in its organization, that science succeeded in activating, and hence regulating, itself in a way which combined the production of esteemed outputs, both as innovations and as propositions for problem solving, with the opportunism and (mostly) controlled risk-taking that is at the basis of its success.

[79] The reason is simply, that this would mean a take over by the intervening system, hence an absorption of the system concerned into the intervening system. By the same token, the advantages of differentiation would get lost. They consist exactly in that diminuition of the decision load that results from accepting or even granting autonomization to other social systems or to subsystems.

5 References

AN DER HEIDEN, Uwe / ROTH, Gerhard / SCHWEGLER, Helmut 1985
"Principles of self-organization and self-maintenance". *Acta Biotheoretica* 34, 125-138.

ARROW, Kenneth J. 1976[8]
Social Choice and Individual Values. New Haven, London.

ASCHE, Holger 1975
Hochschulautonomie – Wissenschaftsfreiheit im Abseits. (Demokratie und Rechtsstaat. Kritische Abhandlungen zur Rechtsstaatlichkeit in der Bundesrepublik. Ed. by R. Wassermann / Th. Rasehorn / F. Benseler. Vol. 28) Darmstadt, Neuwied.

ASHBY, W. Ross 1965
An Introduction to Cybernetics. Methuen, London (First publ. 1956).

BEN-DAVID, Joseph 1971
The Scientist's Role in Society. Englewood Cliffs, N.J.

BESNARD, Philippe 1983
"The 'Année sociologique' team". In: BESNARD, Philippe (ed.) 1983. *The Sociological Domain.* The Durkheimians and the Founding of French Sociology. Cambridge, London, New York. 11-39.

BLUME, Stuart S. 1974
Toward a Political Sociology of Science. New York, London.

BÖCKENFÖRDE, Ernst-Wolfgang 1978
"Organ, Organismus, Organisation, politischer Körper (VII-IX)". *Geschichtliche Grundbegriffe.* Historisches Lexikon zur politisch-sozialen Sprache in Deutschland. Vol. 4, Stuttgart. 561-622.

BÖHME, Gernot 1974
"Die soziale Bedeutung kognitiver Strukturen: Ein handlungstheoretisches Konzept der Scientific Community". *Soziale Welt* 25, 188-208.

– – – – – – 1977
"Cognitive Norms, Knowledge-Interests and the Constitution of the Scientific Object". In: MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977, 129-141.

BÖHME, Gernot / VAN DEN DAELĖ, Wolfgang / KROHN, Wolfgang 1973
"Die Finalisierung der Wissenschaft". *Zeitschrift für Soziologie* 2, 2, 128-144.

CLAESSENS, Dietrich 1962
"Forschungsteam und Persönlichkeitsstruktur". *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 14, 487-503.

CLARK, Sir George 1970
Science and Social Welfare in the Age of Newton. (Kap. III) Oxford.

CONANT, Roger C. / ASHBY, W. Ross 1970
"Every Good Regulator of a System Must Be a Model of that System". *International Journal of Systems Science* 1, 2, 89 – 97.

CRAMER, Jacqueline / EYERMAN, Ron / JAMISON, Andrew 1987
"The Knowledge Interests of the Environmental Movement and its Potential for Influencing the Development of Science". In: BLUME, Stuart / BUNDERS, Joske / LEYDESDORFF, Loet u.a. (Eds.) 1987. *The Social Direction of the Public Sciences.* Causes and Consequences of Cooperation between Scientists and Non – Scientific Groups. (Sociology of the Sciences. Yearbook XI) Dordrecht, Boston, Lancaster. 89 – 115.

CRANE, Diana 1967
"The Gatekeepers of Science: Some Facts Affecting the Selection of Articles for Scientific Journals". In: REYNOLDS, L.T. / REYNOLDS, Janice M. (Eds.) 1970. *The Sociology of Sociology.* New York. 406 – 421.

– – – – – 1972
Invisible Colleges. Diffusion of Knowledge in Scientific Communities. Chicago.

CROSLAND, Maurice 1975
"The Development of a Professional Career in Science in France". *Minerva* 13, 1, 38 – 58.

DAHRENDORF, Ralf 1968
Die angewandte Aufklärung. Gesellschaft und Soziologie in Amerika. Frankfurt, Hamburg.

DARNELL, Regna 1971
"The Professionalisation of American Anthropology. A Case Study in the Sociology of Knowledge". *Social Science Information* 10, 2, 83 – 103.

DOHRN – VAN ROSSUM, Gerhard 1978
"Organ, Organismus, Organisation, politischer Körper (I – VI)". *Geschichtliche Grundbegriffe.* Historisches Lexikon zur politisch – sozialen Sprache in Deutschland. Vol. 4, Stuttgart. 519 – 560.

DURKHEIM, Émile 1973^9 (1893)
De la division du travail social. Etude sur l'organisation des sociétés supérieures. Paris (First publ. 1893).

– – – – – 1987^2 (1888)
"Cours de science sociale. Leçon d'ouverture". In: DURKHEIM, Émile 1987. *La science sociale et l'action.* Ed. and introduced by J. – C. Filloux. (Coll. Le Sociologue) Paris. 77 – 110. (First publ. 1888).

FLECK, Ludwik 1980
Entstehung und Entwicklung einer wissenschaftlichen Tatsache. Einführung in die Lehre vom Denkstil und Denkkollektiv. Introd. and ed. by L. Schäfer und T. Schnelle. Frankfurt a. M. (First publ. 1935).

FOERSTER, Heinz von 1977
"Objects: Tokens for Eigen – Behaviors". *Cybernetic Forum* VIII, 3/4, 91 – 96.

FREEMAN, Derek 1984
Magaret Mead and Samoa. The Making and Unmaking of an Anthropological Myth. Harmondsworth.

GEIGER, Roger L. 1975
"The Institutionalization of Sociological Paradigms: Three Examples from early French Sociology". *Journal of the History of the Behavioral Sciences* 11, 3, 233 – 245.

GIDDENS, Anthony 1971
"The `Individual' in the Writings of Durkheim". *European journal of sociologie / Archives européennes de sociologie* 12, 210 – 228.

GLASERSFELD, Ernst von 1977
"A radical constructivist view of knowledge". Paper pres. at the Annual Meeting of the American Educational Research Association (Symposium on Implications of Constructivism for Human Development). New York. Reprinted in E. v. GLASERSFELD 1987. *Wissen, Sprache und Wirklichkeit.* Braunschweig, Wiesbaden. 131 – 136

– – – – – 1980
"The Concepts of adaptation and viability in a radical constructivist theory of knowledge". In: SIGEL, I. / GOLINKOFF R. / BRODZINSKI, D. (Eds.) 1980. *New Directions in Piagetian Theory and their Application to Education.* Hillsdale/N.J. 87 – 95.

– – – – – 1982
"An interpretation of Piaget's constructivism". *Revue Internationale de Philosophie* 36, 4, 612 – 635.

HALL, A.D. / FAGEN, R.E. 1956
"Definitions of Systems". *General Systems* 1, 18 – 25.

HEJL, Peter M. 1984
"Towards a Theory of Social Systems: Self – Organization and Self – Maintenance, Self – Reference and Syn – Reference". In: ULRICH, H. / PROBST, G. J. B. (Eds.) 1984. *Self – Organization and Management of Social Systems.* Insights, Promises, Doubts, and Questions. Berlin, Heidelberg, New York. 60 – 78.

– – – – – 1987a
"Konstruktion der sozialen Konstruktion: Grundlinien einer konstruktivistischen Sozialtheorie". In: SCHMIDT, S. J. (Ed.) *Der Diskurs des Radikalen Konstruktivismus.* Frankfurt a. M. 303 – 339.

– – – – – 1987b
"Zum Begriff des Individuums. Bemerkungen zum ungeklärten Verhältnis von Psychologie und Soziologie". In: SCHIEPEK, G. (Ed.) 1987. *Systeme erkennen Systeme.* Individuelle soziale und methodische Bedingungen systemischer Diagnostik. München, Weinheim. 115 – 154.

– – – – – 1988
Durkheim und das Thema der Selbstorganisation. (LUMIS Schriften Nr. 18. Universität GH Siegen) Siegen.

– – – – – 1990
Autonomie und Kontrolle (in Prep.).

HESSEN, Boris 1971
"The Social and Economic Roots of Newton's `Principia'". In: BURKHARIN, N. I. (Ed.) 1971. *Science at the Cross Roads.* London. (First published 1931 as a contribution to the International Congress of the History of Science and Technology)

JANTSCH, Erich (Ed.) 1969
Perspectives of Planning. Proceedings of the OECD Working Symposium on Long Range Forecasting and Planning. Bellagio, Italy 27th October – 2nd November 1968. Paris.

KANT, Immanuel 1983 (1790)
Kritik der Urteilskraft und Schriften zur Naturphilosophie. Ed. by W. Weischedel. (Werke. Vol. 8) Darmstadt.

KARADY, Victor 1979
"Stratégies de réuissite et modes de faire – valoir de la sociologie chez les durkheimiens". *Revue Française de Sociologie* 20, 1, 49 – 82.

KNORR, Karin D. 1980
"The Scientist as an Analogical Reasoner: A Critique of the Metaphor Theory of Innovation". In: KNORR, Karin D. / KROHN, Roger / WHITLEY, Richard (Eds.) 1980, 25 – 52.

KNORR – CETINA, Karin D. 1984
Die Fabrikation von Erkenntnis. Zur Anthropologie der Naturwissenschaft. Frankfurt a. M.

KNORR – CETINA, Karin D. / MULKAY, Michael (Eds.) 1983
Science Observed. Perspectives on the Social Studies of Science. London, Beverly Hills, New Delhi.

KNORR, Karin D. / KROHN, Roger / WHITLEY, Richard (Eds.) 1980
The Social Process of Scientific Investigation. (Sociology of the Sciences. Yearbook IV) Dordrecht, Boston, London.

KROHN, Roger 1977
"Scientific Ideology and Scientific Process: The Natural History of a Conceptual Shift". In: MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977, 69 – 99.

KÜPPERS, Günter / LUNDGREEN, Peter / WEINGART, Peter 1978
Umweltforschung – die gesteuerte Wissenschaft? Eine empirische Studie zum Verhältnis von Wissenschaftsentwicklung und Wissenschaftspolitik. Frankfurt a. M.

LARRAIN, Jorge 1980
"Durkheim's Concept of Idèology". *Sociological Review* 28, 1, 129 – 139.

LATOUR, B. 1980
"Is it Possible to Reconstruct the Research Process?: Sociology of a Brain Peptide". In: KNORR, Karin D. / KROHN, Roger / WHITLEY, Richard (Eds.) 1980. 53 – 73.

LATOUR, B. / WOOLGAR, S. 1979
Laboratory Life. The Social Construction of Scientific Facts. London, Beverly Hills.

LAU, Christoph 1975
Theorien gesellschaftlicher Planung. Eine Einführung. Stuttgart, Berlin, Köln.

LENGERMANN, Patricia M. 1979
"The Founding of the American Sociological Review: The Anatomy of a Rebellion". *American Sociological Review* 44, 1, 185 – 198.

LUHMANN, Niklas 1968
"Die Knappheit der Zeit und die Vordringlichkeit des Befristeten". *Die Verwaltung* 1, 3 – 30.

– – – – – – 1970
"Lob der Routine". In: LUHMANN, N. 1970. *Soziologische Aufklärung.* Aufsätze zur Theorie sozialer Systeme. Vol. 1. Opladen. 113 – 142.

– – – – – – 1971
"Politische Planung". In: LUHMANN, N. 1971. *Politische Planung.* Aufsätze zur Soziologie von Politik und Verwaltung. Opladen. 66 – 89.

– – – – – – 1972[2]
Funktion und Folgen formaler Organisation. (Schriftenreihe der Hochschule Speyer. Vol. 20) Berlin.

– – – – – – 1984
Soziale Systeme. Grundriß einer allgemeinen Theorie. Frankfurt.

MANDROU, Robert 1978
From Humanism to Science 1480 – 1700. Harmondsworth.

MATTHES, Joachim 1988
"Projekte – nein, danke? Eine (un)zeitgemäße Betrachtung". *Zeitschrift für Soziologie* 17, 465 – 473.

MATURANA, Humberto R. 1982
Erkennen: Die Organisation und Verkörperung von Wirklichkeit. Ausgewählte Arbeiten zur biologischen Epistemologie. Braunschweig, Wiesbaden.

MATURANA, Humberto R. / VARELA, Francisco J. 1979
Autopoiesis and cognition. (Boston Studies in the Philosophy of Science) Boston.

MAYNTZ, Renate / NEDELMANN, Birgitta 1987
"Eigendynamische soziale Prozesse. Anmerkungen zu einem analytischen Paradigma". *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 39, 648 – 668.

McCULLOCH, Warren S. 1965
"A Heterarchy of Values Determinied by the Topology of Nervous Nets". In: McCULLOCH, Warren S. 1965. *Embodiment of Mind.* Cambridge, Mass. 40 – 45.

MENDELSOHN, Everett 1974
"Revolution und Reduktion: Die Soziologie methodologischer und philosophischer Interessen in der Biologie des 19. Jahrhunderts". In: WEINGART, Peter (Ed.) 1974. *Wissenschaftssoziologie II.* Determinanten wissenschaftlicher Entwicklung. Frankfurt a. M. 241 – 261.

– – – – – 1977
"The Social Construction of Scientific Knowledge". In: MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977, 3–26.

MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977.
The Social Production of Scientific Knowledge. (Sociology of the Sciences. Yearbook I) Dordrecht, Boston.

NOWOTNY, Helga 1975
"Controversies in Science: Remarks on the Different Modes of Production of Knowledge and Their Use". *Zeitschrift für Soziologie* 4, 1, 34–45.

PARSONS, Talcott 1968
The Structure od Social Action. A study in social theory with special reference to a group of recent European writers. New York, London. (1. Free Press Paperback Edition. First publ. 1937).

POLANYI, Michael 1967
"The Growth of Science in Society". *Minerva* 5, 533–545.

ROTTLEUTHNER, Hubert 1988
"Biological Metaphors in Legal Thought". In: TEUBNER, Gunther 1988. (Ed.) *Autopoietic Law: A New Approach to Law and Society.* (European University Institute: Series A. Law. 8) Berlin. 97–127.

SCHARPF, Fritz W. 1973
Planung als politischer Prozeß. Aufsätze zur Theorie der planenden Demokratie. Frankfurt a. M.

SCHMID, Günther / TREIBER, Hubert 1975
Bürokratie und Politik. Zur Struktur und Funktion der Ministerialbürokratie in der Bundesrepublik Deutschland. München.

SHANNON, Claude E. / WEAVER, Warren 1949
The Mathematical Theory of Communication. Urbana, Chicago, London.

SHINN, Terry 1982
"Scientific Disciplines and Organizational Specificity: The Social and Cognitive Configuration of Laboratory Activities". In: ELIAS, Norbert / MARTINS, Herminio / WHITLEY, Richard (Eds.) 1982. *Scientific Establishments and Hierarchies.* (Sociology of the Sciences. Yearbook VI) Dordrecht, London. 239–264.

SIEFERLE, Rolf P. 1984
Fortschrittsfeinde? Opposition gegen Technik und Industrie von der Romantik bis zur Gegenwart. München.

SMITH, Clagett G. 1970
"Consultation and Decision Processes in a Research and Development Laboratory". *Administrative Science Quarterly* 15, 203–215.

– – – – – 1971
"Scientific Performance and the Composition of Research Teams". *Administrative Science Quarterly* 16, 486–495.

STEINMANN, Gunter 1988
"Bevölkerungswachstum, Ressourcen und wirtschaftliche Entwicklung". In: STEINMANN, Gunter / ZIMMERMANN, Klaus F. / HEILIG, Gerhard (Eds.) 1988. *Probleme und Chancen demographischer Entwicklung in der dritten Welt.* Proceedings der 22. Arbeitstagung der Deutschen Gesellschaft für Bevölkerungswissenschaft zum Thema 'Probleme und Chancen demographischer Entwicklung in der dritten Welt', Universität-GH Paderborn, 1.-4. März 1988. (Studies in Contemporary Economics) Berlin, Heidelberg, New York. 36-59.

STORER, Norman W. 1972
"Relations among Scientific Disciplines". In: NAGI, Saad Z. / CORWIN, Ronald G. (Eds.) 1972 *The Social Contexts of Research.* London. 229-268.

VAN DEN DAELE, Wolfgang 1977
"The Social Construction of Science: Institutionalisation and Definition of Positive Science in the Latter Half of the Seventeenth Century". In: MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977. 27-54.

VAN DEN DAELE, Wolfgang / KROHN, Wolfgang / WEINGART, Peter 1977
"The Political Direction of Scientific Development". In: MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977. 219-242.

VARELA, Francisco J. 1979
Principles of Biological Autonomy. New York, Oxford.

WEINGART, Peter / KROLL, J. / BAYERTZ, K. 1988
Rasse, Blut und Gene. Geschichte der Eugenik und Rassenhygiene in Deutschland. Frankfurt a. M.

WHITLEY, Richard 1977
"Changes in the Social and Intellectual Organization of the sciences: Professionalization and the Arithmetic Ideal". In: MENDELSOHN, Everett / WEINGART, Peter / WHITLEY, Richard (Eds.) 1977. 143-169.

WIENER, Philip P. / NOLAND, Aaron (Eds.) 1957
Roots of Scientific Thought. A Cultural Perspective. New York.

WOODWARD, William R. 1974
"Scientific Genius and the Loss of a Parent". *Science Studies* 4, 265-277.

WRIGHT, Peter W. G. 1981
"On the Boundaries of Science in Seventeenth-Century England". In: MENDELSOHN, Everett / ELKANA, Yehuda (Eds.) 1981. *Sciences and Cultures.* Anthropological and Historical Studies of the Sciences. (Sociology of the Sciences. Yearbook V) Dordrecht, Boston, London. 77-100.

ZILSEL, Edgar 1976
Die sozialen Ursprünge der neuzeitlichen Wissenschaft. Ed. and translated by W. Krohn, bibliogr. Note by J. Behrmann. Frankfurt a. M.